

Chapter 0 General

0.0 GENERAL

These Unified Standard Specifications for Materials and Works shall be applicable to all units of Indian Railways, executing Civil Engineering Construction or Maintenance Works. These should be read in conjunction with the "Standard General Conditions of Contract for use in connection with Engineering Works" issued by Railway Board. There are total 25 Chapters in 'Unified Standard Schedule Of Rates' (SOR). However, Specifications Book also has one additional Chapter on 'Mortar' (Chapter 26).

0.1 DEFINITIONS

The Terms "Railway", "Chief Engineer", "Engineer", "Engineer's Representative", "Contractor", "Contract", "Works", "Specifications", "Schedule of Rate", "Drawings", "Constructional Plant", "Temporary Works" and "Site" wherever they appear in the 'Unified Standard Specifications' will have the same meaning as given "Standard General Conditions of Contract".

0.2 GENERAL INSTRUCTIONS

- a) These 'Unified Standard Specifications' are being issued in supersession of all "Standard Specifications for Materials and Works" issued by the Zonal Railways and shall come into effect from a date to be notified by Railway Board.
- b) These Specifications shall be applicable to all works, including those executed through contracts. Special mention has been made, wherever practicable about Contractor's responsibilities and liabilities in regards to quality of materials and workmanship, method of measurement and rates payable.
- c) Various Specifications contained herein have been grouped into 26 Chapters. A decimal system has been adopted for numbering of the para, sub-para etc. in each Chapter, which facilitates cross references being made wherever necessary. Each Chapter deals with one component of Building Works.

- d) Specifications contained herein may, wherever necessary, be supplemented by Special Specifications attached to tenders or contracts for various works, including Zonal Works. In case any provision hereof is found at variance with such Special Specifications, the later shall prevail.
- e) Detailed specifications have been given for both materials and workmanship for most of the items of works covered by 'Unified standard Schedule of Rates'. If any matter arises during execution of the work, wherein these Specifications are not explicit, the Engineer may issue such detailed instructions so as to ensure that work is executed satisfactorily and in a workmanlike manner. In the event of any doubt, dispute or any other difficulty arising out of the provisions in these Specifications, matter shall promptly be referred to Principal Chief Engineer for decision.
- f) Schedules attached to tenders and contracts shall generally be drawn up based on these Specifications. In matters such as mix proportions, thickness etc. which may not have been given in some of the items/Specifications herein, but have been left to be decided by Engineer-in-charge to suit the requirements of individual case, the requisite particulars shall invariably be included in the description of items in the schedule of Quantity, forming contract agreement.
- g)
 - (i) Where Indian Standard Specifications have been quoted in these Specifications, it shall clearly be understood that irrespective of whether the year of issue of an IS Specification has been mentioned or not, the Specifications actually to be followed shall be the one that is current on the date of opening of tender.
 - (ii) In case IS Specifications quoted relate to materials covered by ISI Certification Marks Scheme, it will generally be sufficient if conformity with the relevant IS Specifications is certified by manufacturers under the

provisions of scheme. But if, in any particular case, the Engineer has a doubt about quality, he may order independent tests either locally or through an approved testing agency. Cost of such tests shall be borne by the Railway, if results are in conformity with IS Specifications and by the Contractor, if it be otherwise. In the later case, it shall be left to the Engineer to decide whether to accept the material or to reject it.

(iii) In case of materials not covered by ISI Certification Marks, cost of any test that the Engineer may consider necessary to verify conformity with IS Specifications quoted herein, shall be borne by the Contractor.

- h) If due to any special circumstances, Contractor is not able to arrange materials as per Indian Standard Specifications stipulated as well as in cases where IS Specifications have not been stipulated for any material, alternative materials as approved by the Engineer will be permitted to be used / supplied subject to the materials being found satisfactory for the purpose intended. Before approving use / supply of such materials, the Engineer may require Contractor to arrange for laboratory / field tests and field trials for which the cost shall be borne by the Contractor.
- i) Full list of IS specifications for materials to be used in different types of building works and Codes of Practice for Testing of materials etc. is available in Part 5 on "Building Materials" of "National Building Code of India 2005" issued by Bureau of Indian Standards. However, list of common IS Specifications, required to be used frequently and referred to in the Specifications is given in this Chapter.
- j) In regards to basic items such as materials, mortar, concrete, woodwork, steelwork, painting, etc. which may also be involved in various other Chapters of these Specifications, such basic items shall, unless specified to the contrary, follow the detailed Specifications laid down for the same in the relevant Chapters, irrespective of whether any cross reference to such Specifications has been given or not in various other Chapters.
- k)
 - i) For materials to be supplied by the Contractor - in certain cases samples are approved at the Tender acceptance stage itself. In all such cases, submission of samples for approval shall be governed by the instructions contained in the tender documents and materials actually supplied or used in the works shall be as per sample accepted.
 - ii) In all other cases where approval of samples by the Engineer is stipulated in these Specifications, samples shall be submitted to and got approved by him before materials are actually supplied or used on works.
- l) Generally no materials shall be supplied by Railway to Contractor for any work. In case any material is proposed to be supplied by Railway for any work, it shall be specifically indicated in Contract documents.
- m) Any addition or alteration to these Specifications, as may be found necessary from time to time, will be issued in the form of Correction Slips, serially numbered. All those who hold copies of these Specifications for guidance in execution or supervision of works shall be responsible for maintaining the same upto date, by indexing and posting the correction slips at appropriate places.

0.3 Procedure For Additions / Deletions / Modifications In SOR Items And Specifications

0.3.1 Procedure For Change In SOR Items And Specifications -

Since, unified SOR and Specifications are being issued by Railway Board, any change in the description in SOR items or Specifications can be done with the approval of Railway Board only. In case, any Zonal Railway find there is any discrepancy in SOR items or Specifications which is creating problem in execution of that particular item, it should form a Committee consisting of two nominated Chief Engineers, one each of Open Line and Construction Unit, who should study the problem and give its recommendations. If the change suggested by them has a financial implication, concerned FA&CAO of Open Line shall also be associated in this Committee.

Recommendations of this Committee, duly recommended by Principal Chief Engineer of Zonal Railway shall be forwarded to Concerned Directorate of Railway Board, handling the subject of Unified SOR. At present, Land Management Directorate is dealing with the subject. Railway Board will issue necessary amendment to all Railways after considering the proposal.

0.3.2 Procedure For Addition Of New Items In 'Standard Schedule Of Rates' –

Zonal Railways are authorised to add or delete any particular item from 'Unified SOR'. For addition of new items in SOR, a committee consisting of two Chief Engineers, one from Open Line and other from Construction alongwith concerned FA&CAO of Open Line shall scrutinise the new items to be added in SOR as proposed from any field unit or Division.

The committee shall also scrutinise the Analysis Of Rates of proposed item. These recommendations to add the items shall be put up to PCE of Zonal Railway who shall be the authority to include new items in SOR. Once PCE approves the item, including its analysis, the same may be included by Zonal Railway in the SOR in the respective Chapter.

Zonal Railways shall advise the list of all such new items included in their SOR every year in the month of December to Railway Board. Railway Board will scrutinise all these items received from all Zonal Railways and if found fit, will circulate list of New Items to be included in 'Unified SOR' applicable for all Zonal Railways.

0.3.3 Procedure For Deletion Of Any Item From 'Standard Schedule Of Rates' –

PCE shall be the authority to ban execution of any particular item on the Zonal Railway, if they find that the particular item is not suitable to their Railway system due to any reason. For this purpose, the item may not be deleted from the SOR;; but only a letter under the signature of PCE shall be circulated to all concerned, informing list of items which shall not be operated by the field units. In case,

PCE is of the opinion that any particular item included in 'Unified SOR' is having adverse effect and needs to be deleted from it, the matter shall be referred to Railway Board, which will take necessary decision.

0.4 Procedure For Adopting Base Rate By Zonal Railway To Finalise Rates Of SOR Items :

Analysis Of Rate of each and every item included in 'Unified SOR' has been prepared on 'Excel Spread-Sheet' and will be supplied to all Zonal Railways. Zonal Railways are not authorised to make any changes in the analysis of rates of any item. A separate file containing 'Basic Items' is also attached alongwith SOR / AOR, which also includes basic rates for each item; but these are only for the purpose of guidance and checking consistency in the analysis.

Zonal Railways shall appoint a committee of three JA grade officers including one from the finance who shall be responsible for collecting the market rates for every basic item included in basic list. The committee shall put up their recommendations regarding the rates to be adopted for each item and it shall be approved by the Chief Engineer, nominated by PCE of the Zonal Railway. Thereafter, these rates shall be fed in relevant columns of computerised file of 'Basic Items'.

This exercise will ensure updation of analysis of each item and final rates for all items of 'Unified SOR' shall be available, which may be adopted by the Zonal Railway for operation of SOR.

Since, computerised vetted Analysis of Rates for all items is already available; Basic Rates shall be updated on every three years interval or earlier, as decided by PCE of Zonal Railway. Exercise shall be started in January and be completed by 28th February of that Year.

0.5 Numbering System Of SOR Items

A modern system of numbering SOR items have been adopted for easy identification of item and proper linkage between item number & description of item. This system is

computer friendly and will help in making software for computerisation of estimates & billing processes, whenever these are taken up. Every SOR number consists of 6 numeric digits, as detailed below -

- (i) First 2 digits (left side) indicate Chapter Number from 01 to 26.
- (ii) Next one digit indicates Sub-Group within the Chapter. It can value from 1 to 9 only.
- (iii) Next 2 digits are Main item numbers, varying from 01 to 99. Item numbers are continuous within one Sub-group; but restart from 01 with change of Sub-group.
- (iv) Next one digit, i.e. right-most digit indicates Sub-item within the main item. It can vary from 0 to 9. It will have

value 0, if there is no Sub-item. Also, it will be 0 for main item with Sub-items, but in this case this item will not have any unit or rate, since unit & rate are associated with Sub-item.

0.6 List Of I.S. Codes –

List of I.S. Code which shall cover almost all the materials & processes, adopted for execution of SOR items, is given below. Still, reference of some of IS/International Codes could have been left. The list gives the IS/IRS/IRC Code Number and the subject. Only latest version of Codes, including Amendments & Correction Slips, as applicable on the date of tender opening, shall be used.

LIST OF I.S. CODES

SL	I.S. No.	Subject
1.	16	Shellac : Part I – Hand Made Shellac
2.	16	Shellac : Part II – Machine Made Shellac
3.	63	Whiting for paints and putty
4.	73	Specification For Paving Bitumen
5.	75	Linseed Oil Raw and Refined
6.	77	Linseed Oil Boiled For Paints
7.	102	Ready Mixed Paint, Brushing, Red Lead, Non-setting Priming
8.	104	Specification for Ready Mixed Paint, Brushing, Zinc Chrome, Priming
9.	109	Ready Mixed Paint, brushing priming plaster to IS: Colour No. 361 and 631. White and Off-White
10.	117	Ready Mixed Paint, Brushing, Finishing Exterior, Semi-gloss for General purposes to Indian Standards Colours
11.	123	Specifications for Ready Mixed Paint Semi-gloss for general purposes to some specified Indian Standard Columns
12.	124	Ready Mixed Paint brushing, finishing Semi-gloss for general purposes Part-3 (supersedes IS 119)
13.	133	Enamel, Interior (a) Under Coating (b) Finishing
14.	137	Ready Mixed Paint, Brushing, Matt or Egg Shell Flat, Finishing Interior to Indian Standard colour
15.	158	Ready Mixed Paint, Brushing, Bituminous Black, Lead Free, Acid, Alkali and Heat Resisting
16.	196	Atmospheric Condition of Testing
17.	198	Varnish gold size
18.	204	Specification for tower bolts (Part II) non-ferrous metals
19.	204	Specification for tower bolts (Part I) ferrous metal
20.	205	Specification for non-ferrous metal butt hinges
21.	206	Specification for Tee and strap hinges
22.	207	Gate and shutter hooks and eyes

23.	208	Specification for door handles
24.	210	Grey Iron Castings
25.	217	Specification for Cut Back Bitumen
26.	218	Specification for Creosote and Anthracene Oil for Use as Wood Preservatives
27.	269	Specification for 33 grade Ordinary Portland Cement
28.	277	Specification for Galvanised Steel Sheets
29.	281	Specification for mild steel door bolts for use with padlocks
30.	287	Recommendations for maximum permissible moisture content of timber used for different purposes
31.	290	Coal Tar Black Paint
32.	303	Specification for plywood for general purposes
33.	337	Varnish, Finishing Interior
34.	341	Black Japan, Types 'A', 'B' & 'C'
35.	347	Varnish, Shellac for General Purpose
36.	348	French Polish
37.	362	Specification for parliament hinges
38.	363	Specification for hasps and staples
39.	364	Specification for fanlight catch
40.	383	Specification for coarse and fine aggregate from natural source for concrete
41.	401	Code of practice for preservation of timber
42.	419	Putty for use on Window frames
43.	427	Distemper, Dry Colour as Required
44.	428	Distemper, Oil Emulsion, Colour as Required
45.	432	Specification for mild steel and medium tensile steel bars and hard drawn steel wire for concrete reinforcement Part I mild steel and medium tensile steel bars
46.	432	Specification for mild steel and medium tensile steel bars and hard drawn steel wire for concrete reinforcement Part II Hard drawn steel wire.
47.	451	Technical supply condition for wood screws
48.	452	Specification for door springs rat-tail type
49.	453	Specification for double-acting spring hinges
50.	455	Specification for Portland slag cement
51.	456	Code of Practice for Plain/Reinforced Concrete.
52.	458	Specification For Precast Concrete Pipes (With and Without Reinforcement
53.	459	Corrugated and Semi Corrugated Asbestos Cement Sheets
54.	460	(Part -I) Specification for test sieves : wire cloth test sieves
55.	516	Method of test for strength of concrete
56.	524	Varnish, Finishing, Exterior, Synthetic Air Drying
57.	525	Specification for Varnish, finishing exterior and general purposes
58.	533	Gum Spirit of Turpentine (Oil of Turpentine)
59.	549	Split Pins
60.	554	Dimensions for pipe threads with pressure tight joints on the threads
61.	619	Pruning and slashing knives hooked and curved
62.	621	Forks for plantations and estates
63.	650	Specification for standard sand for testing of cement
64.	651	Specification for salt glazed stoneware pipes and fittings
65.	653	Specification for linoleum sheets and tiles
66.	654	Clay Roofing tiles – Mangalore Pattern

67.	661	Code of practice for thermal insulation of cold storages
68.	702	Specification for industrial bitumen
69.	710	Specification for Marine Plywood
70.	712	Specification for building lime
71.	716	Specification for Pentachlorophenol.
72.	723	Specification for steel countersunk head wire nails
73.	729	Specification for drawer locks, cupboard locks and box locks
74.	733	Specification for wrought Aluminium and Aluminium Alloys, Bars, Rods and Sections (For General Engineering Purposes)
75.	737	Specification for wrought aluminium and Aluminium alloy sheet and strip for general engineering purposes
76.	771	Glazed Fire-Clay Sanitary appliances : Part 1 : General requisites
77.	771	Glazed fire-Clay Sanitary appliances : Part 2 Specific requirements of Kitchen and laboratory sinks
78.	771	Glazed fire Clay Sanitary appliances : Part 3/Sec.I Specific requirements of urinals: Slab Urinals
79.	771	Glazed fire Clay Sanitary Appliances – Part 3.Sec.II Specific requirements of urinals: Small Urinals
80.	772	General requirements for enameled cast iron sanitary appliances
81.	774	Flushing cisterns for water closets and urinals (other than plastic cistern)
82.	775	Cast iron brackets and supports for wash basins and sinks
83.	776	Wooden Seats and covers for water closets
84.	777	Specification for glazed earthenware wall tiles
85.	778	Specification for copper alloy gate, and check valves for water works purposes
86.	779	Specification for water meters (domestic type)
87.	780	Specification for sluice valves for water works purposes (50 to 300 mm size)
88.	781	Specification for cast copper alloy screw down bib taps and stop valves for water services
89.	782	Specification for caulking lead
90.	800	Code of practice for use of structural steel in steel construction
91.	806	Code of practice for use of steel tubes in building construction
92.	808	Dimensions for hot rolled steel beam, column, channel and angle sections
93.	809	Specification for rubber flooring materials for general purposes
94.	812	Glossary of terms relating to welding and cutting of metals
95.	813	Scheme of symbols for welding
96.	814	Part 1 Covered Electrodes for Metal Arc Welding of structural steel for welding other than sheets
97.	814	Part 2 For welding sheets
98.	815	Classification and coding of covered electrodes for metal arc welding of structural steels (2nd Revision) Superseded by IS : 8141 – 1991)
99.	816	Code of Practice for use of Metal arc Welding
100.	817	Code of practice for training and testing of metal arc welders
101.	818	Code of practice for safety and health requirements in electric and gas welding and cutting operations
102.	818	Code of Practice for Safety and Health Requirement in Electric and Gas Welding and Cutting Operations.1968
103.	822	Code of Procedure for Inspection of welds
104.	848	Specification for synthetic resin adhesives for plywood (phenolic and aminoplastic
105.	851	Specification for synthetic resin adhesives for construction work (non-structural) in wood

106.	852	Specification for animal glue for general wood working purposes
107.	875	Code of practice for design Loads (other than Earthquake) for Building and Structures. Part-1 Dead Load-Unit weights of Building Materials & stored 1987
108.	909	Specification for underground fire hydrant; sluice valve type
109.	958	Temporary corrosion prevention grease, soft film, cold application
110.	962	Code of Practice for Architectural and Building drawings
111.	1003	Specification for timber panelled and glazed shutters (Part 1) Door shutters
112.	1003	Specification for timber panelled and glazed shutters (Part II) Window and ventilator shutters
113.	1030	Carbon Steel Castings for General Engineering purposes
114.	1038	Steel doors, windows and ventilators
115.	1077	Common burnt clay building bricks
116.	1081	Code of practice for fixing and glazing of metal (steel and aluminium) doors, windows and ventilators
117.	1121	Methods of test for determination of properties and strengths of natural building stones (Part – 1 Compressive strength).
118.	1122	Methods of test for determination of specific gravity of natural building stones
119.	1123	Methods of identification of natural building stones
120.	1124	Methods of test for determination of water absorption, apparent specific gravity and porosity of natural building stones
121.	1125	Methods of test for determination of weathering of natural building stones
122.	1126	Methods of test for determination of durability of natural building stones
123.	1127	Natural Building Stones
124.	1128	Lime stones (slab & tiles)
125.	1129	Recommendations for dressing of natural building stones.
126.	1130	Specification for marble (blocks, slabs and tiles)
127.	1141	Specification for code of practice for seasoning of timber
128.	1148	Hot rolled steel rivet bars
129.	1149	High tension steel rivet bars for structural purposes
130.	1161	Steel tubes for structural purposes
131.	1172	Code of basic requirement for water supply, drainage and sanitation
132.	1182	Recommended practice for radiographic examination of fusion welded butt joints in steel plates
133.	1195	Bitumen Mastic for Flooring
134.	1197	Code of practice for laying rubber floors
135.	1198	Code of practice for laying fixing and maintenance of linoleum floor
136.	1199	Method of sampling and analysis of Concrete
137.	1200	Methods of measurements of building and Civil engineering works: Part 4 : stone masonry
138.	1200	Method of measurements of building and civil engineering works part 8 steel work and iron works
139.	1200	Method of measurement of building and civil engineering work (concrete work)
140.	1200	Method of Measurements of Building and civil Engineering Works. Part IX: Roof Covering (including Cladding)
141.	1200	Method of measurement of building and civil engineering work – concrete work (Part 5 – Form work).
142.	1200	Method of Measurements of Building and Civil Engineering Works Part X : Ceiling and Lining
143.	1200	Method of Measurements of Building and Civil Engineering Works Part : XII – Plastering and Pointing

144.	1200	Method of Measurements of Building and Civil Engineering Works Part : XIII – White Washing, Colour Washing Distempering and Painting of Building surfaces
145.	1200	Method of measurements of building and civil engineering works Part 3 Brick work
146.	1200	Method of measurement of Building and Civil Engineering work (Part XI) paving, floor finishes, dado and skirting)
147.	1200	Methods of Measurements of Building and Civil Engineering Works : Part XV- Painting, Polishing, Varnishing etc
148.	1200	Method of Measurements of Building and Civil Engineering Works; Part XVIII: Demolition and Dismantling
149.	1200	Method of measurement of building and civil engineering works (Part XIV) Glazing
150.	1200	Method of measurement of Building and civil engineering works. (Part I)Earth work
151.	1200	Method of Measurement of Building & Civil Engg. Works- Part 22- Materials
152.	1200	Method of Measurement of Building & Civil Engg. Works - Part 1- earth work
153.	1200	Method of Measurement of Building & Civil Engg. Works - Part 27- earth work done by mechanical appliances
154.	1200	Method of Measurement of Building and Civil Engineering Works Part 24 - Well Foundations
155.	1202	Determination of Specific Gravity
156.	1203	Determination of Penetration
157.	1205	Determination of Softening Point
158.	1208	Determination of Ductility
159.	1209	Determination of Flash Point and Free Point
160.	1211	Determination of Water Content (Dean and Stark Method)
161.	1212	Determination of Loss On Heating
162.	1216	Determination of Solubility in Carbon Disulphide Trichloroethylene
163.	1230	Cast Iron Rain Water Pipes and Fittings
164.	1237	Specification for cement concrete flooring tiles
165.	1239	Specification for mild steel tubes tubulars and other wrought steel fittings Part II mild street tubulars and other wrought steel pipe fittings
166.	1239	Specification for mild steel tubes tubulars and other wrought steel fittings, Part I mild steel tubes
167.	1254	Corrugated aluminium sheet – Specification
168.	1278	Filler rods and wires for gas welding
169.	1285	Specification for wrought Aluminium and Aluminium Alloy, Extruded Round Tube and Hollow sections (For General Engineering Purposes)
170.	1300	Phenolic moulding materials
171.	1322	Specification for bitumen felt for water proofing and damp proofing
172.	1328	Specification for veneered decorative plywood
173.	1341	Specification for steel butt hinges
174.	1343	Code of Practice for Pre-stressed concrete
175.	1344	Specification for calcined clay Pozzolana
176.	1346	Code of Practice for Water Proofing of roofs with Bitumen Felts
177.	1363	Hexagon Head bolts, screws, and nuts of product grade C PART 1
178.	1363	(Hexagon Head bolt) (Size range M5 to M64) PART2
179.	1363	(Hexagon Head screws) (Size M5 to M64) PART 3
180.	1364	Hexagon head bolts, screws and nuts-Product grade A and B
181.	1367	Technical supply conditions for threaded steel fastener (Parts 1 to 8)

182.	1367	Technical Supply Conditions for Threaded Steel Fasteners Part XIII-Hot Dip Galvanised Coating on Threaded Fasteners
183.	1367	(Part 1 – 19) Technical supply conditions for threaded steel fasteners
184.	1378	Specification for oxidized copper finishes
185.	1395	Low and medium alloy Steel covered electrodes for manual Metal Arc Welding
186.	1443	Code of practice for laying and finishing of cement concrete flooring tiles
187.	1464	Clay ridge and Ceiling tiles
188.	1489	Part 1: Portland Pozzolana Cement: Part 1: Fly-ash based
189.	1489	Part 2: Portland Pozzolana Cement: Part 2: Calcined Clay based
190.	1536	Specification for centrifugally cast (spun) iron pressure pipes for water gas and sewage
191.	1537	Specification for vertically cast iron pressure pipes for water, gas and sewage
192.	1538	Specification for cast iron fittings for pressure pipes for water, gas and sewage,
193.	1542	Specification for sand for plaster
194.	1566	Specification for hard-drawn steel wire fabric for Concrete reinforcement
195.	1568	Specification for wire cloth for general purpose
196.	1580	Bituminous Compounds for Water Proofing and caulking purposes
197.	1592	Specification for Asbestos cement pressure pipes
198.	1597	Code of practice for construction of rubble stone masonry: Part 1 : Rubble Stone masonry
199.	1597	Code of practice for construction of Ashlar stone masonry : Part 2 : Ashlar masonry
200.	1599	Method for bend test for steel products other than sheet, strip, wire and tube (2 nd Revision) (Superseding IS : 1692-1974, IS : 3260-1960, IS : 4598-1968)
201.	1608	Method for tensile testing of steel products
202.	1609	Code of Practice for laying damp-proofing treatment using Bitumen felt
203.	1626	Specifications for Asbestos Cement Building Pipes and Pipe Fittings, gutters and Gutter Fittings and Roofing Fittings: Part –I; Pipe and Pipe Fittings
204.	1626	Specifications for Asbestos Cement Building Pipes and Pipe Fittings, gutters and Gutter Fittings and Roofing Fittings: Part –II; Gutter and Gutter Fittings
205.	1626	Specifications for Asbestos Cement Building Pipes and Pipe Fittings, Gutters and Gutter Fittings and Roofing Fittings: Part –III; Roofing Accessories
206.	1635	Code of Practice for field slaking of lime
207.	1658	Specification for Fibre hard boards
208.	1659	Specification for block boards

209.	1703	Copper alloy float valves (horizontal plunger type) for water supply fittings .
210.	1708	Method of testing of small clear specimens of timber (Pt.1 to 18)
211.	1726	Specification for cast iron manhole covers and frames
212.	1727	Methods of Test for Pozzolanic materials
213.	1729	Specification for sand cast iron spigot and socket soil waste and ventilating pipes, fittings and accessories
214.	1730	Steel plates, sheets, strips and flats for structural and general Engineering purposes - Dimensions
215.	1734	(Pt.1 to 20) Methods of test for plywood
216.	1742	Code of practice for Building drainage
217.	1786	Specification for high strength deformed steel and wires for concrete reinforcement
218.	1791	Specification for batch type concrete mixers
219.	1795	Pillar taps for water supply purposes
220.	1805	Glossary of terms relating to stones, quarrying and dressing.
221.	1821	Dimensions for clearance holes for bolts and screws
222.	1823	Specification for floor door stopper
223.	1837	Specification for fanlight pivots
224.	1852	Rolling and cutting tolerances for hot rolled steel products
225.	1868	Specification for anodic coating on aluminium and its alloy
226.	1875	Carbon Steel Billets, blooms, slabs, bars for forgings
227.	1894	Method for tensile testing of steel tubes
228.	1904	Code of practice for Design and construction of foundations in Soils -
229.	1929	Hot forged steel rivets for hot closing (12-36mm dia)
230.	1948	Specification for Aluminium Doors, Windows and Ventilators
231.	1949	Specification for aluminium windows for industrial buildings
232.	1977	Grade ST 44-0: For non-welded structures not subjected to dynamic loading other than wind (e.g. sheds, buildings, foot over bridges) except structures designed according to plastic theory. Grade ST-32-0: For general purposes where the load carried is not the main consideration (e.g. grills, railings)
233.	1977	Structural steel (ordinary quality)
234.	2004	Carbon Steel Forgings for General Engineering purposes
235.	2016	Plain washers
236.	2062	Steel for general structural purposes (4th Revision) (Supersedes IS : 226 – 1975)
237.	2064	Code of practice on selection, installation and maintenance of sanitary appliances.
238.	2065	Code of Practice for Water Supply in buildings
239.	2074	Ready mix paint , Air drying, Red oxide- Zinc chrome priming
240.	2078	Method of tensile testing of grey cast iron
241.	2093	Code of practice for laying and fixing of sloped roof coverings using plain and corrugated galvanised steel sheet
242.	2095	Specification for gypsum plaster boards
243.	2096	Specification for asbestos cement flat sheets
244.	2104	Specification for water meter boxes (Domestic type)
245.	2114	Code of practice for laying in-situ terrazzo floor finish

246.	2115	Code of Practice for Flat Roof Finish: Mud Phuska
247.	2116	Specification for sand for masonry mortar
248.	2155	Cold forged steel rivets for hot closing (6-16mm dia)
249.	2185	Concrete masonry units: Part I: Hollow and solid concrete blocks. .
250.	2191	Specification for Wooden Flush Door Shutters (Part 1)(Cellular & Hollow Core Type) (Plywood Panels)
251.	2202	Specification for wooden flush door shutters(Part 1) (Solid core type) plywood face panels
252.	2202	Specification for wooden flush door shutters (PART II) 1Solid core type) Particle Board & Hard Board Face Panels
253.	2209	Specification for mortice Locks (Vertical type)
254.	2212	Code of practice for brick work
255.	2238	Spades and Seprangs
256.	2250	Code of Practice for preparation and use of masonry Mortar
257.	2267	Polystyrene moulding materials
258.	2309	Protection of Buildings and allied Structures Against Lightning -Code of Practice
259.	2326	Automatic flushing cisterns for urinals
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306.	2751	Recommended practice for welding of mild steel plain and deformed bars for reinforced construction.
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308.	2906	Specification for sluice valves for water works purposes (350 to1200 mm size)
309.	2932	Enamel, synthetic, Exterior (a) Undercoating, (b) Finishing
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311.	2963	Copper alloy waste fittings for wash basins and sinks
312.	3007	Code of Practice For Laying of Asbestos Cement Sheets Part-II Semi Corrugated Sheets
313.	3007	Code of Practice For Laying of Asbestos Cement Sheets Part-I: Corrugated Sheets
314.	3016	Code of practice for fire precautions in welding and cutting operations 1982
315.	3025	Method of sampling and test for water
316.	3036	Laying Lime Concrete for Water Proofed Roof Finish
317.	3037	Bitumen Mastic for use in Water Proofing of Roofs
318.	3067	Code of Practice for General Design Details and preparatory work for Damp Proofing and Water Proofing of building
319.	3068	Specifications for broken brick (burnt clay) coarse aggregates for use in lime concrete.
320.	3076	Low density polyethylene pipes for potable water supplies
321.	3087	Specification for wood particle boards (Medium density) for general purposes)
322.	3092	Rubber Draining and tapping knife
323.	3093	Jungle Cutting
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326.	3102	Classification of burnt clay solid bricks (1st Revision) (Superseded by) common burnt clay building bricks) (5 th Revision)
327.	3108	Forestry Tools –Pruning Saw
328.	3122	Budding and Grafting Knife combined
329.	3144	Mineral Wool Thermal Insulation Materials Methods of Test
330.	3316	Structural Granite
331.	3346	Method of the Determination of Thermal Conductivity of Thermal insulation Materials (two slab guarded hot plate method)
332.	3348	Specification for Fibre Insulation Boards
333.	3384	Specification for Bitumen primer for use in Water proofing and Damp proofing
334.	3389	Urea-formaldehyde moulding materials
335.	3400	(Part II) Methods of test for Vulcanized rubbers (hardness)
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343.	3495	Method of test for clay building bricks (Part 1 to 4 in one volume)
344.	3502	Chequered plates
345.	3536	Specification for ready mixed paint brushing wood primer
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347.	3564	Specification for door closers (hydraulically regulated)
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349.	3613	Acceptance Tests for wire flux combinations for submerged arc welding of structural steel
350.	3618	Phosphate treatment of iron and steel for protection against corrosion
351.	3620	Laterite stone block for masonry
352.	3622	Specification for sand stone (Slab and Tiles)
353.	3640	Hexagon fit bolts
354.	3670	Code of practice for construction of timber floors
355.	3696	Safety code of Scaffolders - Part 1 - Scaffolds 1987
356.	3697	Part-2 Scaffolds and Ladders Code of Safety-Part 1 Ladders
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359.	3812	Fly Ash for use as Pozzolana and admixture
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362.	3828	Specification for Ventilator chains
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364.	3908	Aluminium equal leg angles
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367.	3965	Dimensions of bar, rods and sections and their tolerances
368.	3989	Specification for centrifugally cast (Spun) iron spigot and socket soil, waste and ventilating pipes, fittings, and accessories
369.	4014	Code of practice for steel tubular scaffolding; Part 2 Safety regulations for scaffolding
370.	4015	Guide for Handling cases of pesticide poisoning 1998
371.	4020	Pts. 1 to Pts.16 Method of Tests for Door Shutters
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373.	4031	(Part I) to (Part XIII) Method of Physical test for hydraulic cement
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379.	4101	Code of practice for external facings and veneers : Part 1 : Stone facing
380.	4111	Code of practice for ancillary structure in sewage system Part 1 manholes Part 2 flushing tanks
381.	4127	Code of practice for laying of glazed stone ware pipes
382.	4130	Demolition of buildings code of Safety
383.	4138	Safety Code for Working in Compressed Air 1977
384.	4351	Specification for steel door frame
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386.	4454	(Part 1) Steel wires for cold formed springs. Patented and cold drawn steel wires unalloyed
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394.	4919	Glossary of terms applicable to Landscape and Horticulture works
395.	4925	Batch Plants Specification for concrete batching and mixing plant.
396.	4948	Specification for welded steel wire fabric for general use
397.	4970	Key for identification of commercial Timbers
398.	4984	Specification for high density polyethylene pipes for potable water supplies, sewage and industrial effluents
399.	4985	Specification for unplasticised PVC pipes for potable water supplies
400.	4992	Specification for door handles for mortice lock (vertical type)
401.	5121	Safety code for Piling and other deep foundations
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419.	5871	Bitumen mastic for Tanking and Damp Proofing
420.	5913	Method of test for asbestos cement products
421.	5916	Safety code for constructions involving the use of hot bituminous materials
422.	5930	Specification for mortice latch (vertical type)
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428.	6313	1987Code of practice for Anti-termite measures in buildings part 3-- treatment for existing buildings
429.	6315	Double action hydraulic floor spring for aluminium doors
430.	6318	Specification for plastic window stays and fasteners
431.	6411	Specification for gel-coated-glass fibre reinforced polyester resin bath tub
432.	6419	Welding rods and bare electrodes for gas shielded arc welding of structural steel
433.	6452	Specification for High Alumina Cement for Structural Use
434.	6477	Dimension of extruded hollow section and tolerances
435.	6494	Code of practice for water proofing of under ground water reservoirs and swimming pools
436.	6523	Specification for pre-cast reinforced concrete door, window frames.
437.	6530	Code of Practice for Laying of Asbestos Cement Pressure pipes
438.	6560	Molybdenum and chromium – molybdenum low alloy steel welding rods and bare electrodes for gas shielded arc welding
439.	6598	Cellular Concrete for Thermal Insulation
440.	6607	Specification for rebated mortice lock (vertical type)
441.	6610	Heavy washers for steel structures
442.	6623	High strength structural nuts
443.	6639	Hexagon bolts for steel structures
444.	6649	Hardened and tempered washers for high strength structural bolts and nuts
445.	6760	Slotted countersunk head wood screws
446.	6909	Specification for Super-sulphated Cement
447.	6922	Criteria for safety and design of structures subject to underground blasts 1973
448.	6932	(Part 1 to 10) Method of test for building lime
449.	7002	Prevailing torque type steel hexagon lock nuts
450.	7193	Glass Fibre base Coal tar pitch and Bitumen felts
451.	7196	Specification for hold fast
452.	7198	Code of Practice for Damp Proofing using Bitumen Mastic
453.	7205	Safety code for Erection of structural steel work
454.	7215	Tolerances for fabrication of steel structures
455.	7231	Plastic flushing cisterns (Valves siphonic type) for water closet and urinals.
456.	7280	Bare wire electrodes for gas shielded arc welding of structural steel
457.	7290	Use of Polyethylene film for water proofing of roofs
458.	7293	Safety code for working with construction machinery
459.	7452	Specifications for hot rolled steel sections for doors, windows and ventilators
460.	7509	Thermal Insulating Cement

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462.	7740	Code of practice for construction and maintenance of road gullies.
463.	7825	Cylinder Type Hand Lawn Mowers – Part 1- Wheel Type
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465.	7861	Code of practice for extreme weather concreting (Part I) recommended practice for hot weather concreting
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467.	7969	Safety code for Handling and storage of building materials
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470.	8043	Hydrophobic Portland Cement
471.	8112	Specification for 43 grade ordinary Portland cement
472.	8183	Bonded Mineral Wool
473.	8229	Specification for Oil Well Cement
474.	8237	Code of practice for protection of slope for reservoir Embankments
475.	8756	Specification for mortice ball catches for use in wooden almirah
476.	8794	Specification for cast iron detachable joints for use with asbestos cement pressure pipes
477.	8944	Chloropyrifos emulsifiable concentration
478.	8989	Safety code for Erection of concrete framed structures
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481.	9103	Admixtures for concrete
482.	9295	Metal arc welding of Carbon and Carbon manganese Steels -recommendations
483.	9375	Specification for pre cast reinforced concrete plant guards.
484.	9417	Recommendations for welding cold worked bars for reinforced concrete construction
485.	9527	Code of Practice for design and construction of port and harbour Structures Part 1 Concrete Monoliths 1981
486.	9556	Code of Practice for Design and Construction of Diaphragm Walls 1980
487.	9575	Power Lawn Mower Pedestrian controlled cylinder (Reel) type
488.	9581	Safety and operational requirements for pedestrian controlled cylinder (Reel) – Power Lawn Mowers
489.	9743	Thermal Insulation Finishing Cements
490.	9759	Guidelines for Dewatering during construction
491.	9762	Specification for polyethylene floats (spherical) for float Valves
492.	9763	Specification for Plastic Bib Tap and Stop Valves (Pressing Spindles) for cold water service
493.	9855	Glossary of terms relating to sowing, planting, Fertilizer and Manure Application Equipment.
494.	9918	Code of Practice for in-situ water proofing and damp proofing treatment with glass fibre tissue reinforced bitumen
495.	10262	Recommended guidelines for concrete mix design.
496.	10772	Quick setting Lime Pozzolana mixture
497.	11134	Code of practice for Setting out of Buildings
498.	11272	Glossary of terms relating to Horticulture equipment.

499.	11652	Woven HDPE sacks for packing cement
500.	11653	Woven polypropylene sacks for packing cement
501.	11817	Classification of joints in buildings for accommodation of dimensional deviations during construction
502.	11972	Code of practice for safety precautions to be taken when entering a sewage system.
503.	12174	Jute synthetic union bags for packing cement
504.	12183	Code of Practice for plumbing multi storied building. Part-1 Water supply
505.	12269	Specification for 53 grade ordinary Portland cement
506.	12288	Code of Practice for use and laying of ductile iron pipes
507.	12330	Specification for sulphate resisting Portland cement
508.	12406	Specification for medium density fibre boards for general purposes
509.	12440	Pre cast concrete stone masonry blocks.
510.	12592	Specification for precast man hole covers and frames
511.	12600	Specification for low heat Portland cement
512.	12701	Rotational Moulded Polyethylene water storage tank – Specification
513.	12806	Indian Timbers for Door and Window Shutters and Frames
514.	12817	Stainless Steel Butt Hinges
515.	12823	Pre-laminated Particle Board
516.	12894	Fly ash-lime bricks.
517.	13182	Water Proofing and Damp Proofing of wet areas in Building – Recommendation
518.	13311	Indian Standard for non-destructive testing of concrete Method of test for ultrasonic pulse velocity. (Part I)
519.	13311	Indian Standard for non-destructive testing of concrete Method of testing for rebound hammer. (Part II)
520.	13415	Code of safety for protective barriers in and around buildings
521.	13416	Recommendations for preventive measures against hazards at workplaces: Part 2 Fall prevention
522.	13416	Preventive measures against Hazards at work places - Part 1 -falling material Hazard prevention
523.	13416	Preventive measures against Hazards at work places - recommendations - Part-III - disposal of debris (MULBA).
524.	13417	Preventive measures against Hazards at work places - recommendations - Part-IV - Timber structure
525.	13418	Preventive measures against Hazards at work places - recommendations - Part-V - fire protection.
526.	13430	Code of practice for safety during additional construction and alteration to existing buildings
527.	13592	Specifications for UPVC pipes for soil and waste discharge systems inside buildings including ventilation and rainwater system
528.	13630	Ceramic Tiles – Methods of Test (Pts 1 to 15)
529.	13712	Ceramic Tiles – Definitions, Classifications, characteristics and marking (under revision)
530.	13817	Soil working equipment – Dry Land Weeders manually operated
531.	13983	Stainless steel sinks for domestic purposes-specifications.
532.	14401	Handling and storage of building times - guidelines
533.	14587	Pre-laminated Fibre Board
534.	14616	Laminated Veneer Lumber
535.	14687	False Work for Concrete Structures - Guidelines
536.	14842	Coir Veneer Board

537.	14856	Glass Fibre Reinforced Plaster (GRP) Panel Type Door Shutters for internal use
538.	15380	Moulded raised High Density (HDF) Panel Doors
539.	15622	Specification for pressed Ceramic Tiles

LIST OF IRS CODES

SL	IRS No	Subject
1	B-1-2001	Steel Girder Bridges
2	M 3-Class I, II, III and IV	Steel forgings, blooms for forgings and billets for re-rolling
3	M-28	Classification, testing and approval of metal arc welding electrodes for use – Indian Railways
4	M-29	Classification, testing and approval of submerged arc welding with flame combination
5	M-41	Corrosion resistance steel
6	M-42	High strength low alloy structural steel with enhanced corrosion resistance
7	M-49	High strength excavating structural steel rivet bars with enhanced corrosion resistance
8	P-31	Zinc Chromate red oxide primer
9	B-3-61 Part 4	Iron and steel tanks and staging : IRS Specification

Chapter 1

Earth Work

1.1 EARTHWORK - GENERAL

1.1.1 Site Clearance : Before work is started, the whole area between the toes of banks or tops of cuttings plus 2m on both sides shall be properly and effectively cleared by the contractor of all small trees (of girth upto 30 cm), roots, bushes, heavy grass etc; The Contractor shall also clear the site of all buildings, abandoned structures etc as directed by the Engineer, for which extra will be made unless otherwise stated in the agreement. The Contractor shall arrange removal of rubbish and other excavated material excluding earth upto a distance of 50 the periphery of the area under site clearance. High portions of the ground shall be cut down and hollow depressions filled upto the required level with the excavated earth so as to give an even neat and tidy look. The work of this nature will be covered by the initial rate for earth work, unless stated to the contrary in the agreement.

1.1.1.1 Trees of girth over 30 cm, measured at a height of 1m above ground level, shall be considered as large trees. Cutting down of large trees shall be paid extra at the rate specified when stumps are grubbed up in addition. Large trees shall not be cut without specific orders from the Engineer. As few trees shall be cut as is absolutely necessary for the execution of work. The roots of trees and saplings shall be removed to a depth of 60 cm below ground level or 30 cm below formation level or 15 cm below subgrade level, whichever is lower. All holes or hollows formed due to removal of roots shall be filled up with earth rammed and levelled. Trees, shrubs, poles, fences, signs, monuments, pipe lines, cable, etc adjacent to the area which are not required to be disturbed during site clearance shall be properly protected by the contractor at his own cost and nothing extra shall be payable. In case any damage to the pipe lines, cables, etc is done due to negligence on part of the contractor the necessary damage charges will be recovered accordingly.

1.1.1.2 Any trees cut down or building materials released from dismantling of structures shall be stacked by the contractor within a distance of 100 metres outside the periphery of the area under site clearance as per instructions of the Engineer. The

contractor shall have no claim to the trees or other material removed during site clearance and the same shall be the property of the Railway.

1.1.2 Demarcation and Profiles : The contractor, before starting work, is to demarcate with a deep furrow, at least 20 cm wide and 15 cm deep, 1m away from the toes of slopes of banks and the outside limits of cuttings on both sides of the centre line, the boundaries of the bottom and the top of the slopes of the borrow pits. This is to be considered as part of the setting out of work, and preliminary to contractor being allowed to start the work; and this dag belling is to be maintained and renewed by contractor as and when necessary, or when ordered by the Engineer. The cost of this is included in the initial rate for earth-work.

1.1.2.1 The centre line will be initially set out by the Railway. The contractor shall, at his own expense, provide all building materials as cement, stone chips, sand, bricks, steel plates, nails, markers, stakes, bamboos, strings, pegs and labour necessary for setting out the centre line and profiles required for the correct execution of work and for marking out borrow pits and slopes and will be responsible to ensure that they are maintained in proper order. The costs of providing and maintaining the above including all materials and labour is included in the initial rate for earth-work.

1.1.2.2 The contractor before starting any work, shall take charge of all bench marks, centre line, demarcation and other field stones and reference pegs and be responsible for their subsequent preservation, and should they disappear or be destroyed after he has taken them over, he shall pay the cost of their replacement or replace them at his own level in consultation with the department.

1.1.3 Maintenance : Banks and cuttings are to be correctly dressed and finished in profile with slopes as specified in each case. Where gullies or water-cuts commence to form on the slopes of embankments or cuttings, the erosion is to be checked as early as practicable and made good with suitable material well rammed into place. Where a gully or water-cut has not been checked at its commencement, it may be advisable to cut it out or step it before filling it

in, and to further protect the place by turving, pitching or other means as may be ordered by the Engineer. Work, before being finally paid for, is to be checked by the Engineer as having been correctly brought up, or carried down, to the proper level and to be otherwise complete in all respects in accordance with the specifications, and with the proper allowance for settlement as specified in **para 1.2.6.**

1.1.3.1 As soon as the work has been satisfactorily completed, the Engineer shall issue a certificate of completion in respect of the work as specified in Clause 48 of the General Conditions of Contract. Unless otherwise specified in the Tender conditions, the contractor shall maintain the banks / cuttings for a period of six months or as per conditions of contract and handing over of banks / cuttings to Railway in proper condition and where necessary, for their restoration to such condition, at the end of maintenance period. Until then, contractor is responsible for all losses due to subsidence, wastage or guttering due to rain, wind, wear, wash or from any other cause whatsoever and he shall have no claim for any extra work or payment on this account.

1.1.4 Spoil from cutting to bank : Up to the normal lead of 50 metres, material from each end of every cutting shall be led forward into the adjoining bank as a matter of course, and the rate to be paid for such material shall be the rate for cutting only. Both bank and cutting will not be paid for. The Engineer shall specify in each case from what point in each cutting to what point in the adjoining bank, spoil shall be led out, payment being made only for the excess lead over and above the initial lead included in the rate for cutting. The Engineer can modify these limits at any stage of the work and all such changes shall be binding on the contractor without any claim for any extra payment on this account. Dressing and compaction of the bank will, however, be paid for in addition.

1.1.5 Classification of Soils : The classification of soils met with in executing the work shall be made by the Engineer/Engineers' representative authorized by the Engineer for this purpose subject to the approval and final decision of the Engineer, if not made by him. The rates to be paid to the contractor in his bills shall be based on these classifications.

Earth work can be divided under the following heads :

1.1.5.1 Soft / Loose Soil : Generally any soil which yields to the ordinary application of pick and shovel, or to phawra, rake or other ordinary digging implements; such as vegetable or organic soil, turf, gravel, sand, silt, loam, clay, peat, etc.

1.1.5.2 Hard/Dense Soil : Generally any soil which requires the close application of picks or jumpers or scarifiers to loosen; such as stiff clay, compact moorum, macadam surfaces of any description, (water bound, grouted, tarmac etc), kankar soil, shingle and boulder studded soil and soft conglomerate etc.

1.1.5.3 Mud (Soil) : A mixture of soil and water in fluid or weak solid state and where inflow of sub soil water is not involved.

1.1.5.4 Soft/Disintegrated Rock (Not Requiring Blasting) : Rock or boulders which may be quarried or split with crow bars. This will also include laterite and hard conglomerate.

1.1.5.5 Hard Rock (Requiring Blasting) : Any rock for the excavation of which blasting is required.

1.1.5.6 Hard Rock (Blasting Prohibited) : Hard rock requiring blasting as described under **sub para 1.1.5.5**, but where blasting is prohibited for any reason and excavation has to be carried out by chiselling, wedging or any other agreed method.

1.1.6 Measurements : Cutting and banks are to be excavated and made up neatly to the lines shown in the cross section as per approved construction drawing. No payment will be made for excess work done outside these lines except when such work is so ordered in writing by the Engineer. However, if any bulges are left in the slopes of cuttings due to practical difficulties and are permitted, deduction as per actual measurements will be made. Similar action will be taken in case of concave surfaces in the slopes of embankments, if permitted.

1.1.6.1 Should the Engineer so desire, he may, at any stage of the work, order the Contractor to increase or reduce the slopes of any cutting or bank or alter the formation level, in which case the amount of work actually done will be paid for in accordance with the specifications and the Schedule of Rates.

1.1.6.2 Unless otherwise specified the initial rate for Earth work is inclusive of an initial lead upto 50 metres and lift of 1.5 metres.

1.1.6.3 Additional lead for the purpose of payment will be measured from the centre of gravity of excavation to the centre of gravity of the bank or spoil heap, and shall be measured along the shortest practicable route and not necessarily the route actually taken.

1.1.6.4 Additional lift for the purpose of payment will be estimated by dividing the cross section of the bank or cutting into successive stages of 1.5m high or deep respectively from the natural ground level and only the quantity contained in each strip shall be paid for at the rate pertaining to its height or depth above or below the natural ground level, respectively. Lift from the borrow-pit to the ground level or from ground level to the spoil bank shall not be taken into account in any payment for lift unless the depth of the borrow-pit or the height of the spoil bank has been made in excess of 1.5m under instructions from the Engineer, and in such cases, only the portion of the borrow-pit below 1.5m depth or of the spoil bank above 1.5m height as measured from the natural ground level, shall be, measured separately for payment of lift on the same basis as for cuttings or banks respectively. No extra payment will be made for descent, ascents, crossing of nullahs and ridges.

1.1.6.5 For purpose of payment, cuttings shall be assumed to be composed of such soil / soils only, as stand exposed on both or one side of the finished cuttings, depending upon whether the cutting is box type or one sided on a transversely sloping ground. The content of each type of soil thus assigned to any cross section shall be determined as indicated below. It is to be noted that no portion of cutting will be payable for any such type of soil as is not exhibited on the finished side slope, where the side slope exists.

(a) For box type cutting : The centre line of the alignment will be marked vertically on the cross section and the content of each type of soil will be determined by computing the area of the strip, formed by joining the points, which form the extremity of occurrence of the particular soil on the finished side slope of cutting, by straight horizontal lines terminating on the centre line. **Figure No.1.1** is illustrative of the manner in which payment is to be made.

(b) For one sided cutting on a transversely sloping ground : Content of each type of soil will be determined by computing the area of the strip, formed by joining the points, which form the extremity of occurrence of the particular soil on the

finished side slope of the cutting, by straight lines to the zero point. **Figure No.1.2** is illustrative of the manner in which the payment for the cutting will be made

(c) For widening of existing cuttings for one or more lines where the existing cutting slope disappears and a fresh slope stands : Before undertaking widening of the cutting, pre-classification of the existing cutting slope (which will disappear) should be done after clearing and cleaning the surface and the strata met marked on the cross-section sheets. After completion of the work various strata as stand exposed on the new finished slope of the cutting shall again be marked on the cross-sections. Then the demarcation points of adjacent strata as determined by classification of the existing slope and the final slope should be joined as shown in **Figure No. 1.3**.

The cross-sectional areas for different strata may be worked out and quantities payable classification-wise assessed accordingly.

(d) For extension to the existing cutting where no fresh cutting slope is available after work : Before execution of the work pre-classification of the existing cutting slope which will not be finally available, should be done and recorded in the initial cross-section. **Figure No. 1.4** is illustrative of the manner in which the payment for the cutting is to be made for soil of different classifications.

1.1.6.6 Classification in the above manner shall be made only at such points where the cross sections giving the ground profile have been recorded. The classification as recorded in the above manner in case of cuttings shall be signed by the contractor in token of his acceptance. The classification as recorded by the Authorized representative of the Engineer in the above cases for cuttings is subject to confirmation by the Engineer, whose decision shall be final and binding on the contractor. Where there is disagreement between the Contractor and the Authorized representative of the Engineer on classification of soil, payment shall be effected "on account" as per lower classification as made by the Authorised representative of the Engineer. Payment for extra at the rate for higher classification shall be made after final decision by the Engineer on the admissibility of the Contractor's claim for higher classification.

1.1.6.7 In computing the quantity of earth work in cuttings and side drains, no cognizance will be taken of the additional

excavation, which may be necessitated during the progress of the work due to the presence of boulders or other material, and payment will only be made for the quantity as per cross sections required to be provided.

1.1.6.8 Where cutting spoil is utilised for making the bank, stones over 15 cm size, which are not to be used in the bank, shall be stacked separately at a site to be indicated by the Engineer. To determine the quantity of cutting spoil led out for making the bank, the sectional quantity of the cutting shall be reduced by the volume of stones and boulders stacked outside, which will be arrived at by deducting 50% for voids from the stack measurements of these stones and boulders. The stacking of these stones and boulders including lead upto 50 metres and lift upto 1.5 metres is covered by the initial rate of Earth work.

1.1.6.9 Stones and boulders over 15 cm size shall not be used in making embankments. In embankments where payment is made on the basis of cross section measurements, the stones and boulders over 15 cm size shall be stacked separately, and their volume, after deducting 50% for voids from the stack measurements of these stones and boulders, shall be included as extra, for payment for earthwork in excavation from borrow pits.

1.1.6.10 Payment : It must be clearly understood that the Contract rates are intended to cover the full cost of finished work. Banks and cuttings are to be carefully dressed to formation with such slopes as may be specified in each case. The payment for the quantity of earth work in cutting / bank shall normally be made on cross sectional measurements. The existing ground / bank profile shall be taken and plotted by the Authorised representative of the Engineer in the presence of contractor or his authorized agent before commencement of the work. The profile of the bank or the cutting required to be provided including allowance of settlement in case of embankment, shall also be plotted on the same sheets. The levels and cross sections shall be signed by both the Authorised representative of the Engineer and the contractor / his authorized agent. (The profiles of the bank or cutting as required to

be provided are for the guidance of the contractor and not for the purpose of measurements).

The profiles of the finished and plotted bank/ cutting shall like-wise be taken in the presence of the contractor or his authorised agent and super-imposed on the original ground profile. These profiles are to be taken at locations as directed by the Engineer, atleast at 25m intervals on straight and at least at every 15m on Curves with radii sharper than 600m and at extra locations in special cases such as irregular or side long ground etc. The gross volume of earth work shall be calculated from the original and finished profile of the bank/ cutting. For the purpose of payment the gross quantity thus calculated shall be reduced by 10% towards shrinkage allowance for earth work in embankments only, but no such deductions shall be made for earth work in cuttings. Where the embankment has been compacted by heavy machinery as stipulated in subsequent **Para 1.9** or in accordance with any other special specifications, on the specific instructions of the Engineer in writing, shrinkage allowance shall be deducted at the rate of 5% of the gross quantity of earth work. Irrespective of the type of soil, number of monsoons passed over the embankment, shrinkage / compaction which may be caused due to base settlement, wash out, mode of working, i.e. use of trucks, camel carts, donkeys etc, and other reasons, whatsoever and the actual shrinkage allowance provided in setting out the profiles in different sections.

As it may, at times, be difficult to measure by means of cross sections the quantity of rock excavated by blasting or chiselling, owing to its irregular configuration or intermixture with other materials, the quantity of rock may be measured after stacking the excavated rock spoil. The same procedure also applies to any other type of soil, which requires to be measured separately from the material constituting the bulk of the spoil. In all such cases, the payable quantity of the stacked material is to be arrived at by making suitable deductions for voids from the measured cubical contents of the stacks as specified below :

Type Of Soil Stacked	Deduction
(a) Rock spoil of different sizes	30 per cent
(b) Sandy materials	7 ½ per cent
(c) Black cotton soil	20 per cent

- (d) Other soils, including coal ashes 15 per cent

To facilitate measurement, all stacks to be measured shall be made rectangular in plan and of uniform height, on level ground or ground levelled for this purpose. The stacking of spoil shall be done in a compact manner to the satisfaction of the Engineer. The rates provided shall include all charges on account of such stacking as well as any lead or lift, as also the re-stacking of stacks or portions of stacks which the Engineer considers, in his sole discretion, as not properly stacked.

As far as possible spoils from cuttings fit for embankment shall be used to make up the bank. If however, this is found to be uneconomical due to excessive lead or lift, the earth if available from the borrow pits in Railway land it may be used if permitted. If sufficient quantity of good earth fit for embankment is not available from the source of cut spoils and the source of borrow pits, Contractor's earth shall be utilised. As far as possible each stretch of bank should be made of earth from only one source so as to avoid mix up. If however, this is not possible due to exigencies of work, earth from one source should be utilised first and compaction done before earth from the next source is allowed to be dumped. Initial cross section of bank and cross section after compaction of earth from each of the sources should be taken. Based on the cross sectional areas, the gross quantity of earth work embankment executed by utilising the earth from different sources shall be determined. The net quantity shall be assessed after deduction of shrinkage allowance at the rate of 10%/5% as the case may be, depending upon the type of compaction done.

Final measurements shall be taken only after the bank/ cutting has been completed to the required profile as directed by the Engineer irrespective of the period of completion and number of monsoons that may pass during execution. Shrinkage allowance shall be applied on these final measurements for banks.

1.1.6.11 At the end of final measurements, following certificate shall be recorded in the Measurement Book by Authorised representative of the Engineer.

"Certified that necessary allowance for shrinkage as prescribed was made while giving profiles to the contractor for doing earth work and the same has been provided by the Contractor".

1.1.6.12 Where, for any reason at the discretion of the Engineer, borrow-pit measurements are resorted to, all matams and roads and excess earth work, such as bulges in the slopes of the banks / cuttings, shall be excluded from the measurements.

1.1.6.13 Nothing extra shall be paid for :

- (i) Excavation for insertion of planking and strutting.
- (ii) Removing slips or falls in excavations
- (iii) Bailing out water in excavations from rains, ordinary springs not requiring pumping etc.
- (Note : Pumping out water caused by powerful springs, tidal or river seepage, broken water mains or drains and the like, shall be paid separately if provided for in the Agreement)
- (iv) Unauthorised battering or benching of excavations.
- (v) Forming steps in sides of deep excavations and their removal after measurements.
- (vi) Protective measures for protection against risk of accidents to the public due to open excavation.
- (vii) Protective measures / precautions taken to avoid damage to existing Signal / Electrical / Telecom / other Miscellaneous Cables, Pipes, installations etc.

1.1.7 Dressing Surface :

1.1.7.1 This specification is applicable to Surface dressing executed as a separate work for purposes other than Earthwork for Embankment or Cutting. In case of Earthwork for Embankment or cutting, provisions of **Para 1.1.1** will apply and the surface dressing will be covered by the initial rate of earthwork unless stated to the contrary in the Agreement. This specification shall also be applicable only to work involving Soft / Loose soil and Hard / Dense soil.

1.1.7.2 The terms "Dressing Surface" shall be taken to mean the cutting down of high portion of a specified area of ground and using the excavated earth to fill up the hollows and the depressions. The maximum depth of excavation or filling shall be restricted to 15 cms.

1.1.7.3 The levels to which the ground is to be dressed shall be such that the quantity filled is nearly equal to the quantity cut and the finished surface is even and tidy with

such slopes as may be necessary for proper drainage. Before the work is commenced the proposed levels shall be set up at regular intervals both for the cuts and for the fills, by suitable means as directed by the Engineer and these shall be got checked and approved by him.

1.1.7.4 Unless otherwise provided for in the Contract, the rates shall be inclusive of removal of rubbish upto a distance of 50m outside the periphery of the area cleared.

1.2 EARTH WORK IN EMBANKMENTS

1.2.1 Embankment in Water-logged ground etc. : When embankments are to be carried across water-logged or swampy ground or to be made in soil which requires special protective measures, it rests with the Contractor in all such cases to bring these facts to the notice of the Engineer concerned who will direct on the methods to be adopted and the rates to be paid, and will arrange for a special agreement for the same if necessary.

1.2.2 Selection of Earth : If due to non availability of adequate quantity of earth from Railway land, the contract provides for contractor's earth the contractor shall get the prior approval of the Engineer for the quality of earth and where Contract Conditions provide for lead based on the distance from the sources of supply to site, the lead to be paid. The disturbed / undisturbed soil samples along with the test results as per specifications will be submitted by the contractor for approval of the source from where the earth is proposed to be borrowed before the Earth work in embankment is started or in case of change in location of the source.

1.2.3 Formation Width : The formation widths are to be as shown in the drawings.

1.2.4 Side Slopes : The side slopes will ordinarily be 2:1, but the Engineer or his Authorised representative may, by order in writing, vary this slope to suit local conditions. The side slopes shall be carried up simultaneously with the rest of the work and not filled in afterwards. This can only be ensured by insisting on the whole width of embankment from the toes of the slope coming up simultaneously. The slopes of banks composed of sand shall, if directed by the Engineer be covered by a layer of not less than 30 cm thickness of Moorum or other good soil to facilitate turfing and extra payment will be made for the same.

1.2.5 Profiles : Profiles for banks shall be set out where-ever cross section has been taken. These profiles shall be set up atleast every 25m on the straight and every 15m on curves with radii shorter than 600m. Profiles shall also be set up at any additional places if ordered by the Engineer.

1.2.6 Allowance for settlement : In width of formation 50mm extra should be provided for each 30 cm of the height of the bank as shown on the section upto a maximum of 0.60m. This does not affect the width at the toes of the slopes, which will be set out from the height given on the section. In setting up profiles for bank, due allowance for settlement must be made and added to the height of the profile over and above the height of formation as shown in the approved drawing. As a guide the following shrinkage allowances per metre height are suggested for adoption with different classes of soil:- The additional earth has to be removed after final dressing and it can be used elsewhere after a stretch of the work is completed, dressed to final profile and taken over by the railways.

Shrinkage allowance for work done manually per metre height :

Bank made of rocky fills	0	to	2 cm
Bank made of moorum and sandy soils	8	to	12 cm
Bank made of fills with considerable clay content	16	to	20 cm

The Engineer will decide the scale of allowance for settlement for each section and shall be at liberty to vary the same during the progress of the work to suit the nature of soil met with, the method adopted for executing the earth work, the consolidation achieved during the progress of the work and any other factors affecting the earth work.

1.2.6.1 The above shrinkage allowances are only for the purpose of setting out of the work. For payment, the deduction for shrinkage shall be as specified in para **1.1.6.10**.

1.2.7 Borrow Pits : The Engineer concerned will direct from where material is to be obtained and has powers to refuse to allow any unsuitable material to be put into a

bank. As far as possible, Bank should be made of homogeneous material with no mix of rubble or boulders with soil. No excavation for borrow pits shall be made within 2m of the limits of the acquired land. Borrow pits shall not be dug close to level crossings, bridges or culverts, telegraph poles, electric poles, or close to inhabited areas, unless they can be properly drained to prevent water stagnating. Borrow pits within station limits shall be avoided as far as possible. The earth is to be excavated and thrown to such width, depth and height and in such places as may be from time to time decided.

1.2.7.1 During excavation, the contractor shall take particular care to avoid damage to drains, water mains, cables or other underground work. Should any damage be caused, the Engineer shall be notified immediately and the damage shall be made good at the contractor's expense.

1.2.7.2 Borrow pits shall be excavated within the limits of railway land as directed by the Engineer. The pits must be rectangular or conform to the land boundaries. The sides of the pits next to the toe of the bank are to be sloped down at 2:1, and elsewhere at a slope of 1:1 unless otherwise directed by the Engineer. Any pits wrongly excavated shall be refilled by the contractor at his own cost, and in such a manner as the Engineer directs.

1.2.7.3 Borrow pits are not to be made of uneven depth but the whole area of each pit is to be neatly excavated to the same level. The outer or the most distant half of the borrow-pits is to be excavated first, so that in the event of the pits being flooded by rain, there will still be ground available for work.

1.2.7.4 A berm 15m wide is to be left untouched initially at every 85m between edges of borrow-pits, and is not to be encroached upon for any excavation except under the instructions of the Engineer. If it is necessary for drainage purposes to cut through the berm, the channel will be made on the side remote from the Bank.

1.2.7.5 In side long ground, the borrow pits are to be dug on the upper side of the bank, and are to be continuous to serve as catch water drains; and, if so ordered, the contractor shall get the earth for the bank exclusively from such pits till the catch water drain is complete to the required length, section and level as prescribed by the Engineer.

1.2.7.6 When doing repair work to banks it is absolutely essential that diagonal bunds be

kept, when digging fresh borrow-pits in the old ones, as a precautionary measure for correct assessment of the work. Diagonal bunds are also to be kept in borrow-pits for new works where payments are to be made on borrow-pit measurements. When doing earthwork repairs, Authorised representative of the Engineer should bear this point in mind and refuse to measure up any pit in which a diagonal bund has not been kept. For repair works it would save a large amount of unnecessary detailed measurements if all pits were excavated to a uniform size as far as practicable.

1.2.8 Bank executed manually : All banks, if executed manually shall be made in successive layers, not more than 30 cm in depth, over the whole width and slightly concave in section so as to retain water for subsidence. The subsequent top layer shall be started only when the previous layer has been completed for a length not less than 30m along the embankment.

1.2.9 Clods:- All large clods (larger the 15 cm) shall be broken up in the borrow pits or bank by labour specially deputed for this work. This shall be strictly ensured.

1.2.10 Bunding of Bank Top : In banks executed manually/mechanically, before the commencement of monsoon, continuous longitudinal earth bunds, 25 cm high and 30 cm wide on the top with side slopes of 2:1, are to be made on the outer edges of the top of embankments, together with cross bunds of the same dimensions at every 15m, so as to impound rain water to expedite consolidation. This work shall be paid for separately at the rate for soft/loose soil and may be left uncompacted.

1.2.11 Benching : In widening an existing bank, steps 30cm in height and approximately 60 cm wide, shall be cut in the existing bank before any new earth is placed, to form a bond between the new and old earth work. Similar benching is to be provided in side-long ground of which the slope at right angles to the alignment of the banks is 3 Horizontal to 1 vertical or steeper or if ordered by the Engineer. The benching in side long ground will not be separately measured or paid for, but is deemed to be covered by the initial rate for earth work.

1.2.12 Stream diversions : When it has been decided to divert a stream adjoining the bank, the excavation for this work is to be undertaken and completed before any borrow pit work is done at site and all earth from such diversion is to be put into the main bank, if so ordered. If earth excavated from

the drain is led into the bank, payment will only be made for the quantity excavated including lead and lift if any and not for both cut and fill. In excavating for diversion of stream, care must be exercised by the Engineer that such diversion does not start a land slip.

1.2.13 Backing to bridges : In carrying embankments over a bridge or a culvert intended to be covered by the work, the earth work shall be brought up evenly on both sides of the structure so that the pressure may be equalised. In filling in the approaches of a bridge, or the spandrels between small arches, the earth filling shall be raised simultaneously with the wing walls in the former case and with the face walls in the latter, in order that the filling may be well trodden down under the feet of the labourers; and in filling in foundations and backing to revetments, the earth work shall similarly be brought up level as the masonry proceeds. Filling for the backing of bridges or culverts will conform to specifications under **Para 1.6**, and subsequent sub paras, or as ordered by the Engineer. Cast iron rammers should be used to consolidate the earthwork where mechanical compaction can not be done due to practical constraints.

1.2.14 Dressing : After completion of earth work the slopes shall be neatly dressed to the correct profiles, and shall be made up where required during the maintenance period. The top should be neatly dressed off sloping at an inclination of 1 in 30 either side from the centre line unless otherwise specified in the drawings.

1.2.15 Turfing : Turfing of banks shall be done during the monsoon season, preferably after a heavy shower, when it can be ensured that the bank slopes will remain wet for a long time after planting the grass. Turfing shall be paid for separately. Turfing shall not be commenced without the prior written permission of the Engineer. The stretch of embankment where turfing is to be done should be completed in all respects and should be so recorded in the level books and profiles. Contractor should be given permission in writing to this effect before starting the Turfing.

1.2.15.1 Before turfing is commenced, the side slopes are to be dressed to the specified section. This dressing is included in the initial rate for earth work, and should a contractor stop work before dressing the bank, he shall be debited with the estimated cost of the dressing to be done by another contractor or departmental labour, as

decided by the Engineer. Where the slope is already consolidated, it should be loosened for a depth of about 4 cms before the sods are laid.

1.2.15.2 Turfing shall consist of sods, not less than 10 cm thick and 20 cm square well beaten into the bank till they get a proper hold and form a level and compact mat. The contractor shall be responsible for watering where necessary to ensure that the turf grows properly; and in the event of it not doing so, he will returf such parts as have not grown, at his own cost. The turfing shall be measured and taken over only after the grass has rooted well and has formed a sufficiently dense growth over the earth slopes. Turing with sarkanda or other varieties of locally available grass may also be permitted by the Engineer incharge depending upon the local conditions.

1.2.15.3 Turfing of side slopes of cuttings if ordered by the Engineer shall be carried out in a manner similar to Turfing of bank.

1.2.16 Sarkanda or similar type of planting on bank slopes : Where Sarkanda is planted on bank slopes, the minimum distance centre to centre in rows shall be 40 cm in either direction. The plantation in adjacent rows will be staggered for proper coverage of the area. For other types of plantation, the local practice shall be followed as directed by the Engineer. Where directed to be done, this item will be paid for extra.

1.3 EARTH WORK IN CUTTINGS

1.3.1 Formation width : The formation widths, exclusive of side drains, are to be as shown in the drawings :

The top width of each side drain will ordinarily be 120 cm at formation level and depth 30 cm, unless shown otherwise in the drawing. For longer drains specially designed sections will be adopted depending upon the catchment area, length and slope of the drain which should be finalized before completion of the cuttings.

1.3.2 Side Slopes : The side slopes will ordinarily be 1:1 unless otherwise ordered by the Engineer.

1.3.3 Excavation :

1.3.3.1 When so ordered, the centre portion of gullet of the cutting shall be first taken out to the full width of formation to enable the Engineer to determine the slopes suitable to the full length of the particular cutting or to different lengths of it. When the gullet is cut out to its full depth in shallow cuttings, or to

the depth of the first cut in deep cuttings, the side portions or triangular sections up to the slopes may be excavated. In deep cuttings, the second cut will not be started until the top portion is thus completed.

The necessity of excavating cuttings in this manner is evident as, in the event of heavy rain occurring with work partly completed, and the bottom of the excavation uneven and incapable of drainage, excessive delay might occur or excessive pumping might become necessary. The contractor is solely responsible for any such contingency and the railway will not be liable for any compensation.

1.3.3.2 All cuttings shall be taken down carefully to the precise level and section as delineated in the drawings or as ordered by the Engineer. In case the bottom of the cutting is taken down deeper than is necessary by oversight or neglect of the contractor or due to blasting operations, the hollow must be filled up to true depth with selected material and rammed, at contractor's expense. Cuttings with the formation in rock will be excavated upto 15 cm (Max.) below the true formation and filled up to true level with cutting spoil to ensure that no lumps of solid rock project above formation level. The bottom sloping from centre towards side drains shall be as given in Sub Para 1.3.3.3 below. Payment will, however be made for earth work in cutting up to the true formation level only.

1.3.3.3 In soft soil the excavation of cuttings shall, in the first instances be carried to about 15 cms short of the full depth, so much being left for dressing the bottom true to the formation. The side slopes shall be dressed true and straight and the bottom shall then be completed by sloping if from the centre line towards the side drains to a slope of 1 in 30 or any other slope as shown in the drawing.

1.3.4 Drainage of cuttings :

1.3.4.1 In excavating cuttings, special precautions are to be taken to ensure that the excavations drain themselves automatically. To ensure this, the central block of earth or gullet is to be excavated first. This will be done in such a manner that the bottom of the excavation shall, where possible, slope downwards from the centre of the cutting towards the ends. It will be made in such cuts or steps as may from time to time, be directed. Generally, in deep cuttings the first cut or step will approximately follow the surface of the ground, where this will secure the necessary

slope for drainage, and will be excavated to such depth not exceeding 3m as may be ordered, with perpendicular sides leaving pathways for workmen along the sides of the cut parallel to the central line about every 15 m. In shallow cuttings, not exceeding 2m in the deepest part, the gullet may be cut out at once to formation level.

1.3.4.2 Side drains according to the cross section shown in the drawing shall be provided at the toe of the slope in all cuttings to ensure proper drainage. Excavation to the required cross section and longitudinal slope to form the side drain will be paid for at the same rates for cutting.

1.3.5 Catch-water drains : Where required, catch water drains cut to the section and profile prescribed, shall be constructed on the up hill side leaving a berm of one metre from the boundary of the railway land or as decided to suit the local conditions and shall be paid for at the same rates as for cutting. The cross sectional area of the catch water drain shall normally not exceed 0.75 sqm.

The spoil from the catch water drain will be deposited to make a uniform slope from the edge of the cutting towards the drain. The material derived from the catch water drain will be used to the extent required to provide the slope and the surplus earth should be deposited in the spoil bank of the cuttings. Unless ordered to the contrary by the Engineer, the Catch water drain must be excavated before the cutting is started.

1.3.6 Berms and spoil banks : No spoil shall be deposited within a distance of 10 m from the top edge of the slope of any cutting duly taking into account the location of the catch water drain, if any. While doing so, the Engineer may bear in mind the side on which the doubling may eventually be done and may be suitably increased.

1.3.6.1 The spoil heap shall be roughly but neatly dressed off to a slope of 1 ½: 1, and shall form a continuous bund along the top of the cutting. In country where there is any cross fall, sufficient spoil shall be thrown on the up hill side of the cutting to supplement the catch water drain and assist in keeping drainage out. This work must be done first.

1.3.6.2 (a) All material excavated from cuttings suitable for pitching, ballast, masonry or any other purpose whatever, shall be the property of the Railway, and shall be stacked, as also disposed off, as directed by the Engineer, within the limits of lead specified for stacking of spoil. This is included in the rate for cutting.

(b) Any finds of archaeological interest such as relics of antiquity, coins, fossils or other articles of value shall be delivered to the Engineer and shall be the property of the Railways.

1.3.7 Springs or Inflow : Should springs or inflow of water appear in cuttings, or should they be flooded, the contractor must arrange for bailing, pumping or drainage of water, without obstruction to adjacent works. Payment for the same shall not be made unless otherwise provided for in the Agreement with the Contractor.

1.3.8 Protections : Excavation, where directed by the Engineer, shall be securely fenced and provided with proper caution signs, conspicuously displayed during the day and properly illuminated with red lights during the night, to avoid accidents. The Contractor shall take adequate protective measures to see that the excavation operations do not damage the adjoining structures or dislocate the services. Water supply pipes, sluice valve chambers, sewerage pipes, manholes, drainage pipes & chambers, communication cables, power supply cables etc. met within the course of excavation shall be properly supported and adequately protected, so that these services remain functional. No extra payment will be made for taking such measures unless otherwise specifically provided for in the Contract.

Excavation shall not be carried out below the foundation level of adjacent buildings until underpinning; shoring etc. is done as per the directions of the Engineer for which payment shall be made separately. The temporary arrangement drawings should be submitted by the contractor and got approved before undertaking such excavation.

1.3.9 Blasting : If any blasting operations are necessary, they shall be carried out in accordance with the Explosives Act and the Rules as amended upto date. Extracts from the Explosives Rules 1983 are kept at **Annexure 1.1** for strict adherence by the Contractor's staff as well as Railway employees engaged in blasting operations. For general guidance, the instructions contained in Chapter X of Indian Railways Works Manual may be referred to. The following specifications are supplementary to the above.

1.3.9.1 Where hard rock is met with and blasting operations are considered necessary, the contractor shall obtain the approval of the Engineer in writing for resorting to blasting operation.

Note : In ordinary rock, not requiring blasting, blasting operations shall not be generally adopted. However, the contractor may resort to blasting with the permission of the Engineer, but nothing extra shall be paid for such blasting operations.

The contractor shall obtain licence from the competent authority for undertaking blasting work as well as for containing and storing the explosive as per the Explosive Act, 1884 as amended upto date and the Explosive Rules, 1983. The contractor shall purchase the explosives fuses, detonators etc. only from a licenced dealer. Transportation and storage of explosive at site shall conform to the aforesaid Explosive Act and Explosive Rules. The contractor shall be responsible for the safe custody and proper accounting of the explosive materials. Fuses and detonators shall be stored separately and away from the explosives. The Engineer or his authorised representative shall have the right to check the contractor's store and account of explosives. The contractor shall provide necessary facilities for this.

The contractor shall be responsible for any damage arising out of accident to workmen public or property due to storage, transportation and use of explosive during blasting operation.

1.3.9.2 Blasting operations shall be carried out under the supervision of a responsible authorized agent of the contractor (referred subsequently as agent on duty), during specified hours as approved in writing by the Engineer. The agent shall be a licensed blaster. In case of blasting with dynamite or any other high explosive, the position of all the bore holes to be drilled shall be marked in circles with white paint. These shall be inspected by the Contractor's agent. Bore holes shall be of a size that the cartridge can easily pass down. After the drilling operation, the agent shall inspect the holes to ensure that drilling has been done only at the marked locations and no extra hole has been drilled. The agent shall then prepare the necessary charge separately for each bore hole. The bore holes shall be thoroughly cleaned before a cartridge is inserted. Only cylindrical wooden tamping rods shall be used for tamping. Metal rods or rods having pointed ends shall never be used for tamping. One cartridge shall be placed in the bore hole and gently pressed but not rammed down. Other cartridges shall then be added as may be required to makeup the necessary charge for the bore hole. The top most cartridge shall be connected to the

detonator which shall in turn be connected to the safety fuses of required length. All fuses shall be cut to the length required before being inserted into the holes. Joints in fuses shall be avoided. Where joints are unavoidable, a semi-circular notch shall be cut in one piece of fuse about 2 cm deep from the end and the end of other piece inserted into the notch. The two pieces shall then be wrapped together with string. All joints exposed to dampness shall be wrapped with rubber tape.

The charges shall be fired successively and not simultaneously. Immediately before firing, warning shall be given and the agent shall see that all persons have retired to a place of safety. The safety fuses of the charged holes shall be ignited in the presence of the agent, who shall see that all the fuses are properly ignited.

Careful count shall be kept by the agent and others of each blast as it explodes. In case all the charged bore holes have exploded, the agent shall inspect the site soon after the blast but in case of misfire, the agent shall inspect the site after half an hour and mark red crosses (X) over the holes which have not exploded. During this interval of half an hour, nobody shall approach the misfired holes. No driller shall work near such bore until either of the following operations have been done by the agent for the misfired boreholes.

(a) The contractor's agent shall very carefully (when the tamping is of damp clay) extract the tamping with a wooden scraper and withdraw the fuse, primer and detonator.

(b) The holes shall be cleaned for 30 cm of tamping and its direction ascertained by placing a stick in the hole. Another hole shall then be drilled 15cm away and parallel to it. This hole shall be charged and fired. The misfired holes shall also explode along with the new one.

Before leaving the site of work, the agent of one shift shall inform the agent relieving him for the next shift, of any case of misfire and each such location shall be jointly inspected and the action to be taken in the matter shall be explained to the relieving agent.

The Engineer shall also be informed by the agent of all cases of misfires, their causes and steps taken in that connection.

1.3.9.3 General Precautions : For safety of persons, red flags shall be prominently displayed around the area where blasting operations are to be carried out. All the workers at site, except those who actually

ignite the fuse, shall withdraw to a safe distance of atleast 150 metres from the blasting site. Audio warning by blowing whistle shall be given before igniting the fuse.

Blasting work shall be done under careful supervision of a licensed blaster and trained personnel shall be employed. Blasting shall not be done within 100 metres of an existing structure, unless specifically permitted by the Engineer in writing. In such cases, the Authorised representative of the Engineer must be present to ensure that special precautions as may be prescribed by the Engineer and those stipulated by the licensing authority are taken and that necessary warning is given to the inhabitants.

All procedures and safety precautions for the use of explosives drilling and loading of explosives before and after shot firing and disposal of explosives shall be taken by the contractor as detailed in IS 4081, Safety code for blasting and related drilling operation.

1.3.9.4 Precautions against misfire : The safety fuse shall be cut in an oblique direction with a knife. All saw dust shall be cleared from inside of the detonator. This can be done by blowing down the detonator and tapping the open end. No tools shall be inserted into the detonator for this purpose.

If there is water present or if the bore hole is damp, the junction of the fuse and detonator shall be made water tight by means of tough grease or any other suitable material.

The detonator shall be inserted into the cartridge so that about one-third of the copper tube is left exposed outside the explosive. The safety fuse just above the detonator shall be securely tied in position in the cartridge. Water proof fuse only shall be used in the damp bore hole or when water is present in the bore hole.

If a misfire has been found to be due to defective fuse, detonator or dynamite, the entire consignment from which the fuse, detonator or dynamite was taken shall be got inspected by the Engineer or his authorised representative before resuming the blasting or returning the consignment.

1.4 EARTH WORK BY DEPARTMENTAL MATERIAL TRAINS ;

Normally earthwork is not done by DMT these days.

1.5 EXCAVATION OF FOUNDATIONS FOR BUILDINGS / TRENCHES FOR PIPELINES ETC.

1.5.1 Clearance of Site : The contractor will, at his own expense, clear the site of all obstructions to enable the setting out to be done, and will also provide all necessary labour, pegs, string, building materials including cement etc. required for the proper setting out of the work. If any huts or other structures, trees (girth 30 cm and above) etc. are to be removed they will be paid for separately.

1.5.2 Setting out : The centre longitudinal or face line and atleast one main cross line shall be marked by means of small masonry pillars built clear of the point to which the slopes of the excavation will extend. On each pillar there shall be an accurate mark to enable a theodolite being set up over it for setting out purposes. These pillars shall be adequately protected from any possibility of damage during the course of the work. The provision and protection of the pillars shall be at the expense of the contractor, for which nothing extra shall be paid.

1.5.3 Size and Form of Excavation: The excavation for the foundations of bridges, culverts, columns and buildings and all other structures as well as trenches for sewers, drains and pipes, shall be executed to the depths shown on the drawings, or to such greater or lesser depth as the character of the ground necessitates to ensure a stable and solid foundation, and as directed by the Engineer. Should the trenches be excavated by the contractor by negligence or mistake to greater dimensions than are necessary, no payment shall be made for this extra excavation and the contractor will bear the cost of the concrete of the mix proportion stipulated for bed concrete and for levelling the concrete required to fill up the excess excavation.

1.5.4 Sides and Shoring : Excavations for foundations and trenches shall be executed with sloping sides, or shall be properly timbered with vertical sides as may be necessary and as directed by the Engineer. Whatever be the method adopted for the excavation, it shall be efficiently carried out to ensure its stability and safety of adjoining lands, railway line, pipes and other structures, as also the safety of the labourers employed on excavation work. No excavation shall be carried out below the foundation level of adjacent structures until adequate safety measures, as directed by the Engineer, have been taken. Any

measures as may be necessary or as directed by the Engineer for protection against risk of accidents to the public due to open excavation shall be provided by the Contractor. These may include temporary fencing, lighting of site etc.

1.5.5 Trenches for Sewers, Pipe lines or drains : The excavation of the trench shall be carried out accurately to the depths, gradients, lengths and directions shown in the drawing. All trenches which are to be with gradients, must be excavated commencing from the lowest point and advancing towards the highest point, the excavation of man-holes, chambers, etc. at the different points being completed before the excavation of the trench advances beyond those points. Trenches for laying of pipes shall be excavated wide enough to allow a space of 22.5cm unless otherwise directed by the Engineer, on either side of the collars, sockets or flanges of the pipes when laid, so as to provide walking space for workmen. No extra payment shall be made for making a trench to any special shape as may be specified in the case of drains, pipes bedded on earth etc.

1.5.6 Sight rails etc. : The Contractor shall supply and erect proper sight rails and supply boning rods, as necessary for the proper execution of the excavation work. Boning shall be done at intervals not exceeding 1.8m along the length of the trench. In the case of trenches for pipes and drains, where the boning rod is devised to show the invert level, a block of wood of height equal to the difference in level between the invert and the bottom of foundation should be used in boning the excavated trench.

1.5.7 Wet Excavation : All excavations in foundations shall be paid for as “dry”, except such as is actually below sub-soil water level and requiring continuous bailing or pumping. The contractor will be responsible that no work in excavation at the increased rate for “wet” excavation is commenced, until the work has been inspected by the Engineer or the Authorised representative of the Engineer, and approval obtained stating the point from which the “wet” excavation commences.

1.5.7.1 In all pumping and other operations, special care shall be taken to prevent “blowing” and to ensure that sand or other material is not withdrawn from the bottom or sides of the trenches and the adjoining ground. The contractor shall take adequate measures for bailing and / or pumping out

water from excavations and construct diversion channels, bunds, sumps, coffer dams etc. as may be required. Pumping shall be done directly from the foundation trenches or from a sump outside the excavation in such a manner as to preclude the possibility of movement of water through any fresh concrete or masonry and washing away parts of concrete or mortar. During laying of concrete or masonry and for a period of at least 24 hours thereafter, pumping shall be done from a suitable sump separated from concrete or masonry by effective means. Capacity and number of pumps, locations at which the pumps are to be installed, pumping hours etc. shall be decided from time to time in consultation with the Engineer.

Pumping shall be done in such a way as not to cause damage to the work or adjoining property by subsidence etc. Disposal of water shall not cause inconvenience or nuisance in the area or cause damage to the property and structures nearby.

1.5.7.2 The rate for dry excavation includes seepage water standing up to a maximum of 15 cm in depth in 3 hours when work is not in progress. The rate for wet excavation includes the cost of pumping or bailing out water with the contractor's tools, plants, fuel and labour.

1.5.7.3 Should it be necessary to do "Shoring" as approved by the Engineer the same will be paid for.

1.5.8 Bottom of foundations : The bottom of all foundations and trenches shall be accurately excavated to the form of the permanent work, and carefully levelled and cleaned, and if dry, shall be well watered and thoroughly rammed, and all loose or soft material of every kind shall be entirely removed before building work is started. Where the excavation is in rock, the sides of the trenches shall be properly sheared and cut, and the bottom shall be dressed and stepped for proper bearing as per plans or as directed by the Engineer, all without any extra payment beyond the contract rates.

1.5.9 Special measures : When a safe and solid foundation cannot be obtained at the depth shown in the plans, special measures (to be determined in all cases by the Engineer) may be necessary, and the carrying out of these must be made the matter of a special agreement before hand.

1.5.10 Disposal of soil : All spoil from excavation of foundations shall be neatly spread to make up the adjacent ground, or otherwise disposed of as directed by the

Engineer. Nothing extra shall be paid for the neat spreading of the spoil.

1.5.10.1 No excavated earth is to be heaped within 2 m of the edge of the trench or half the depth of the trench, whichever is more.

1.5.11 Inspection : Foundation trenches shall be passed by the Engineer or the Authorised representative of the Engineer before laying the concrete. The bottom of the excavation shall be carefully examined for any soft spots. Should any such places be found, all the soft earth must be removed and the hollow space filled with concrete with the same mix as the foundation concrete or as directed by the Engineer. If differences of level have to be provided for, it shall be done by means of vertical steps.

1.5.12 Measurements : The quantity of excavation to be paid for is to be the product of the area of the foundation trench as shown in the plan and the depth to which the trench has been carried, and is not to include slopes and slips due to the falling in of the sides or due to undermining, or any other cause whatsoever. Where shoring is considered necessary and approved by the Engineer, it shall be paid for at the rate as provided for in the Contract.

However, in case where excavations with sloping sides or with varying widths at different depths has been specifically permitted by the Engineer, the quantity of earth work in excavation will be paid for as actually executed.

1.6 EARTH FILLING IN FOUNDATION TRENCHES AND PLINTH, UNDER FLOORS AND BEHIND ABUTMENTS ETC.

1.6.1 Foundation Trenches : The space between the sides of the foundation trenches and the masonry is to be filled with sound impervious material such as moorum, chips, spawls, gravel or other sandy material well rammed in layers not exceeding 15 cm, each layer being watered, rammed and consolidated before the succeeding one is laid. Earth shall be rammed with iron rammers where feasible, and with the butt ends of crow bars / wooden ballies where rammers cannot be used. Earth used for filling shall be free from salts, organic or other foreign matter. All clods of earth shall be broken or removed.

1.6.1.1 Where there is likelihood of rain, the earth filling may closely follow the masonry until ground level is reached, but the

contractor shall only do this after obtaining the written permission of the Engineer.

1.6.1.2 Where concrete foundations are brought up in reducing off-sets, it will be necessary to bring the earth filling up with the form walls but in such cases special care shall be taken that no earth is allowed to fall on the concrete surface, on which further concrete is to be laid.

1.6.2 Plinth filling or filling under floors : After allowing 7 days / 14 days setting time respectively for Cement / Lime masonry, filling in plinth or under floors shall be similarly done with earth in layers not exceeding 15 cm, watered and consolidated by ramming with iron rammers and with butt ends of crow bars / wooden ballies. Only sandy soil, free from salts, organic or other foreign matter and white ants shall be used for such filling. Where there is black cotton soil, this shall be removed to a depth of 60 cm as it is liable to absorb moisture and expand and thus ruin a floor. The top 30 cm immediately below or as shown in the drawings the floor shall be filled with sand or cinder. If earth of good quality fit for this filling is not available from earth generated by excavation for foundation etc, or from borrow pits from within the Railway land, good contractor's earth should be used.

1.6.2.1 To prevent future sinkage, and damage to the floor it is necessary, when convenient to do so, that the plinth area be flooded with water for minimum 3 days so as to enable the earth filling to consolidate thoroughly. In this case, however, the earth filling shall be allowed to dry and then rammed and consolidated, before the pucca flooring is laid.

1.6.2.2 In all fillings sufficient allowance shall be made for settlement of all materials and restoration of the surface to the required level.

1.6.2.3 The filling shall not be commenced until the recording of levels, measurements etc as maybe necessary in respect of the existing ground or of any work to be filled over or likely to be hidden by the filling has been completed and permission in writing has been given to the contractor by the Engineer to start the filling.

1.6.2.4 The finished level of the filling shall be kept to slope intended to be given to the floor.

1.6.3 Filling behind abutments etc. : Unless otherwise specified, the space next to the masonry at the back of all bridge abutments, wing walls and return walls is to

be "Backed" or filled by hand packed graded coarse material such as boulders and cobbles, quarry rubbish, chips, spawls, hand packed dry rubble or other hard and drainable materials for a thickness of at least 60 cm. or to such thickness as may be shown in the drawings, or as directed by the Engineer with the smaller size material towards the back.

1.6.3.1 The space at the back of this packing is to be filled with granular material such as moorum, sand or sandy oil, well watered and rammed in layers 15 cm or less thick. Under no circumstances is black cotton soil or any clayey or silty soil to be used for backing. Each layer shall have a slope of about 45° towards the ground level, toe slope to commence from immediately behind the abutments. Compactions of the layers shall be done by vibratory plate compactors or as directed by the Engineer.

1.6.4 Dressing of surrounding ground : On the completion of a building, the ground all round up to a distance of 15m is to be carefully dressed, and when practicable, given a gentle slope outwards. This dressing will be paid for separately.

1.6.5 Use of earth from excavation: If the excavated earth from the foundations of a bridge is thrown up to form part of the guide bund, embankment or backing of a bridge, it is to be understood that the only items (over and above the rate for the excavation) to be paid for are any extra "Lift", "Lead" "Dressing" and "Compaction" which may be thus necessitated.

1.6.6 Filling of Trenches for Pipes etc. : The filling back of pipe-line trenches shall not be commenced until any testing as required to be done has been carried out and the pipe-line passed. The filling shall generally be done using the material excavated from the same trench. But any excavated rock used for filling back shall be mixed with finer material so as to fill up all the voids. In refilling, care shall be exercised to avoid damaging or disturbing the pipe line or other work being covered up. The manner in which filling and consolidation are to be done shall, in other respects, be the same as laid down for foundation trenches. Where the trench carries a pipe-line or an arch barrel, sand or other stable soil approved by the Engineer shall be used upto a height of 15 cm above the top of the pipe or barrel. This height shall be increased to 30 cm in the case of trenches cut in rock. In case of sand filling as per drawing additional payment as per relevant item will be made.

1.6.7 Measurement : The measurement shall in all cases be of the space filled and all the hidden details required for the same shall be measured up before being filled over and deductions made accordingly. No deduction shall be made for shrinkage or subsidence, provided the Engineer is satisfied that the consolidation has been done properly, as specified in each case. In the filling for foundations and other trenches, any extra work done on account of over cuts, slips, etc. shall not be paid for.

1.6.8 Rates : The rate for each type of filling shall include the cost of all the operations as described above for each, except that in cases where the excavated earth available within the initial lead and lift is not adequate for the filling, the procurement of the extra earth required will be a matter of special agreement.

1.7 SHORING OR TIMBERING FOR TRENCHES

1.7.1 General : In case of deep trenches, exceeding 2 metres or where the soil is soft or slushy, the sides of trenches shall be prevented from collapsing by stepping, sloping and / or shoring or timbering as may be decided by the Engineer or the Authorized representative of the Engineer. Timbering shall be “Close” or “Open” depending on the nature of soil and the depth of the trench and the type of timbering shall be determined by the Authorised representative of the Engineer or the Engineer. It shall be the responsibility of the contractor to take all necessary steps to prevent the sides of trenches from collapsing. Guidance may be taken from IS 3764 for designing the shoring and strutting arrangements.

1.7.2 Close Timbering : Close timbering shall be done by completely covering the sides of the trench generally with short, upright members called ‘polling boards’. These shall be 25 cm x 4cm section or as directed by the Engineer. The boards shall generally be placed in position vertically in pairs, one board on each side of cutting, and shall be kept apart by horizontal walings of strong wood at 1.0 to 1.2m spacings, cross strutted with ballies or as directed by the Engineer. The length of the ballies shall depend upon the width of the trench. Typical sketch of close timbering is given in **Figures 1.5A & 1.5B**.

1.7.2.1 In case the soil is very soft and loose, the boards shall be placed horizontally against the sides of the excavation and

supported by vertical walings, which shall be strutted to similar timber pieces on the opposite face of the trench. The lowest boards supporting the sides shall be taken into the ground. No portion of the vertical side of the trench shall remain exposed, so that earth is not liable to slip out.

1.7.2.2 The withdrawal of the timber shall be done very carefully to prevent the collapse of the trench. It shall be started at one end and proceed systematically to the other end. Concrete or masonry shall not be damaged in the removal of timber. Where planking and strutting are required to be left permanently in position as directed by the Engineer, extra payment will be made under the relevant schedule item. In cases where there is no such specific directive of the Engineer no claim shall be entertained for any timber, which cannot be withdrawn and is lost, damaged or buried.

1.7.3 Open Timbering : In case of open timbering, the entire side of the trench is not required to be covered. The vertical boards of 25 cm width shall be spaced sufficiently apart to leave unsupported strips of 50 cm average width. The detailed arrangement, sizes of the timber and the distances apart shall be subject to the approval of the Engineer. In all other respects, specifications for close timbering shall apply to open timbering. A typical sketch of open timbering is given in **Figures 1.5A & 1.5B**.

1.7.4 Measurements : The area of longitudinal section of the timbered trench shall be measured for the purpose of payment. This shall be the area of one side of the trench timbered on both sides. In case of basements, where the opposite sides, are not connected by struts but, each side is supported by slanting struts and toe supports, the measurements for timbering shall be taken for the area of all the walls supported by timbering. The dimensions shall be measured correct to a cm.

1.8 PUDDLE

1.8.1 Composition : Puddle shall consist of good adhesive and stiff clay containing nearly 20% sand by weight. So called ‘Sodium Clays’, containing sodium carbonate shall generally be preferred. If adequate quantity of sand is not present in the clay, suitable amount of sand may be mixed with the clay after it has been weathered and pulverised. The clay shall be free from roots, turf, shale and other injurious materials, and should be approved by the Engineer.

1.8.2 Preparation : The clay should be dry and exposed to the sun and pulverised with rammers. Additional sand if necessary shall be uniformly mixed with the powdered clay two days previous to that on which the clay is required for use. The clay and sand mixture shall be wetted and thoroughly worked up into a plastic homogeneous mass of the toughest consistency, in a pug mill or under men's feet.

1.8.3 Laying As soon as possible after it has been worked up into puddle it shall be deposited in place, spread in even layers 15 cm thick, each layer laid out to its full extent, rammed, trodden and if necessary, cross cut and made perfectly water-tight.

1.8.3.1 The puddle shall be carried in baskets or wheel-borrow as convenient. Each batch shall be well consolidated with rammers or trodden under feet until it is thoroughly integrated with the batch already in place. Stones, bricks, roots, grass, etc. shall not be allowed to remain in the puddle.

1.8.3.2 If at any time the puddle surface should become dry/hard or soft, it shall be excavated and removed from the work before another layer is laid. Puddle walls must be supported on each side by selected material.

1.8.4 Protection : All puddle after placing shall be protected from the strong rays of the sun by covering with wet gunny bags or mats.

1.8.4.1 Contractor's liability and maintenance : The contractor shall make good at his own expense any defect that may occur either in the puddle or in its junction with the ground or walls whether during the construction stage or during the period of maintenance.

1.9 MECHANICAL COMPACTION OF EARTHWORK

Note : Based on RDSO's "Guidelines for Earthwork in Railway Projects" (July 2003 – Guideline No.GE:G-1 to which reference may be made for further details.)

1.9.1 Orders for compaction : Depending upon the height of the embankment the type of the soil, time available for completing the embankment, the importance of the line and other relevant factors such as axle load, permitting higher speeds within a limited time etc, the Engineer shall decide whether Mechanical compaction is to be done for the full or part height of the embankment.

1.9.2 Advantages of Compaction :

1.9.2.1 Compaction is the process of increasing the density of soil by mechanical means by packing the soil particles closer together with reduction of air voids and to obtain a homogeneous soil mass having improved soil properties. Compaction brings many desirable changes in the soil properties as follows:

- a) Helps soils to acquire increase in strength in both bearing resistance and shear strength.
- b) Reduces compressibility, thus minimising uneven settlement during services.
- c) Increased density and reduces permeability, thereby reducing susceptibility to change in moisture content.
- d) Reduction in erodibility
- e) Results in homogeneous uniform soil mass of known properties.
- f) Reduction in frost susceptibility in cold regions.

1.9.3 Factors affecting Compaction in the filed :

Compaction of a particular soil is affected by moisture content, compacting effort, type of roller etc as explained below:

(a) **Compacting Effort :** In modern construction projects, heavy compaction machinery is deployed to provide compaction energy. Types of machinery required are decided based on type of soil to be compacted. The method of compaction is primarily of four types viz kneading compaction, static compaction, dynamic or impact compaction and vibratory compaction. Different type of action is effective in different type of soils such as for cohesive soils, Sheep's foot rollers or pneumatic rollers provide the kneading action. Silty soil can be effectively compacted by Sheep's-foot roller / pneumatic roller or smooth wheel roller. For compacting sandy and gravelly soil, vibratory rollers are most effective. If granular soil has some fines both smooth wheeled and pneumatic rollers can be used.

(b) **Moisture Control :** Proper control of moisture content in soil is necessary for achieving desired density. Maximum density with minimum compacting effort can be achieved by compaction of soil near its OMC (Optimum Moisture Content). If natural moisture content of the soil is less than the OMC, calculated amount of water should be added with sprinkler attached to water tanker and mixed with soil by motor grader for uniform moisture content. When soil is too

wet it is required to be dried by aeration to reach upto OMC.

(c) **Soil Type** : Type of soil has a great influence on its compaction characteristics. Normally, heavy clays, clays and silts offer higher resistance to compaction, whereas, sandy soils and coarse grained or gravelly soils are amenable for easy compaction. Coarse-grained soils yield higher densities in comparison to clay. A well-graded soil can be compacted to higher density.

(d) **Thickness of Layer** : Suitable thickness of soil of each layer is necessary to achieve uniform compaction. Layer thickness depends upon type of soil involved and type of roller, its weight and contact pressure of its drums. Normally, 200-300mm layer thickness is optimum in the field for achieving homogeneous compaction.

(e) **Number of Passes** : Density of soil will increase with the number of passes of roller but after optimum number of passes, further increase in density is insignificant for additional number of passes. For determination of optimum number of passes for given type or roller and optimum thickness of layer at a predetermined moisture content, a field trial for compaction is necessary which will be arranged by the Engineer for which the Contractor shall make all arrangements and bear the cost of test / tests as required.

1.9.4 Compaction procedure for Different soils

The embankments are constructed with locally available soil provided it fulfils the specified requirements. Procedure of compaction to be adopted will depend on the type of soil being used in construction. General guidelines to deal with compaction of various types of soils for attaining optimum dry density/ relative density at minimum effort, have been briefly given as under. The procedure to be adopted will be decided by the Engineer for strict adherence by the Contractor.

1.9.4.1 Compaction of Cohesion less gravelly and Sandy soil

i) Sandy & gravelly soils should be compacted with vibratory rollers. If fines are less in these types of soils, it can be compacted with minimum number of passes of vibratory rollers without strict control of moisture to achieve desired Relative Density. With higher percentage of fines, sandy and gravelly soils need to be brought to OMC level to get effective compaction. Uniformly graded sand and gravel are difficult to be

compacted. Top layer of sand and gravel remains loose in vibratory compaction. Therefore, in final pass the roller should move smoothly without vibration. Dry densities attained in field trials normally should be around MDD/ specified Relative Density as obtained from laboratory tests and should form the basis for specification and quality control.

ii) Poorly graded sand and gravel with $C_u < 2.0$, should not be used in earthwork for the banks to safeguard against liquefaction under moving loads or especially due to earthquake tremor. Generally, fine sand is prone to liquefaction. This aspect should be specifically examined to prevent possibility of any liquefaction.

1.9.4.2 Compaction of Silty - Clayey Soils

Silty soil is a fine-grained soil. These can be plastic or non-plastic depending upon the clay content in it. Silts and fine sands with high water content have a tendency to undergo liquefaction under vibrating rolling due to the pore water pressure generated by mechanical work. Silty soils can be compacted satisfactorily near about OMC either with smooth rollers or vibratory rollers. Vibratory roller will give high degree of compaction and higher lift. Compaction of silty clays will have to be handled in a manner similar to clays.

1.9.4.3 Compaction of Clays

i) Water content plays very important role in compaction of clays. Main objective of compacting predominantly clays is to achieve uniform mass of soil with no voids between the lumps of clays. If moisture content is too high, roller tends to sink into the soil and if too low the chunks would not yield to rolling by rollers. Appropriate water content i.e. OMC of the soil is in the range of about plastic limit plus two percent. Sheep-foot rollers are most effective in breaking the clods and filling large spaces.

ii) Thickness of layer should not be more than depth of feet of roller plus 50mm. Pad foot vibratory roller with drum module weight of 7 tonne (total static weight of 11 tons) for a lift thickness of 30 cm is found quite effective for compaction of clays. For better results, initial rolling with static pad foot roller followed by 15 tons vibratory roller can be tried.

iii) In case of such soils, the MDD and OMC as determined in the Laboratory may not be very relevant and therefore achievable MDD and practicable moisture content at which such soils can be

compacted should be determined by conducting field trials for which the Contractor shall make all arrangements and bear the cost of field trials as required.

1.9.5 Selection of Compacting Equipment :

The performance of roller is dependent mainly on type of soil used in construction. Guidelines on selection of compacting equipment are given in **Annexure 1.2**. Vibratory rollers which can be used in static as well as dynamic mode with plain and pad drum, are now being manufactured by reputed Indian Companies also. Salient features of some of models are given in **Annexure 1.3**. The Contractor should get the Engineer's approval for the type of equipment to be deployed for compaction.

1.9.6 General aspects of Mechanical Compaction

a) The spreading of material in layers of desired thickness over the entire width of embankment should be done by mechanical means and finished by a motor grader. The motor grader blade shall have hydraulic control suitable for initial adjustment and maintain the same so as to achieve the slope and grade.

b) Thickness of layer is decided based on field compaction trials. However, as a good practice thickness of layer should be generally kept as 300mm for fill material and 250mm for blanket material in loose state before compaction.

c) If natural moisture content (NMC) of the soil is less than the OMC, calculated amount of water based on the difference between OMC and NMC and quantity of earthwork being done at a time, should be added with sprinkler attached to water tanker and mixed with soil by motor grader or by other means for obtaining uniform moisture content. When soil is too wet, it is required to be dried by aeration to reduce moisture content near to OMC. Efforts should be made to keep moisture content level of the soil in the range of $OMC \pm 2\%$ at the time of compaction.

d) Fill shall be placed and compacted in layers of specified thickness. The rate of progress should be, as far as possible, uniform so that the work is completed to final level almost at the same time.

e) The rolling for compaction of fill material should commence from edges towards center with minimum overlap of 200mm between each run of the roller. In final pass, roller should simply move over the

surface without vibration so that top surface is properly finished.

f) Extra bank width of 500mm on either side shall be rolled to ensure proper compaction at the edges. The extra soil would be cut and dressed to avoid any loose earth at the slopes. This should preferably be done with help of grade cutter. The earth so cut in final stages will not be paid but can be used at other places by the contractor.

g) At the end of the working day, fill material should not be left uncompacted. Care should be taken during rolling to provide suitable slope on toe of the bank to facilitate quick shedding of water and avoid ponding on formation.

h) During construction of formation, there may be rainfall to the extent that rain cuts may develop on the surface of formation due to erosion of soil. Care should be taken that these rain cuts are not allowed to develop wide and deep otherwise these locations will remain weak spots.

i) Top of the formation should be finished to cross slope of 1 in 30 from one end to other towards cess / drain in multiple lines and from center of formation to both sides in single line.

j) Once the top surface of the formation has been finished to proper slope and level, movement of material vehicle for transportation of ballast, sleepers etc. should be avoided since these movements will cause development of unevenness, ruts on the surface which will accumulate water and weaken the formation.

k) In conversion / doubling / rehabilitation projects, suitable benching of existing slope shall be done as provided for in the contract before new earthwork is taken up to provide proper bonding between old and new earthworks. It should be ensured that there is no humus material left on the benched slope. Care needs to be taken to avoid entry of rainwater into the formation from this weak junction; otherwise this would result in development of weak formation, slope failure, maintenance problem due to uneven settlement etc.

l) At locations where the water table is high and the fill soil is fine-grained, it may be desirable to provide a granular layer of about 30 cm thickness at the base, above subsoil across the full width of formation. This work will be carried out if directed by the Engineer for which extra rate will be paid.

1.9.7 Quality Control of Compacted Earth / Blanket layer

1.9.7.1 Compacted Earth : Degree of compaction of each layer of compacted soil should be ascertained by measurement of dry density / Relative Density of soil at locations selected in specified pattern. The method of sampling, frequency of tests, method of tests to be conducted and acceptance criteria to be adopted are as under.

a) Method of Sampling :

i) Various methods of selection of sample points for check of in-situ dry density are in vogue. The sampling adopted has to be such that effectiveness of proper compaction having been done for the entire area under consideration can be judged. For this, the Engineer will lay down in detail the method to be adopted in detail depending on site conditions and accordingly records of checks done are to be properly maintained. However, in absence of such procedure laid down, following method should be adopted.

Suggested Method of Sampling : For each layer, a minimum of one sample at a predetermined interval (in compliance with the requirement stated in next para) along the centre line of the alignment, would be taken in a staggered pattern so as to attain a minimum frequency of tests as given in sub para "b" below. For subsequent layer, the stagger should be such that the point of

sampling does not fall vertically on the earlier sampling points of the layer immediately below. Additional sampling points can be taken, as considered necessary.

ii) In case of bank widening, sampling should be done at an interval of minimum 25 metres on widened side(s) of embankment.

b) Frequency of Tests :

Density check would be done for every layer of compacted fill / blanket material as per following minimum frequency:

i) At least one density check for every 200 sqm. for blanket layers and top one metre of sub-grade.

ii) Atleast one density check for every 100 sqm. for other than blanket and one metre of sub-grade.

In case of bridge approaches or special locations closer frequency may be adopted.

c) Method of In-situ Dry Density Measurements

Any of the following methods could be adopted as per the requirements at site. RDSO's guidance may be taken for adoption of other methods such as by use of Nuclear Moisture Density gauge and Compact Meter fitted on rollers.

Method Of Measurement	Procedure Of Test	Parameters To Be Measured	Remarks
i) Sand Replace-ment Method	As per IS-2720 (Part 28) 1974	a) In-situ Dry Density b) Moisture content	May be adopted for all type of soils
ii) Core Cutter Method	As per IS-2720 (Part 29) 1975	a) In-situ Dry Density b) Moisture content	In some of the coarse grained soils (with little fines) taking core cutter samples is difficult. In such cases, sand replacement method may be used for density measurement.

d) Acceptance Criteria :

i) Coarse grained soils which contains fines passing 75 micron IS Sieve, upto 5 percent should have the Density Index (Relative Density) a minimum of 70% as obtained in accordance with IS:2720 (Part-14)-1983.

ii) For other soils, field dry density should not be less than maximum attainable dry density obtained in field compaction trial. However, in field compaction trial, the maximum attainable dry density should not be less than 98% of MDD values as

obtained by Heavy Compaction Test (IS 2720 (part 8) – 1983) in the laboratory.

In case, there are difficulties in achieving 98% of the MDD values as obtained by Laboratory test, in the field trials, the same may be relaxed upto 95% of MDD with the specific approval of the Engineer, recording reasons of such relaxation.

iii) During widening of bank in case of gauge conversion and rehabilitation of unstable formation, compaction of earthwork should be minimum 95% of MDD as obtained by Laboratory test as per Heavy

Compaction Test (IS:2720 (part 8) – 1983) or 70% Relative Density for cohesion less soil (IS:2720 (Part 14) –1983).

1.9.7.2 Formation Level : Finished top of sub-grade level may have variation from design level by ± 25 mm and finished top of blanket layer may also be permitted to have variation from design level by plus 25mm. The ballast should be placed only on level formation without ruts or low pockets.

1.9.7.3 Cross Slope : Cross slope should be within 1 in 28 to 1 in 30.

1.9.7.4 Side Slopes : Side slope should in no case be steeper than designed side slope. Provision of berm width should not be less than the designed width.

1.9.7.5 Formation Width : Formation width should not be less than the specified width.

1.10 BLANKETING

Note : Based on RDSO's Specification no. GE.IRS.2 (Final) dated July 2005 on "Mechanically produced Blanketing Material for Railway formation including Guidelines for Laying" to which reference may be made for further details.

1.10.1 Scope : Where the drawings provide for a Blanket of coarse and granular material of thickness as shown therein over the full width of formation, the contractor shall arrange for the supply of the materials at site, spreading over the formation earthwork and for consolidation as detailed below. The thickness of blanketing layer shall be fixed in light of the Guidelines dated July 2005 of RDSO referred to in the Note above.

1.10.2 Sample for Material : The successful contractor should submit for

approval by the Engineer samples of the Blanketing material in three wide mouth sealed glass jars of a quantity of 0.035 Cum. each. The material to be used by the contractor for blanketing should strictly adhere to the quality of material as approved by the Engineer.

1.10.3 Specifications of Blanket Material

Blanket material produced in a plant should generally conform to following specifications :

- It should be coarse, granular and well graded.
- Skip graded material is not permitted.
- Non -plastic fines (particles of size less than 75 micron) are limited maximum to 12%, whereas plastic fines are limited maximum to 5%.
- The blanket material should have particle size distribution curve within one of the bands of enveloping curves shown in **Figure 1.6** or the percent passing of the material through each IS sieves should lie between the upper and lower limit of blanket material as given in the **Table 1.1**
- The material should be well graded with C_u & C_c as under :

$$7 \quad \text{Uniformity coefficient, } C_u = D_{60}/D_{10} >$$

$$\text{Coefficient of curvature, } C_c = \frac{D_{30}^2}{D_{60} \times D_{10}} \text{ between 1 and 3}$$

- Particle size distribution must follow one of the gradation ranges tabulated below :

Table 1.1 : Particle size distribution ranges for different grades of blanket material

	Headings	Headings	Headings	Headings
1.	40 mm	100	95-100	95-100
2.	20 mm	100	93-100	80-100
3.	10 mm	95-100	85-95	65-85
4.	4.75 mm	92-99	70-92	43-70
5.	2 mm	65-90	46-65	22-46
6.	600 micron	33-50	22-33	08-22
7.	425 micron	28-40	18-28	05-18
8.	212 micron	16-27	10-16	00-10
9.	75 micron	00-12	00-10	00-08

1.10.4 Selection of Blanket Material

Depending on the source of material, the blanket material can be categorized in the following categories:

- Natural material
- Machine manufactured material
- Crushed material
- Blended material

1.10.4.1 Proper survey of area close to projects needs to be carried out to identify suitable sources of blanket material required for the project. Aim of such source identification survey is to use naturally available material, or select alternatives of machine manufactured blanket material through crushing, blending or a combination, which is cheap and conforms to the specifications laid down.

1.10.4.2 The parent material of the blanket material so chosen should be chemically inactive and sturdy in normal working environment. Brickbats, factory slag, weak dissolvable stones like lime, shale, laterite etc. need not be selected as blanket material.

1.10.4.3 The choice of gradation as provided in 1.10.3 (f), above, may be exercised judiciously, based on the availability of material. It may be advisable to choose the grade A for finest subgrade soils (requiring 1.0m thick layer of blanket), and grade B or C for coarser subgrades (requiring less thickness of blanket).

1.10.5 Mechanical Production :

The Blanket can be produced by adopting either crushing methodology or Blending Methodology as described in Paras 6.1 and 6.2 respectively of RDSO's Specification No.GE.IRS.2 (Final) dated July 2005 and to which reference can be made for any details. Crushing Methodology is resorted to in the event of non availability of natural source of blanket materials and involves crushing the rock / boulder to produce crushed blanket material. Blending methodology involves proper blending of two or more soils or in combination with soils crushed material like stone chips or quarry dust.

1.10.6 Quality Control on Blanket Material at Production site

1.10.6.1 The source of blanket material, detailed in para 1.10.4, needs to be identified based on tests & studies conducted and conformity of the material to the Specification as laid down in para 1.10.3.

1.10.6.2 It is desirable to have a check on quality of material at source/manufacturing point so that major deviation in quality of the material being sent to site does not exist. It would be in the interest of the supplier to have such tests conducted on his own to avoid any complication at a later stage.

1.10.6.3 The frequency of such test could be laid down by the engineer in-charge, if need be. In the absence of any other instructions, at least one test may be performed per day to check the particle size gradation at the point of loading into the trucks. However, the final acceptance of the blanket material should be at the site where it is laid, as per para 1.10.6.6.

1.10.6.4 The supplier/ Engineer may also lay down proforma for 'Incoming Material Register' to be maintained at manufacturing point for having a control on utilization of different grades of material, especially where blending is done using crushed as well as local material.

1.10.6.5 Test for Quality : Blanket material should be tested as per IS: 2720 (Part 4) of a minimum of one test per 500 cum. or part thereof to plot particle size distribution curve, so as to assess its suitability. It would be necessary to carry out wet analysis to assess actual percentage of fines. To expedite testing work, dry sieve analysis may be carried out if variation between results of dry and wet analysis is not significant and adequate margin exists with respect to acceptance criteria. However, in such cases also, wet analysis has to be carried out at frequent interval to verify the extent of variation. In any situation, acceptance of blanket material would be based on wet analysis only. The sample for wet analysis should be prepared as per para 4.3 of IS: 2720 (Part 4).

1.10.6.6 Acceptance Criteria :

The material should generally conform to specification as given at para 1.10.3.

1.10.7 Transportation:

The blanket material should be transported wet after mixing water in order to achieve OMC, in tippers for direct unloading on formation.

1.10.8 Laying, Spreading and Compacting

1.10.8.1 The blanket material must be spread with a tractor mounted grader or a paver-finisher in layers of uniform thickness, before allowing compaction.

1.10.8.2 Compaction to specified levels of RD or percentage of MDD (para 1.10.10.3) will be carried out through a number of passes of vibratory rollers of 100-120 kN static weight or equivalent capacity. A combination of vibrating rolling initially and static finishing rolling may be established through trials. Speed of roller shall not exceed 5 km/hr.

1.10.8.3 Proper control of moisture is required to optimize the compaction effort. Optimum moisture content may be established through Modified Proctor Apparatus (IS: 2720, part 8) and moisture may be added by sprinkling at the plant or at site as per the requirement.

1.10.8.4 Rolling is to be carried out in layers of not more than 300 mm each, following the same camber profile as provided in the subgrade layer and to be maintained upto the top layer.

1.10.8.5 No provision for uncompacted portion may be made on the edges of embankment. The sides may be hand rammed with a suitable rammer.

Note : The engineer should generally expect to get MDD above 2.1 gm/cc, and OMC in the range of 5-9%, as matter of guidance.

1.10.9 Quality Control Checks on Finished blanket work :

1.10.9.1 Degree of compaction of each layer of compacted blanket should be ascertained by measurement of dry density/Relative Density of soil at locations

selected in specified pattern. The method of sampling, frequency of tests, method of tests to be conducted and acceptance criteria to be adopted are as under.

1.10.9.2 Method of Sampling :

(a) The sampling adopted has to be such that effectiveness of proper compaction having been done for the entire area under consideration can be judged. For this, the Engineer in-charge should lay down the method adopted in detail depending on site conditions and accordingly records of checks done are properly maintained. However, in absence of such procedure laid down, following method should be adopted:

(b) Suggested method of sampling : For each layer, a minimum of one sample at a predetermined interval (in compliance with the requirement stated in next para) along the centre line of the alignment would be taken. The checking points may be staggered to the extent possible.

(c) Frequency of Tests : Density check would be done for every layer of blanket material as per following min. frequency :

At least one density check for every 200 sqm of blanket layer. (say, every 18 to 30 m for single line, or doubling work and every 12 to 16 m for a double line construction.)

1.10.9.3 Method of in-situ dry density measurements :

Any of the following methods could be adopted as per the requirements at site –

Method of measurement	Procedure of test	Parameters to be measured	Remarks
i) Sand Replacement Method	As per IS-2720 (Part 28) 1974	a) In-situ Dry Density b) Moisture content	May be adopted for all type of material
ii) Core Cutter Method	As per IS-2720 (Part 29) 1975	c) In-situ Dry Density d) Moisture content	In some of the coarse-grained soils (with little fines) taking core cutter samples is difficult. In such cases, sand replacement method may be used for density measurement.
iii) Nuclear Moisture Density Gauge	As issued by RDSO	a) Bulk density b) Moisture content c) Dry density d) Degree of compaction	May be used in consultation with RDSO
iv) Compaction meters fitted on roller (On roller continuous compaction control)	As issued by RDSO	As issued by RDSO	May be used in consultation with RDSO

1.10.10 Acceptance Criteria :

1.10.10.1 1.10.1 to 1.10.4 above.

1.10.10.2 The blanket material, which contains fines passing 75 micron IS Sieve, upto 5 percent should have the Density Index (Relative Density) a minimum of 70% as obtained in accordance with IS: 2720 (Part 14) – 1983.

1.10.10.3 For other materials, field dry density should not be less than maximum attainable dry density obtained in field compaction trial. However, in field compaction trial, the maximum attainable dry density should not be less than 98% of MDD values as obtained by Heavy Compaction Test (IS: 2720 (part 8) – 1983) in the laboratory. In case, there are difficulties in achieving 98% of the MDD values as obtained by Laboratory test, in the field trials, the same may be relaxed upto 95% of MDD with the specific approval of Chief Engineer, recording reasons of such relaxation.

1.10.10.4 During widening of bank in case of gauge conversion and rehabilitation of unstable formation, compaction of blanket layer should be minimum 95% of MDD as obtained by Laboratory test as per Heavy Compaction Test (IS: 2720 (part 8) – 1983) or 70% Relative Density for cohesionless soil (IS: 2720 (Part 14) – 1983).

1.10.11 Measurement :

1.10.11.1 Measurement of blanket material should be done on the basis of finished cross section after the material and workmanship have been accepted as per the above criteria. No deduction is to be made towards voids.

1.10.11.2 In very rare cases, where it is not possible to take blanket material on finished subgrade, measurement may be done on the basis of stack measurement with the permission of Chief Engineer in-charge. It may be necessary to frame different schedule items for different methods of measurement. There should be no occasion to change the method of measurement unless specifically provided

for in the tender documents duly approved by competent authority.

1.10.11.3 Method of measurement in case of stack measurement may be the same as in case of ballast incorporated in "Specification for track ballast-1999".

1.10.11.4 It is advisable to tally the quantity and quality measured at site with the 'Incoming Materials Register' maintained at plant (para 1.10.6.4) as a means of double check.

1.11 SPECIFICATIONS OF BIAXIAL GEOGRIDS FOR TRACKBED STABILIZATION

Biaxial Geogrids of Punched & oriented type with large aperture with below mentioned specifications are to be used for trackbed stabilization application.

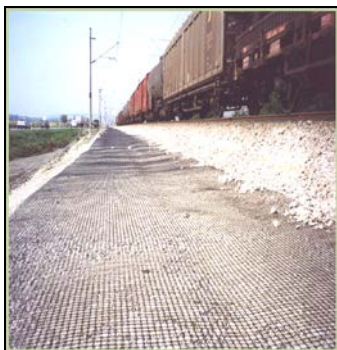
Biaxial Geogrids shall be manufactured from carefully selected polypropylene (PP). Grade of PP used shall in manufacturing of Geogrids shall combine optimum values of strength, stiffness, toughness and durability. Biaxial Geogrids shall be made by extruding a sheet of PP to very precise tolerances, punching an accurate pattern of holes, then stretching the sheet under controlled temperature, firstly in longitudinal direction, then in transverse direction. Process shall create a geogrid with square or almost square apertures by stretching in two orthogonal directions.

The polymers long chain molecules shall be orientated in the direction of stretching resulting in a dramatic increase in both strength and stiffness. This orientation shall pass through both the narrower ribs and the thicker nodes. The resulting product shall be monolithic grid with square edged ribs and integral junctions which possesses both geometrical and molecular symmetry; critical for consistency in manufacture and efficient load transfer in service.

The geogrid shall be supplied in standard width of 3.8m and roll length of minimum 40m.

SL	Property	Test Method	Values	Testing Facilities At
General Properties :				
1.	Polymer	Polypropylene / HDPE or similar polymer		IIT-Chennai, IIT-Delhi, IIT-Bombay, BTRA-Mumbai, BICS-Hyderabad, BTTG-Ahmedabad, SASMIRA-Mumbai, CBRI-Roorkee, CIPET-Chennai
2.	Carbon Black	BS 2782 Part-4 Method 452B:1993	2% (min.)	
3.	Mass Per Unit Area	IS:14716 / ASTM	320 g/m ² (min.)	

		D : 3776		Bombay, BTRA-Mumbai, BICS-Hyderabad, BTTG-Ahmedabad, SASMIRA-Mumbai, CBRI-Roorkee
4.	Aperture Size	Square opening of suitable size with tolerance of ±10% : Size of 60mm to 70mm at the interface of ballast & blanket, i.e. for ballast reinforcement application, such that effective interlocking takes place with existing ballast particles.		
5.	Rib Profile & Thickness	Rectangular with 1.5mm rib depth (min.)		
6.	Roll Width	3.8m to 4.0m, as per site requirement and width attachment to BCM		Not Applicable
7.	Roll Length	40m to 50m (<i>However, it has to be ensured that final roll dia does not exceed 350mm or else geo-grids may get struck underneath the sleepers during installation on existing tracks</i>)		Not Applicable
Mechanical Properties :				
8.	Ultimate Tensile Strength (CD & MD)	IS:13162 Part-5 & IS:13325 And ASTM D 6637/ BS EN ISO 10319:1996	30 kN/m (min.)	IIT-Chennai, IIT-Delhi, IIT-Bombay, BTRA-Mumbai, BICS-Hyderabad, BTTG-Ahmedabad, SASMIRA-Mumbai, CBRI-Roorkee
9.	Strain at Ultimate Tensile Strength (CD & MD)		8% To 12%	
10.	Load at 5% Strain (CD & MD)		21.0 kN/m (min.)	
11.	Junction Efficiency (CD & MD)	GRI-GG2-87 and GRI-GG1-87	95 %	IIT-Chennai, IIT-Delhi, IIT-Bombay, BTRA-Mumbai, BICS-Hyderabad, BTTG-Ahmedabad, CBRI-Roorkee
12.	Radial Stiffness at low strain, (@ 0.5% strain)	ISO 10319:1996	350 kN/m (min.)	IIT-Chennai, IIT-Delhi, IIT-Bombay, BTRA-Mumbai, BICS-Hyderabad, BTTG-Ahmedabad, SASMIRA-Mumbai, CBRI-Roorkee
13.	Aperture Stability	U.S. Army Corps of Engineers Methodology for measurement of Torsional Rigidity	3.5 Kg-cm/deg (min.)	BICS-Hyderabad, BTTG-Ahmedabad, Tensar – UK
14.	Resistance to Installation Damage	BS 8006:1995 & ISO 10319:1996	> 90 %	IIT-Chennai, IIT-Delhi, IIT-Bombay, BICS-Hyderabad, BTTG-Ahmedabad, CBRI-Roorkee
15.	Resistance to Chemical Degradation	EPA 9090	100 %	IIT-Chennai, IIT-Delhi, IIT-Bombay, BTRA-Mumbai, BICS-Hyderabad, BTTG-Ahmedabad, SASMIRA-Mumbai, CBRI-Roorkee, CIPET-Chennai
16.	Resistance to UV Light Weathering	ASTM D4355	100 %	



1.11.1 Installation Methodology

The formation shall be prepared as per Indian Railway standards. It shall be free

from stumps, stones or other large protrusions which could cause damage to the grids.

Biaxial Geogrids shall be placed over the formation just below the ballast.

Adjacent rolls are secured along both the longitudinal and transverse edges by forming 300mm overlaps. Ballast must be placed over Geogrid so that it is able to fully interlock with the grid to ensure continuity of strength between adjacent rolls.

1.12 WOVEN GEOTEXTILE AS SEPERATOR TO SUBGRADE AND BLANKET LAYER

The geotextile shall be made from polypropylene multifilament yarns, woven together into a stable fabric structure with a superior combination of mechanical and hydraulic properties. Finished product shall have excellent resistance to biological and chemical environments normally found in soils and shall be stable against short-term exposure to ultraviolet radiation.

The woven geotextile shall conform to property values listed below :

Specifications of Multifilament Woven Geotextile

SL	Property	Test Method	Value (MARV)
I	Polymer Composition, Structure and Physical Properties		
1	Polymer	Polypropylene	
2	Structure	Woven with multifilament yarn in both warp and weft directions	
3	Mass per unit area	ASTM D 5261	240 g/m ²
II	Mechanical Properties		
1	Tensile strength	Warp	55 kN/m
		Weft	40 kN/m
2	Elongation at specified Tensile Strength	Warp	25 %
		Weft	25 %
3	Trapezoid tearing strength	Warp	1100 N
		Weft	750 N
4	Puncture strength	ASTM D 4833	600 N
III	Hydraulic Properties		
1	Apparent opening size	ASTM D 4751	150 microns
2	Water flow rate normal to the plane	ASTM D 4491	32 l/m ² /s
Roll Dimensions		Standard roll length : 100m, Standard roll width : 5m	

1. Values listed are minimum average roll values except for II-2 and III-1, which are maximum average roll values.

2. The elongations reported are the actual fabric elongations at the specified

tensile strength measured over a gauge length of 100mm marked at the center of specimen.

3. Roll length and Roll width may vary as per requirement.



1.12.1 Installation of Woven Geotextile as Separator

The woven geotextile shall be laid directly on the site, having removed major protrusions such as rocks and bush stumps and also having filled local hollows and depressions with the approved fill.

The geotextile rolls of specified width shall be laid in the longitudinal direction (parallel to the track) on the prepared subgrade. A 300mm overlap shall be provided between any joint of two geotextile rolls (transversely or longitudinally).

After laying the geotextile, first layer of blanket layer as per drawing is to be constructed and compacted.

1.13 Jute Geotextile

Jute Geotextile improves performance of soil. It imparts strength to soil by not allowing soil particles to migrate on one hand and by easing out water through its pores on the other. Jute Geotextile is capable of performing functions of separating drainage and initial reinforcement.

The application of Jute Geotextile in slopes of Railway embankment is to be done in accordance with RDSO's guidelines for application of jute geotextile in Railway embankments and hill slopes vide RDSO's report no. RDSO/2007/GE:G-0008 or its subsequent versions including earth work and fixing arrangement.

The guidelines for application of jute geotextile for Rain water erosion control in Road & Railway embankment and hill slopes have also been issued by Bureau of Indian Standard (BIS) vide (IS-14986-2001) and woven geotextile Specifications (IS-14715: 2000 under revision), these may be referred to for further guidance and application.

Tests

The sample of jute geotextile may be got tested at Institute of Jute Technology (IJT) Kolkata or Indian Jute Industries Research Association (IJIRA) or any authorized jute testing laboratory.



ANNEXURE 1.1**EXTRACTS FROM THE EXPLOSIVES RULES, 1983****4. Safety distance categories of explosives**

(1) Explosives are divided into four categories according to the risks which they present when initiated, namely-

(i) Category X — those explosives which have a fire or a slight explosion risk or both but the effect of which will be local.

(ii) Category Y — Those explosives which have a mass fire risk or a moderate explosion risk, but not the risk of mass explosion.

(iii) Category Z — Those explosives which have a mass explosion risk and major missile effect.

(iv) Category ZZ. — Those explosives which have a mass explosion risk and minor missile effect.

(2) If any question arises as to whether any explosive belongs to Category X, Category Y, Category Z or Category ZZ, the matter shall be referred to the Chief Controller whose decision shall be final.

General Provisions**7. Restriction on delivery and dispatch of explosives —**

(1) No person shall deliver or dispatch any explosive to any one other than a person who —

(a) is the holder of a licence, to possess the explosives or the agent of a holder of such a licence duly authorised by him in writing in this behalf; or

(b) is entitled under these rules to possess the explosives without a licence.

(2) The explosives so delivered or dispatched shall in no case exceed the quantity which the person to whom they are delivered or dispatched is authorised to possess with or without a licence under these rules.

(3) (i) No person shall receive explosives from any person other than the holder of a licence granted under these rules.

(ii) No person shall receive from or transfer explosives to any person for a temporary storage or safe custody in a licensed premises, unless prior approval is obtained from the Chief Controller.

11. Competent person to be Incharge of operations — Every person holding or

acting under a licence granted under these rules shall, whenever explosives are loaded, unloaded or handled, depute a competent person experienced in the handling of explosives to be present at and to conduct the operations in accordance with these rules.

12. Precautions to be observed in handling explosives —

(1) The floor of any place or any carriage or vessel in which any explosive is or is to be laid and the ground gangway, decks and other places over which the explosive is to be conveyed during loading or unloading shall be —

(i) Carefully examined to ensure that there is nothing thereon in contravention of these rules or likely to endanger the safety of the consignment;

(ii) Thoroughly cleaned and swept before and after use,

(2) The packages containing the explosives shall not be thrown or dropped down or rolled or pulled along the ground or floor but shall be passed from hand to hand and carefully deposited and stored.

(3) Where a package is to be slung, due precaution shall be taken to slung it in such a manner as effectively to prevent the possibility of a fall.

(4) After the handling of explosives has commenced, the operations shall proceed with due diligence and without unnecessary stoppage.

13. Restriction on handling of explosives after sunset — No person shall handle or cause to be handled any explosive between the hours of sunset and sunrise:

Provided that nothing in this rule shall apply to handling of explosives during the dark hours if proper illumination is provided in the area and the place is guarded,

14. Prohibition of smoking, fires, lights and dangerous substances — No person shall smoke, and no fires, lights or articles or substances of a flammable nature or liable to spontaneous ignition, or to cause or communicate fire or explosion such as acids, petroleum, carbide of calcium, compressed gases or such other hazardous substances, shall be allowed-

(a) at any time within 15 metres from a place where an explosive is stored; or

(b) at any place where an explosive is handled, during transport, one hour before and during such handling:

Provided that nothing in this rule shall apply to the use on a ship of —

- (i) an engine room fire, if such fire has been previously carefully banked up or
- (ii) any artificial light or ship's signal lights or of a type approved in writing by the Chief Controller in areas outside port limits and by the Conservator of the Port within port limits.

15. Prohibition of matches etc. — No person on, in, or near any place where explosives are stored or handled or on any carriage conveying explosives shall —

- (a) have in his possession any matches, fuses or other appliances for producing ignition or explosion or any knives or other articles made of iron or steel; or
- (b) wear boots or shoes with iron nails or shod or strengthened with iron, unless such boots or shoes are covered with leather, rubber, felt or other material, in the form overshoes or other.

41. Protection from fire or explosion —

(1) No carriage or aircraft or vessel shall be used for transporting explosives unless all iron or steel therein with which a package containing any explosive is likely to come in contact is effectually covered with lead, leather, wood, cloth or other suitable material.

(2) Where the weight of the explosives transported in any carriage exceeds 1000 kg, they shall be placed in the interior of the carriage which shall be enclosed on all sides with wood or metal so as effectually to protect the explosives from communication of fire and the carriage shall be locked.

(3) Where the weight of explosives transported in any vessel exceeds 1000 kg, they shall be placed in the hold of the vessel which shall have a closed deck and closely fitting hatches and double water-tight bulk heads shall be provided at each end of the hold where the explosives are stowed and the hatches shall be locked.

(4) Where the explosives carried in carriage or vessel do not exceed 1000 kg in weight, the explosives shall, unless they are conveyed in the manner specified in sub-rule (2) or sub-rule (3), as the case may be, be completely covered with fireproof cloth tarpaulin or any other suitable material as effectually to protect the explosives from communication of fire.

(5) All doors, hatches and coverings of every compartments or hold containing explosives in or on any carriage or vessel shall be kept closed and secured except when explosives are being loaded or unloaded into, onto or from it.

(6) When explosives are being carried in or on a carriage or aircraft or vessel, they shall be kept away from anything whether in the carriage or vessel or elsewhere that would be liable to cause them to ignite or explode.

42. Delay in transit to be avoided — If the quantity of explosives transported in any carriage or vessel exceeds 2.5 kg, the person or persons incharge of such carriage of vessel shall not stop or delay at any place for a longer time than may be reasonably necessary, nor stop unnecessarily at any place where such stopping would be attended with danger to public.

44. Small quantities of fireworks exempted — Nothing contained in Rules 35, 40 and 41 shall apply to the transport of manufactured fireworks in the custody of a person entitled to possess them without a licence under Rule 14 provided that not more than 2.5 kg of manufactured fireworks, securely packed, shall be so transported in any motor vehicle licensed for conveyance of more than six passengers.

113. Licence for possession, sale and use —

(1) No person shall possess, sell or use any explosive except under and in accordance with a licence granted under these rules.

(2) The licensee shall be responsible for all operations in connection with the possession, sale or use of explosives which may be conducted in the premises covered by the licence.

114. No licence needed for possession and sale in certain cases -

(i) notwithstanding anything contained in Rule 113, no licence shall be necessary for the possession.

(a) of any explosive by a carrier or other person for the purpose of (transport, when the same is being kept or transported in accordance with the provisions of Chapter IV regulating transport of such explosives: or

(b) by any person of manufactured fireworks in any quantity not exceeding 25 kg Provided that the fireworks -

(i) are obtained and intended by such person for immediate use and not for sale

and are possessed by him for a period not exceeding 14 days; and

(ii) are kept in substantial receptacle which is exclusively appropriated to the keeping of explosives and is closed and secured so as to prevent unauthorised person from having access to the explosives; or

(c) by any person for his own private use and not for sale of gunpowder not exceeding 5 kg and 50 metres of safety fuse for blasting in any State, other than Bihar, Kerala, Tamil Nadu and West Bengal, and of small arm nitre-compound not exceeding 5 kg except in the State of Kerala and Tamil Nadu;

(d) by Railway Administration for flare lights or other explosives for its own use and not for sale to any other person by transfer or otherwise for maintaining railways, tracks, tunnels, provided that the provisions of the Act and these rules or otherwise complied with;

(e) of any explosive, which is not for sale and is required solely for the navigation of aircraft, when kept in an aircraft for use therein, or for distribution to other aircraft or to aerodromes or at an aerodrome for use there or for distribution to aircraft or to other aerodromes, provided that the maximum quantity so possessed shall not exceed 25 kg when carried in an aircraft and 50 kg, when kept at an aerodrome;

(f) and sale from a shop of amorces (an explosive of Class 7 and division 2) in quantity not exceeding 12.5 kg Provided that in respect of clauses (b) and (c) the Central Government may prohibit the possession of any explosive or prescribe any conditions under which the explosives can be possessed without a licence when considered necessary for the security of public peace.

(2) Notwithstanding anything contained in Rule 113, no licence shall be necessary for the sale of such explosives manufactured by the Armed Forces of the Union and Ordnance Factories or other establishment of such Forces as are sold or delivered to any person who is in possession of a valid licence issued under these rules for the class and quantity of the explosives so sold or delivered.

116. Protection from lightning —

(1) Every magazine shall have attached thereto one or more efficient lightning, conductors designed and erected in accordance with the specification laid down

in Indian Standard Specification No. 2309 as amended from time to time.

(2) The connections to various parts of earth resistance of the lightning conductor terminal on the building to the earth shall be tested at least once in every year by a qualified electrical engineer or any other competent person holding a certificate of competency in this behalf from the State Electricity Department. A certificate showing the results of such test and the date of the last test shall be hung up in conspicuous place in the building -

117. Precautions during thunderstorm

- Whenever a thunderstorm appears to be imminent in the vicinity of a magazine or store house every person engaged in or about such magazine or store house shall be withdrawn to a safe distance from such magazine and store house and the magazine and the store house shall be kept closed and locked until the thunderstorm has ceased or the threat of it has passed.

119. Maintenance of records — Every person holding a licence granted under these rules for possession, sale or use of explosives shall maintain records in the prescribed Forms and shall produce such records on demand to an inspecting officer.

120. Repairing of licensed magazine or store house — Before repairs are done to any magazine or store house or part thereof used for storage of explosives, that magazine or Store house shall be cleaned by removal of all explosives and by thorough washing.

122. Premises to be kept locked —

(1) Any licensed magazine or store house shall be kept securely closed or locked at all times except when goods, are being placed in or taken from it or when it must be kept open for some other purpose in connection with the management of such premises.

(2) The keys of the licensed magazine shall, at all times be kept secured in licensee's, own custody or of his authorised agent and shall be produced for opening the magazine or store house whenever so required by an inspecting officer. The name and address of the person with whom the keys will be kept shall be intimated to the licensing authority and the controller of Explosives having Jurisdiction.

123. Guards to be provided —

(1) The licensee shall at his own expenses provide for round the clock safe custody of the magazine or store house a guard which shall be of such strength as the

District Authority may consider it to be sufficient.

(2) The licensee, shall provide a shelter for the watchman on duty near the magazine or store house,

124. Repacking or opening of packages —

(1) No packages containing explosives shall be opened in magazine or store house.

(2) Repacking of explosives shall be done, where the necessary in an approved open sided shed having smoothly finished cemented floor at a distance as approved by licensing authority.

125. Explosives not to be kept in damaged boxes — The licensee of every magazine or store house shall ensure that the explosives are always kept in their original outer package. In case the outer package gets damaged so that the explosives contained therein cannot be stored or transported, such explosives shall be repacked only after the same are examined by a Cont

126. Storage of explosives In excess of licensed quantity —

(1) The quantity of any kind of explosives kept in any licensed magazine or store house shall not exceed the quantity entered in the licence against such kind of explosives,

(2) Notwithstanding anything contained in sub-rule (1), the Chief Controller may issue a permit, on payment of the prescribed fee to a holder of licence in Form 22 and such holders of licence in Form 21 who also have licence in Form 20 (for the class of explosives) for keeping of explosives in excess of the licensed quantity entered in the licence when he is satisfied that such excess storage is essential and unavoidable due to circumstances beyond the control of the licensee. The validity of such permit shall not exceed 30 days

(i) the licensing authority shall not issue any permit for excess storage of explosives if the magazine or store house cannot observe the requisite safety distances for the total quantity entered in the licence plus the additional quantity of the explosives so permitted.

(ii) no permit for storage of explosives in excess of the licensed capacity shall be

granted if the specified distances on the licence around the magazine or store house or the floor space in the specified rooms for storage of each kind of explosives is not adequate for keeping of the total quantity of explosives, including the excess quantity applied for.

(iii) The licensing authority may refuse to grant a permit for excess storage of explosives if such excess storage is of a repeated nature.

(iv) No explosive in excess of the licensed quantity shall be stored in the magazine or store house unless a permit in this behalf is obtained from the licensing authority by a letter or telegram.

129. Storage in a magazine — An explosive if stored in a magazine shall be stored either in Mode 'A' or Mode 'B' magazine as specified in Schedule VII.

130. Restriction, on use of Mode 'B' magazine — Mode 'B' magazine shall be used for storage of explosive required (or use for a temporary period for a specific purpose and such magazine shall not be used for sale of explosives.

131. Mound of magazines — A substantial mound shall be provided near a magazine, if so required by the licensing authority. Such mound shall be of a type approved by the licensing authority and shall always be maintained in good condition to provide effective protection.

135. Construction of premises :

(1) All explosives on the premises shall be kept in a brick, stone or concrete building which is closed and secured so as to prevent unauthorized person from having access thereto.

(2) The premises shall have a floor area of minimum nine square metres.

(3) The premises shall have independent entry and exit.

(4) If the premises are situated in a building used for other purposes also, such premises shall not be situated under a staircase and shall be so located as not to obstruct any passage in from or to the building in case of fire or accident.

(5) The premises shall be situated at ground level.

ANNEXURE 1.2**Typical Compaction Characteristics for natural soils, rocks and artificial materials****(Ref: BS: 6031-1981, Table 4)**

Material	Major Divisions	Subgroups	Suitable type of compaction plant	Maximum number of passes for satisfactory compaction	Maximum thickness of compacted layer (mm)	Remarks
(1)	(2)	(3)	(4)	(5)	(6)	(7)
Rock-like materials	Natural rocks	All rock fill (except chalk)	Heavy vibratory roller not less than 180 kg per 100mm of roll Grid roller not less 180 kg per 100mm of roll	4 to 12	500 to 1500 depending on plant used	If well graded or easily broken down then this can be classified as a coarse-grained soil for the purpose of compaction. The maximum diameter of the rock fragment should not exceed two third of the later thickness.
		Chalk	See remarks	3	500	This material can be very sensitive to weight and operation of compacting effort and spreading plant. Less compactive effort is needed than with other rocks
Artificial	Waste material	Burnt and unburnt colliery shale	Vibratory roller Smooth wheeled roller Self-propelled tamping roller	4 to 12 depending on weight of plant	300	
		Pulverized fuel ash	Vibratory roller Self - propelled tamping roller Smooth wheeled roller Pneumatic tired roller			Includes lagoon and furnace bottom ash
		Broken concrete, bricks, steel works, slag,	Heavy vibratory roller Self- propelled tamping roller			Non-processed sulphide brick slag should be use with caution

		etc.	Smooth wheeled roller			
Coarse-grained soils	Gravel sand, gravelly soils	Well graded gravel and gravel/ sand mixture: little or no fines Well graded gravel / sand mixtures with excellent clay binder Uniform gravel: little or no fines Poorly graded gravel and gravel / sand mixtures: little or no fines. Gravel with excess fines, silty gravel, clayey gravel, poorly graded gravel / sand / clay mixtures	Grid roller over 540 kg per 100mm of roll. Pneumatic tired over 2000 kg per wheel Vibratory plate compactor over 1100 kg /Sq.m. of base plate Smooth wheel roller Vibratory roller Vibro rammer Self-propelled temping roller	3 to 12 depending on type of plant	75 to 275 depending on type of plant	
	Sand and sandy soils	Well graded gravel and gravel/ sand mixture: little or no fines Well graded gravel / sand mixtures with excellent clay binder Uniform gravel: little or no fines Poorly graded gravel and gravel / sand mixtures: little or no fines. Gravel with excess fines				
	Uniform sands and gravels	Uniform gravels; little or no fines. Uniform sands; little or no fines. Poorly graded sands; little or no fines. Sands with	Smooth wheeled roller below 500 kg per 100mm of roll. Grid roller below 540 kg per 100mm of rolling. Pneumatic tired roller	3 to 16 depending on type of plant	75 to 300 depending on type of plant	

		finer, silty sands, clayey sands, poorly graded sand / clay mixtures	below 1500 kg per wheel. Vibratory roller. Vibrating plate compactor Vibro-tamper			
Fines soils	Soils having low plasticity	Silts (inorganic) and very fine sands, rock flour, silty or clayey fine sands with slight plasticity Clayey silts (inorganic) Organic silts of low plasticity	Sheepsfoot roller Smooth wheeled roller Pneumatic tired roller Vibratory roller over 70 kg per 100 mm of roll Vibratory plate compactor over 1400 kgs./sqm. of base plate Vibro tamper Power rammer	4 to 8 depending on type of plant	100 to 450 depending on type of plant	If water content is low, it may be preferable to use vibratory roller. Sheeps foot rollers are best suited to soils at water contents below their plastic limit.
	Soils having medium plasticity	Silty and sandy clays (inorganic) of medium plasticity Clays (inorganic) of medium plasticity Organic clays of medium plasticity				Generally unsuitable for Earthworks
	Soils having high plasticity	Micaceous or diatomaceous fine sandy and silty soils, plastic silts Clay (inorganic) of high plasticity, fat clays Organic clays of high plasticity				Should only be used when circumstances are favourable Should not be used for earthworks

Note: The information in this table should be taken only as a general guide. Field trials for compaction should be conducted for working out optimum layer thickness and number of roller passes for the type of compaction equipment being used. Compaction of mixed soils should be based on that subgrade requiring most compactive effort.

ANNEXURE 1.3**SALIENT FEATURES OF VIBRATORY ROLLERS MANUFACTURED IN INDIA**

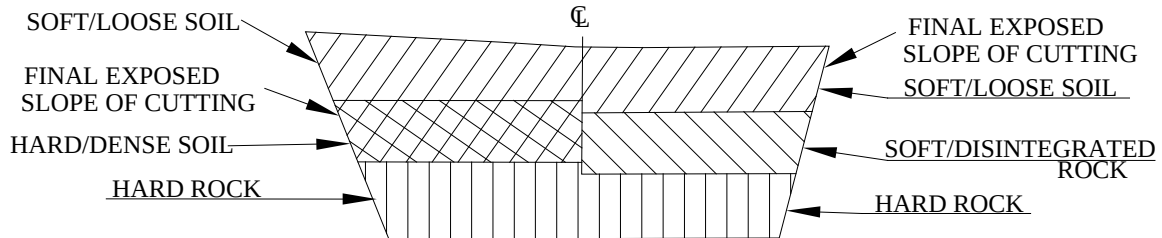
MAKE	MODEL No.	Operati ng Weight (Kg.)	Drum Detail			Normal Amplitu de (Mm)	Vibrati ng Freque ncy (Hz)	REMARKS
			DRUM WIDTH (Mm)	AXLE LOAD (T)				
				Front	Rear			
ESCORTS	EC 5250 STD	9350	2130	5.050	4.300	1.72	30	
		9550	2130	5.250	4.300	1.72	30	It is used for better gradeability
		10500	2130	6.650	4.300	1.53	30	It is used for better gradeability & breaking clods
		9300	1680	4.650	4.300	1.27/0.7 5	0- 30/42	
GREAVES BOMAG	BW 212- D-2 (2A)	10424	2100	6.463	3.961	1.67	40/31	It is used for better gradeability
	BW 212- PD-2	10879	2100	6.201	4.678	1.5	30	It is used for better gradeability & breaking clods
L&T	1104 STD	11150	2330	5.770	5.380	1.6/0.6	28/36	
	1104 D	11150	2330	5.900	5.535	1.6/0.6	28/36	It is used for better gradeability
	1104 PD	11835	2330	6.300	5.535	1.6	28	It is used for better gradeability & breaking clods
INGERSOL LRAND	ISD-100 STD	10740	2135	6.210	4.535	1.7	0-30	
	ISD-100 D	10830	2135	6.295	4.535	1.7	0-30	It is used for better gradeability
	ISD-100F	11740	2135	7.205	4.535	1.41	0-30	

NOTE : The rollers indicated above can also be used in Static mode. The list includes rollers manufactured by reputed firms only.

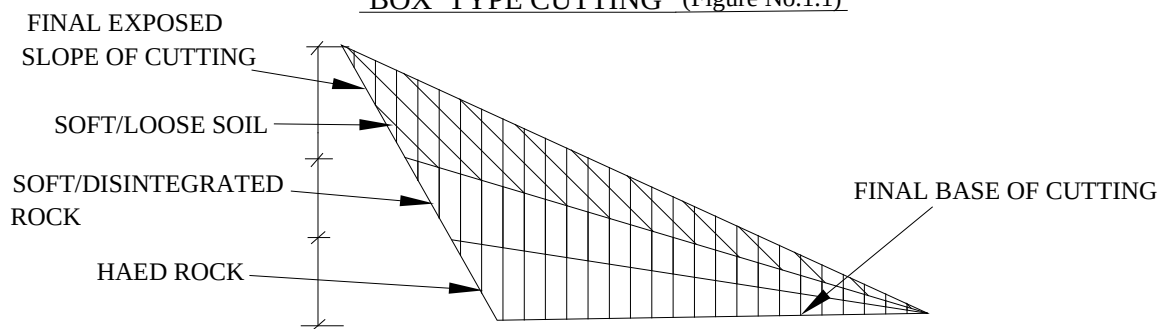
LEGEND : STD- Standard Type, D- Drum Type & PD - Pads + Drum Type

SKETCHES SHOWING MANNER OF COMPUTATION OF QUANTITIES OF
VARIOUS CLASSIFICATIONS OF SOIL

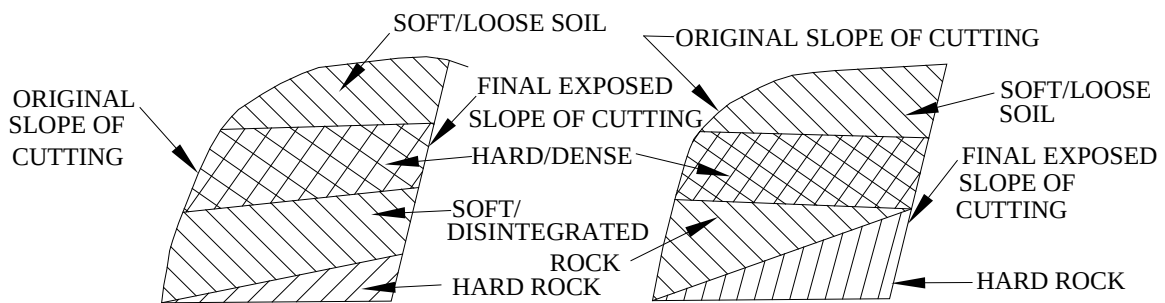
(FIG. NOS.1.1 TO1.4)



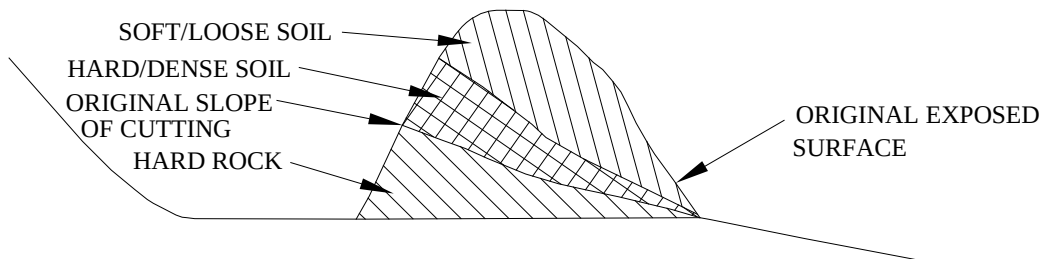
BOX TYPE CUTTING (Figure No.1.1)



ONE SIDED CUTTING IN A TRANSVERSE SLOPING GROUND (Figure No.1.2)



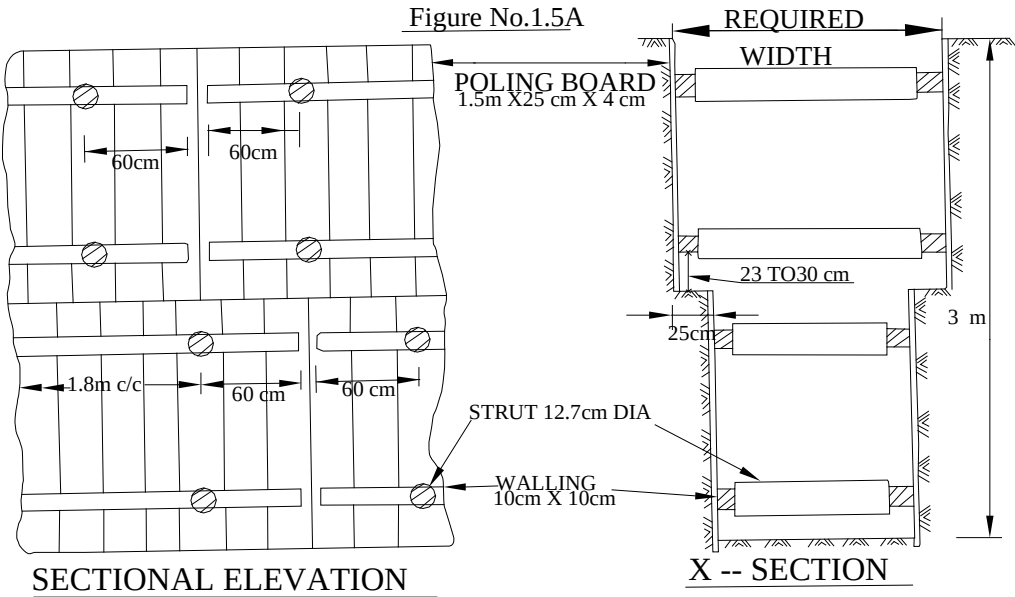
WIDENING OF CUTTING WHERE THE EXISTING
CUTTING SLOPE DISAPPEARS AND A FRESH SLOPE ARISES (Figure No.1.3)



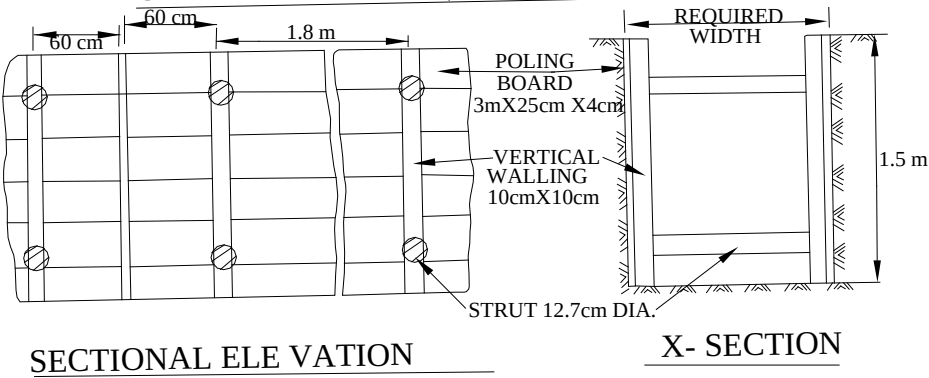
EXTENSION OF EXISTING CUTTING WHERE NO
FRESH CUTTING SLOPE IS AVAILABLE AFTER THE WORK. (Figure No.1.4)

DETAILS OF CLOSE AND OPEN TIMBERING
(SECTIONAL ELEVATION & CROSS SECTION) NOT TO SCALE

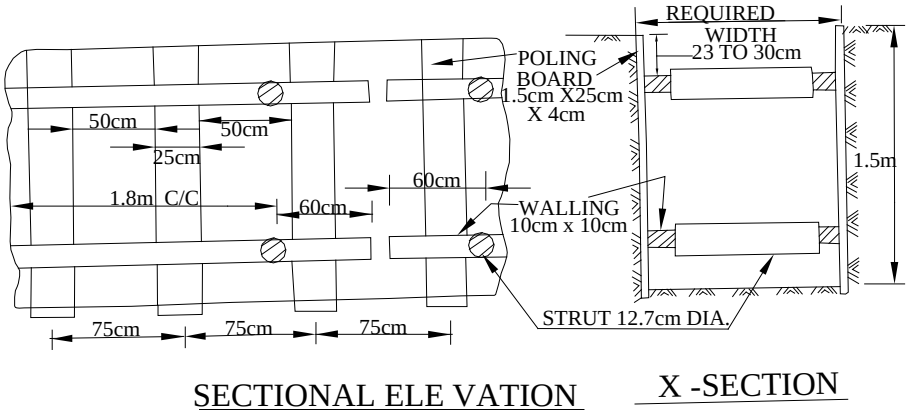
DETAILS OF CLOSE & OPEN TIMBERING
CLOSE TIMBERING (With vertical poling boards)



CLOSE TIMBERING (WITH LONGITUDINAL POLING BOARD)



OPEN TIMBERING



DETAILS OF CLOSE AND OPEN TIMBERING
(ISOMETRIC VIEW)

Figure No.1.5B

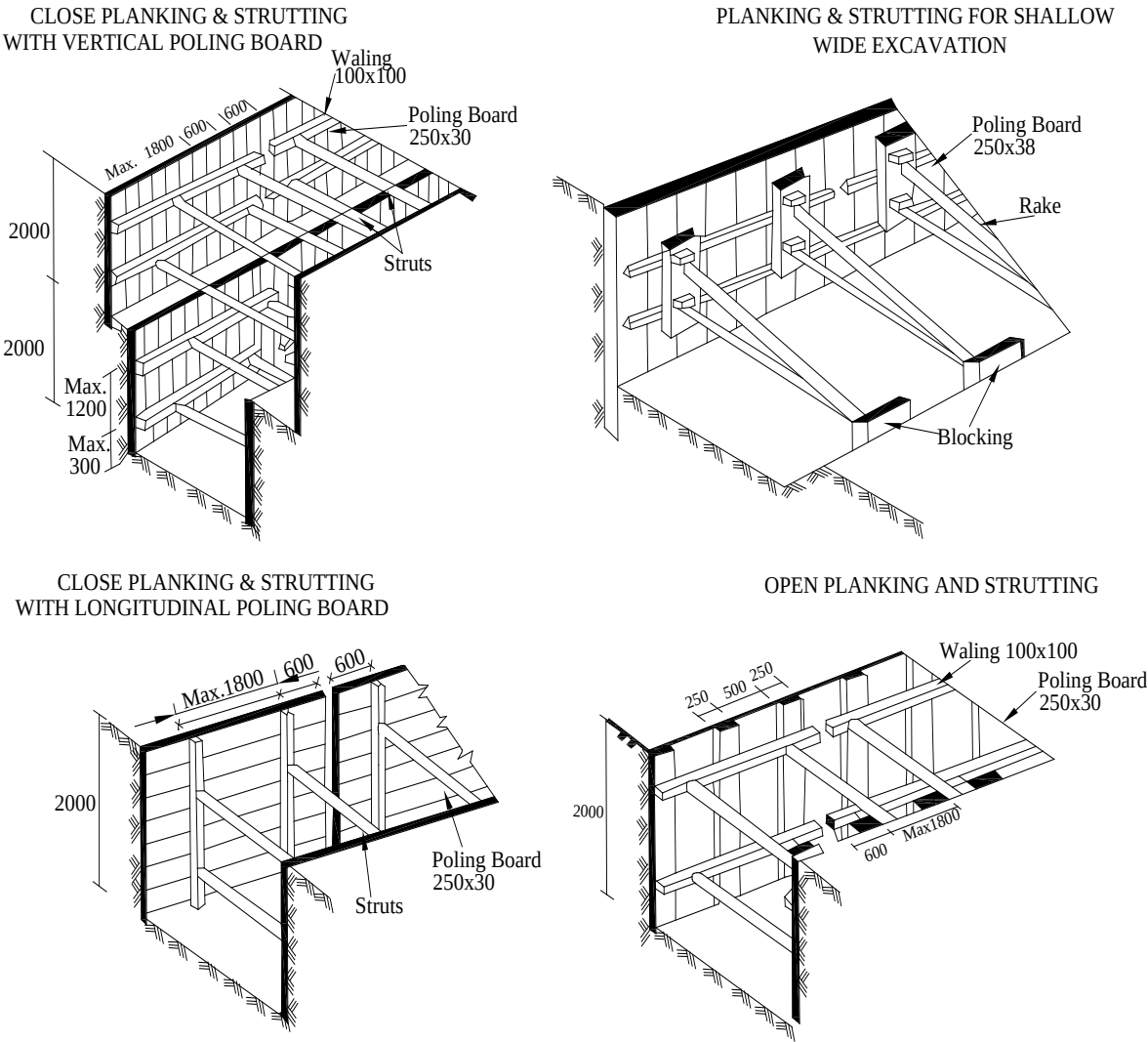
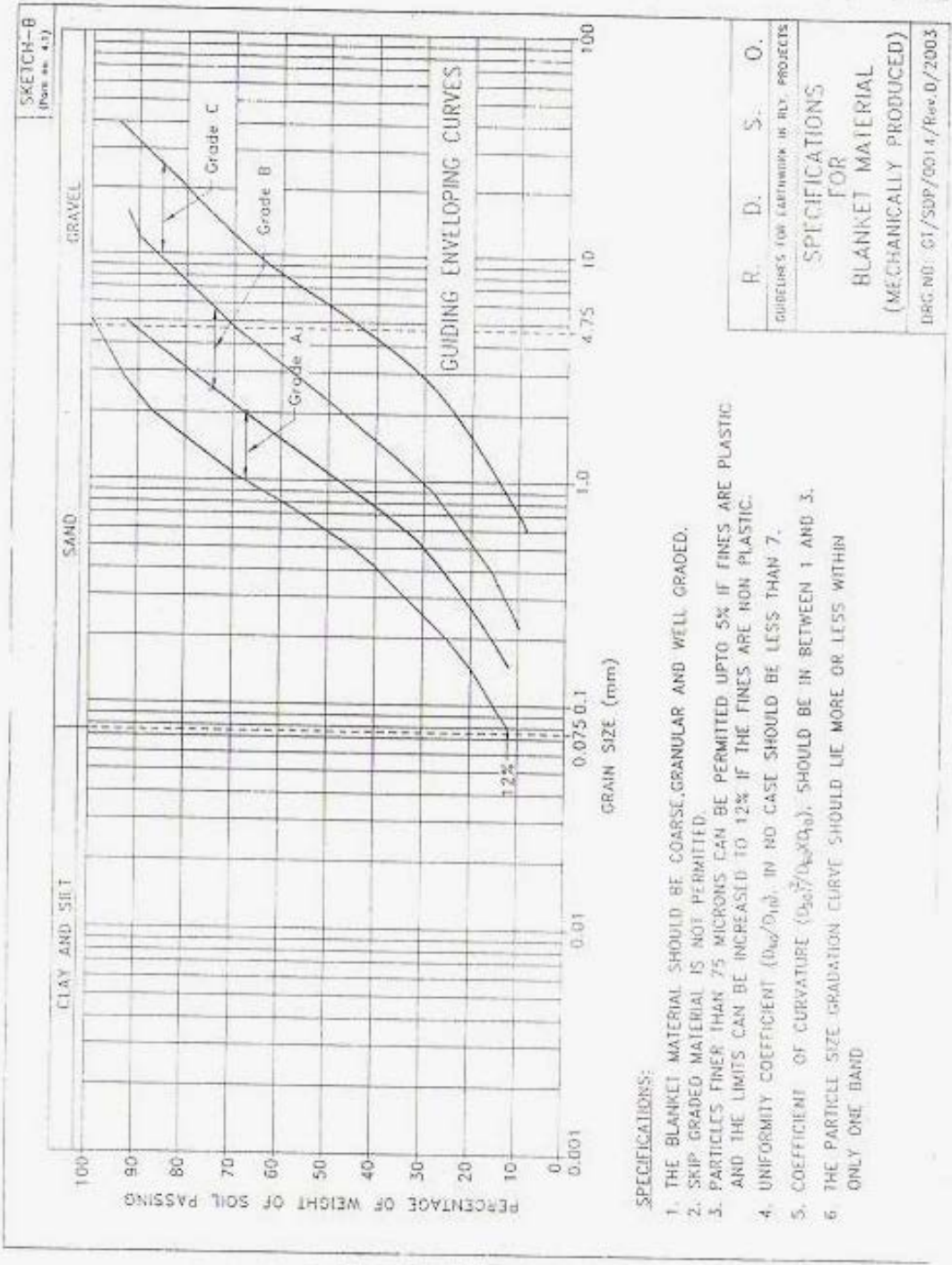


Figure No.1.6
(Para No.1.10.3)

SPECIFICATIONS FOR BLANKET MATERIAL



Chapter 2

Carriage Of Materials

1-2.1 SUPPLY OF QUARRY PRODUCTS TO RAILWAYS

The Contractor shall arrange at his own cost all labour, explosives, tools, baskets, carts, lorries and other conveyance required for excavation, quarrying, leading, stacking, loading etc. When blasting is necessary, it shall be carried out in accordance with the statutory rules in force. The rate payable to the contractor is inclusive of all charges, royalty, compensation to land owners for right of passage, sales tax, octroi etc.

2.1.1 Site for stacking

Sites for stacking materials shall be located within the railway boundaries and close to the place of use and as directed by the Engineer. The sites for stacking of materials should be got approved before collection is commenced. The collection of materials made on stacking grounds not approved by the Engineer will be liable for rejection. The stacking grounds shall be levelled. The Engineer shall direct the contractor to level the ground where required and for this purpose no payment will be made.

2.1.2 Deductions

Payment shall be made for the materials on the actual measurements of the stacks with such deductions as are laid down in the relevant chapter of the specifications for each type of material.

2.1.3 Opening out

At any time required by the Engineer or his authorised representative while stacking is in progress and at the time measurement is taken, the contractor shall supply at his own cost, labour, tools and other facilities to open out all or any of the stacks for the purpose of inspection or measurement.

2.1.4 Non conforming materials

Materials not conforming to the detailed specifications shall be removed from the Railway's premises by the Contractor within the time specified by the Engineer. Failing such removal after issue of notice, the Railway shall be at liberty to dispose of the materials at the risk and cost of Contractor. No compensation shall be payable to the Contractor for the materials so disposed of by the Administration.

2.1.5 Samples

When calling for tenders for supply of materials, samples of the materials should be called for along with each tender. No materials should be accepted which are inferior to the approved samples under any circumstances. In all cases of dispute about the quality of the materials whether conforming to accepted sample or not, the decision of the Engineer shall be final and binding.

2.2 SUPPLY OF MISCELLANEOUS MATERIALS TO RAILWAYS

2-5.12.2.1 BAMBOOS

2-5.1.12.2.1.1 General : The bamboos to be supplied or to be used on works shall be sound and shall be free from attacks of ~~weevils~~ or other boring insects. They shall be sufficiently seasoned.

2-5.1.22.2.1.2 Size : The bamboos shall be of the specified girth, the measurement of girth being taken at the centre of the length of each bamboo. The Engineer's representative may, at his discretion, exclude from the length of the bamboos any tapered end which is too thin to be of use.

2-5.22.2.2 CASUARINA POSTS

2-5.2.12.2.2.1 Quality : The posts shall be reasonably straight and sound, and free from projecting knots, remnants of branches, splits, hollows, rot or any other defect which may affect their strength or usefulness to any appreciable extent, in the opinion of the Engineer's representative.

2-5.2.22.2.2.2 Size : The provisions of Para 2.4.1.2 will apply, substituting the word "casuarinas posts" in place of "bamboos".

2-5.32.2.3 BAMBOO MATTING

2-5.3.12.2.3.1 Mats : The bamboo mats shall be of the specified type, viz. "Ordinary" or "double", the latter meaning the thicker variety, with the outer skin of bamboos covering one face of the mat. The quality of mats to be supplied or used on works shall invariably be got approved by the Engineer in advance. All edges shall be properly bound, in weaving, to prevent fraying. The bamboo strips used shall be reasonably uniform in width and thickness and shall be closely woven.

2-5.3.22.2.3.2 Size : When using bamboo matting in claddings, partitions, etc, side and end laps of atleast 15 cm shall be provided

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between individual mats. The matting shall be fixed to the supports in an approved manner. When fillets of wood or bamboo are used for securing the matting, the fixing shall be done with nails driven through the fillets. Any cut edges shall be properly bound to prevent fraying.

2.2.42.2.4 CHICKS

2.2.42.2.4.1 Bamboo Chicks : The chick shall be formed out of bamboo laths of width 6 to 10mm, thickness not less than 3mm and length equal to the full width of the chick, split out of good mature bamboo. The laths shall be planed smooth with knife to be of fairly uniform size and free from projecting knots and fibres. They shall then be arranged on the ground and closely bound together by country twine, with the spacing between laths kept to a minimum and the spacing between consecutive twines not exceeding 20 cm. The binding shall be such that the laths are held fast, while at the same time there is freedom for rolling. Two straight solid bamboos of diameter not less than 5 cm shall be tied to the top and bottom edges of the chick so formed,

2.2.4.2

2.2.4.2 Cane Chicks : Where cane chicks are prescribed, the chicks shall be formed out of mature cane of diameter from 6 to 10mm instead of bamboo laths. In other respects, the constructional details shall be the same as given in para 2.4.4.1.

2.2.4.3 Binding : Blue dungry cloth of the best quality, formed to the required size, shall be spread over the chick so as to cover the whole of the chick and folded back at the edges for a width of 4 cm on both sides and 7.5cm at the top and bottom, and well stitched on. Best white tape, 8 cm wide, shall then be stitched securely along both the sides, covering approximately 4 cm on either face of the chick. Additional tapes 4 cm wide shall also be stitched on, either diagonally, or in vertical bands of spacing not exceeding 1.2m as may be directed by the Engineer, to prevent flapping of the cloth.

2.2.4.4 All chicks shall be provided with 2 nos. of endless cotton ropes 12mm dia for the full depth so as to enable their being

secured to the floor and prevented from flapping in the lowered position. In addition, slip rings and wooden plugs shall be provided for holding the chick when rolled up to any desired height. For chicks of height exceeding 3m and in other cases where specified, two wooden / steel pulleys of approved quality shall also be supplied, along with an adequate extra length of 12 mm cotton rope to enable the chick being raised or lowered.

2.2.4.5 Rate : Unless otherwise stipulated, the rate for supply of chicks shall be all inclusive and nothing extra shall be payable for pulleys, ropes, rings etc.

2.2.5 POLYETHYLENE CANE – Should be as per IS:-2828:1964

2.2.5.1 TYPES

- a) Type 1 – Produced from high density polyethylene; and
- b) Type 2 – Produced from blends of high and low density polyethylene.

2.2.5.2 High Density Polyethylene

High density polyethylene used for manufacturing cane shall be of grade designation. PE TGN A 50 T 022 or PE TGN A 57 T 022 as per IS 7328 : 1992. But density, in any case, shall not be less than 0.950 g/ml and melt flow index (is) shall not exceed 2.0 g/10 Min.

2.2.5.3 Low Density Polyethylene

Low density polyethylene used for manufacturing cane shall be of grade designation LDPE 23 Y 00 or LDPE 33 Y 00 as per IS 3395 : 1984. But density, in any case shall not be less than 0.92 g/ml and melt flow index (is) shall not exceed 3.0 g/10/Min.

2.2.5.4 The material shall be smooth and glossy and its edges shall be free from sharp cuts. It shall not split while weaving.

2.2.5.5 Tolerance on Width and Thickness

The polyethylene cane shall be supplied in two sizes, one for seat and back and the other for border. The permissible tolerance on width and thickness for the two sizes shall be as follows :

	Width	Thickness
For the seat and back	± 0.10 mm	± 0.02 mm
For border	± 0.15 mm	± 0.03 mm

Notes :

1. Following sizes of polyethylene cane are most suitable and are used in furniture trade :

	Width	Thickness
For the seat and back	2.00 mm	0.02 mm
For border	3.50 mm	0.03 mm

2. The thickness may be determined by a micro meter in mm.

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2.3. CARRIAGE OF MATERIALS**2.3.0 General**

The carriage and stacking of materials shall be done as directed by the Engineer. Any tools and plants required for the work shall be arranged by the Contractor. The carriage of materials includes loading within a lead of 50 metres, unloading and stacking within a lead of 50 metres.

2.3.1 Responsibility for Loss or Damage

Loading, carriage, unloading and stacking shall be done carefully to avoid loss or damage to the materials. In case of any loss or damage, recovery shall be affected from the contractor at twice the Departmental issue rates of the materials. If the departmental issue rates of the materials are not available, then the recovery shall be affected at twice the prevailing market rates as determined by the Engineer.

2.3.2 Mode of Carriage

Depending upon the feasibility and economy, the Engineer shall determine the mode of carriage viz. whether by mechanical or animal transport or manual labour.

2.3.3 Lead

2.3.3.1 All distances shall be measured over the shortest practical route and not necessarily the route actually taken.

2.3.3.2 Carriage by manual labour shall be reckoned in units of 50 metres.

2.3.4.3.2.3.3 Carriage by animal and mechanical transport shall be reckoned in one km unit. Distances of 0.5km or more shall be taken as 1 km and distance of less than 0.5 km shall be ignored. However, when the total lead is less than 0.5 km., it will not be ignored but paid for separately in successive stages of 50 metres subject to the condition that the rate worked on this basis does not exceed the rate for initial lead of 1 km. by mechanical / animal transport.

2.3.4 Stacking - IS 4082:1996 may be seen for further details.

2.3.4.0 Material shall be stacked in such a manner as to ensure the preservation of their quality and fitness for the work. Different types of materials shall be stacked separately and in such a way that counting and measurements can be done without disturbing the stacks.

2.3.4.1 Earth, dismantled materials, malba and other similar materials shall be stacked as directed by the Engineer.

2.3.4.2 Cement bags, steel bars, structural steel sections, bricks and timber and other similar materials shall be stacked in regular tiers.

2.3.4.3 Pipes of RCC, SW, GI, CI etc. shall be stacked in rows.

2.3.5.5 Lime, stone, metal, sand and such similar materials shall be stacked as directed by the Engineer.

2.3.5 Measurements

Length, breadth and height of stacks shall be measured correct to a cm. The quantity shall be worked out in cubic metre correct to two places of decimal. The volume of stacks, shall be reduced by percentages as shown against each for looseness in stacking to arrive at the net quantity for payment. No reduction shall be made in respect of articles or materials for which mode of payment is by length or weight or number.

2.3.5.1 Earth

i) In loose stacks such as cart loads, lorry loads etc- 20%

ii) In fills consolidated by light mechanical machinery or manually – 10% (Refer Para 1.1.6.11)

iii) In fills consolidated by heavy mechanical machinery at or near OMC – 5% (Refer Para 1.1.6.11)

iv) Consolidated fills in confined situation such as under floors etc. Nil

2.3.5.2 Manure or sludge – 8% (Refer Para 16.2.1.1 & 16.2.4.2)

2.3.5.3 Moorum, building rubbish, Lime – 7.5 %

2.3.5.4 Sand / Sandy Material – 7.5% (Refer Para 1.1.6.11)

2.3.5.5 Stone material, 40mm nominal size and above 10.0%

2.3.5.6 Coarse aggregate / stone metal below 40mm nominal size – 7.5 %

2.3.5.7 Soling Stone / Boulder 100mm and above – 15%

2.3.5.8 Excavated rocks – 30%

2.3.6 Rate : The rate for carriage of materials is inclusive of all the operations described above.

2.4 STORAGE OF MATERIALS

Para 17.9 of Chapter 17 may be referred to.

2.5 FLOOR AND LEVELS**2.5.1 Buildings :**

2.5.1.1 Floor 1 is the lowest floor above the ground level in the building unless otherwise

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specified in a particular case. The floors above floor 1 shall be numbered in sequence as floor 2, floor 3 and so on. The number shall increase upwards.

2.5.1.2 Floor level : For floor 1 top level of finished floor shall be the floor level and for all other floors above floor 1, top level of the structural slabs shall be the floor level.

2.5.1.3 Plinth level : Floor 1 level or 1.2m above the ground level whichever is lower shall be the plinth level.

2.5.1.4 Plinth level - For abutments piers & return walls of culverts and bridges, walls of water reservoirs and basements - Floor level

2.5.1.5 Plinth level - For retaining walls where floor level is not determinate 1.2 metres above average ground level or bed level whichever is lower.

2.5.1.6 Plinth level - For breast walls Formation level

2.5.1.7 Plinth level - For platform walls Formation level of track

2.5.52.5.2 Special Structures

For all other structures like chimneys, over head reservoirs/ tanks and other elevated structures, where elevations/ height above a defined datum level have not been specified and identification of floors cannot be done 1.2m above the ground level shall be the plinth level.

2.6 MEASUREMENTS

2.6.1 In booking dimensions, the order shall be consistent and in the sequence of length, width and height or depth or thickness.

2.6.2 Rounding Off

Rounding off where required shall be done in accordance with IS : 2. The number of significant places rounded in the rounded off value should be as specified.

2.7.2.7 SAFETY IN CONSTRUCTION

2.7.1 The Contractor shall employ only such methods of construction, tools and plant as are appropriate for the type of work or as approved by Engineer in writing.

2.7.2 The Contractor shall take all precautions and measures to ensure safety of works and workman and shall be fully responsible for the same. Safety pertaining to construction works such as excavation, centring and shuttering, trenching, blasting demolition, electric connections, scaffolds, ladders, working platforms gangway, mixing of bituminous materials, electric and gas welding, use of hoisting and construction machinery shall be governed by the relevant

IS Safety Codes and the direction of the Engineer.

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Chapter 3

Plain Concrete

3.1 MATERIALS

3.1.1 General : Water, cement, lime and fine aggregate shall be as specified in **Chapter 26 'Mortar'**. Fine aggregates are divided into four Zones as described in **Table 26.1 of Chapter 26**. Most of the natural sand found in the country has grading corresponding to one or other of these zones. Typical good sand falls in Zone II Grading. However Finer Sand (Zones III and IV) and Coarse sand (Zone I) may be used with suitable adjustments in the ratio of quantities of Fine to Coarse aggregates as indicated in **Table 3.15** for Nominal Mix Concrete. fine sand coming under Zone IV grading should not be used except where the concrete is closely controlled by the use of Design Mix. With nominal mix concrete, it is not advisable to use Zone IV Sand under any circumstances and Zone I sand should be avoided if a lean concrete mix is desired.

3.1.2 Coarse Aggregate

3.1.2.1 General : Aggregate, most of which is retained on 4.75mm IS Sieve and contains only as much fine material as is permitted in IS:383 for various sizes and grading is known as Coarse aggregate. Coarse aggregate shall be stone aggregate, gravel or brick aggregate as described below and it shall be obtained from approved / authorized sources.

On Stone aggregate, Gravel and Brick aggregates the following should be kept note of:

(a) **Stone Aggregate :** It shall consist of naturally occurring (uncrushed, crushed or broken) stones. It shall be hard, strong, dense, durable and clean. It shall be free from veins, adherent coatings, injurious amounts of disintegrated pieces, alkali, vegetable matter and other deleterious substances. It shall be roughly cubical in shape; Flaky and elongated pieces shall be avoided. It shall conform to IS:383 unless otherwise specified. Where required by the Engineer, test shall be done in accordance with IS 2386 (Parts I to VIII) with the cost

fully borne by the Contractor except where otherwise stipulated in the Contract.

(b) **Gravel :** It shall consist of naturally occurring (uncrushed, crushed or broken) river bed shingle or pit gravel. It shall be sound, hard and clean. It shall be free from flat particles of shale or similar laminated material, powdered clay, silt, loam, adherent coatings, alkali, vegetable matter and other deleterious substances. Pit gravel shall be washed if it contains soil materials adhering to it. These shall conform to IS:383 unless otherwise specified. Where required by the Engineer, Tests shall be done in accordance with IS 2386 (Parts I to VIII) with the cost fully borne by the Contractor except where otherwise stipulated in the Contract.

(c) **Brick Aggregate :** Brick aggregate which can be used for Plain Cement/ Lime Concrete shall be obtained by breaking well burnt or over burnt dense bricks / brick bats. They shall be homogeneous in texture, roughly cubical in shape and clean. They shall be free from unburnt clay particles, soluble salt, silt, adherent coating of soil, vegetable matter and other deleterious substances. Such aggregate should not contain more than one percent of sulphates and should not absorb more than 20% of their own mass of water.

(d) Light weight aggregates such as bloated clay aggregate and sintered fly ash aggregate may also be used provided the Engineer is satisfied with the data on the properties of concrete made with them.

3.1.2.2 Marine Aggregates (Concrete Bridge Code – C.S. no.1 dated 26.04.2000)

In general, marine aggregate shall not be used for reinforced concrete and prestressed concrete bridges. However, in special cases, use of marine aggregates may be permitted by the Engineer subject to the following :

The marine aggregates shall be thoroughly washed.

Generally, the limits for chloride content and sulphate content in aggregates after washing will be as under :

	Fine Aggregates	Coarse Aggregates
Chloride content (Cl.) max.	0.04% by wt. acid soluble	0.02% by wt. acid soluble
Sulphates (SO ₃) max.	0.4% by wt. acid soluble	0.4% by wt. Acid soluble

After washing and drying, the aggregates should conform to IS:383. The designer should take into account grading of aggregates after washing.

3.1.2.3 Deleterious Material : Coarse aggregate shall not contain any deleterious material, such as pyrites, coal, lignite, mica, shale or similar laminated material, clay, alkali, soft fragments, sea shells and organic impurities in such quantity as to affect the strength or durability of the concrete. Coarse aggregate to be used for reinforced cement concrete shall not contain any material liable to attack the steel reinforcement.

Aggregates which are chemically reactive with alkalies of cement shall not be used. The maximum quantity of deleterious

material shall not be more than five per cent of the weight of coarse aggregate when determined in accordance with IS:2386 (I).

3.1.2.4. Size and Grading

(i) Stone aggregate and gravel

It shall be either graded or single sized as specified. Nominal size and grading shall be as under :

(a) Nominal sizes of graded stone aggregate or gravel shall be 40, 20, 16, or 12.5 mm as specified. For any one of the nominal sizes, the proportion of other sizes as determined by the method prescribed in Annexure 3.1 shall be in accordance with **Table.3.1.**

TABLE 3.1
GRADED STONE AGGREGATE OR GRAVEL

IS Sieve Designation	Percentage passing (by weight) for nominal size of			
	40 mm	20 mm	16 mm	12.5 mm
80 mm	100	-	-	-
40 mm	95 to 100	100	-	-
20 mm	30 to 70	95 to 100	100	100
16 mm	-	-	90 to 100	--
12.5 mm	-	-	-	90 to 100
10 mm	10 to 35	25 to 55	30 to 70	40 to 85
4.75 mm	0 to 5	0 to 10	0 to 10	0 to 10

(b) Nominal sizes of single sized stone aggregate or gravel shall be 63, 40, 20, 16, 12.5 or 10 mm as specified. For any of the nominal size, the proportion of other sizes

as determined by the method prescribed in **Annexure 3.1** shall be in accordance with **Table.3.2.**

TABLE 3.2
SINGLE SIZED (UNGRADED) STONE AGGREGATE OR GRAVEL

IS Sieve Designation	Percentage passing (by weight) for nominal size of					
	63 mm	40 mm	20 mm	16 mm	2.5 mm	10 mm
80 mm	100	--	--	--	--	--
63 mm	85-100	100	-	-	-	-

40 mm	0-30	85-100	100	-	-	-
20 mm	0-5	0-20	85-100	100	-	-
16 mm	--	-	-	85-100	100	--
12.5 mm	--	-	-	-	85-100	100
10 mm	0-5	0-5	0-20	0-30	0-45	85-100
4.75 mm	--	-	0-5	0-5	0-10	0-20
2.36 mm	--	-	-	-	-	0-5

(c) When stone aggregate or gravel brought to site is single sized (ungraded), it shall be mixed with single size aggregates of different sizes in the proportion to be determined by field tests to obtain graded aggregate of specified nominal size. For the required nominal size, the proportions of other sizes in mixed aggregate as

determined by the method prescribed in **Annexure 3.1** shall be in accordance with **Table 3.1** Recommended proportions by volume for mixing of different sizes of single size aggregate to obtain the required nominal size of graded aggregate are given in **Table 3.3**.

TABLE 3.3
MIXING SINGLE SIZED (UNGRADED) STONE AGGREGATE OR GRAVEL TO PRODUCE GRADED AGGREGATE (BY VOLUME)

Cement concrete	Nominal size of graded aggregate required	Parts of single size aggregate of size to be mixed to get graded aggregate (By volume)				
		50 mm	40 mm	20mm	12.5 mm	10mm
1:6:12	63	9	-	3	-	-
1:6:12	40	-	9	3	-	-
1:5:10	63	7 ½	-	2 ½	-	-
1:5:10	40	-	7 ½	2 ½	-	-
1:4:8	63	6	-	2	-	-
1:4:8	40	-	6	2	-	-
1:3:6	63	4 ½	-	1 ½	-	-
1:3:6	40	-	4 ½	1 ½	-	-
1:3:6	20	-	-	4 ½	-	1 ½
1:2:4	40	-	2 ½	1	-	½
1:2:4	20	-	-	3	-	1
1:2:4	12.5	-	-	-	3	1
1:1½:3	20	-	-	2	-	1

Note :

(i) The proportions indicated in **Table 3.3** above are by volume. When considered necessary, these proportions may be varied marginally by the Engineer after making sieve analysis of aggregates brought to site

for obtaining required graded aggregate. No adjustments in rate for item of cement concrete shall be made for any variation in the proportions so ordered by the Engineer. If single size coarse aggregates are not premixed at site, to obtain the graded coarse

aggregate required for the mix, the volume of single size aggregates required to be arranged from the source of supply for making the mix shall be suitably increased to account for reduction in total volume at the site of mixing.

(ii) **Brick Aggregate** : Nominal size of brick aggregate shall be 40 mm and its grading shall be as specified in **Table 3.4** when tested for sieve analysis by the method prescribed in **Annexure 3.1**.

TABLE 3.4
BRICK AGGREGATE

IS Sieve designation	Percentage passing (by weight)
80 mm	100
37.5 mm	95-100
20.0 mm	45-100
4.75 mm	0-5

3.1.2.5 Size of Coarse aggregate

a) The nominal maximum size of coarse aggregate should be as large as possible within limits specified but in no case greater than one fourth of the minimum thickness of the members, provided that the concrete can be placed without difficulty to fill all corners of the form and to surround all reinforcement. For reinforced concrete work and pre-stressed concrete work, aggregates having a nominal size of 20mm are generally considered satisfactory. In special cases larger size may be specifically permitted by the Engineer but in no case the nominal maximum size in such RC/ PSC structures shall be more than 40mm.

Plums above 160mm and upto any reasonable size may be used in plain concrete work upto a maximum limit of 20 percent by volume of concrete when specifically permitted by the Engineer. The plums shall be distributed evenly and shall not be closer than 160mm from the surface. Necessary payment for providing plums and deduction in the rate of CC will however be done accordingly in individual cases.

b) For heavily reinforced concrete members, as in the case of ribs of main beams, the nominal maximum size of aggregate should usually be restricted to 5mm less than the minimum clear distance

between the main bars or 5mm less than the minimum cover to reinforcement whichever is smaller.

Where reinforcement is widely spaced as in solid slabs, limitations on the size of the aggregate may not be so important and the nominal maximum size may sometimes be as great or even greater than the minimum cover.

c) Coarse and fine aggregates shall preferably be batched separately, specially for design mix concrete.

d) The largest possible size, properly graded, should be used in order to reduce the water demand. For high compressive strengths of concrete, this is usually economical.

3.1.2.6 All-in-Aggregate grading

In cases where specifically provided for in the contract, if supply is taken for premixed aggregate consisting of a mix of coarse and fine aggregates, also called All-in-Aggregate they should conform to requirements in **Table 3.5**. If such combined Aggregate supply is taken, there is no need to separate them into Fine and Coarse aggregates, but necessary adjustment may be made in grading by addition of single size aggregate as found necessary.

TABLE 3.5
ALL IN AGGREGATE GRADING

IS Sieve designation	Percentage passing for All-in-Aggregate of	
	40mm nominal size	20mm nominal size
80mm	100	--
40mm	95-100	95-100
20mm	45-75	95-100

4.75mm	25-45	30-50
600 micron	8-30	10-35
150 micron	0-6	0-6

3.1.2.7. Stacking: Aggregates shall be stacked on a hard, dry and level patch of ground. When stockpiling, the aggregate shall not form pyramids resulting in segregation of different sized materials. It shall be stacked separately according to nominal size of coarse aggregates. Stacking shall be done in regular stacks of height not exceeding 100 cm. Coarse aggregates supplied in different sizes and stacked in separate stockpiles shall be mixed only after the quantity required for each size has been separately measured.

3.1.2.8. Testing: Coarse aggregate shall be tested for the following (as per IS: 2386):

- Determination of particle size and shape (**Annexure 3.1**). The aggregate failing in the test should be got removed from the site.
- Estimation of organic impurities (As per IS: 2386 Part II):
- Surface moisture (**Annexure 3.2**)
- Determination of 10% fine value (**Annexure 3.3**)

3.1.3. Chemical Admixtures

3.1.3.1 General:- When required, admixtures of approved quality shall be mixed with concrete, as specified. The admixtures shall conform to IS : 9103.

3.1.3.2. Admixtures may be any one of the following classes for use in concrete:-

- Water reducing Admixtures
- Retarding Admixtures
- Accelerating Admixtures
- Water reducing and retarding Admixtures
- Water reducing and accelerating Admixtures
- Permeability reducing (water proofing) Admixtures

3.1.3.3. Liquid admixtures : Admixtures introduced into the concrete as liquids generally fall into the following categories.

- Air entraining
- Water reducing
- Water reducing retarders
- Retarders
- Water reducing accelerators
- Accelerators

3.1.3.4. Dosage of these admixtures may vary according to manufacturer's specification.

3.1.3.5. Two or more admixtures may not be compatible in the same solution. It is therefore mandatory that when two admixtures manufactured by the same manufacturer are to be used simultaneously, the manufacturer shall certify their compatibility. In case the two or more admixtures are produced by different manufacturers, then, before their use in concrete, test shall be got performed by the manufacturers to establish their compatibility and all such test reports shall be furnished by the Contractor to the Engineer for his approval before their use in concrete.

3.1.3.6 Some admixtures may be in the form of powder particle or high concentration liquids which may require mixing with water prior to dosing. Under these conditions water in solution shall be considered as part of total water content in the batch in order to maintain the stipulated water – cement ratio.

3.1.3.7 Manufacturer's recommendation shall be carefully followed so as to ensure complete solution of the product or to prepare a standard solution of uniform strength for easier use.

3.1.3.8 Certain admixtures may contain significant amounts of finely divided insoluble materials or active ingredients which may or may not be readily soluble. It is essential for such admixtures that precautions be taken to ensure that these constituents be kept in a state of uniform suspension before actual batching. When relatively small amounts of powdered admixtures are to be used directly, these shall be pre-blended with cement.

3.1.3.9 Admixtures are sold under various trade names and may be in the form of liquids or powders. The proprietary name and the net quantity of content shall be clearly indicated in each package or container of admixtures. The admixtures shall be uniform within each batch and uniform between all batches.

3.1.3.10 No admixtures shall be accepted for use in concrete unless these are tested in accordance with IS: 9103 and the test results are approved by the Engineer.

3.1.3.11 Functions of Admixtures

a) Accelerating admixtures

These are added to hasten the rate of early strength development, which would facilitate early removal of form work; or reduce the required period of curing or concreting in cold weather or in emergency repairs.

Common accelerators are calcium chloride, fluoro-silicates and triethanolamine; but chloride content in concrete shall be carefully checked before permitting its use.

b) Retarding admixtures

These admixtures tend to slow down the rate of setting of cement. They are useful in hot weather concreting; for avoiding cold joints in mass concrete works and for special treatment of concrete surfaces. Common retarders are starches, cellulose products, sugars and hydroxyl - carboxylic acids and their salts.

c) Water reducing or plasticizing admixtures

These admixtures allow greater workability to be achieved for a given water cement ratio; or for the same workability reduces water content. When used in sufficient quantities, these admixtures function as set-retarders.

The basic ingredients of water reducing admixture are either ligno-sulphonate or poly hydroxy compounds.

d) Air entraining admixtures

These are used to intentionally entrain a controlled quantity of air in the concrete, without altering the setting or hardening of concrete significantly. Their use improves durability, water tightness and workability.

Commonly used air-entraining agents are animal and vegetable oils and fats; natural wood resins and their sodium salts; and alkali salts of sulphated and sulphonated organic compounds.

3.1.3.12 Special Precautions in use of Admixtures

Previous experience with and data on such materials should be considered in relation to the likely standards of supervision and workmanship to the work being specified.

Admixtures should not impair durability of concrete nor combine with the cement to form harmful compounds nor increase the risk of corrosion of reinforcement.

The workability, compressive strength and the slump loss of concrete with and without the use of admixtures shall be established during the trial mixes before use of admixtures.

The relative density of liquid admixtures shall be checked for each drum containing admixtures and compared with the specified value before acceptance.

The chloride content of admixtures shall be independently tested for each batch before acceptance.

If two or more admixtures are used simultaneously in the same concrete mix, data should be obtained to assess their interaction and to ensure their compatibility.

3.1.3.13 As stipulated in Paras 4.4.2 and 4.4.3 of Indian Railways Concrete Bridge Code (Revised 1997), the following should be strictly adhered to

i) Calcium chloride or admixtures containing calcium chloride shall not be used in structural concrete containing reinforcement, pre-stressing tendon or other embedded metal.

ii) The admixture containing Cl & SO₃ ions shall not be used. Admixtures containing nitrates shall also not be used. Admixtures based on Thiocyanate may promote corrosion and therefore shall be prohibited.

3.2 CEMENT CONCRETE**3.2.1 Designation of Concrete :**

3.2.1.1 Designation by Grade : IS 456, Code of Practice for Plain and Reinforced Concrete, designates concrete only by Grade e.g. M15, M20 etc – the number denoting its 28 day characteristic compressive strength in N/mm².

3.2.1.2 Designation by Volume Proportion (Ordinary Concrete) :

Traditionally concrete was being designated by volumetric proportion of its constituents e.g. 1:1½:3, 1:2:4, 1:3:6 etc. Such concrete is generally referred to as ordinary concrete. IS 456, since its 1978 version, has stopped designating concrete by such volumetric proportion as it is not considered correct engineering practice. However in most government departments, including railways, in CPWD, particularly on old standard and type drawings and schedule of rates, concrete by volumetric proportion is still specified and therefore is used. Although use of such concrete is not a recommended practice and should be discouraged, in this Specification it has been included and has been referred to as Ordinary Concrete. It is to be noted that Ordinary Concrete is not Volumetric Mix of Grade Concrete permitted in special circumstances described in Para 3.2.6.4 below.

3.2.2 Classification of Concrete :

3.2.2.1 Grades of Concrete : The concrete shall be in grades designated as given in **Table 3.6**.

TABLE 3.6
GRADES OF CONCRETE

(Based on IS 456-2000; Table-2 of Concrete Bridge Code 1997 CS No.8 dated 15.02.06)

Group	Grade Designation	Specified Characteristic* Compressive Strength of 150 mm Cube at 28 Days in N/mm ²
Ordinary Concrete	M10	10
	M15	15
	M20	20
Standard Concrete	M25	25
	M30	30
	M35	35
	M40	40
	M45	45
	M50	50
	M55	55
High Strength Concrete	M60	60
	M65	65
	M70	70
	M75	75
	M80	80

* The characteristic strength is defined as the strength of material below which not more than 5 per cent of the test results are expected to fall

Notes :

1. In the designation of concrete mix M refers to the mix and the number to the specified compressive strength of 150 mm size cube at 28 days, expressed in N/mm²
2. For concrete of compressive strength greater than M55, mix designs may be obtained from specialized literatures and experimental results.

3. Concrete of grade lower than M-10 may be used for Plain Concrete Constructions, lean concrete, simple foundations, foundations for masonry walls and other simple or temporary reinforced concrete constructions.

3.2.2.2 Mix of Ordinary Concrete :

Ordinary concrete is classified according to the mix proportion by volume of its ingredients viz. cement: fine aggregate: coarse aggregate. The Ordinary Concrete of different mixes to be used for different types of structures are given in **Table 3.7** below for guidance. The list is only indicative.

TABLE 3.7
MIXES OF ORDINARY CONCRETE
DIFFERENT MIXES OF ORDINARY CONCRETE AND THEIR APPLICATION

SL	Type of works	Mix of Ordinary Concrete	Maximum size of coarse aggregate	Water in Litres per Bag of cement	Consistency
1	Concrete deposited under water, RCC water retaining structures, well	1:1 ½ :3	12mm to 20mm	30	Medium

	kerbs, platforms, important RC structures, piles, arches etc.				
2	Beams, slabs, columns, retaining walls, roads, pavements, drive ways, bunkers, foundation of bridges, bed blocks, drain linings etc.	1:2:4	12mm to 40mm	32 to 36	Stiff to medium
3	Mass concrete work for retaining walls, compound walls, part of flooring of water tanks resting on ground, machine bases, foundation of bridges etc.	1:3:6	12mm to 40mm	37 to 40	Stiff to medium
4	Foundations under column footings, wall foundations, mass concrete for heavy wall, Plain Concrete, Hearting of abutments & pipes, retaining walls with stone facing in hilly area etc	1:4:8	20mm to 40mm	45	Medium
5	Foundations of ordinary buildings encasing pipes etc / of light structures	1:5:10	20mm to 40mm	60	Medium

The anticipated compressive strength of different mixes of Ordinary Concrete is as under :

Concrete Mix	Compressive Strength (kg/cm ²)	
	7 days	28 days
1: 1 ½ : 3	175	265
1:2:4	140	210

3.2.3 Durability of Concrete

3.2.3.1 General

A durable concrete is one that performs satisfactorily in the working environment during its anticipated exposure conditions during service. The materials and mix proportions shall be such as to maintain its integrity and, if applicable, to protect reinforcement from corrosion.

The factors influencing durability include :

- the environment;
- the cover to embedded steel;
- the type and quality of constituent materials;
- the cement content and water/cement ratio of the concrete;
- workmanship, to obtain full compaction and efficient curing; and
- the shape and size of the member.

3.2.3.2 Requirements for Durability

3.2.3.2.1 General environment The durability of concrete depends on its resistance to deterioration and the environment in which it is placed. The resistance of concrete to weathering, chemical attack, abrasion, frost and fire depends largely upon its quality and constituents materials. Susceptibility to corrosion of the steel is governed by the cover provided and the permeability of concrete. The cube crushing strength alone is not a reliable guide to the quality and durability of concrete; it must also have an adequate cement content and water-cement ratio. The general environment to which the concrete will be exposed during its working life is classified in five levels of severity that is mild, moderate, severe, very severe and extreme, as described below in **Table 3.8**.

TABLE 3.8
ENVIRONMENTAL EXPOSURE CONDITIONS

(Based on Table 3 of IS 456:2000 and Table in Para 5.4.1 of Concrete Bridge Code, 1997
C.S.No.1 dated 26.04.2000)

SL	Environment	Exposure Conditions
i)	Mild	Concrete surfaces protected against weather or aggressive conditions, except those situated in coastal area.
ii)	Moderate	Concrete surface sheltered from severe rain or freezing whilst wet; Concrete exposed to condensation and rain; Concrete continuously underwater. Concrete in contact or buried under non-aggressive soil/ ground water. Concrete surfaces sheltered from saturated salt air in coastal area.
iii)	Severe	Concrete surfaces exposed to severe rain, alternate wetting and drying or occasional freezing whilst wet or severe condensation; Concrete completely immersed in sea water; Concrete exposed to coastal environment.
iv)	Very severe	Concrete surfaces exposed to sea water spray, corrosive fumes or severe freezing conditions whilst wet. Concrete in contact with or buried under aggressive sub-soil/ ground water.
v)	Extreme	Concrete surface exposed to abrasive action/ Surface of members in tidal zone. Members in direct contact with liquid / solid aggressive chemicals.

Note : For the purpose of determining exposure conditions, all places within a distance of 10 km of coastal line, sea front would be treated as coastal area.

3.2.3.2.2 Freezing and Thawing: Where freezing and thawing actions under wet conditions exist, enhanced durability can be

obtained by the use of suitable air entraining admixtures. When concrete lower than grade M50 is used under these conditions, the mean total air content by volume of the fresh concrete at the time of delivery into the construction site should be as under.

Nominal Maximum Size Aggregate (mm)	Entrained Air Percentage
20	5 ± 1
40	4 ± 1

3.2.3.2.3 Exposure to sulphate attack : For the very high sulphate concentration in Class 5 conditions given in **Table 3.9** below; some form of lining such as polychloroprene

sheet; or surface coating based on asphalt, chlorinated rubber, epoxy, or polyurethane materials should also be used to prevent access by the sulphate solution.

TABLE 3.9
REQUIREMENTS FOR CONCRETE EXPOSED TO SULPHATE ATTACK
 (Based on IS 456-2000 Table 4)

SL	Class	Concentration of Sulphates Expressed as SO ₃ Concrete in Soil			Type of Cement	Dense, fully compacted made with 20 mm Nominal Maximum Size Aggregates Complying with IS: 383	
		In soil		In Ground Water		Minimum Cement Content kg/m ³	Maximum Free Water Cement Ratio
		Total SO ₃ Percent	SO ₃ in 2:1 Water: Soil Extract gms/ litre				
(i)	1	Traces (<0.2)	Less than 1-0	Less than 0.3	Ordinary Portland cement or Portland slag cement or Portland Pozzolana cement	280	0.55
(ii)	2	0,2 to 0,5	1.0 to 1.9	0.3 to 1.2	Ordinary Portland cement or Portland slag cement or Portland Pozzolana cement	330	0.50
					Super sulphated cement or sulphate resisting Portland cement	310	0.50
(iii)	3	0.5 to 1.0	1.9 to 3.1	1.2 to 2.5	Super sulphated cement or sulphate resisting Portland cement	330	0.50
					Portland Pozzolana cement or Portland slag cement	350	0.45
(iv)	4	1.0 to 2.0	3.1 to 5.0	2.5 to 5.0	Super sulphated cement or sulphate resisting Portland cement	370	0.45
(v)	5	More than 2.0	More than 5.0	More than 5.0	Sulphate resisting cement or Super sulphated cement with protective coatings.	400	0.40

Notes :

1. Cement content given in this table is irrespective of grades of cement.
2. Use of super sulphated cement is generally restricted where the prevailing temperature is above 40°C.
3. Super sulphated cement gives an acceptable life provided that the concrete is dense and prepared with a water-cement ratio of 0.4 or less, in mineral acids, down to pH 3.5.
4. The cement contents as given in col.7 of this table are the minimum recommended. For SO₃ contents near the upper limit of any

class, cement contents above these minimum are advised.

5. For severe conditions, such as thin sections under hydrostatic pressure on one side only and sections partly immersed, considerations should be given to a further reduction of water-cement ratio.
6. Portland slag cement conforming to IS : 455 with slag cement more than 50 percent exhibits better sulphate resisting properties.
7. Where chloride is encountered with sulphate in soil or ground water, ordinary Portland cement with C₃A content from 5 to 8 percent shall be desirable to be used in concrete, instead of sulphate resisting

cement. Alternatively, Portland slag cement conforming to IS:455 having more than 50 percent slag or a blend of ordinary Portland cement and slag may be used provided sufficient information is available on

performance of such blended cements in these conditions.

3.2.3.2.4 Chlorides in Concrete : The total amount of chlorides content (as C1) in the concrete at the time of placing shall be as given in **Table 3.10** below.

TABLE 3.10
MAX. CHLORIDE CONTENT VIS-À-VIS TYPE OF USE
(BASED ON IS 456-2000 TABLE 7)

SL	Type of Use of Concrete	Maximum Total Acid Soluble – Chloride Content Expressed as kg/m ³ of Concrete
(1)	(2)	(3)
(i)	Concrete containing metal and steam cured at elevated temperature and pre-stressed concrete.	0.4
(ii)	Reinforced concrete or plain concrete containing embedded metal.	0.6
(iii)	Concrete not containing embedded metal or any material requiring protection from chloride.	3.0

3.2.3.2.5 Sulphates in Concrete : The total water-soluble sulphate content of the concrete mix, expressed as SO₃, should not exceed 4 percent by mass of the cement in the mix. The sulphate content should be calculated as the total from the various constituents of the mix.

The 4 percent limit does not apply to concrete made with super-sulphated cement complying with IS: 6909.

3.2.3.2.6 Minimum Grade of Concrete

From durability consideration, depending upon the environment to which the structure is likely to be exposed during its service life, minimum grade of concrete shall be as given as per Table 5 of IS-456-2000. However in case of bridges, it shall be as per **Table 4 (b) of IRS Concrete Bridge Code 1997**.

3.2.3.2.7 Maximum Water Cement Ratio for different Environmental Conditions

One of the main characteristics influencing the durability of any concrete is its permeability. With strong, dense aggregates, a suitably low permeability is achieved by having a sufficiently low water-cement ratio, by ensuring as thorough compaction of the concrete as possible and by ensuring sufficient hydration of cement through proper curing methods. Therefore, for given aggregates, the cement content should be sufficient to provide adequate workability with a low water-cement ratio so that concrete can be completely compacted by vibration.

The limits for maximum water cement ratio for design mix shall be based on environmental conditions as defined in **Para 3.2.3.2.1**. The limits for maximum water-cement ratio for different environmental conditions shall be as given in **Table No.3.12** below.

Table 3.12 MAXIMUM WATER CEMENT RATIO
(Based on Table 4(a) C.Slip No.8 dated 15.02.2006 of Concrete Bridge Code 1997)

Environment	Plain Concrete (PCC)	Reinforced Concrete (RCC)	Pre-stressed Concrete (PSC)
Mild	0.55	0.50	0.45
Moderate	0.50	0.50	0.40
Severe	0.50	0.45	0.40

Very Severe	0.50	0.45	0.35
Extreme	0.45	0.40	0.35

3.2.3.2.8 Cementitious Material Content:- (Refer Correction Slip No.8 dated 15.02.2006 to Concrete Bridge Code, 1997) Depending upon the environment to which the structure is likely to be exposed during its service life, minimum cementitious material content in concrete shall be as given in

Table 3.13. Maximum cementitious material content shall be limited to 500 kg/ m³. Cementitious material means cement or cement mixed with mineral admixtures like Pozzolanic Fly Ash (PFA) / Grounded granulated Blast furnace slag (GGBFS), Microsilica, etc.

Table 3.13 MINIMUM CEMENTITIOUS MATERIAL CONTENT
(Based on Table 4(c) C. Slip No.8 dated 15.02.2006 of Concrete Bridge Code 1997)

Environment	Minimum cementitious material content in Kg/m ³		
	Plain Concrete (PCC)	Reinforced Concrete (RCC)	Pre-stressed Concrete (PSC)
Mild	210	300	350
Moderate	250	300	400
Severe	250	350	430
Very Severe	300	400	440
Extreme	300	400	440

Note : For underwater Concrete 10% extra Cement should be added over and above the normal cement content of the Concrete mix specified above.

3.2.4 Workability of Concrete

3.2.4.1 The concrete mix proportion chosen should be such that the concrete is of adequate workability for the placing conditions of the concrete and can properly be compacted with the means available. Suggested ranges of workability of concrete measured in accordance with IS : 1199 are given in **Table 3.14A**. Slump is to be measured by Slump Test (See **Annexure 3.4**). Where required suitable type of plasticiser/ Admixture may be used to achieve the desired workability. Degree of workability and slump are for concreting with vibration. Where concreting is done without vibration, higher degree of workability / greater slump will be required. For concreting with aggregate of smaller size

than 20mm, the workability / slump will be lower whether it is Design Mix Concrete, Nominal Mix Concrete or Ordinary Concrete. The Designer should clearly indicate the Water Cement ratio and slump for the mix based on strength and workability criteria. The field Engineer can then do field check to see if the workability is satisfactory with the water cement ratio stipulated, taking into account the site conditions. Even if there is any difficulty in workability, the water cement ratio should be maintained and the workability improved by use of Plasticiser / admixture with the approval of the Engineer or alternatively by adding more water with corresponding extra quantity of cement. At the time of making the mix at site, the total quantity of free water to be added to the mix based on Water Cement ratio should be reduced to the extent of surface water in the wet aggregates. This aspect has been dealt with in detail in subsequent para 3.2.6.7.

TABLE 3.14A
WORKABILITY VIS-À-VIS PLACING CONDITIONS
 (Based on IS 456-2000; Para 7.1)

Placing Conditions	Degree of Workability	Slump (mm)
Blinding concrete; Shallow sections; Pavements using pavers	Very low	See Note 2
Mass concrete; Lightly reinforced sections in slabs, beams, walls, columns, Floors, Hand placed pavements; Canal lining; Strip footings	Low	25-75
Heavily reinforced sections in slabs, beams, walls, columns	Medium	50-100
Slip form work; Pumped concrete	Medium	75-100
Trench fill; In-Situ piling	High	100-150
Tremie concrete	Very high	See Note 3

Note : 1) For most of the placing conditions, internal vibrators (needle vibrators) are suitable. The diameter of the needle shall be determined based on the density and spacing of reinforcement bars and thickness of sections. For tremie concrete, vibrators are not required to be used (see also Para 3.2.11.5)

2) In the 'very low' category of workability where strict control is necessary, for example, pavement quality concrete, measurement of workability by determination of compacting factor will be more appropriate

than slump (see IS : 1199) and a value of compacting factor of 0.75 to 0.80 is suggested.

3) In the 'very high' category of workability, measurement of workability by determination of flow will be appropriate (see IS : 9103).

3.2.4.2 Para 5.3.1 of Concrete Bridge Code 1997 has laid down the following on workability as given in **Table 3.14B**.

TABLE 3.14B
WORKABILITY VIS-À-VIS PLACING CONDITIONS
 (Based on Para 5.3.1 of Concrete Bridge Code 1997)

Placing conditions	Degree of workability	Values of workability
(1)	(2)	(3)
Concreting of shallow sections with vibration	Very low	20-10 seconds vee-bee time or 0.75-0.80 compacting factor
Concreting of lightly reinforced sections with vibration	Low	10-5 seconds vee-bee time or 0.80-0.85 Compacting factor
Placing conditions	Degree of workability	Values of workability
Concreting of lightly reinforced sections without vibration or heavily reinforced section with vibration	Medium	5-2 seconds vee-bee time or 0.85-0.92 compacting factor or 25-75 mm slump for 20mm aggregate (see Note 1)
Concreting of heavily reinforced sections without vibration	High	Above 0.92 compacting factor or 75-125mm slump for 20mm aggregate. (See Note 1)

Note : 1) For smaller aggregates the slump values will be lower.

2) Suitable plasticizer/ admixture may be used to achieve workability of the order of 160/200mm. Plasticizer/admixture should

conform to Clause 4.4 of Concrete Bridge Code, extracts given in Para 3.1.3.13 above.

3.2.5 Concrete Mix Proportioning :

3.2.5.1 Mix Proportion

The mix proportion shall be selected to ensure the workability of the fresh concrete and when concrete is hardened, it shall have the required strength, durability and surface finish.

Information required:- In specifying a particular grade of concrete, the following information shall be included:-

- i) Type of mix i.e. design mix concrete or nominal mix concrete;
- ii) Grade designation;
- iii) Type of cement;
- iv) Maximum nominal size of aggregate;
- v) Minimum cement content (for design mix concrete);
- vi) Maximum water cement ratio;
- vii) Workability;
- viii) Mix proportion (for nominal mix concrete);
- ix) Exposure conditions;
- x) Maximum Temperature of concrete at the time of placing;
- xi) Method of placing;
- xii) Degree of supervision;
- xiii) Type of aggregate;
- xiv) Maximum cement content; and
- xv) Whether an admixture shall or shall not be used and the type of admixture and the conditions of use; and

3.2.5.2. Proportioning for Grade Concrete:

The determination of the proportion of cement, aggregate and water to attain the required strengths shall be made as follows:-

- (a) Design Mix: By designing the concrete mix; such concrete shall be called "Design mix concrete".
- (b) Nominal Mix: By adopting nominal concrete mix such concrete shall be called 'Nominal mix concrete'.

Design mix concrete is preferred to nominal mix. If design mix concrete cannot be used on a work for any reason such as non availability of a competent Engineer who can do the design, small quantity of Concrete involved in the work etc., for grades of M20 or lower, nominal mixes, as indicated in **Para 3.2.5.5** below, may be used with the permission of the Engineer.

It should be noted that in Nominal Mix Concrete the proportion of ingredients is by weight and not by volume.

3.2.5.3 Proportioning for Ordinary Concrete:

Since 1978 IS 456 does not include volumetric mix method of mix proportioning and therefore its use is to be discouraged. In exceptional circumstances, when even nominal mix Grade concrete can not be used, volumetric mix may be used for concrete of grade M20 and below with the permission of the Engineer. The volumetric mixes equivalent to various grades is indicated in **Para 3.2.5.6** below.

Similarly in some of the existing Type drawings etc, ordinary Concrete with the volumetric proportions like 1:2:4, 1:3:6 etc are specified and the same shall be used for mix proportioning.

3.2.5.4 Design Mix Concrete: (Grade Concrete)

(a) **General** :-This is the recommended method for all concrete designated by Grade. Design Mix is mandatory for grades higher than M20. For concrete of compressive strength greater than M55 specialised literature should be consulted.

(b) Mix design and proportioning:

Recommended Guidelines for Concrete Mix Design are given in IS 10262 which may be referred to for details. As mentioned therein in order that not more than the specified proportion of test results are likely to fall below the characteristic strength, the concrete mix has to be designed for a somewhat higher target average compressive strength. In terms of Clause 9.2.2 of IS 456 the Target Mean Strength of Concrete mix should be equal to the characteristic strength plus 1.65 times the Standard Deviation. Mix proportions shall be designed to ensure that the workability of fresh concrete is suitable for conditions of handling and placing, so that after compaction it surrounds all reinforcements and completely fills the form work. When concrete is hardened, it shall have the stipulated strength, durability and impermeability.

Determination of the proportions by weight of cement, aggregate and water shall be based on design of the mix.

As a trial the manufacturer of concrete may prepare a preliminary mix according to provisions of SP:23-1982. (Special Publication 23-1982 of Bureau of Indian Standards).

Mix design shall be tried and the mix proportions checked on the basis of tests conducted at a recognized laboratory approved by the Engineer.

All concrete proportions for various grades of concrete shall be designed separately and the mix proportions established keeping in view the workability for various structural elements, methods of placing and compacting.

(c) Standard Deviation

Standard deviation calculations of test results based on tests conducted on the same mix design for a particular grade destination shall be done in accordance with Clause 9.2.4 of IS 456. Table 8 of IS 456 gives the standard deviation that can be assumed for design of mix in the first instance. The final standard deviation figures may be determined based on test results for the particular grade of concrete when available.

(d) Approval of Design Mix

The producer/manufacturer/contractor of concrete shall submit details of each trial mix

of each grade of concrete designed for various workability conditions to the Engineer for his comments and approval. Concrete or any particular design mix and grade shall be produced/manufactured for works only on obtaining written approval of the Engineer.

For any change in quality/quantity in the ingredients of a particular concrete, for which mix has been designed earlier and approved by the Engineer the mix has to be redesigned and approval obtained again.

3.2.5.5 Nominal Mix Concrete : (Grade Concrete)

(a) With the approval of the Engineer, Nominal Mix Concrete (proportions by mass/weight) may be used for concrete of Grade M15 or lower. The proportions of materials for nominal mix concrete shall be in accordance with **Table.3.15** below.

TABLE 3.15
(a) PROPORTIONS FOR NOMINAL MIX CONCRETE M5 TO M 15
(On other than Bridge works Based on IS 456-2000: Table 9)

Grade of Concrete	Total Quantity of Dry Aggregates by Mass per 50 Kg of Cement, to be taken as the Sum of the Individual Masses of Fine and Coarse Aggregates, Kg. Max.	Proportion of Fine Aggregate to Coarse Aggregate (by Mass)	Quantity of Water per 50 kg. Of Cement, Max.
M5	800	Generally 1:2 but subject to an upper limit of 1:1 ½ and a lower limit of 1:2 ½.	60
M 7.5	625		45
M 10	480		34
M 15	330		32

Note :

1) The proportion of the fine to coarse aggregates should be adjusted from upper limit to lower limit progressively as the grading of fine aggregates becomes finer and the maximum size of coarse aggregate becomes larger. Graded coarse aggregate shall be used. Example : For an average grading of fine aggregate falling under Zone II of Table 4 of IS : 383-The proportions shall be 1:1 ½ , 1 : 2 and 1 : 2 ½ for maximum size of aggregates in the ascending order 10 mm, 20 mm and 40 mm respectively.

2) The proportion of Fine to Coarse Aggregate should be fixed keeping in mind the above guidelines and Cubes of mix cast and tested at 28 days to confirm that the minimum characteristic strength stipulated has been attained with Cement, fine aggregate, Coarse aggregate and water (all

by weight) on the proportions given in **Table 3.15**

3) The cement content of the mix specified above shall be proportionately increased if the quantity of water in a mix has to be increased to overcome the difficulties of placement and compaction, so that the water-cement ratio as specified is not exceeded.

4) In case of vibrated concrete the limit specified for water may be suitably reduced to avoid segregation.

5) The quantity of water used in the concrete mix for reinforced concrete work should be sufficient, but not more than sufficient to produce a dense concrete of adequate workability for its purpose, which will surround and properly grip all the reinforcement. Workability of the concrete should be controlled by maintaining a water content that is found to give a concrete,

which is just sufficiently wet to be placed and compacted without difficulty by means available.

6) If nominal mix concrete made in accordance with the proportions given for a particular grade does not yield the specified strength, such concrete shall be specified as belonging to the appropriate lower grade. Nominal mix concrete proportioned for a given grade in accordance with Table 3.15 above shall not however be classified in higher grade on the ground that the test strengths are higher than the minimum specified.

7) It is recommended that fine aggregate conforming to grading Zone IV should not be used in reinforced concrete unless tests have been made to ascertain the suitability of proposed mixed proportions.

3.2.5.6 Ordinary Mix Concrete:

a) (i) For concrete of Grades M 20 and lower when volumetric mix is used the following volumetric mixes can be assumed to correspond to the Grade of concrete shown against them. These figures were included in IS 456-1964 for general guidance on approximate correspondence between Grade concrete and Ordinary Concrete. In subsequent revisions of IS 456 these equalising mix proportions have not been included.

M-10	--	1:3:6
With 40mm Coarse Aggregate		
M-15	--	1:2:4
M-20	--	1:1 ½:3

Though not mentioned in any earlier IS, based on field experience M-5 can be taken as equivalent to 1:5:10/ 1:6:12 and M-7.5 equivalent to 1:4:8. Volumetric mix will also become applicable in cases of works to be carried out as per older type plans of buildings etc wherein concrete mix has been shown as 1:3:6, 1:2:4, 1: 1 ½ :3 etc.

These volumetric proportions are to be taken with the aggregates in a surface dry condition. Accordingly allowance should be made for the bulking in volume of fine aggregate to be used in the mix. Also the quantity of free water to be added to the mix should take into account the surface moisture already present in the wet aggregates. Similarly the water required for bone dry aggregates to become surface dry should also be kept in mind. Detailed explanation on this issue has been given in subsequent **Para 3.2.6.7**.

b) **Proportioning** : All ingredients shall be measured separately and accurately in

properly constructed gauge boxes on a clean platform. If the sand is moist necessary allowance shall be made for bulking. The contents of the gauge boxes shall not be consolidated by ramming but it will be desirable to shake them lightly in order to remove the excessive looseness.

Notes :

- 1) All aggregates to be used should be graded aggregates.
- 2) Sand should be coarse sand only. Stone dust should not be used for any RCC work or important mass concrete.
- 3) Fine sand can be used only for 1:3:6 concrete with 40mm coarse aggregate and other leaner mixes.
- 4) Cement shall be measured by weight only. A standard bag of Cement can be partaken as weighing 50 kg. or 0.50 quintal equivalent volume of 0.035 cum.

3.2.6 Batching

3.2.6.1 (a) To avoid confusion and error in batching, consideration should be given to using the smallest practical number of different concrete mixes on any site or in any one plant. In batching concrete, the quantity of both cement and aggregate shall be determined by mass except where volumetric batching is permitted by the Engineer; admixture, if solid, by mass; liquid admixture may however be measured in volume or mass as recommended by manufacturer; water shall be weighed or measured by volume in a calibrated tank (see also IS : 4925). Batching plant, if used, should conform to IS:4925.

(b) Ready-mixed concrete supplied by ready-mixed concrete plant shall be preferred. For large and medium project sites the concrete shall be sourced from ready-mixed concrete plants or from on site or off site batching and mixing plants. (see IS : 4926). **Annexure 3.5** may be seen for details.

3.2.6.2 Except where it can be shown to the satisfaction of the Engineer that supply of properly graded aggregate of uniform quality can be maintained over a period of work, the grading of aggregate should be controlled by obtaining the coarse aggregates in different sizes (single size upgraded) and blending them in the right proportions when required, the different sizes being stocked in separate stock – piles. The materials should be stock-piled for several hours preferably a day before use. The grading of coarse and fine aggregate should be checked as frequently as possible, the frequency for a given job

being determined by the Engineer to ensure that the specified grading is maintained. The grading of coarse aggregates shall be as per IS 383 (see **Table 3.1**). The combined aggregate shall also conform to "All in aggregate" of the grading under IS 383 (See **Table 3.5**).

3.2.6.3 The accuracy of the measuring equipment shall be within ± 2 percent of the quantity of cement being measured and ± 3 percent of the quantity of aggregate, admixtures and water being measured.

3.2.6.4 In terms of Para 5.6.2.2 of Concrete Bridge Code, in case uniformity in the materials used for concrete making has been established over a period of time, the proportioning may be done by volume batching for M 20 grade and below Grade concrete with the approval of the engineer, provided the materials and aggregates conform to the grading as per IS:383. Where weigh batching is not practicable, the quantities of fine and coarse aggregate (not cement) may be determined by volume batching for concrete of grade upto M 20. If the fine aggregate is moist and volume

batching is adopted, allowance shall be made for bulking in accordance with IS:2386 (Part III).

3.2.6.5 It is important to maintain the water-cement ratio constant at its correct value. To this end, determination of moisture contents in both fine and coarse aggregates shall be made as frequently as possible, the frequency for a given job being determined by the Engineer according to weather conditions. The amount of the added water shall be adjusted to compensate for any observed variations in the moisture contents. For determination of moisture content in the aggregates. IS : 2386 (Part 3) may be referred to. To allow for the variation in mass of aggregate due to variation in their moisture content, suitable adjustments in the masses of aggregates shall also be made. In the absence of exact data, only in the case of nominal mixes, the amount of surface water may be estimated from the values given in **Table 3.17** below. Field Test for determination of Surface Moisture is at **Annexure 3.2**.

TABLE 3.17
SURFACE WATER CARRIED BY AGGREGATE
(Based on IS:456-2000, Table 10/ Concrete Bridge Code 1997 Table 6)

SL	Aggregate	Approximate Quantity of Surface Water	
		Percent by Mass	Litre /m ³ of aggregate
(i)	Very wet sand	7.5	120
(ii)	Moderately wet sand	5.0	80
(iii)	Moist sand	2.5	40
(iv)	Moist gravel or crushed rock	1.25-2.5	20-40

Note : Coarser the aggregate, less the surface water it will carry for the same Volume of aggregate.

3.2.6.6 No substitutions in materials used on the work or alteration in the established proportions, except as permitted in 3.2.6.4. and 3.2.6.5. shall be made without additional tests to show that the quality and strength of concrete are satisfactory.

3.2.6.7 Implication of existence of Surface Water or absence of it in coarse and fine aggregates

a) Bulking of aggregates : This phenomenon is prominent in fine aggregate and is not taken into account for the coarse aggregate. Surface Dry and fully saturated

sand have almost the same volume. But damp sand increases in volume depending upon moisture content. The allowance for bulking for any sample of sand shall be determined as per IS 2386 (Part III). Reference may be made Table 26.4 of Chapter 26 on "Mortar" giving relation between the moisture content and percentage of bulking of average sand.

b) **Absorption of water by Bone dry aggregate** : In hot summer the sand and coarse aggregate will be bone dry and will actually absorb some water from the concrete mix to become "surface dry". This absorption will reduce the effective quantity of water in the mix. In the absence of a regular test to determine the absorption

capacity of the aggregates, absorption may be assumed as 1.00% by weight for average sand and 0.50% by weight for coarse aggregates such as Trap rock and granite.

c) Surface water in aggregates : For the determination of actual moisture content in the aggregates, **Annexure 3.2** and IS 2386 (Part III) may be referred to. In the absence of exact data, only in the case of mixes other than design mix, the amount of surface water may be estimated from the values given on Table 10 of IS 456 given as **Table 3.17**.

d) Mix Proportion on volumetric Basis – Fine aggregate to be used : In this case the volume of sand is stipulated on the assumption that the sand is surface dry. If it is wet or has surface water, there will be bulking. The actual bulking % should be determined as per IS 2386 (Pt. III). In absence of test result, the figures given in sub para (c) above may be assumed. Thus, if the volume of surface dry sand (average grade) in the mix is specified as 100 litres, the actual wet sand volume to be used will be 122 litres, if the moisture content % by weight is 3%.

e) Mix Proportion on weight basis – Coarse and Fine aggregates to be added : In this case also, the weights of coarse and fine aggregates are stipulated on the assumption that they are surface dry. If they are wet, their unit weight will be more due to weight of surface water. This should be correctly assessed by tests as per IS 2386 (part III). In absence of exact data, the % by mass for fine and coarse aggregates may be taken as shown in (e) above. Thus if 100 gm of surface dry sand is to be used and at site it is very wet sand, the weight of wet sand to be used will be 107.50 gm; Similarly if 100 gm of coarse aggregate is to be used and it is moist; the weight of moist coarse aggregate to be used will be 101.25 gm to 102.50 gms depending on the coarseness.

f) Mix proportions whether on Volumetric basis or weight basis – quantity of free water to be added : The water cement ratio is specified for the mix and the weight and corresponding volume of water to be used for the mix per bag of cement can be determined based on the same

If the aggregates are wet with surface water, they will contribute to this requirement of water as indicated in (e) above. While the actual volume of surface water has to be determined by IS 2386 (Part III), the approximate figures may be seen in (e)

above. Thus from the quantity of water stipulated as per water cement ratio, the surface water available in Fine and coarse aggregates should be deducted before adding free water to the mix.

If the aggregates are bone dry, they will absorb some water to become surface dry as explained in (d) above. Thus, for the quantity of water stipulated as per water cement ratio, extra quantity of free water should be added to maintain the water cement ratio as stipulated.

In all cases, if there is any difficulty in placement and compaction due to non workability with the water cement ratio as stipulated for the mix, extra water as required may be added but simultaneously adding extra cement so that the stipulated water cement ratio is not exceeded. Alternatively with the approval of the Engineer, suitable plasticizer / admixtures may be used to improve workability.

3.2.7 Mixing

3.2.7.1 General : To avoid confusion and error in batching, consideration should be given to using the smallest practical number of different concrete mixes on any site or in any one plant. A competent person shall supervise all stages of production of concrete. Competent person is one who has been authorized by the Engineer for executing and supervising relevant aspect of concreting. Preparation of test specimens and site tests shall be properly supervised. The Engineer shall be afforded all reasonable opportunity and facility to inspect the materials and the manufacture of concrete and to take any samples or to make any tests.

Concrete shall be mixed in mechanical batch type concrete mixers conforming to IS : 1791 having two blades and fitted with power loader (lifting hopper type). Half bag mixers and mixers without lifting hoppers shall not be used for mixing concrete.

In exceptional circumstances, such as mechanical break down of mixer, work in remote areas or power breakdown and when the quantity of concrete work is very small, hand mixing may be done with the specific prior permission of the Engineer in writing subject to adding 10% extra cement. When hand mixing is permitted, it shall be carried out on a water tight platform and care shall be taken to ensure that mixing is continued until the concrete is uniform in colour and consistency. In case Brick aggregate is used, before mixing, the brick aggregate shall be well soaked with water for a minimum period

of two hours and stone aggregate or gravel shall be washed with water to remove, dirt, dust and other foreign materials. For guidance, the mixing time may be 1 ½ to 2 minutes for normal mixer and 45 to 60 seconds for high rated Batching Plant. For hydrophobic cement it may be taken as 2 ½ to 3 minutes.

3.2.7.2 Power Loader: Mixer will be fitted with a power loader complying with the following requirements:-

(a) The hopper shall be of adequate capacity to receive and discharge the maximum nominal batch of unmixed materials without spillage under normal operating conditions on a level site.

Note : In such a case the volume of the maximum nominal batch of mixed material will be 50% greater than the nominal mixed batch capacity.

(b) The minimum inside width of the feeding edge of the hopper shall be as specified below.

Nominal size of mixer (T, NT or R) litre	Minimum inside width of hopper feeding edge (metre)
140	1.0
200	1.1
280	1.2
375	1.4
500	1.5
1000	2.0

T – tilting NT – non-tilting R – Reverse

c) The design of the loader shall be such that it allows the loading hopper to be elevated to such a height that the centre line of the chute plate of the hopper when in discharge position, is at an angle of not less than 50° to the horizontal. A mechanical device to aid discharge of the contents as quickly as possible from the hopper to the drum may also be provided. Even when a mechanical device is provided, it is recommended that the angle of centre line of the chute plate of the hopper when in discharge position, should be as large as practicable, preferably not less than 40° to horizontal.

(d) When the means of raising and lowering the loading hopper includes flexible wire ropes winding on to a drum or drums, the method of fastening the wire to rope to the drums shall be such as to avoid, as far as possible any tendency to cut the strands of the ropes and the fastening should preferably be positioned clear of the barrel of the drum as for example, outside the drums flange. When the loading hopper is lowered to its normal loading position, there should be at least one and a half drums of rope on the drum.

(e) Clutch brake and hydraulic control lever shall be designed so as to prevent displacement due to liberation by accidental contact with any person.

(f) The clutch and brake control arrangements also be so designed that the operator can control the falling speed of the loader.

(g) Safety device shall be provided to secure the hopper in raised position when not in use.

3.2.7.3 Mixing Efficiency : (a) The mixer shall be tested under normal working conditions in accordance with the method specified in IS: 4643 with a view to check its ability to mix the ingredients to obtain concrete having uniformity within the prescribed limits.

3.2.7.4. Procedure for Machine Mixing: The mixer shall be flushed clean with water. Measured quantity of coarse aggregate shall be placed first in the hopper. This shall be followed with measured quantity of fine aggregate and then cement. In case fine aggregate is damp, half the required quantity of coarse aggregate shall be placed in the hopper, followed by fine aggregate and cement. Finally the balance quantity of coarse aggregate shall be fed in the hopper. Then the dry materials are slipped into the drum by raising the hopper and the dry materials mixed for at least four turns of the drum. While the drum is rotating, water shall be added gradually to achieve the water cement ratio as specified or as directed by

the Engineer. After adding water, the mixing shall be continued until concrete of uniform colour, uniformly distributed material and consistency is obtained. Mixing shall be done for at least two minutes after adding water. If there is segregation after unloading from the mixer, the concrete should be remixed. The drum shall be emptied before recharging. When the mixer is closed down for any time exceeding 20 minutes, the drum shall be flushed clean with water.

3.2.7.5 Procedure for Hand Mixing : When hand mixing has been specifically permitted in exceptional circumstances by the Engineer subject to adding **10% extra cement**, it shall be carried out on a smooth, clean and water tight platform of suitable size. Measured quantity of sand shall be spread evenly on the platform and the cement shall be dumped on the sand and distributed evenly. Sand and cement shall be mixed intimately with spade until mixture is of even colour throughout. Measured quantity of coarse aggregate shall be spread on top of cement sand mixture. Three quarters of the total quantity of water required shall be added in a hollow made in the middle of the mixed pile and the material is turned towards the middle of pile with spade. The whole mixture is turned slowly over again and again and the remaining quantity of water is added gradually. The mixing shall be continued until concrete of uniform colour and consistency is obtained. The mixing platform shall be washed and cleaned at the end of the day.

3.2.7.6. Transportation and Handling: Concrete shall be transported from the mixer to the place of laying as rapidly as possible by methods which will prevent the segregation or loss of any of the ingredients duly maintaining the required workability.

During hot or cold weather, concrete shall be transported in deep containers. Other suitable methods to reduce the loss of water by evaporation in hot weather and heat loss in cold weather may also be adopted.

3.2.8 Placing

3.2.8.1 The concrete shall be deposited as nearly as practicable in its final position to avoid re-handling. It shall be laid gently (not thrown) and shall be thoroughly vibrated and compacted before setting commences and should not be subsequently disturbed. Method of placing shall be such as to preclude segregation. Care shall be taken to avoid displacement of reinforcement or movement of form work and damage due to rains. As a general guidance, the maximum

free fall of concrete that can be permitted may be taken as 1.5 metre.

3.2.8.2 To place concrete on heights, the most economical and convenient method is concrete lift. For large works cranes are used. Concrete is also conveyed by means of pumps in very large work. The concrete should be placed in horizontal layers of uniform thickness. Unless the previous layer is properly compacted the second layer should not be started. The concrete should be laid fast as otherwise before the second layer is started the first layer may get set thus forming a cold joint. The thickness of layer in an RCC work can be 150mm to 200mm and for plain concrete the same can be 375mm to 500mm. While concreting members like walls, beams, and girders, the first batch should be placed at the ends and the subsequent pouring continued towards the centre. When the concrete has to be placed at a lower level, chutes are generally used. However, an open chute should not be permitted under any circumstance. A totally covered chute should be used. The slope of chute should be between 1:2 to 1:3 and must be adequately supported on all sides. To prevent any segregation, the height of drop of concrete from chute to the point of placing should be properly adjusted. Sometimes it is noticed that while speedily concreting the tall forms, water gathers on the top surface of concrete. This should not be allowed. In such a case the concreting should be stopped for about half an hour when the top 300mm high concrete is to be laid. The concreting can be restarted immediately thereafter. At the same time, one should carefully note that no initial set takes place as it will result in forming a cold joint. In arch work, the arch must be subdivided in the direction of the axis of the barrel into such widths that a complete ring can be laid continuously without stopping. These rings should be laid alternately and the gaps between laid afterwards. The Engineer or his authorized representative must always supervise all concrete laid in arches. If, from any unforeseen occurrence, it is found not possible to complete by continuous laying any ring of an arch, the cement concrete must be stopped with a slope that is radial to the soffits of the arch. Before the arch ring is completed oiled paper must be placed over the surface of the already deposited concrete so as to form a joint.

3.2.9 Compaction

3.2.9.1 General : Concrete shall be thoroughly compacted and fully worked around embedded fixtures and into corners of the form work. Compaction shall be done by mechanical vibrator of appropriate type till a dense concrete is obtained. The mechanical vibrators shall conform to IS: 2505, IS:2506, IS.2514 and IS.4856. To prevent segregation, over vibration shall be avoided.

Compaction shall be completed before the initial setting starts. For the items where mechanical vibrators are not to be used, the contractor shall take permission of the Engineer in writing before the start of the work. After compaction the top surface if exposed but not subject to wear shall be finished even and smooth with wooden trowel before the concrete begins to set. Any excess water or cream on the surface shall be removed. Dry cement or a dry mixture of cement and sand shall not be sprinkled on the surface to absorb such excess moisture.

3.2.9.2 Hand Compaction : This, where permitted by the Engineer, is the most suitable method for small jobs and in very thin sections where a mechanical vibrator of any type cannot be used.

The hand tapping is done by a tamping rod of suitable length and thapi. The rod should be long enough to reach the bottom and thin enough to pass through the reinforcements to reach the bottom.

Another method of hand tapping is spading. In this case the trowel (Thapi) or spade like tool is inserted between side of form work and concrete, thus forcing the larger aggregate of concrete deeper into the mass of concrete. This way, the air entrapped during transporting and placing is able to escape.

In case of paving work or a heavy flooring work, a heavy timber beam with proper camber is placed on the top of concrete and the same is rammed. This gives proper compaction.

3.2.9.3 Compaction by Machines

(a) The following **advantages** accrue by compacting the concrete by machines and is to be adopted in circumstances other than in **Para 3.2.9.2** above.

- i) Mix with low water cement ratio can be used.
- ii) A section with heavy and congested reinforcements can be successfully compacted.

- iii) With perfect vibration higher density concrete with good homogeneity and higher strength can be obtained.
- iv) Concrete with greater durability can be achieved.

Different types of vibrators in use are as follows :

- 1) Internal pin vibrators
- 2) External form vibrators
- 3) Table vibrators
- 4) Plate vibrators
- 5) Screed vibrators

(b) Vibration Functions

External or internal vibration is commonly used on construction works, for compacting concrete. When concrete is vibrated, the vibration produces a series of rapid compressive impulses which greatly reduces the friction, or internal cohesion between various size particles of the mix. Thus, the concrete just behaves like liquid and easily settles under the action of gravity in the forms, and during the process the unwanted entrapped air rises to the top surface. As soon as the vibration is stopped the internal friction gets re-established and the concrete starts setting.

(c) Internal Pin Vibrators

These vibrators are called immersion vibrators or needle vibrators or poker vibrators. They are operated on petrol, diesel or even on electricity. The vibrating heads called needles range from 20mm to 175mm diameter connected to the flexible shaft. The vibrating head is immersed in concrete imparting vibratory motion in the concrete.

(d) External Form Vibrators

These vibrators are attached to the form work. The forms must be strong enough to withstand the effect of vibration. Form vibrators are either electrically or pneumatically operated. They should be so placed that the intensity of vibration is uniformly spread over the form. The time required for proper vibration by a form vibrator is considerably longer than by internal vibration.

When the form vibrators are being used, the top 750mm portion should not be covered by the action of the form vibrators. The above gap can be vibrated by internal vibrator.

The form vibrators are most suitable when the reinforced section is very heavy and the internal vibrator cannot be used at all. Form vibrator can be attached to the exposed face of the reinforcement bars to vibrate them.

This will help remove the air trapped under the bars. This type of vibration will increase the bond between the concrete and reinforcement bars.

(e) Table Vibrators

These vibrators are mainly used for pre-cast items. These are attached to the tables where the precasting moulds are kept and the unit vibrates along with the table top.

(f) Plate/ Surface Vibrators

These are best suited for pavement and similar type works. They apply vibration through a flat plate at bottom direct to the concrete surface. These vibrators save a great deal of labour in levelling and finishing of concrete. These vibrators should not be used for concrete with a slump greater than 75mm.

Also the surface vibrators should not be used on a surface which is already adequately compacted since the additional vibration will result in accumulation of mortar and fine material in excess quantity on the surface which in turn will reduce wear resistance.

(g) Screed Vibrators

These are mostly used for road works. The vibrator is attached to the timber section having handles on both ends. The unit is thus called screed vibrator. All the conditions mentioned for surface vibrators apply to screed vibrators as well.

3.2.10. Construction Joints

3.2.10.1 : Concreting shall be carried out continuously up to construction joints. The position and arrangement of construction joints shall be as shown in the structural drawings or as directed by the Engineer. Number of such joints shall be kept minimum. Joints shall be kept as straight as possible. Construction joints should comply with IS:11817.

3.2.10.2 When the work has to be resumed on a surface which has hardened, such surface shall be roughened. It shall then be swept clean and thoroughly wetted. For vertical joints, neat cement slurry of workable consistency by using 2 Kg of cement per sqm shall be applied on the surface before it is dry. For horizontal joints, the surface shall be covered with a layer of mortar about 10-15 mm thick composed of cement and sand in the same ratio as the cement and sand in concrete mix. This layer of cement slurry or mortar shall be freshly mixed and applied immediately before placing of the concrete.

3.2.10.3 Where the concrete has not fully hardened, all laitance shall be removed by

scrubbing the wet surface with wire or bristle brushes, care being taken to avoid dislodgement of particles of coarse aggregate. The surface shall be thoroughly wetted and all free water removed. The surface shall then be coated with neat cement slurry @ 2 kg. of cement per sqm. On this surface, a layer of concrete not exceeding 150 mm in thickness shall first be placed and shall be well rammed against corners and close spots of work. Thereafter, work shall proceed in the normal way.

3.2.10.4 On construction joints in plain and reinforced concrete in General Bridge Constructions reference may be made to Para 8.5 and Appendix "A" of Concrete Bridge Code, 1997.

3.2.11 Concreting under Special Conditions

3.2.11.1 Mass Concrete

(a) Mass Concrete is to be deposited in layers not exceeding 40 cm thickness and complete layers of concrete should be laid in a day.

(b) Care shall be exercised to avoid disturbing the setting action of the concrete, and unless sufficient time has elapsed for the setting to take place, no imposed load, such as that caused by walking over it, laying planks or other timber upon it or other loads, however light, shall be allowed. Earth must never be rammed in the vicinity of reinforced concrete less than one month old.

(c) Use of Stone plums : Stone plums upto a maximum limit of 20 percent of the volume of concrete may be used in mass concrete, where so specified or permitted by the Engineer, with a view to economy. The plums shall be of granite or other approved hard stone, and of maximum dimension from 150 to 220mm but not greater than one-third the least dimension of the concrete mass. The plums shall be located only in zones not subject to tensile stresses, which may generally be taken as the middle half of the cross section on the case of piers and the front three-fourth in the case of abutments. The plums shall be free from sharp corners and shall be staggered laterally and spaced suitably apart to permit proper filling and consolidation of the inter-space with concrete.

3.2.11.2 Concreting in Cold weather

During cold weather, precautions shall be taken, to the satisfaction of the Engineer to ensure that the concrete shall have a temperature of atleast 4.5 deg. C and that the temperature of the concrete shall be

maintained above 2°C until it has thoroughly hardened. If necessary, aggregates and / or water used on mix shall be heated before mixing. No frozen materials or material containing ice shall be used. The concrete placed shall be protected against frost by suitable covering. Dependence should not be placed on salt or other chemicals for the prevention of freezing.

3.2.11.3 Concreting in hot weather

During hot weather, precautions shall be taken to see that the temperature of wet concrete does not exceed 38 deg. C. For this, concreting may be avoided during the hottest part of the day and may be done during the morning and evening hours.

3.2.11.4 Concreting in Rainy Weather

During rainy weather, sufficient supply of tarpaulins or other water proof cloth shall be provided by the contractor at the site of work. Any time when it rains, all freshly laid concrete which has not been covered for curing purposes, shall be adequately protected by means of such tarpaulins or other waterproof cloth. Any concrete injured by rain shall be removed and replaced at the expense of the contractor.

3.2.11.5 Concreting under water

(a) When it is necessary to deposit concrete under water, the methods, equipment, materials and proportions of the mix to be used shall be submitted to, and approved by the Engineer before the work is started.

(b) Concrete shall not be placed in water having a temperature below 4.5°C. The temperature of the concrete, when deposited, shall be not less than 16 deg. C nor more than 38 deg. C.

(c) The concrete shall contain at least 10 percent more cement than that required for the same mix placed in the dry, the quantity of extra cement varying with conditions of placing. The volume or weight of the coarse aggregate shall be not less than one and a half times, nor more than twice, that of the fine aggregate. The concrete shall be so proportioned as to produce a concrete having a slump of not less than 10 cm and not more than 18 cm.

(d) The water under which the concrete is laid shall be quite still and any movement in the water shall be stopped by sheeting so as to divide into compartments the place where the concrete is being deposited.

(e) In case cofferdams or forms are being provided, the same shall be sufficiently tight to ensure still water if practicable, and in any

case to reduce the flow of water to less than 3m per minute through the space into which concrete is to be deposited. Cofferdams or forms in still water shall be sufficiently tight to prevent loss of mortar through the walls. Dewatering by Pumping shall not be done while concrete is being placed, or until 24 hours thereafter.

(f) Concrete shall be deposited continuously until it is brought to the required height. While depositing, the top surface shall be kept as nearly level as possible and the formation of seams avoided. The methods to be used for depositing concrete under water shall be one of the following:-

Tremie : The concrete should be coherent and slump shall be more than 150mm but should not exceed 180mm. When concreting is carried out under water, a temporary casing should be installed to the full depth of bore hole or 2 m into non-collapsible stratum, so that fragments of ground cannot drop from the sides of the hole into the concrete as it is placed. The temporary casing may not be required except near the top when concreting under drilling mud. The top section of the tremie shall be a hopper large enough to hold one entire batch of mix or the entire contents of the transporting bucket when one is used. The tremie pipe shall be not less than 200mm in diameter and shall be large enough to allow free flow of concrete and strong enough to withstand the external pressure of the water in which it is suspended, even if a partial vacuum develops inside the pipe. Preferably flanged steel pipe of adequate strength to sustain the greatest length and weight required for the job should be used. A separate lifting device shall be provided for each tremie pipe with its hopper at the upper end. Unless the lower end of the pipe is equipped with an approved automatic check valve, the upper end of the pipe shall be plugged with a wadding of gunny sacking or other approved material before delivering the concrete to the tremie pipe through the hopper, which plug will be forced out of the bottom end of the pipe by filling the pipe with concrete. It will be necessary to raise slowly the tremie by 25 cm to 30 cm in order to cause a uniform flow of the concrete, but the tremie shall not be emptied so that water enters above the concrete in the pipe. At all times after the placing of concrete is started and until all the concrete is placed, the lower end of the tremie pipe shall be at least 600mm below the top surface of the plastic concrete as ascertained by sounding.. This will cause the concrete to build up from below instead

of flowing out over the surface, to avoid formation of laitance layers. If the charge in the tremie is lost while depositing, the tremie shall be raised above the concrete surface, and unless sealed by a check valve, it shall be re-plugged at the top end, as at the beginning, before refilling for depositing concrete.

Drop Bottom Bucket : The concrete shall be gently laid in position by means of approved skips or buckets with flaps or doors automatically opening at the bottom. The top of the bucket shall be open. The bottom doors shall open freely downward and outward when tripped. The bucket shall be filled completely and lowered slowly to avoid backwash. It shall not be dumped until it rests on the surface upon which the concrete is to be deposited and when discharged shall be withdrawn slowly until well above the concrete.

(g) To minimise the formation of laitance, great care shall be exercised to disturb the concrete as little as possible while it is being deposited. No tamping or ramming shall be done until the concrete surface rises above water level, and even then, the surface shall be tamped gently so as not to squeeze the water. Care must be taken that tamping is not done in a manner as to permit any disturbance of mortar or leakage or suction of the same from the concrete.

3.2.11.6 Concrete in Sea Water: Concrete in sea-water or exposed directly along the sea-coast shall be at least M20 Grade in the case of plain concrete and M30 in case of reinforced concrete. The use of slag or Pozzolana cement is advantageous under such conditions.

(i) Special attention shall be given to the design of the mix to obtain the densest possible concrete. Slag, broken brick, soft lime stone, soft sandstone, or other porous or weak aggregates shall not be used.

(ii) As far as possible, preference shall be given to use of pre cast members unreinforced, well-cured and hardened, without sharp corners, and having trowel-smooth finished surfaces free from crazing, cracks or other defects. Plastering should be avoided.

(iii) No construction joint shall be allowed within 60 mm below low water-level or within 60 mm of the upper and lower planes of wave action. Where unusually severe conditions or abrasion are anticipated, such parts of the work shall be protected by bituminous or silico-fluoride coatings or stone facing bedded with bitumen.

(iv) In reinforced concrete structures, care shall be taken to protect the reinforcement from exposure to saline atmosphere during storage, fabrication and use. It may be achieved by treating the surface of reinforcement with cement wash or by other suitable methods as provided for in the Contract.

3.2.11.7 Concrete in Aggressive Soils and Water

The destructive action of aggressive waters on concrete is progressive. The rate of deterioration which varies with the alkali resisting property of the cement used decreases as the concrete is made stronger and more impermeable, and increases as the salt content of the water increases. Where structures are only partially immersed or are in contact with aggressive soils or water on one side only, evaporation may cause serious concentrations of salts with subsequent deterioration even where the original salt content of the soil or water is not high. The selection of type of cement, therefore, should be made after thorough investigation. For particular problems the Engineer should decide upon the method. No concrete shall be allowed to come in contact with sea water within 72 hours of casting.

3.2.12 Curing

3.2.12.1 General : Curing is the process of preventing loss of moisture from the concrete. The importance of curing can be appreciated from the details given at **Annexure 3.6**. The following methods shall be employed for effecting curing.

3.2.12.2. Moist curing : Exposed surfaces of concrete shall be kept continuously in a damp or wet condition by ponding or by covering with a layer of sacking, canvas, Hessian or similar materials and kept constantly wet for at least 7 days from the date of placing concrete in case of ordinary Portland cement and at least 10 days where mineral admixtures or blended cements are used. The period of curing shall not be less than 10 days for concrete exposed to dry and hot weather conditions. In the case of concrete where mineral admixtures or blended cements are used, it is recommended that above minimum period may be extended to 14 days.

3.2.12.3 Membrane Curing: Approved curing compounds may be used in lieu of moist curing with the permission of the Engineer. Such compound shall be applied to all exposed surfaces of the concrete as soon as possible after the concrete has set.

Impermeable membrane such as polythene sheet covering the concrete surface may also be used to provide effective barrier against the evaporation.

3.2.12.4 Freshly laid concrete shall be protected from rain by suitable covering.

3.2.12.5 Over the foundation concrete, the masonry work may be started after 48 hours of its completion, but the curing of exposed surfaces of cement concrete shall be continued along with the masonry work for at least 7 days. And where the cement concrete is used as base concrete for flooring, the flooring may be commenced before the curing period of base concrete is over but the curing of base concrete shall be continued along with top layer of flooring for a minimum period of 7 days.

3.2.13 Testing of concrete :

This will be done as described in Chapter 4 on R.C.C.

3.2.14 Form work

Form work shall be as described in Chapter 4 on R.C.C. and shall be paid for separately unless otherwise specified.

3.2.15 Finishes

Plastering and special finishes other than those obtained through form work shall be specified and paid for separately unless otherwise provided for in the Contract.

3.2.16 Application of Load

The following minimum periods shall be allowed to elapse after the concreting is completed before the load is imposed on it.

	50 percent of designed load	75 percent of designed load	Full designed load
Ordinary Cement concrete	7 days	14 days	28 days
Rapid - hardening Cement Concrete	5 days	10 days	14 days

Note : 1. The expression "Load" means the total calculated load with the appropriate impact allowance specified for the speed at which the load is permitted.

2. The above periods shall be suitably increased where the mean air temperature is less than 5°C.

3.2.17. Measurements

3.2.17.1. Dimensions of length, breadth and thickness shall be measured correct to nearest cm. except for the thickness of slab and partition which shall be measured to nearest 5 mm. Areas shall be worked out to nearest 0.01 sqm and the cubic contents of consolidated concrete shall be worked out to nearest 0.001 cum. Any work done in excess over the specified dimensions or sections shown in the drawing shall be ignored.

3.2.17.2. Concrete work executed in the following conditions shall be measured separately, unless otherwise specified in the contract.

- Work in or under water
- Work in liquid mud
- Work in or under foul positions

3.2.17.3. Cast-in-situ concrete and /or pre-cast concrete work shall be measured in stages described in the Schedule of item of work:

3.2.17.4 No deduction shall be made for the following:-

- Ends of dissimilar materials for example beams, posts, girders, rafters, purlins, trusses, corbels and steps up to 500 sq.cm in cross sections.
- Opening upto 0.1 sq.metre (1000 sq.cm.)
- Volume occupied by pipes, conduits, sheathing etc., not exceeding 100 sq.cm. each in cross sectional areas.
- Small voids when these do not exceed 40 sq.cm. each in cross section.

Note : In calculating area of opening, the thickness of any separate lintel or sill shall be included in the height. Nothing extra shall be payable for forming such openings or voids.

3.2.17.5 Cast-in-situ and precast concrete work shall be measured separately.

3.2.17.6 Cast-in-situ concrete shall be classified and measured as follows, unless otherwise stipulated in the Schedule of Rates.

- Foundation, footings, bases for columns.
- Walls (any thickness) including attached pilasters, buttresses, plinth and string courses, fillets etc.,
- Shelves
- Slabs

5. Chajjas including portions bearing on the wall
6. Lintels, beams and bressummers
7. Columns, piers, abutments, pillars, post and struts
8. Staircase including stringer beams but excluding landings
9. Balustrades, Newels and sailing
10. Spiral staircase (including landings)
11. Arches
12. Domes, vaults
13. Shell roof, arch ribs and folded plates
14. Chimneys and shaft
15. Breast walls, retaining, walls return walls
16. Concrete filling to precast components

17. Kerbs, steps and the like

18. String or lacing courses, parapets, copings, bed block, anchor blocks, plain window sills and the like

19. Cornices and moulded windows sills.

20. Louvres, fins, fascia

3.2.17.7 Precast cement concrete solid articles shall be measured separately and shall include use of moulds, finishing the top surfaces even and smooth with wooden trowel, before setting in position in cement mortar 1:2 (1 cement:2 coarse sand) Plain and moulded work shall be measured separately and the work shall be classified and measured as under :

Classifications	Method of measurement
(a) Wall panels	In square meters stating the thickness.
(b) String or lacing courses, copings bed plats, plain windows sills, shelves, louvers, steps etc.	In cubic meters.
(c) Kerbs, edgings etc.,	In cubic meters.
(d) Solid block work	In square meters stating the thickness or in cubic meters.
(e) Hollow block work	In square meters stating the thickness or in cubic meters.
(f) Light weight Partitions	In square meters stating the partition's thickness.

3.2.18 Rate

The rate is inclusive of the cost of labour and materials involved in all the operations described above, unless otherwise provided for in the Contract.

3.3. CEMENT FLY ASH CONCRETE

3.3.1. General:-

3.3.1.1 Fly Ash Concrete shall be prepared by mixing graded coarse aggregate of nominal size as specified with fine aggregate, ordinary Portland cement and fly ash in specified proportions with required quantity of water. The recommended composition of cement-fly ash concrete is given in **Table 3.18** below for Ordinary Mix Concrete.

TABLE 3.18
FLY ASH CONCRETE MIXES

Composition	(Dry volume)	Compressive strength at 7 days
Lean Concrete (1:5:10)		2.8 kg. /cm ²
Cement (Ordinary Port land)	1.0	
Fly Ash	2.5	
Sand	4.0	
Stone Aggregate	11.0	
Lean Concrete (1:4:8)		3.7 kg/cm ²
Cement (Ordinary Port land)	1.0	

Fly ash	2.0	
Sand	3.5	
Stone aggregate	9.0	

Note : No fly ash is to be added to Pozzolana cement.

3.3.1.2 In terms of Correction Slip No. 9 dated 27.03.2006 to Concrete Bridge Code, when Portland Pozzolana Cement is used in Plain and Reinforced Concrete, it is to be ensured that proper damp curing of concrete is done atleast for 14 days and supporting form work is not removed till concrete attains atleast 75% of Design strength.

3.3.2. Proportioning : This shall be as specified in 3.2.5.

3.3.3. Mixing : This shall be as specified in 3.2.7 except that the fly ash shall be placed in the hopper before cement in case of machine mixing.

3.3.4 Placing and compaction : This shall be as specified in 3.2.8 and 3.2.9.3

3.3.5 Curing:- This shall be as specified in 3.2.12

3.3.6 Form work : This shall be as specified in 3.2.14.

3.3.7 Measurements : This shall be as specified in 3.2.17.

3.3.8 Rate : This shall be as specified in 3.2.18.

3.4 DAMP PROOF COURSE WITH CEMENT CONCRETE

3.4.1 Cement Concrete layer

This shall consist of cement concrete of specified proportions and thickness. The surface of brick or stone masonry work shall be levelled and prepared before laying the cement concrete. Edge of damp proof course shall be straight, even and vertical. Side shuttering shall consist of steel forms and shall be strong and properly fixed so that it does not get disturbed during compaction and the mortar does not leak through. The concrete mix shall be of workable consistency and shall be tamped thoroughly to make a dense mass. When the sides are removed, the surface should come out smooth without honey-combing. Continuity shall be maintained while laying the cement concrete layer and laying shall be terminated only at the predetermined location where damp proof course is to be discontinued. There shall be no construction joint in the Damp Proof Course.

3.4.2 Curing

Damp proof course shall be cured for at least seven days, after which it shall be allowed to dry.

3.4.3 Application of Hot Bitumen

Where so directed, hot bitumen in specified quantity shall be applied over the dried up surface of cement concrete properly cleaned with brushes and finally with a piece of cloth soaked in kerosene oil. Bitumen of penetration A 90 or equivalent where used shall be heated to a temperature of $160^{\circ} \pm 5^{\circ}\text{C}$. The hot bitumen shall be applied uniformly all over, so that no blank spaces are left anywhere. It will be paid for separately.

3.4.4 Water proofing Materials

Where so specified, water proofing material of approved quality shall be added to the concrete mixture in accordance with the manufacturer's specifications stating the quantity of water proofing material in litres or kg per 50 kg of cement and this will be paid for separately. A layer of 400 micron thick polyethylene sheet may be laid over the bitumen layer which will be paid extra.

3.4.5 Measurements

The length and breadth shall be measured correct to a cm and its area shall be calculated in square metres correct to two places of decimal. The depth shall not be less than the specified thickness at any section.

3.4.6 Rate

The rate is inclusive of the cost of materials and labour involved in all the operations described above except for the applications of a coat of hot bitumen and addition of water proofing materials which shall be paid for separately, unless otherwise specified.

3.5 Specifications for Bisphenol and Butyl Based Products :

3.5.1 Bisphenol and Butyl Based Epoxy Coating

The coating should adhere to following **Standards :**

1. ISO Standards as per ISO / TS / 16949-2002 / 069734 TS2

2. EN Standards – EN ISO 14001 – 2004 / 069734 UM
3. OHSAS 18001 : 1999 / 069734 OH
4. CFIA standards.

Product **Characteristics** :

1. Curing – 24 hours.
2. Working life @ 25 °C : 40 to 60 minutes (Easy application)
3. Compressive Strength as per ASTM D695 : 15000 psi
4. High Temperature Resistant : -29°C to +107°C
5. Non Shrinking after 100% curing
6. Resistant to Chemicals and Ultra Violet light.

3.5.2 Magnesium Poly Phosphate Based Concrete Fast Repair Epoxy :

The coating should adhere to following **Standards** :

1. ISO Standards as per ISO / TS / 16949-2002 / 069734 TS2
2. EN Standards – EN ISO 14001 – 2004 / 069734 UM
3. OHSAS 18001 : 1999 / 069734 OH
4. CFIA standards.

Concrete Fast Repair (*Beam Repair – Before*)



Concrete Fast Repair (*Beam Repair – After*)



Product **Characteristics** :

1. Fast Curing – 1 hours.
2. Compressive Strength as per ASTM C109 13000 psi
3. High Temperature Resistant : -29°C to +1090°C
4. Coefficient of Thermal Expansion as per ASTM C 531:10 power -6 in/in/F

Pre Tg	- 5.95
Post Tg	- 6.11
5. Resistant to Chemicals and Ultra Violet light.

3.5.3 Gun Grade, Poly Urethane Based Crack Sealer :

The coating should adhere to the following **Standards** :

1. ISO Standards as per ISO / TS / 16949-2002 / 069734 TS2
2. EN Standards – EN ISO 14001 – 2004 / 069734 UM
3. OHSAS 18001 : 1999 / 069734 OH
4. CFIA standards.
5. USDA Approved.

Product **Characteristic** :

1. Tensile Strength as per ASTM D 412 - 200 psi
2. Shear Strength as per ASTM D 1002 - 170 psi
3. Elongation at Break as per ASTM D 412 - 1000 %
4. Hardness in Shore A – 33.
5. Can be used for indoor and outdoor applications.
6. Paintable.
7. Resistant to chemicals and ultra Violet light.

3.5.4 Bisphenol Polyurethane Coating of 100% Solid Epoxy :

The coating should adhere to the following **Standards** :

1. ISO Standards as per ISO / TS / 16949-2002 / 069734 TS2
2. EN Standards – EN ISO 14001 – 2004 / 069734 UM
3. OHSAS 18001 : 1999 / 069734 OH
4. CFIA standards.
5. Salt water spray resistant with min. 1000 hrs. spray.
6. Compatible to potable water.

Product Characteristic :

1. Viscosity – 40000 – 60000 cps.
2. Coefficient of Thermal Expansion as per ASTM C 531 K-1
Pre Tg - 5.95
Post Tg – 6.11
3. Compressive Strength as per ASTM D695 – 9840 psi
4. Shear Strength as per ISO 4587 – 2190 psi.
5. Abrasion Resistant as per ASTM D 4060 – 49 mg.
6. Water Vapour Transmission rate as per ASTM E 96 – 4×10^{-11}
7. Thermal Conductivity as per ASTM F – 433 watt / mk – 0.42.

3.5.5 Special Anti-Slip Coating :

Supplying and applying of two components anti-slip coating, which should withstand heavy vehicular and pedestrian traffic. It should also adhere to metal, wood and concrete surfaces. Coating must be chemical and corrosion resistant. Job includes cleaning and priming of the surface with suitable metal or concrete primer, abrasive cleaning of surface followed by cleaning with suitable solvents.

The coating should adhere to following **Standards** :

1. ISO Standards as per ISO /TS / 16949-2002 / 069734 TS2
2. EN Standards - EN ISO 14001 -2004 / 069734 UM
3. OHSAS 18001 : 1999 / 069734 OH
4. CFIA standards.

**Product Characteristic :**

1. Curing – Light pedestrian traffic: 12 hours. Heavy pedestrian traffic: 72 Hours
2. Working life @ 25 ° Cel – 04 Hours (Easy application)
3. Coefficient of friction, ASTM F609, 1.05
4. High Temperature Resistant: - 29° C to 60° C.
5. Resistant to acids, alkalis, solvents, grease, oil, salt water, detergents, alcohol, gasoline, jet fuels & hydraulic oils.

Scope of Work :

1. The surface to be repaired has to be cleaned thoroughly using water based cleaner to remove all visible and invisible contaminants.
2. Area has to be roughened using sander, chipping or other tools as will be required.
3. Re-cleaning of area with brush or dry compressed air.
4. Application of the product on the prepared surface using primer as per substrate concrete / metal.
5. Finish it off with roller or brush.

ANNEXURE 3.1**DETERMINATION OF PARTICLE SIZE**

The apparatus, sample size and test procedure shall be same as specified in Annexure 26.4 in Chapter 26 on "Mortar".

In order that the sieves shall not be overloaded, care must be taken to ensure that the maximum sieve loads shown in table below are not exceeded at the completion of sieving.

I.S. Sieve	Maximum weight for	
	45 cm dia sieve (kg)	30 cm dia sieve (kg)
45 mm	10	4.5
40 mm	8	3.5
31.5 mm or 22.1 mm	6	2.5
20 mm	4	2
16 mm or 12.5 mm	3	1.5
10 mm	2	1.0
5.6 mm	1.5	0.75
4.75 mm	1.0	0.50
3.35 mm	--	0.30

The sample weights taken will thus normally require several operations on each sieve. Each sieve should be shaken separately over a clean tray or receiver until no more than a trace passes, but in any case for not less than two minutes. Material should not be forced through the apertures but hand

placing is permitted. A light brush should be used with fine sieves. The cumulative weight passing each sieve should be calculated as a percentage of the total sample weight to the nearest whole number.

ANNEXURE 3.2**TEST FOR SURFACE MOISTURE**

Take a sample of wet aggregate and weigh it (A). Then place it in a frying pan and gently apply heat, meanwhile stirring with a glass rod until the surface moisture disappears. This is apparent when the aggregate loses its shining wet appearance and becomes dull, or when it just attains a free running condition. The saturated surface-dry material is then weighed (B). Continue the

heating thereafter until the moisture is evaporated and weigh the dry sample (C). The surface moisture is then calculated as follows:-

$$\text{Surface moisture} = 100 \frac{A - B}{C}$$

It is expressed as a percentage of dry aggregate.

ANNEXURE 3.3**DETERMINATION OF TEN PERCENT FINE VALUE**

Apparatus : The apparatus for the standard test shall consist of the following:

- (a) A 15 cm diameter open-ended steel cylinder, with plunger and base plate. The surfaces in contact with the aggregate shall be machined and case hardened or otherwise treated so as to have a diamond (VH) pyramid hardness number of not less than 650 VH.
- (b) A straight metal tamping rod of circular cross-section 16 mm in diameter and 45 to 60 cm long. Rounded at one end.
- (c) A balance of capacity 3 kg. readable and accurate to one gram.
- (d) I.S. Sieve of 12.5, 10 and 2.36 mm.
- (e) A compression testing machine capable of applying a load of 50 tonnes and which can be operated to give a uniform rate of loading so that the maximum load in any test is reached in 10 minutes. This load may vary from 0.5 to 50 tonnes.
- (f) For measuring the sample, a cylindrical metal measure of sufficient rigidity to retain its form under rough usage and of the following internal dimensions:-

Diameter	11.5 cm
Height	18.0 cm

- (g) Means of measuring the reduction in the distance between the plates of the testing machine to the nearest one millimetre during the test (for example, dial gauge).

Test Sample : Material for the test shall consist of aggregate passing a 12.5 mm I.S. Sieve and retained on a 10 mm I.S. Sieve. The aggregate shall be tested in a surface dry condition. If dried by heating, the period of drying shall not exceed four hours, the temperature shall be 100°C to 110°C and the aggregate shall be cooled to room temperature before testing.

The quantity of aggregate shall be such that the depth of material in the cylinder, after tamping as described below, shall be 10 cm.

The weight of material comprising the test sample shall be determined (weight A) and the same weight of sample shall be taken for the repeat test.

Note : About 6.5 kg. of natural aggregate is required to provide the two test samples. The measuring cylinder is filled in three layers of approximately equal depth with aggregate passing a 12.5 mm I.S. Sieve and

retained on 10 mm I.S. Sieve. Each layer is subjected to 25 strokes from the tamping rod (16 mm dia and 45 to 60 cm long) rounded at one end, care being taken in case of weak materials not to break the particles. The surface of the aggregate shall be carefully levelled and the plunger inserted so that it rests horizontally on this surface.

Test procedure : The apparatus, with the test sample and plunger in position, shall then be placed in the compression testing machine. The load shall be applied at a uniform rate so as to cause a total penetration of a plunger in 10 minutes of about 15.0 mm for rounded or partially rounded aggregates (for example, expanded shales and slags). These figures may be varied according to the extent of the rounding or honey combing.

After reaching the required maximum penetration, the load shall be released and the whole of the material removed from the cylinder and sieved on a 2.36 mm I.S. Sieve. The fines passing the sieve shall be weighed, and this weight expressed as a percentage of the weight of the test sample. Normally, this percentage will fall within the range 7.5 to 12.5 but if it does not, a further test shall be made at a load adjusted appropriately, to bring the percentage fines within the range of 7.5 to 12.5.

A repeat test shall be made at the load that gives as percentage fines within the range 7.5 to 12.5.

Calculations : The mean percentage fines from the two tests at this load shall be used in the following formula to calculate the load required to give 10 percentage fines.

$$\text{Load required for 10 percent fines} = \frac{14 \times Y}{Y + 4}$$

Where X = Load in Tonnes and

Y = Mean percentage of fines from two tests at X Tonnes load.

Reporting of results : The load required to produce 10 percent fines shall be reported to the nearest whole number for loads of 10 tonnes or more and the nearest 0.5 tonne for loads of less than 10 tonnes. The value expressed to the nearest 0.5 tonne should be as follows:-

- (a) For normal concrete, not less than 5 tonnes.
- (b) For wearing surfaces, not less than 10 tonnes.
- (c) For granolithic concrete not less than 15 tonnes.

ANNEXURE 3.4**SLUMP TEST**

Apparatus : Mould shall consist of a metal frustum of cone having the following internal dimensions:

Bottom diameter	20 cm
Top diameter	10 cm
Height	30 cm

The mould shall be of a metal other than brass and aluminium of at least 1.6 mm (or 16 BG) thickness. The top and bottom shall be open and at right angles to the axis of the cone. The mould shall have a smooth internal surface. It shall be provided with suitable foot pieces and handles to facilitate lifting it from the moulded concrete test specimen in a vertical direction as required by the test. A mould provided with a suitable guide attachment may be used.

Tamping rod shall be of steel or other suitable material 16 mm in diameter 60 mm long and rounded at one end.

Procedure : The internal surface of the mould shall be thoroughly cleaned and free from superfluous moisture and any set concrete before commencing the test. The mould shall be placed on a smooth horizontal, rigid and non absorbent surface viz. levelled metal plate. The operator shall hold the mould firmly in place while it is being filled with test specimen of concrete. The mould shall be filled in four layers, each approximately one quarter of height of mould. Each layer shall be tamped with twenty five strokes of the rounded end of the tamping rod. The strokes shall be distributed in a uniform manner over the cross-section of the mould and for the

second and subsequent layers shall penetrate into the underlying layer. The bottom Layer shall be tamped through out its depth. After the top layer has been rodded, the concrete shall be struck off level with trowel or the tamping rod, so that the mould is exactly filled. Any mortar which shall leak out between the mould and the base plate shall be cleaned away. The mould shall be removed from the concrete immediately after filling by raising it slowly and carefully in a vertical direction. The moulded concrete shall then be allowed to subside and the slump shall be measured immediately by determining the difference between the height of the mould and that of the highest point of specimen.

The above operations shall be carried out at a place free from vibration or shock, and within a period of two minutes after sampling.

Result : The sump shall be recorded in terms of millimetres of subsidence of the specimen during the test. Any slump specimen which collapses or shears off laterally gives incorrect result. If this occurs, the test shall be repeated with another sample.

The slump test shall not be used for dry mixes as the results obtained are not accurate.

ANNEXURE 3.5**READY MIX CONCRETE**

Indian Railway Standard Code of Practice for Plain, Reinforced and Pre-stressed concrete for General Bridge Construction (Concrete Bridge Code)

Note : Based on Correction Slip No. 3 dated 01.08.2000 to Concrete Bridge Code 1997.

1. "Ready Mixed Concrete (RMC) : RMC means concrete produced by completely mixing cement, aggregates, admixtures, if any, and water at a Central Batching and Mixing Plant and delivered in fresh condition at site of construction.

2. Use of Ready Mixed Concrete : Ready Mixed Concrete may be used, wherever required. It shall conform to the specifications of concrete, as laid down in Concrete Bridge Code. For other aspects, which are not covered in Concrete Bridge Code IS: 4926 (Specification for Ready Mixed Concrete) may be referred.

3. Effect of transit (transportation) time on Ready Mixed Concrete : As Ready Mixed Concrete is available for placement

after lapse of transit time, reduction in workability occurs, which may lead to difficulty in placement of concrete. In addition, in case of longer transit time, initial setting of concrete may also take place, which may render it unusable. Thus, while planning for using of Ready Mixed Concrete, these aspects should be kept in view.

4. Checking suitability of Admixtures :

Generally admixtures, like water reducing agent, retarder etc., are used in Ready Mixed Concrete for retention of desired workability and to avoid setting of concrete. In such cases, admixtures should be tested for their suitability as per IS: 9103 at the time of finalizing mix design. Regarding specification of admixtures, clause 4.4 of Concrete Bridge Code may be referred.

5. Re-tempering with Concrete : Under any circumstances, re-tempering i.e. addition of water after initial mixing, shall not be allowed, as it may affect the strength and other properties of concrete.

6. Time period for delivery of concrete :

The concrete shall be delivered completely to the site of work within 1½ hours (when the atmospheric temperature is above 20°C) and within 2 hours (when the atmospheric temperature is at or below 20°C) of adding the mixing water to the dry mix of cement

and aggregate or adding the cement to the aggregate, whichever is earlier. In case, location of site of construction is such that this time period is considered inadequate, increased time period may be specified provided that properties of concrete have been tested after lapse of the proposed delivery period at the time of finalizing mix design.

7. Transportation of Ready Mixed Concrete :

The Ready Mixed Concrete shall be transported in concrete transit agitators conforming to IS: 5892 (Specification for concrete transit mixers and agitators). Agitating speed of the agitators during transit shall not be less than 2 revolutions per minute nor more than 6 revolutions per minute.

ANNEXURE 3.6

IMPORTANCE OF CURING

Curing :

The most important aspect in concrete is curing. A concrete which is cured properly will be stronger, durable, impermeable and will be in a position to take up stress.

Chemical Action During Curing

When water is mixed in concrete a chemical reaction called hydration takes place. This hydration continues rapidly for first few days, after the concrete is placed, but, for this hydration to take place without interruption, favourable temperature and moisture conditions are to be maintained. The act of protection of hydration in concrete is in broad terms called curing.

Thus, it can be concluded that to facilitate the hydration in cement, the water that is added in concrete during construction should be prevented from evaporation. In other words, it is prevention or replenishment of the loss of moisture from freshly placed concrete, which is termed as curing.

The loss of water due to evaporation from the freshly laid concrete depends mainly upon the temperature and relative humidity of the surrounding air. The velocity of wind over the surface of newly laid concrete also adds to quick evaporation. Thus, if the temperature is hot with low relative humidity and hot winds blowing one must be very careful about curing.

It has to be understood that if hydration is halted as a result of the loss of water due to evaporation, the concrete in question shrinks, thus creating tensile stresses within the concrete, and if these stresses develop before the concrete reaches its tensile strength the surface starts cracking endangering the stability of the structure itself. Therefore to protect the quality of concrete adequate curing arrangement should be made and this is applicable whether the work is big or small.

The strength of concrete directly depends upon the period of curing a concrete member is subjected to as may be seen from the Table below.

EFFECT OF CURING IN ACHIEVING THE STRENGTH IN CONCRETE

SL	Curing Days	Compressive Strength percent of 28 day moist cured concrete
1	No curing after laying	50% to 55%
2	Just 3 days curing	75% to 80%
3	7 days curing	95% to 100%
4	Full 28 days curing	120% to 125%

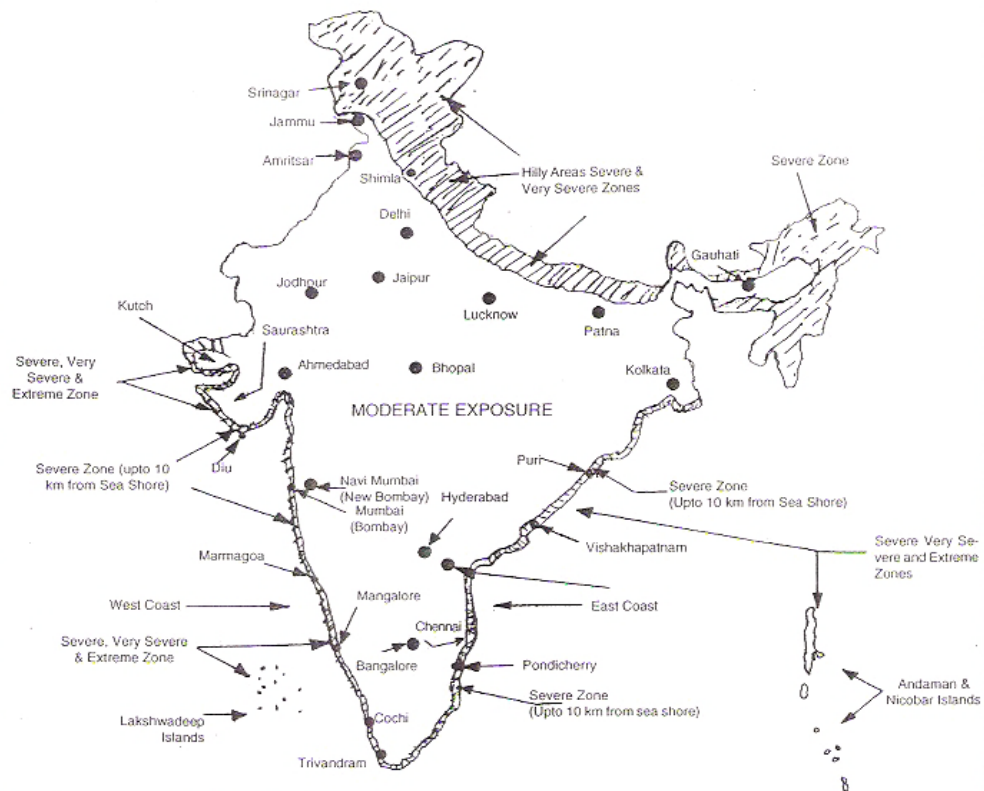
RECOMMENDED LIST OF TESTS ON MATERIALS AND WORKS

Material	Para	Test	Field / Laboratory	Test Procedure	Minimum quantity of Material for carrying out test	Frequency of testing
Stone aggregate	3.1.2.1	Percentage of soft or deleterious material	General visual Inspection / Laboratory Test where required by the Engineer	IS 2386 Part I	One test for each source	One test for each source
	3.1.2.4	Particle size distribution	Field / Lab	Annexure 3.1	10 cum	Every 40 cum or part thereof
	3.1.2.8	(a) Estimation of organic impurities	Field / Lab	IS 2386 Part II	10 cum	-do-
		(b) Surface moisture	Field / Lab	IS 2386	10 cum	-do-
		(c) Determination of 10% fine value	Field / Lab	IS 2386	10 cum	-do-
		(d) Specific gravity	Field / Lab	IS 2386	10 cum	-do-
		(e) Bulk density	Field/ Lab	IS 2386	10 cum	-do-
		(f) Aggregate crushing strength	Field /Lab	IS 2386	10 cum	-do-
		(g) Aggregate impact value	Field/Lab	IS 2386	10 cum	-do-
Concrete	3.2.4.1	Slump test	Field	ANNEXURE 3.4	10 cum	15 cum or part thereof

Figure 3.1
(Para 3.2.1.6 (b))

ENVIRONMENTAL EXPOSURE CONDITIONS (GEOGRAPHICAL)

A. Moderate, Severe and Very Severe Exposure Conditions



B. Very Severe Exposure Condition (Coastal Area)



C. Extreme Exposure Condition (Just on Seashore)

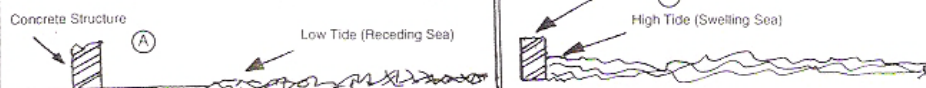


Exhibit 4.2 : Geographical Environmental Exposure Conditions

Chapter 4

Reinforced Cement Concrete

4.0 GENERAL

Reinforced cement concrete work may be cast-in-situ or pre-cast as may be directed by the Engineer according to the nature of work. Reinforced cement concrete work shall comprise of the following which may be paid separately or collectively as per the description of the item of work.

- a) Form work (Centring and Shuttering)
- b) Reinforcement
- c) Concreting : (1) Cast-in-situ (2) Pre-cast

4.1 MATERIALS

4.1.1 General

Water, cement, fine and coarse aggregate shall be as specified under respective paras of Chapter 26 - Mortars and Chapter 3 - Concrete Work as applicable. Portland Pozzolana Cement described in Chapter 26 cannot be used for PSC works and can be used for RCC works with certain precautions. The cement used shall be any of the following and the type selected should be appropriate for the intended use.

- (a) 33 grade ordinary Portland cement conforming to IS:269
- (b) 43 grade ordinary Portland cement conforming to IS: 8112
- (c) 53 grade ordinary Portland cement conforming to IS:12269
- (d) Rapid hardening Portland cement conforming to IS:8041
- (e) Portland Slag cement conforming to IS:455
- (f) Portland pozzolona cement (flyash based) conforming to IS:1489 (part 1)
- (g) Portland Pozzolana cement (calcined clay based) conforming to IS:1489 (part 2)
- (h) Hydrophobic cement conforming to IS:8043.
- (i) Low heat Portland cement conforming to IS:12600
- (j) Sulphate resisting Portland cement conforming to IS:12330.

Different types of cement shall not be mixed together. In case more than one type of

cement is used in any work, a record shall be kept showing the location and the types of cement used.

4.1.2 Steel for Reinforcement

The Steel reinforcement for RCC Works shall be any of the following types:-

- a) Mild steel and medium tensile bars conforming to IS: 432 (Part.I) (some important provisions are included in Para 4.1.3 below)
- b) High strength deformed steel bars conforming to IS:1786 (some important provisions are included in Para 4.1.4 below)
- c) Hard drawn steel wire fabric conforming to IS:1566
- d) Rolled Steel Structural steel conforming to IS: 2062 Grade A & Grade B.
- e) Thermo-mechanically treated bars TMT Bars (Refer Annexure 4.1)

4.1.3 Mild Steel & Medium Tensile Steel

4.1.3.1 Types and Grades

Reinforcement supplied in accordance with Para 4.1.2 shall be classified into the following types :

- a) Mild steel bars: It shall be supplied in the following two grades.
 - i) Mild steel bars grade I designated as Fe 410-S
 - ii) Mild steel bars grade II designated as Fe 410-O
- b) Medium tensile steel bars, grade II designated as Fe-540-W-HT.

Independent test check on quality of steel drawn from each lot shall be conducted. The Modulus of elasticity of steel shall be taken as 200 KN/ mm². The characteristic yield strength of different steel shall be assumed as the minimum yield stress / 0.2 percent of proof stress specified in the relevant Indian Standard.

4.1.3.2 Nominal Mass/Weight

The tolerance on mass/weight for round and square bars shall be the percentage given in Table 4.1 of the mass/weight calculated on the basis that steel weighs 0.785 kg/cm², cross sectional area per metre run.

TABLE 4.1
TOLERANCE ON NOMINAL MASS

Nominal size in mm	Tolerance* on the nominal mass Percent		
	Batch	Individual sample **	Individual sample for coil ***
(a) Up to and including 10	± 7	± 8	± 8
(b) Over 10 up to and including 16	+5	-6	+6
(c) Over 16	± 3	-4	+4

* tolerance shall be determined in accordance with method given in IS:1786.

** for individual sample, plus tolerance is not specified for (b) and (c).

*** for coil batch tolerance is not applicable.

4.1.3.3 Physical Requirement

Physical requirements are given in Table 4.2.

TABLE 4.2

SL	Type and nominal size of bar	Ultimate tensile Stress N/mm ² minimum	Yield stress N/mm ²	Elongation percent minimum
1.	Mild steel grade I			
	For bars upto and including 20 mm	410	250	23
	For bars over 20 mm upto and including 50 mm	410	240	23
2.	Mild steel grade II			
	For bars upto and including 20 mm	370	225	23
	For bars over 20 mm upto and including 50 mm	370	215	23
3.	Medium tensile steel			
	For bars upto and including 16 mm	540	350	20
	For bars over 16 mm, upto and including 32 mm	540	340	20
	For bars over 32mm, upto and including 50mm	510	330	20

Elongation Percent is on gauge length of $5.65 \sqrt{S_0}$ where S_0 is the cross sectional area of the test piece.

Note : 1. Grade (II) Mild steel bars are not recommended for use in structures located in earthquake zone subjected to severe damage and for structures subjected to dynamic loading (other than wind loading) such as bridges. Grade II Mild Steel Bars shall not be used in Railway Bridges. (Refer Correction Slip No.2 dated 17.05.2000 to Concrete Bridge Code).

2. Welding of reinforcement bars covered in this specification shall be done in accordance with requirements of IS:2751.

4.1.3.4 Selection and Preparation of Test Sample :

This shall be done in accordance with provisions of IS :1786. All test pieces shall be selected by the Engineer or his authorized representative either –

a. From cutting of bars

or

b. If he so desires, from any bar after it has been cut to the required or specified size and the test piece taken from any part of it.

In neither case, the test pieces shall be detached from the bar or coil except in the presence of the Engineer or his authorized representative.

The test pieces obtained in accordance with above shall be full sections of the bars as rolled and shall be subjected to physical tests without any further modifications. No reduction in size by machining or otherwise shall be permissible except in case of bars of size 28mm and above. No test piece shall be annealed or otherwise subject to heat treatment. Any straightening which a test piece may require shall be done cold.

4.1.3.5 Testing

Following lab tests shall be carried out

- a) Tensile Tests : This shall be done as per IS:1608.
- b) Bend Test : This shall be done as per IS:1599.

4.1.3.6 Retest

Should any one of the test pieces first selected fail to pass any of the tests specified above, two further samples shall be selected for testing in respect of each failure. Should the test pieces from both these additional samples pass, the materials represented by the test samples shall be deemed to comply with the requirement of the particular test. Should the test piece from either of these additional samples fail, the material represented by the test samples shall be considered as not having complied with standard.

4.1.4 High strength Deformed Bars and Wires.

4.1.4.1 Physical Requirements

For all sizes of steel bars, requirements are mentioned below in Table 4.3.

TABLE 4.3

SL	Property	Grade		
		Fe 415	Fe 500	Fe 550
1.	0.2% proof Stress/yield stress, min. N/mm ²	415	500	550
2.	Elongation, percent min. on gauge length $5.65\sqrt{S_o}$, where S_o is the X-Sectional Area of the test piece.	14.5	12	8
3.	Tensile strength	10% more than actual 0.2% proof stress but not less than 465 N/mm ²	8% more than actual 0.2% proof stress but not less than 545 N/mm ²	6% more than actual 0.2% proof stress but not less than 585 N/mm ²

4.1.4.2 Selection and Preparation of Test Sample

Please refer Para 4.1.3.4 above.

4.1.4.3 Testing

Following lab tests shall be carried out

1. Tensile Test. This shall be done as per IS:1608.
2. Bend Test: This shall be done as per IS:1599
3. Rebend Test: This shall be done as per IS:1786

4.1.4.4 Rebend test (As per IS-1786)

Please refer Para 4.1.3.6 above.

4.1.5 Thermo-Mechanically Treated Bars

Note on these bars is at Annexure 4.1.

4.1.6 Stacking and Storage

Steel for reinforcement shall be stored in such a way as to prevent distortion and

corrosion. Care shall be taken to protect the reinforcement from exposure to saline atmosphere during storage, fabrication and use. It may be achieved by treating the surface of reinforcement with cement wash or by other suitable methods. Bars of different classifications, sizes and lengths shall be stored separately to facilitate issue in such sizes and lengths to cause minimum wastage in cutting from standard length.

In case of long storage reinforcement bars shall be stacked above ground level by at least 150 mm upon platforms, skids, or other suitable supports to avoid distortion of sections. A coat of cement wash shall be given for such long storage to prevent scaling and rusting.

4.1.7 FUSION BONDED EPOXY COATED REINFORCING BARS – As per IS 13620 : 1993 (Some important para of the above IS

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code are reproduced below for information and guidance.

1 SCOPE

This standard covers deformed steel reinforcing bars with protective epoxy coating applied by electrostatic spray method.

2 REFERENCES

The Indian Standards mentioned below are a necessary adjunct to this standard:

IS No.	Title
1786 : 1985	High strength deformed steel bars and wires for concrete reinforcement (third revision)
6885 : 1973	Method for knoop hardness testing of metals

3. COATING MATERIALS

3.1 The coating material shall meet the requirements specified in Annex A.

3.2 The patching or repairing material or both, shall be compatible with the coating, inert in concrete and feasible for repairs at the coating plant or in the field. This material shall be approved by the purchaser prior to use. The patching or repair shall be performed in accordance with the recommendation of the material manufacturer.

4. REINFORCING STEEL

4.1 Steel reinforcing bars to be coated shall conform to IS 1786 : 1985.

5. SURFACE PREPARATION

5.1 The surface of the steel reinforcing bars to be coated shall be cleaned by abrasive blast cleaning to near white metal. The surface profile shall be free from mill scale, rust and foreign matter when viewed under well-lit conditions.

5.2 The coating shall be applied to the cleaned surface as soon as possible after cleaning. Any formation of rust blooms on the cleaned bars is to be removed by blast cleaning before application of the coating. However, in no case shall the coating be delayed more than eight hours after cleaning unless otherwise permitted by the purchaser.

6 APPLICATION OF COATING

The coating shall be applied as an electrostatically charged dry powder sprayed onto the grounded steel bar using an electrostatic spray gun. The powder may be applied to either a hot or cold bar. The

coated bar shall be given a thermal treatment specified by the manufacturer of the epoxy resin which will provide a fully cured finish coating. Temperature shall be controlled as recommended by the manufacturer of the coating to ensure a workman like job without blistering or other defects.

7. REQUIREMENTS OF COATED BARS

5.1.1 Coating Thickness

7.1.1 For acceptance purpose at least 90 percent of all coating thickness measurements shall be 0.1 mm to 0.3 mm after curing. The coating thickness limits do not apply to patched areas. A minimum of 15 measurements shall be taken approximately evenly spaced along each side of the test bar. At least 90 percent of these measurements shall be within the specified limits.

NOTE - By mutual agreement between the purchaser and the manufacturer, thicker coating may be accepted where the bars are not to be bent or worked after the coating has been applied.

7.2 Continuity of Coating

The coating shall be visually inspected after curing for continuity of the coating and shall be free from holes, voids, contamination, cracks and damaged areas discernible to the unaided eye. In addition, there shall be not more than an average of two holidays per 300mm when tested in accordance with **8.2**.

7.3 Adhesion

The adhesion of coating shall be evaluated on a representative number of bars selected in accordance with **9.4** from each production lot. No visible cracks or disbanding in the coating on the outside radius shall be allowed when tested in accordance with **8.3**.

8. TEST METHODS

8.1 The thickness of the coating shall be measured on the body of reinforcing bar between deformations and ribs or both, on a straight length. Non-destructive coating thickness measurements using magnetic gauges shall be used.

8.1.1 'Pencil' type pull-off gauges which require the operator to observe the reading at the instant the magnet is pulled from the surface and do not hold shims tightly against the steel plate during calibration are not recommended for use.

8.1.2 Gauge calibrating with shims shall be performed on a smooth, clean, low-carbon

steel plate (at least 75x75x13 mm), rather than on a clean reinforcing bar.

8.1.3 A correction factor defining the effect of the bar preparation process shall be obtained as the difference between (a) the average of the 10 gauge readings on a cleaned but uncoated reinforcing bar of the size and lot being coated and (b) the average of 5 gauge readings on a smooth mild steel plate. This correction factor shall than be subtracted from all subsequent gauge readings on coated bars.

8.1.4 Fixed probe gauges shall be checked to ensure that the force generated by the spring loaded probe housing is sufficient to ensure intimate contact between the probe tip and the coating on the curved bar surface. If intimate contact does not result, it will be necessary to remove the probe housing and utilize hand-pressure to obtain valid indicated thicknesses.

8.2 Holidays

Table 1 Mandrel diameter for Bend Test Requirement (Clause 8.3)

Bar diameter (mm)	Mandrel Diameter (mm)
(1)	(2)
6	60
7	80
10	100
12	100
16	125
18	150
20	150
22	200
25	200
28	225
32	280
36	280
40	400
45	450
50	500

9. FREQUENCY OF TEST

9.1 Coating thickness shall be tested at a frequency of not less than one full length bar every twenty bars for each size.

9.2 Continuity of coating shall be determined by testing one full length bars for each size.

9.3 Coating thickness over the whole of the coated bar section shall be determined

A 67.5 volts holiday detector shall be used in accordance with detector manufacturer's instructions. Detector may be an in line DC detector or a hand held DC detector.

8.3 Adhesion of Coating

The adhesion of the coating shall be evaluated by bending production coated bars 120 degrees (after rebound) around a mandrel of size as prescribed in Table 1. The bend test shall be made at a uniform rate and shall take up to 90 seconds to complete. The two longitudinal deformations shall be placed in a plane perpendicular to the mandrel radius and the test specimen shall be at thermal equilibrium between 25 C and 35 C.

NOTE – the fracture or partial failure of steel reinforcing bar in the bend test for adhesion of coating shall not be considered as an adhesion failure of the coating.

by sectioning and examining one bar in every twenty tones for each size.

9.4 For testing adhesion of coating, samples shall be selected from each size according to the frequency given below:

Nominal Bar Size/mm	No. of Samples
Up to 16	1 for every 1 T
Above 16 and upto 25	1 for every 2 T
Above 25	1 for every 4 T

10. RETEST

10.1 If the specimen for coating thickness or for adhesion of coating fails to meet the specified requirements, twice the number of samples originally selected shall be tested for each failure test. If the results of these retests meet the specified requirements, the coated bar represented by the samples shall be accepted.

11. HANDLING AND IDENTIFICATION

11.1 All systems for handling coated bars shall have padded contact areas. All bundling shall be used to prevent damage to the coating. All bundles of coated bars shall be lifted with a strong back, spreader bar, multiple supports, or a platform bridge to prevent bar-to-bar abrasion from sags in the bundles of coated bars. The bars or bundles shall not be dropped or dragged.

11.2 The identification of all reinforcing bars shall be maintained throughout the fabrication and coating processes to the point of shipment.

12. INSPECTION

All tests and inspection shall be made at the place of manufacture prior to shipment, unless otherwise specified.

13. PERMISSIBLE COATING DAMAGE AND REPAIR AFTER COATING APPLICATION

13.1 Coating damage due to fabrication and handling need not be repaired in case where the damaged area is 40 mm² or smaller.

13.2 All damaged areas larger than 40 mm² shall be repaired with patching material.

13.3 Maximum amount of damage shall not exceed 2 percent of the surface area of each bar (total of damage in **13.1** and **13.2**)

13.4 Patching shall be done in accordance with the patching material manufacturer's recommendations.

14. REJECTION

Coated bars represented by the samples that do not meet the requirements of this specification shall be rejected. By mutual agreement between the purchaser and the manufacturer, such bar may be stripped of coating, recleaned, re-coated, and resubmitted for acceptance test in accordance with the requirements of the specification.

15. MANUFACTURER'S CERTIFICATE

If requested by the purchaser, the manufacturer shall furnish, at the time of shipment, a written certificate that the

coated reinforcing bars meet the requirements of this specification.

16. IDENTIFICATION AND MARKING

16.1 The manufacturer or supplier shall mark the bars in such a way that all finished bars can be traced to the cast from which they are made or the original identification mark of the bars.

16.2 Each bundle containing the bars may also be suitably marked with the Standard Mark in which case the concerned test certificate shall also bear the Standard Mark.

For each bundle of bars a tag shall be attached indicating the Cast No./Lot No., grade and size of bars

4.2 FORM WORK (CENTRING AND SHUTTERING)**4.2.1 Form Work**

Form work, also termed as false work in IS: 14687, shall include all temporary or permanent forms or moulds required for forming the concrete which is cast-in-situ, together with all temporary construction required for their support. For detailed Guidelines on Form work for Concrete structures, IS: 14687 may be referred to.

4.2.2 Design & Tolerance in Construction

Form work shall be designed and constructed to the shapes, lines and dimensions shown on the drawings with the tolerances given below. (Clause 9.6 of IS:14687)

- a) Deviation from specified dimension of cross section of Columns and beams :
+ 12 mm to - 6 mm
- b) Deviation from dimensions of footings
 - i) Dimension in Plan : + 50 mm to - 12 mm
 - ii) Eccentricity in plan : 0.02 times the width of footings in the direction of deviation but not more than 50mm.
 - iii) Thickness : ± 0.05 times the specified thickness.

(Note : Tolerances apply to concrete dimensions only and not to positioning of vertical steel or dowels).

4.2.3 General Requirement

- a) Forms shall be designed to ensure safety of permanent constructions and of workmen.
- b) The design of form work shall conform to sound Engineering practices and relevant IS codes. It shall be strong enough to withstand the dead and live loads and forces caused by ramming and vibrations of

concrete and other incidental loads, imposed upon it during and after casting of concrete. It shall be made sufficiently rigid by using adequate number of ties and braces. Screw jacks or hard board wedges where required shall be provided to make up any settlement in the form work either before or during the placing of concrete.

c) Forms shall be so constructed as to be removable in sections in the desired sequence, without damaging the surface of concrete or disturbing other sections. Care shall be taken to see that no piece is keyed into the concrete.

d) The scheme of Form work should facilitate adequate and safe access to all areas for inspection.

e) The Form work shall be erected such that the shape and dimensions of the Concrete Structures conform to the drawings, the specifications and tolerances. Cambers, bevelled edges and mouldings if specified should be provided in the Form.

f) Commercially available Form work may be used provided they satisfy the requirements mentioned in IS: 14687-1999.

4.2.3.1 Material for Form Work

a) Propping and Centring: All propping and centring should be either of steel tubes with extension pieces or built up sections of rolled steel. Use of wooden ballies should be discouraged.

b) Centring / Staging: Staging should be as designed with required extension pieces as approved by Engineer to ensure proper slopes, as per design for slabs/beams etc. and as per levels as shown in drawings. All stagings should be either of Tubular steel structure with adequate bracings as approved or made of built up structural sections made from rolled structural steel sections.

c) In case of structures with two or more floors, the weight of concrete, centering and shuttering of any upper floor being cast shall be suitably supported on one floor below the top most floor already cast.

d) Form work and concreting of upper floor shall not be done until concrete of lower floor has set at least for 14 days.

4.2.3.2 Shuttering

Shuttering used shall be of sufficient stiffness to avoid excessive deflection and joints shall be tightly butted to avoid leakage of slurry. If required, rubberized lining of

material as approved by the Engineer shall be provided in the joints.

Steel shuttering used for concreting should be sufficiently stiffened. The steel shuttering should also be properly repaired before use and properly cleaned to avoid stains, honey combing, seepage of slurry through joints etc. Timber Shuttering should be discouraged and should be permitted only with the specific approval of the Engineer. This is in consideration of conservation of timber and the fact that the finish of concrete surface with timber shuttering cannot be as good as with steel shuttering. If wood forms are allowed to be used, the boards must be uniform in thickness, tongued and grooved, smoothly finished on the surface next to the concreting evenly matched and tightly placed, except where the desired surface or appearance requires special treatment, use of forms of Plywood / similar product which can absorb water is recommended.

4.2.3.3 Design of Form Work

Form work shall be properly designed for self weight, weight of reinforcement, weight of fresh concrete, and in addition, the various live loads likely to be imposed during the construction process (such as workmen, materials and equipment). In case the height of centering exceeds 3.50 metres, the prop may be provided in multi-stages.

4.2.3.4 Camber

Suitable camber shall be provided in horizontal members of structure, especially in cantilever spans to counteract the effect of deflection. The form work shall be so assembled as to provide for camber. The camber for beams and slabs shall be 4 mm per metre (1 to 250) or as directed by the Engineer, so as to offset the subsequent deflection. For cantilevers the camber at free end shall be $1/50^{\text{th}}$ of the projected length or as directed by the Engineer.

4.2.3.5 Walls

The form faces have to be kept at fixed distance apart and an arrangement of wall ties with spacer tubes or bolts is considered best. The two shutters of the wall are to be kept in place by appropriate ties, braces and studs.

4.2.3.6 Removal of Form work (Stripping time)

In normal circumstances and where ordinary Portland cement is used, forms may generally be removed after the expiry of the following periods. (Based on Clause 9.5.1 of IS: 14687-1999)

Type of Formwork	Minimum Period before striking Form work
(a) Vertical formwork to columns, walls, beams	16 – 24 hours
(b) Soffit formwork to slabs (Props to be refixed immediately after removal of formwork)	3 days
(c) Soffit formwork to - beams (Props to be refixed immediately after removal of formwork)	7 days
(d) Props to slabs (1) Spanning up to 4.5m (2) Spanning over 4.5 m (3) Spann	7 days 14 days
(e) Props to beams and arches: (1) Spanning up to 6m (4)(2) Spanning over 6m	14 days 21 days

Formatted: Bullets and Numbering

Note 1 For other types of cement, the stripping time recommended for ordinary Portland cement may be suitably modified. If Portland Pozzolana or low heat cement has been used for concrete, the stripping time will be 10/7 of the period stated above.

Note 2 The number of props left under, their sizes and disposition shall be such as to be able to safely carry the full dead load of the slab, beam or arch as the case may be together with any live load likely to occur during curing or further construction.

Note 3 For rapid hardening cement, 3/7 of above periods will be sufficient in all cases except for vertical side of slabs, beams and columns which should be retained for atleast 24 hours.

Note 4 In case of cantilever slabs and beams, the centering shall remain till structures for counteracting or bearing down have been erected and have attained sufficient strength.

Note 5 Proper precautions should be taken to allow for the decrease in the rate of hardening that occurs with all types of cement in cold weather and accordingly stripping time shall be increased.

Note 6 All Form work shall be removed without any shock or vibration as would damage the reinforced concrete. Before the soffits and struts are removed, the concrete surface shall be exposed, where necessary to ascertain that the concrete has sufficiently hardened.

Note 7 Work damaged through premature or careless removal of forms shall be reconstructed.

Note 8 In terms of Para 4.2.3.1 (c) above in multistoreyed buildings, the centering and shuttering of any upper floor being cast should be supported on one floor below the top most floor already cast. The props supporting such an upper floor being concreted should continue to remain in position till the form work of the freshly laid concrete can be removed.

4.2.4 Surface Treatment

4.2.4.1 Oiling the Surface

Shuttering gives much longer service life if the surfaces are coated with suitable coating or releasing agent which acts both as a parting agent and also gives surface protections. Provision of Clause 6.3 of IS: 14687 "Guidelines on False work for Concrete Structures" may be referred in this regard.

After 3-4 uses and also in cases when shuttering has been stored for a long time, it should be recoated before the next use. In no case the used black oil is to be used for oiling.

4.2.5 Inspection of Form work

The completed form work shall be inspected and approved by the Engineer before the reinforcement bars are placed in position.

Proper form work should be adopted for concreting so as to avoid honey combing, blow holes, grout loss, stains or discoloration of concrete etc., Proper and accurate alignment and profile of finished concrete surface will be ensured by proper designing and erection of form work which will be approved by Engineer.

Shuttering surface before concreting should be free from any defect/deposits and fully

4.2.5.1 Erection of Form Work (centering and shuttering)

a) Any member which is to remain in position after the general dismantling is done, should be clearly marked.

- b) Material used should be checked to ensure that, wrong items/rejects are not used.

- c) If there are any excavations nearby which may influence the safety of form works, corrective and strengthening action must be taken.

- d) i) The bearing soil must be sound and well prepared and the sole plates shall bear well on the ground.

- ii) Sole plates shall be properly seated on their bearing pads or sleepers.

- iii) The bearing plates of steel props shall not be distorted.

- iv) The steel parts on the bearing members shall have adequate bearing areas.

- e) Safety measures to prevent impact of traffic, scour due to water etc., should be taken. Adequate precautionary measures shall be taken to prevent accidental impacts etc..

- f) Bracing, struts and ties shall be installed along with the progress of form work to ensure strength and stability of form work at intermediate stage. Steel sections (especially deep sections) shall be adequately restrained against tilting, overturning and form work should be restrained against horizontal loads. All the securing devices and bracing shall be tightened.

- g) The stacked materials shall be placed as catered for in the design.

- h) When adjustable steel props are used, they should:

- i) be undamaged and not visibly bent.

- iv)ii) have the steel pins provided by the manufacturers for use.

- iv) iii) be restrained laterally near each end.

k) Screw adjustment of adjustable props shall not be over extended.

- k)) Double wedges shall be provided for adjustment of the form to the required position wherever any settlement/elastic shortening of props occurs. Wedges should be used only at the bottom end of single prop. Wedges should not be too steep and one of the pair should be tightened/clamped down after adjustment to prevent their shifting.

- k) No member shall be eccentric upon vertical member.

- m) The number of nuts and bolts shall be adequate.

- m) All provisions of the design and/or drawings shall be complied with.

Cantilever supports shall be adequate.

- ⊕n) Props shall be directly under one another in multistage constructions as far as possible.

- g) Guy ropes or stays shall be tensioned properly.

- ⊕p) There shall be adequate provision for the movement and operation of vibrators and other construction plant and equipment.

- q) Required camber shall be provided over long spans.

- r) Supports shall be adequate, and in plumb within the specified tolerances.

4.2.6 Measurements

4.2.6.1 4.2.6.1 General

The form work shall include the following:

- a) Splayed edges, notching, allowance for overlaps and passing at angles, sheathing battens, strutting, bolting, nailing, wedging, easing, striking and removal.

- b) All supports, struts, braces, wedges as well as mud sills, piles or other suitable arrangements to support the form work.

- c) Bolts, wire ties, clamps, spreaders, nails or any other items to hold the sheathing together.

- d) Working scaffolds, ladders, gangways and similar items.

- e) Filleting to form stop chamfered edges of splayed external angles not exceeding 20 mm wide to beams, columns and the like.

- f) Where required, the temporary openings provided in the forms for pouring concrete, inserting vibrators, and cleaning

holes for removing rubbish from the interior of the sheathing before pouring concrete.

- g) Dressing with oil to prevent adhesion and
- h) Raking or circular cutting.

4.2.6.2 Area to be measured

Where it is stipulated that the form work shall be paid for separately, measurements shall be taken of the area of shuttering in contact with the concrete surface. Dimensions of the form work shall be measured correct to a cm.

4.2.6.3 Classification of Measurements

The measurements shall be taken separately for the following:-

- a) Foundations, footings, bases of columns etc. and for mass concrete and pre cast shelves.
- b) Walls (any thickness) including attached pilasters, buttresses, plinth and string courses etc.,
- c) Suspended floors, roofs, landings, shelves and their supports and balconies.
- d) Lintels beams, girders bressummers and cantilevers.
- e) Columns, pillars, posts and struts.
- f) Spiral (excluding landings) except Spiral Staircase.
- g) Spiral staircases (including landings).
- h) Arches.
- i) Domes, vaults, shell roofs, arch ribs and folded plates.
- j) Chimneys and shafts.
- k) Well steining.
- l) Vertical and horizontal fins individually or forming box, louvers and bands.
- m) Waffle or ribbed slabs.
- n) Edges of slabs and breaks in floors and walls (to be measured in running metres where below 200 mm in width or thickness).
- o) Cornices and mouldings
- p) Small surfaces, such as cantilevers ends, brackets and ends of steps, caps and boxes to pilaster and columns and the like.
- q) Chullah hoods, weather shades, chhajjas, corbels etc., including edges and

4.2.6.4 Centring, and shuttering where exceeding 3.5 metre height in one floor shall be measured and paid for separately.

4.2.6.5 Where it is not specifically stated in the description of the item that form work shall be paid for separately, the rate of the RCC item shall be deemed to include the cost of form work.

4.2.6.6 No deductions from the shuttering due to the openings/ obstructions shall be made if the area of such openings/obstructions does not exceed 0.1 square metre. Nothing extra shall be paid for forming such openings.

4.2.7 Rate

The rate of the form work includes the cost of labour and materials required for all the operations described above.

4.3 REINFORCEMENT

4.3.1 General requirements

Steel conforming to para 4.1.2 for reinforcement shall be clear and free from loose mill scales, dust, loose rust, coats of paints, oil or other coatings, which may destroy or reduce bond. It shall be stored in such a way as to avoid distortion and to prevent deterioration and corrosion. Prior to assembly of reinforcement on no account any oily substance shall be used for removing the rust.

4.3.1.1 Assembly of Reinforcement

Bars shall be bent correctly and accurately to the size and shape as shown in the detailed drawing or as directed by the Engineer. Preferably bars of full length shall be used. Necessary cutting and straightening is also included in the Rates and no extra payment will be made for the same. Over lapping of bars, where necessary, shall be done as directed by the Engineer. The overlapping bars shall not touch each other and these shall be kept apart with concrete between them by 25 mm or $1\frac{1}{4}$ times the maximum size of the coarse aggregate whichever is greater. But where this is not possible, the overlapping bars shall be bound together at intervals not exceeding twice the dia. of such bars with two strands annealed steel wire of 0.90 mm to 1.6 mm twisted tight. The overlaps/splices shall be staggered as per directions of the Engineer. But in no case the over lapping shall be provided in more than 50% of cross sectional area at one section.

4.3.1.2 Bonds and Hooks Forming End Anchorages

Reinforcement shall be bent and fixed in accordance with procedure specified in IS: 2502, Code of practice for bending and fixing of bars for concrete reinforcement. The details of bends and hooks are shown below for guidance. In case of high strength deformed bars hooks are not required.

a) U – Type Hook : In case of mild steel plain bars, standard U type hook shall be provided by bending ends of rod into semicircular hooks having clear diameter equal to four times the diameter of the bar as shown in **Figure 4.1A**.

Note : In case of work in seismic zone, the size of hooks at the end of the rod shall be eight times the diameter of bar or as given in the structural drawing.

b) Bends : Bend forming anchorage to a M.S. plain bar shall be bent with an internal radius equal to two times the diameter of the bar with a minimum length beyond the bend equal to four times the diameter of the bar as shown in **Figure 4.1B**.

4.3.1.3 Anchoring Bars in Tension

Deformed bars may be used without end anchorages provided, development length requirement is satisfied. Hooks should normally be provided for plain bars in tension. Development length of bars will be determined as per IS: 456 – 2000.

4.3.1.4 Anchoring Bars in Compression

The anchorage length of straight bar in compression shall be equal to the 'Development length' of bars in compression as specified in IS: 456-2000. The projected length of hooks, bends and straight lengths beyond bend, if provided for a bar in compression, shall be considered for development length.

4.3.1.5 Binders, stirrups, links etc.,

In case of binders, stirrups, links etc., the straight portion beyond the curve at the end shall be not less than eight times nominal size of bar.

4.3.1.6 Welding of Bars

Wherever facility for electric arc welding is available, welding of bars shall be done in lieu of overlap. The location and type of welding shall be got approved by the Engineer. Welding shall be as per IS: 2751 and IS: 9417.

4.3.2 Placing in Position

4.3.2.1 Fabricated reinforcement bars shall be placed in position as shown in the drawings or as directed by the Engineer. The bars crossing one another shall be tied together at every intersection with two strands of annealed steel wire 0.9 to 1.6 mm thickness twisted tight to make the skeleton of the steel work rigid so that the reinforcement does not get displaced during deposition of concrete.

Tack welding in crossing bars shall also be permitted in lieu of binding with steel wire if approved by the Engineer.

4.3.2.2 The bars shall be kept in correct position by the following methods:-

a) In case of beam and slab construction precast cover blocks in cement mortar 1:2 (1 cement : 2 coarse sand) about 4 x 4 cm section and of thickness equal to the specified cover shall be placed between the bars and shuttering, so as to secure and maintain the requisite cover of concrete over reinforcement.

b) In case of cantilevered and doubly reinforced beams or slabs, the vertical distance between the horizontal bars shall be maintained by introducing chairs, spacers or support bars of steel at 1.0 metre or at shorter spacing to avoid sagging.

c) In case of columns and walls, the vertical bars shall be kept in position by means of timber templates with slots accurately cut in them; or with block of cement mortar 1:2 (1 Cement:2 coarse sand) of required size suitably tied to the reinforcement to ensure that they are in correct position during concreting.

d) In case of other RC.C. structures such as arches, domes, shells, storage tanks etc., a combination of cover blocks, spacers and templates shall be used as directed by the Engineer.

4.3.2.3 Tolerance on Placing of Reinforcement

Unless otherwise specified by the Engineer, reinforcement shall be placed within the following tolerances:- (National Building Code, 2005; Para 11.3.1; Part 6 Section 5.5A)

	Tolerance in spacing
(a) For effective depth, 200 mm or less	+/- 10 mm
(b) For effective depth, more than 200 mm	+/- 15 mm

4.3.2.4 Cover

Minimum cover in structural members shall be maintained as for moderate exposure. However, in slabs (excluding roof slab, chhajjas, fins) mild exposure would be permitted. The minimum nominal cover to meet durability requirements shall be as under :

Exposure	Nominal Concrete Cover in mm not less than
Mild	20
Moderate	30
Severe	45
Very severe	50
Extreme	75

Notes : 1. For main reinforcement up to 12 mm diameter bar for mild exposure the nominal cover may be reduced by 5 mm.

2. Unless specified otherwise, actual concrete cover should not deviate from the required nominal cover by + 10 mm/ -0mm.

3. For exposure condition 'severe' and 'very severe' reduction of 5 mm may be made, where concrete grade is M35 and above.

4. In terms of Para 12.3.2 Part 6 Section 5 & 5A of National Building Code, 2006, spacers, chairs and other supports detailed on drawings, together with such other supports as may be necessary, should be used to maintain the specified nominal cover to the steel reinforcement. Spacers, chairs or steel support bars should be placed at a maximum spacing of 1m. Closer spacing may sometimes be necessary. Spacers and cover blocks should be of concrete of same strength or PVC or of steel.

4.3.2.5 Bending at Construction Joints

Where reinforcement bars are bent aside at construction joints and afterwards bent back

into their original position care should be taken to ensure that at no time the radius of the bend is less than 4 bar diameters for plain mild steel or 6 bar diameters for deformed bars. Care shall be taken when bending back bars to ensure that the concrete around the bar is not damaged.

4.3.3 Measurement

Reinforcement including authorized spacer bars and laps shall be measured in length of different diameters, as actually (not more than as specified in the drgs.) used in the work nearest to a centimeter and their weight calculated on the basis of standard weight given in **Table 4.4** below. Wastage and unauthorized overlaps shall not be paid for. Annealed steel wire required for binding or tack welding shall not be measured, its cost being included in the rate of reinforcement.

Wherever tack welding is used in lieu of binding, such welds shall not be measured. Chairs, separators etc., shall be provided as directed by the Engineer and measured separately and paid for.

TABLE 4.4
CROSS SECTIONAL AREA AND MASS OF STEEL BAR
(As per IS: 1786-Clause 5.2)

Nominal Size mm	Cross Sectional Area Sq.mm.	Mass per metre Run Kg.
6	28.3	0.222
8	50.3	0.395
10	78.6	0.617
12	113.1	0.888
16	201.2	1.58
18	254.6	2.00

20	314.3	2.47
22	380.3	2.98
25	491.1	3.85
28	616.0	4.83
32	804.6	6.31
36	1018.3	7.99
40	1257.2	9.85
45	1591.1	12.50
50	1964.3	15.42

4.3.4 Rate

The rate for reinforcement shall include the cost of labour and materials required for all operations described above such as cleaning of reinforcement bars, straightening, cutting, hooking, bending, binding, placing in position etc., as required or directed including tack welding on crossing of bars in lieu of binding with wires, as well as welding of bars in lieu of overlap.

4.4 CONCRETING

4.4.1 General

The concrete shall be as specified under **Chapter 3 Concrete work**. The proportion by volume or by the weight of ingredients shall be as specified.

4.4.2 Consistency

The concrete which will flow sluggishly into the forms and around the reinforcement without any segregation of coarse aggregate from the mortar, shall be used. The consistency shall depend on whether the concrete is vibrated or hand tamped. It shall be determined by slump test as prescribed in **Chapter 3 on 'Concrete'**.

4.4.3 Placing of Concrete

4.4.3.1 Concreting shall be commenced only after the Engineer has inspected the centering, shuttering and reinforcement as placed and passed the same. Shuttering shall be clean and free from all shavings, saw dust, pieces of wood, or other foreign material and surfaces shall be treated as prescribed in para 4.2.4.

4.4.3.2 In case of concreting of slabs and beams, wooden plank or cat walks of Chequered MS plates or bamboo chalis or any other suitable material supported directly on the centering by means of wooden blocks or lugs shall be provided to convey the concrete to the place of deposition without disturbing the

reinforcement in any way. Labour shall not be allowed to walk over the reinforcement.

4.4.3.3 In case of columns and walls, it is desirable to place concrete without construction joints. The progress of concreting in the vertical direction, shall be restricted to one metre per hour.

4.4.3.4 The concrete shall be deposited in its final position in a manner to preclude segregation of ingredients. In deep trenches and footings concrete shall be placed through chutes or as directed by the Engineer. In case of columns and walls, the shuttering shall be so adjusted that the vertical drop of concrete is not more than 1.5 metres at a time.

4.4.3.5 During cold weather, concreting shall be done as stipulated in Para 3.2.11.2

4.4.3.6 During hot weather Concreting shall be done as stipulated in Para 3.2.11.3.

4.4.3.7 It is necessary that the time between mixing and placing of concrete shall not exceed 30 minutes so that the initial setting process is not interfered with unless some retarders or quick setting cement are added as per design.

4.4.4 Compaction

It shall be as specified in Para 3.2.9 of Chapter 3 'Concrete Work' of the Specification.

4.4.4.1 Concrete shall be compacted into dense mass immediately after placing by means of mechanical vibrators designed for continuous operations. The Engineer may however relax this conditions at his discretion for certain items, depending on the thickness of the members and feasibility of vibrating the same and permit hand compaction instead. Hand compaction shall be done with the help of tamping rods so that concrete is thoroughly compacted and completely worked around the reinforcement, embedded fixtures, and into

corners of the form. The layers of concrete shall be so placed that the bottom layer does not finally set before the top layer is placed. The vibrators shall maintain the whole of concrete under treatment in an adequate state of agitation, such that deaeration and effective compaction is attained at a rate commensurate with the supply of concrete from the mixers. The vibration shall continue during the whole period occupied by placing of concrete, the vibrators being adjusted so that the center of vibrations approximates to the center of the mass being compacted at the time of placing.

4.4.4.2 Concrete shall be judged to be properly compacted, when the mortar fills the spaces between the coarse aggregate and begins to cream up to form an even surface. When this condition has been attained, the vibrator shall be stopped in case of vibrating tables and external vibrators. Needle vibrators shall be withdrawn slowly so as to prevent formation of loose pockets in case of internal vibrators. In case both internal and external vibrators are being used, the internal vibrators shall be first withdrawn slowly after which the external vibrators shall be stopped so that no loose pocket is left in the body of the concrete. The specific instructions of the makers of the particular type of vibrator used shall be strictly complied with. Shaking of reinforcement for the purpose of compaction should be avoided. Compaction shall be completed before the initial setting starts, i.e. within 30 minutes of addition of water to the dry mixture or within the initial setting time if retarders have been added in the concrete.

4.4.5 Construction Joints

4.4.5.1 Concreting shall be carried out continuously up to the construction joints, the position and details of which shall be as shown in structural drawing or as indicated in **Fig.4.2** or as directed by the Engineer. Number of such joints shall be kept to minimum. The joints shall be kept at places where the shear force is the minimum. These shall be straight and shall be at right angles to the direction of main reinforcement. Construction joints should comply with IS:11817.

4.4.5.2 In case of columns the joints shall be horizontal and 10 to 15 cm below the bottom of the beam running into the column head. The portion of the column between the stepping off level and the top of the slab shall be concreted with the beam.

4.4.5.3 When stopping the concrete on a vertical plane in slabs and beams an approved stop-board (see **Fig.4.2**) shall be placed with necessary slots for reinforcement bars or any other obstruction to pass the bars freely without bending. The construction joints shall be keyed by providing triangular or trapezoidal filler nailed on the stop-board. Inclined or feather joints shall not be permitted. Any concrete flowing through the joints of stop-board shall be removed soon after the initial set. When concrete is stopped on a horizontal plane, the surface shall be roughened and cleaned after the initial set.

4.4.5.4 When the work has to be resumed, the joint shall be thoroughly cleaned with wire brush and loose particles removed. A coat of neat cement slurry at the rate of 2.75 kg. of cement per square meter shall then be applied on the roughened surface before fresh concrete is laid.

4.4.5.5 In case of bridge construction "Specification for Construction Joints" including the position of Construction Joints, preparing the surface of the Joint and concreting at Construction Joints, Appendix A (Para 8.5.3) of Concrete Bridge Code, 1997 may be referred to.

4.4.6 Expansion Joints

Expansion joints shall be provided as shown in the structural drawings or as indicated in **Figures 4.3A to 4.3P** for the purpose of general guidance or as directed by the Engineer. However it is recommended that structures exceeding 45 m in length shall be divided by one or more expansion joints. The filling of these joints with bitumen filler, bitumen felt or any such material and provision of copper plate, etc., shall be paid for separately in running metre. The measurement shall be taken up to two places of decimal stating the depth and width of joint.

4.4.7 Curing

After the concrete has begun to harden i.e. about 1 to 2 hours after its laying, it shall be protected from quick drying by covering with moist gunny bags, sand, canvas hessian or any other material approved by the Engineer. After 24 hours of laying of concrete, the surface shall be cured by ponding with water for a minimum period of 7 days from the date of placing of concrete in case of OPC and at least 10 days where mineral admixtures or blended cements are used. The period of curing shall not be less than 10 days for concrete exposed to dry

and hot weather condition. Para 3.2.12 under **Chapter 3** may also be referred.

4.4.8 Finishing

4.4.8.1 In case of roof slabs the top surface shall be finished even and smooth with wooden trowel, before the concrete begins to set.

4.4.8.2 Immediately on removal of forms, the R.C.C. work shall be examined by the Engineer, before any defects are made good.

.1 The work that has sagged or contains honey combing to an extent detrimental to structural safety or architectural concept shall be rejected as given in Para 4.4.10.5 based on visual inspection test.

.2 Surface defects of a minor nature may be accepted. On acceptance of such a work by the Engineer, the same shall be rectified as follows:-

a) Surface defects which require repair when forms are removed, usually consist of bulges due to movement of forms, ridges at form joints, honey-combed areas, damage resulting from the stripping of forms, and bolt holes.

b) Bulges and ridges are removed by careful chipping or tooling and the surface is then rubbed with a grinding stone.

c) Honey-combed and other defective areas must be chipped out, the edges being cut as straight as possible and perpendicularly to the surface, or preferably slightly undercut to provide a key at the edge of the patch.

i) Shallow patches are first treated with a coat of thin grout composed of one part of cement and one part of fine sand and then filled with mortar similar to that used in the concrete. The mortar is placed in layers not more than 10 mm thick and each layer is given a scratch finish to secure bond with the succeeding layer. The last layer is finished to match the surrounding concrete by floating, rubbing or tooling on formed surfaces by pressing the form material against the patch while the mortar is still plastic.

ii) Large and deep patches require filling up with concrete held in place by forms. Such patches are reinforced and carefully dowelled to the hardened concrete.

d) Holes left by bolts are filled with mortar carefully packed into places in small amounts. The mortar is mixed as dry as possible, with just enough water so that it

will be tightly compacted when forced into place.

e) Tiered holes extending right through the concrete may be filled with mortar with a pressure gun similar to the gun used for greasing motor cars.

f) Normally, patches appear darker than the surrounding concrete, possibly owing to the presence on their surface of less cement laitance. Where uniform surface colour is important this defect shall be remedied by adding 10 to 20 percent of white Portland cement to the patching mortar, the exact quantity determined by trial.

g) The same amount of care to cure the material in the patches should be taken as with the whole structure. Curing must be started as soon as possible, after the patch is finished to prevent early drying. Damp hessian may be used but in some locations it may be difficult to hold it in place. A membrane curing compound in these cases will be most convenient.

.3 The exposed surface of R.C.C. work shall be plastered with cement mortar 1:3 (1cement and 3 fine sand) of thickness not exceeding 6 mm to give smooth and even surface true to line and form. Any 'RCC surface which remains permanently exposed to view in the completed structure shall be considered exposed surface for the purpose of this specification. Where such exposed surface exceeding 0.5 sqm. in each location is not plastered with cement mortar 1:3 (1 cement : 3 fine sand) 6 mm thick, necessary deduction shall be made for plastering not done.

.4 The surface which is to receive plaster or where it is to be joined with brick masonry wall, shall be properly roughened immediately after the shuttering is removed, taking care to remove the laitance completely without disturbing the concrete. The roughening shall be done by hacking. Before the surface is plastered, it shall be cleaned and wetted so as to give bond between concrete and plaster.

RCC work shall be done carefully so that the thickness of plaster required for finishing the surface is not more than 6 mm.

.5 The surface of RCC slab on which the cement concrete or mosaic floor is to be laid shall be roughened with brushes while the concrete is green. This shall be done without disturbing the concrete.

4.4.9. Testing of Concrete – Grade Concrete:

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4.4.9.1 For concrete designated by Grade, Sampling and Testing shall be carried out in accordance with Clause 15 of IS:456.

4.4.9.2 The Acceptance Criteria shall be as indicated in Clause 16 of IS: 456.

4.4.9.3 In case 'established values of standard deviation' are not available for the purpose of Col. 2 of Table 11 referred in Clause 16, following values as indicated in Table 8 of IRC Bridge Code may be assumed.

TABLE 4.5
ASSUMED STANDARD DEVIATION
(Table 8 of IRC Bridge Code)

GRADE OF CONCRETE	ASSUMED STANDARD DEVIATION N/mm^2
M 20	4.6
M 25	5.3
M 30	6.0
M 35	6.3
M 40	6.6
M 45	7.0
M 50	7.4
M 55	7.6
M 60	7.8

4.4.9.4 In order to get a relatively quick idea of the quality of concrete, optional tests on beams for modulus of rupture at 72 + 2 hours or at 7 days, or compressive strength tests at 7 days may be carried out in addition to 28 days compressive strength tests. For this purpose, the values given in Table 4.6 below may be taken for general guidance in case of concrete made with

ordinary Portland cement. In all cases, the 28 days compressive strength specified in Table 3.6 on "Grades of Concrete" in Chapter 3 'Concrete Work' shall alone be the criterion for acceptance or rejection of the concrete. In terms of which the specified characteristic compressive strength at 28 days in N/mm^2 is 20 in case of M-20, 25 in case of M-25 and so on.

TABLE 4.6
OPTIONAL TESTS REQUIREMENTS OF CONCRETE
(Table 7 of IRC Bridge Code)

GRADE OF CONCRETE	COMPRESSIVE STRENGTH ON 15 cm CUBES (N/mm^2)	MODULUS OF RUPTURE BY BEAM TEST Min. (N/mm^2)	
	Min. at 7 days	At 72 + 2 h	At 7 days
(1)	(2)	(3)	(4)
M 20	13.5	1.7	2.4
M 25	17.0	1.9	2.7
M 30	20.0	2.1	3.0
M 35	23.5	2.3	3.2
M 40	27.0	2.5	3.4
M 45	30.0	2.7	3.6
M 50	33.5	2.9	3.8
M 55	37.0	3.1	4.0
M 60	40.0	3.3	4.2

4.4.9.5 Clauses 15 & 16 of IS: 456-2000 are extracted as Annexure 4.2 for ready reference.

4.4.10 Testing of Concrete - Ordinary Concrete

4.4.10.1 Regular mandatory tests on the workability of the fresh concrete shall be done to achieve the specified compressive strength of concrete as detailed in Chapter 3 'Concrete Work'. These will be of two types.

- a) Mandatory Test - Lab. Test – Cube Test for Compressive Strength of Concrete
- b) Additional Field Test - Cube Test for Compressive Strength of Concrete

Results of Field Test will prevail over Lab. Test

4.4.10.2 Mandatory Lab Test

It shall be carried out as prescribed in Annexure 4.3.

4.4.10.3 Additional Field Test

Additional test if required, shall be carried out as prescribed in **Annexure 4.4.**

4.4.10.4 Slump Test

This test shall be carried out as prescribed in Annexure 3.4 of Chapter 3 'Concrete Work'.

4.4.10.5 Visual Inspection Test

The concrete will be inspected after removal of the form work as described in Para 4.4.8.2. The question of carrying out tests described in Annexures 4.3 and 4.4 (Paras 4.4.10.2 and 4.4.10.3.) will arise only after satisfactory report of visual inspection.

The concrete is liable to be rejected if:

- (i) it is porous or honeycombed .
- (ii) its placing has been interrupted without providing a proper construction joint.
- (iii) the reinforcement has been displaced beyond tolerance specified; or construction tolerances have not been met.

However, the hardened concrete may be accepted after carrying out suitable remedial measures to the satisfaction of the Engineer at the risk and cost of the contractor.

4.4.11 Standard of Acceptance – Ordinary Concrete

Concrete shall be accepted if it satisfies the criteria laid down in para 16 of IS-456 which is reproduced in Annex 4.2.

4.4.12 Measurement

4.4.12.1 Dimensions shall be measured nearest to a cm except for the thickness of slab which shall be measured correct to 0.5 cm. The areas shall be worked out nearest

to 0.01 sqm. The cubical contents shall be worked out to nearest 0.01 cubic metre. However additional length, breadth and thickness over and above as shown in the drawings will not be paid.

4.4.12.2 Reinforced cement concrete whether cast-in-situ or precast shall be classified and measured separately as follows :

- a) Raft, footing, bases of columns etc., and mass concrete.
- b) Walls (any thickness) including attached pilasters, buttresses, plinth and string course, fillets etc.,
- c) Suspended floors, roofs, landings and balconies.
- d) Shelves
- e) Chajjas
- f) Lintels, beams and bressummers
- g) Columns, pillars, piers, abutments, posts and struts.
- h) Stair-cases including waist or waist-less slab but excluding landing except in (i) below.
- i) Spiral stair-case (including landing)
- j) Arches, arch ribs, domes and vaults.
- k) Chimneys and shafts.
- l) Well steining.
- m) Vertical and horizontal fins individually or forming box, louvers and facias.
- n) Kerbs, steps and the like.
- o) String courses, bands, coping, bed plates, anchor blocks, plain window sills and the like.
- p) Mouldings as in cornices window sills etc.,
- q) Shell, dome and folded plates.
- r) Extra for shuttering in circular work in plan.

4.4.12.3 Work under the following categories shall be measured separately.

- a) Rafts, footings, basis of columns etc., and mass concrete.
- b) All other items up to 2 floor level above Plinth
- c) Every additional floor above floor level 2
- d) R.C.C. above roof level shall be measured along with R.C.C. work in floor just below.

4.4.12.4 No deduction shall be made for the following:-

- a) Ends of dis-similar materials (e.g. Joists, beams, post girders, rafters, purlins

trusses, corbels steps etc.,) up to 500 sq cm in cross-section.

- b) Opening up to 0.10 sqm.

Note : In calculating area of openings up to 0.1 sqm the size of opening shall include the thickness of any separate lintels or sills. No extra labour for forming such openings or voids shall be paid for.

- c) The volume occupied by reinforcement.
d) The volume occupied by water pipes, conduits etc. not exceeding 25 sq_cm each in cross sectional area. Nothing extra shall be paid for leaving and finishing such cavities and holes.

4.4.12.5 Measurement shall be taken before any rendering is done in concrete members. Measurement will not include rendering. The measurement of R.C.C. work between various units shall be regulated as below:-

- a) Slabs shall be taken as running continuously through except when slab is monolithic with the beam. In that case it will be from the face to face of the beam.
b) Beams shall be measured from face to face of columns and shall include haunches, if any, between columns and beam. The depth of the beam shall be from the bottom of slab to the bottom of beam if beam and slab are not monolithic. In case of monolithic construction where slabs are integrally connected with beam, the depth of beam shall be from the top of the slab to the bottom of beam.
c) The columns measurement shall be taken through.
d) Chajjas along with its bearing on wall shall be measured in cubic metre nearest to two places of decimal. When chajja is combined with lintel, slab or beam, the projecting portion shall be measured as chajjas; built in bearing shall be measured as per item of lintel, slab or beam in which chajja bears.
e) Where the band and lintel are of the same height and the band serves as lintel, the portion of the band to be measured as lintel shall be for clear length of opening plus twice the over all depth of band.

4.4.13 Tolerances

Subject to the condition that structural safety is not impaired and architectural concept is not hampered, the tolerances in dimensions

of R.C.C. members shall be as specified in the drawings by the designer. Whenever these are not specified, the permissible tolerance shall be decided by the Engineer on lines of Para 4.2.2 above or after consultations with the Designer, if necessary.

When tolerances in dimensions are permitted, following procedure for measurements shall apply.

- a) If the actual dimensions of R.C.C. members do not exceed or are less than the design dimensions of the members plus or minus tolerance limit specified above, the design dimensions shall be taken for the purpose of measurement.
b) If the actual dimensions exceed the design dimensions by more than the tolerance limit, the design dimensions only shall be measured for the purpose of payment.
c) If the actual dimensions are less beyond the tolerance limit specified, the actual dimensions of the RCC members shall be taken for the purpose of measurement and payment.
d) For acceptance of RCC members whose dimensions are not exactly as per design dimensions, the decision of the Engineer shall be final. For the purpose of payment, however, the clarification as given in Paras a, b & c above shall apply.

4.4.14 Rate

4.4.14.1 The rate includes the cost of materials and labour involved in all the operations described above.

4.4.14.2 No extra payment for richer mix which projects into any member from another member during concreting of junctions of beams and columns etc. will be made except to the extent structurally considered necessary and when so indicated in the structural drawings. The payments for work done under items of different mixes shall be limited strictly to what is indicated in the structural drawings.

4.5 ENCASING STEEL ROLLED SECTIONS

4.5.1 General

Before concrete work is started, the Engineer shall check that all rolled steel sections to be encased, have been erected truly in position. The sections shall be unpainted and shall be wire brushed to remove the loose rust/scales etc., Where so specified, ungalvanised metal, having mesh

or perforations large enough to permit the free passage of 12.5 mm nominal size aggregate through them, shall be wrapped round the section to be encased in concrete and paid for separately.

4.5.2 Wrapping

4.5.2.1 In case of columns, the wrapping shall be arranged as illustrated in **Figure 4.4A** to pass through the center of the concrete covering. The wrapping of the entire length of the columns should be carried out in stages and no stage shall cover more than 1.5 metre of height of columns. Successive wrappings shall be carried out only after the immediate adjacent wrapping has been encased in concrete. The surface and edges of the flanges of the steel columns shall have a concrete cover of not less than 50 mm. The wrappings of successive stages shall be tied together.

4.5.2.2 In the case of beams and grillages, the wire mesh or expanded metal shall be wrapped round the lower flange of the beam as illustrated in **Figure 4.4B** and wrapping shall be suspended by wire hangers 5 mm diameter placed at about 1.2 metres centers. The surfaces and edges of the steel sections shall have a concrete cover of not less than 50 mm. The wrapping shall pass through the center of the concrete covering at the edges and soffits of the flanges.

4.5.3 Form work

This shall be as prescribed in Para 4.2

4.5.4 Concreting

Concrete shall consist of an Ordinary mix of 1:2:4 (1 cement: 2 coarse and 4 graded stone aggregate of 12.5 mm nominal size) unless a richer mix is specified. The mix shall be poured solidly around the steel sections and around the wrapping by vibrating the concrete in to position. Consistency of concrete, placing of concrete and its compaction, curing, finishing and strength of concrete shall be as described in Para 4.4.

4.5.5 Measurements

The length shall be measured correct to one cm and other dimensions correct to 0.5 cm. The cement concrete shall be measured as per gross dimensions of the encasing exclusive of the thickness of plaster. No deduction shall be made for the volume of steel sections, expanded metal, mesh or any other reinforcement used therein. However, in case of boxed stanchions or girders, the boxed portion only shall be deducted.

Fabric reinforcement such as expanded metal shall be measured separately in square metres stating the mesh and size of strands.

4.5.6 Rate

The rate shall include the cost of materials and labour required for all the operations described above except the cost of fabric reinforcement. It shall also include the cost of bending of the fabric as necessary circular cutting or wastage. The cost of providing and erecting steel section and wire hangers shall be paid for separately.

4.6 PRE CAST REINFORCED CONCRETE

4.6.1 General Requirements

4.6.1.1 Precast reinforced concrete units such as columns, fencing, posts, door and window frames, lintels, chhajjas, copings, sills, shelves, slabs, louvers etc., shall be of grade or mix as specified and cast in forms or moulds. The forms/moulds shall be of steel sections for better finish. Provision shall be made in the forms and moulds to accommodate fixing devices such as nibs, clips, hooks, bolts and forming of notches and holes. The contractor may pre cast the units on a cement or steel platform which shall be adequately oiled provided the surface finish is of the same standard as obtained in the forms. Each unit shall be cast in one operation.

4.6.1.2 Concrete used for precasting the units should be well proportioned, mixed, placed and thoroughly compacted by vibrators or tamping to give a dense concrete free from voids and honey combing.

4.6.1.3 Precast articles shall have a dense surface finish showing no coarse aggregate and shall have no cracks or crevices likely to assist in disintegration of concrete or rusting of steel or other defects that would interfere with the proper placing of the units. All angles of the pre cast units with the exception of the angles resulting from the splayed or chamfered faces shall be true right angles. The arises shall be clean and sharp except those specified or shown to be rounded. The wearing surface shall be true to the lines. On being fractured, the interior of the units should present a clean homogeneous appearance.

4.6.1.4 The longitudinal reinforcement shall have a minimum cover of 12 mm or twice the diameter of the main bar, whichever is more, unless otherwise directed in respect of all items except

fencing posts or electric posts where the minimum cover shall be 25 mm.

4.6.2 Curing

4.6.2.1 After having been cast in the mould or form the concrete shall be adequately protected during setting in the first stages of hardening from shocks and from harmful effects of frost, sunshine, drying winds and cold. The concrete shall be cured at least for 7 days from the date of casting.

4.6.2.2 The precast articles shall be matured for 28 days before erection or being built so that the concrete shall have sufficient strength to prevent damage to units when first handled.

4.6.3 Marking

Precast units shall be clearly engraved / to indicate the top of member and its location and orientation in the structure.

4.6.4 Storing and Transporting

Precast units shall be stored, transported and placed in position in such a manner that they will not be over-stressed or damaged.

4.7 PRECAST CEMENT CONCRETE JALI

4.7.1 General

The Jali shall be of cement concrete 1:2:4 (1 cement:2 coarse sand : 4 stone aggregate 6 mm nominal size) reinforced with 1.6 mm thick mild steel wire, unless otherwise specified.

4.7.2 Fixing

The Jali shall be set in position true to plumb and level before the jambs, sills and soffits of the openings are plastered. It shall then be properly grouted with cement mortar 1:3 (1 cement:3 coarse sand) and rechecked for levels. Finally the jambs, sills and soffits shall be plastered embedding the Jali uniformly on all sides.

4.7.3 Measurements

The Jali shall be measured for its gross superficial area. The length and breadth shall be measured correct to a cm. The thickness shall not be less than that specified.

4.7.4 Rate

The rate shall be inclusive of materials and labour involved in all the operations described above except plastering of jambs, sills and soffits, which will be paid for under relevant items of plastering.

4.8 MIX DESIGN

4.8.1 Mix design and proportioning

4.8.1.1 Recommended Guidelines for Concrete Mix Design are given in IS: 10262-1982 which may be referred to for details. As mentioned therein in order that not more than the specified proportion of test results are likely to fall below the characteristic strength, the concrete mix has to be designed for a somewhat higher target average compressive strength. In terms of Clause 9.2.2 of IS: 456-2000 the Target Mean Strength of Concrete mix should be equal to the characteristic strength plus 1.65 times the Standard Deviation. Mix proportions shall be designed to ensure that the workability of fresh concrete is suitable for conditions of handling and placing, so that after compaction it surrounds all reinforcements and completely fills the form work. When concrete is hardened, it shall have the stipulated strength, durability and impermeability.

4.8.1.2 Standard deviation calculations of test results based on tests conducted on the same mix design for a particular grade designation shall be done in accordance with Clause 9.2.4 of IS: 456-2000. Table 8 of IS: 456-2000 gives the standard deviation that can be assumed for design of mix in the first instance. The final standard deviation figures may be determined based on test results for the particular grade of concrete when available.

4.8.1.3 Determination of the proportions by weight of cement, aggregate and water shall be based on design of the mix.

4.8.1.4 As a trial the manufacturer of concrete may prepare a preliminary mix according to provisions of SP:23-1982. (Special Publication 23-1982 of Bureau of Indian Standards).

4.8.1.5 Mix design shall be tried and the mix proportions checked on the basis of tests conducted at a recognized laboratory approved by the Engineer.

4.8.1.6 All concrete proportions for various grades of concrete shall be designed separately and the mix proportions established keeping in view the workability for various structural elements, methods of placing and compacting.

4.8.2 Approval of Design Mix

4.8.2.1 The producer/manufacturer/contractor of concrete shall submit details of each trial mix of each grade of concrete designed for various workability conditions to the Engineer for his comments and approval. Concrete of any particular design mix and

grade shall be produced/manufactured for works only on obtaining written approval of the Engineer.

4.8.2.2 For any change in quality/quantity in the ingredients of a particular concrete, for which mix has been designed earlier and approved by the Engineer the mix has to be redesigned and approval obtained again.

4.9 TRANSPORTATION OF CONCRETE & PUMPING OF CONCRETE

4.9.1 General

Fresh concrete can be transported to the placement area by a variety of methods. Common among them are:

- Mixer trucks
- Stationary truck bodies with or without agitators.
- Buckets hauled by trucks.
- Conveyor belts.
- Hose or pipe line by pumping.

Each type of transportation has specific advantages and limitations depending on the condition of use, mix, accessibility and location of placing.

4.9.2 Transportation by Mixer Trucks

4.9.2.1 These are essentially revolving drums mounted on truck chassis. Truck mixers used in the job shall be labelled permanently to indicate the manufacturers specifications for mixing like:-

- Capacity of drum.
- Total number of drum revolutions for complete mixing.
- Mixing speed
- Maximum time limit before completion of discharge and after cement has entered the drum.
- Reduction in time period of discharge due to warm weather or other variables.

All above information shall only form guidelines for the manufacturer/producer of concrete.

4.9.2.2 Fulfilment of the stipulated number of revolutions or elapsed time shall not be the acceptable criterion. As long as the mixing water limit is not exceeded and the concrete has satisfactory plastic physical properties and is of satisfactory consistency and homogeneity for satisfactory placement and consolidation and is without initial set, the concrete shall be acceptable.

4.9.2.3 When the concrete is totally mixed in transporting trucks volume of concrete being transported shall not exceed

63% of the rated capacity of the drum. In case the concrete is totally mixed in the central batching plant, the transporting truck may be loaded up to 80% of the rated capacity of the drum. In this case the drum shall be rotated at charging speed during loading and reduced to agitating speed after loading is complete.

4.9.2.4 When transporting concrete by truck mixers, delivery time shall be restricted to 90 minutes or initial setting time whichever is less from the time cement has entered the mixer to completion of discharge.

4.9.3 Transporting by Agitating / Non-agitating Trucks.

4.9.3.1 Transporting ready mix concrete by this method shall consist of truck chassis mounted with open top bodies. The metal body shall be smooth and streamlined for easy discharge. Discharge may be from the rear when the body is mechanically tilted. Body of the truck shall have a provision of discharge gate. Mechanical vibrators shall be installed at the discharge gate for control of discharge flow.

4.9.3.2 Agitators, if mounted, also aid in the discharging of concrete from the truck in addition to keeping the concrete alive.

4.9.3.3 Water shall not be added to concrete in transport through this system.

4.9.3.4 Bodies of trucks shall be provided with protective covers during period of inclement weather.

4.9.3.5 Delivery period, when adopting this system of transporting concrete shall be restricted to 30 minutes from the moment all ingredients including cement and water enter in mixer to completion of discharge.

4.9.4 Transporting by Buckets

4.9.4.1 This method of transportation is very common for transportation of centrally mixed concrete. Buckets of suitable capacities may be filled with concrete which is totally mixed in central plant and hauled to the job site. Buckets then may be conveyed to the actual point of placement either with the help of crane/hoist or they may be carted.

4.9.4.2 As in the case of open truck transportation, extra water shall not be added to concrete transported in buckets. Concrete shall be protected from inclement weather by necessary covering arrangements. Also, maximum delivery period for this system of transportation from the time cement is introduced into the mixer

to completion of discharge shall not exceed 30 minutes.

4.9.5 Cleaning

Before loading concrete in either truck mixer, open bodied trucks or buckets, the containers shall be thoroughly cleaned, washed and dried, so that there is no water or moisture in the container which may affect the designed water content of the concrete.

4.9.6 Other Methods of Transportation

4.9.6.1 Transportation of concrete either by belt conveyors or by pumping is envisaged in some works.

4.9.6.2 If, the producer/manufacturer/purchaser of ready mix concrete desires to use such methods of transportation, they may do so provided their scheme and complete specifications are submitted to the Engineer for his record and approval.

4.9.7 Objective

4.9.7.1 Method of transportation used shall ensure:-

Efficient delivery of concrete

No significant alteration of properties with regard to water cement ratio, slump, air content and homogeneity.

4.9.7.2 All variables in transportation, considering type and accessibility of placement locations, distance, time interval etc., shall be carefully studied before arriving at the method used.

4.9.8 Pumpable Concrete (Extracted from Para 8.9 of Concrete Bridge Code, 1997)

4.9.8.1 General- Pumpable concrete is the concrete which is conveyed by pressure through either rigid pipe or flexible hose and discharged directly into the desired area. It is especially used where space for construction equipment is very limited.

4.9.8.2 Pumping Rate and Range – Depending on the equipment, pumping rate should be 10 to 70 cum. per hour. Effective pumping range is upto 300m horizontally and 90m vertically.

4.9.8.3 Proportioning Pumpable Concrete

a) **Basic Consideration** More emphasis on quality control is essential to the proportioning and use of a dependable pump mix. Concrete mixes for pumping must be plastic. Particular attention must be given to the mortar and to the amounts and sizes of coarse aggregates.

b) The maximum size of angular coarse aggregate is limited to one-third of smallest inside diameter of the hose or pipe. Provisions should be made for elimination of oversized particles in the concrete by finish screening or by careful selection of aggregates.

4.9.8.4 Pumping Concrete

a) Proper planning of concrete supply, pump locations, line layout, placing sequences and the entire pumping operation will result in saving of cost and time. The pump should be placed as near the placing area as practicable and the entire surrounding area must have adequate bearing strength. Lines from the pump to the placing area should be laid out with a minimum of bends. The pipe line shall be rigidly supported.

b) While pumping downward 15m or more, it is desirable to provide an air release valve at the middle of the top bend to prevent vacuum or air build up. When pumping upward, it is desirable to have a valve near the pump to prevent reverse flow.

4.10 PRECAST REINFORCED CONCRETE DOOR AND WINDOW FRAMES

4.10.1 Manufacture

Manufacture of precast reinforced concrete door and window frames is described here. These will conform to IS 6523 in all respects unless otherwise specified. Frames shall be manufactured in an approved factory with all necessary arrangements for fixing hinges or hinges fixed at position as specified with hole for receiving Tower bolt, sliding bolt etc., as specified.

4.10.2 Shapes and Dimensions

4.10.2.1 Precast reinforced concrete door and window frames shall be 60 x 100 mm or 70 x 75 mm in cross section for single shutter and 60 x 120 mm for double shutter door, cross section generally conforming to **Figures 4.5A to 4.5C**. Where specified, suitable groove for receiving wall plaster shall be provided.

4.10.2.2 The over all sizes (width and height) shall be as per **Figures 4.5A to 4.5C** or as specified.

4.10.3 Materials

4.10.3.1 Standard

Materials used for manufacturing of the frames shall comply with standards given in Table 1 of IS:6523.

4.10.3.2 Aggregate: The aggregate used shall be of well graded mixture of clean

coarse and fine aggregates. The normal size of coarse aggregate shall not exceed 10 mm.

4.10.3.3 Concrete: Concrete shall be as specified or as directed by the Engineer. But the mix shall not be weaker than M20 controlled mix or 1:1 ½ :3 (1 cement : 1 ½ coarse sand: 3 stone aggregate 10mm nominal size by volume mix) and shall be suitable for producing a dense concrete without voids after proper vibration.

4.10.3.4 Reinforcement: There shall be a minimum of three bars of 6 mm dia or equivalent. The longitudinal reinforcement for each vertical or horizontal member shall be one piece and shall be firmly held by 3 mm dia ties spaced at not more than 300 mm center to center.

The longitudinal reinforcement shall have a maximum cover of 12mm or twice the diameter of main bar, whichever is higher.

4.10.4 Casting

The entire frame may be cast complete in one piece or each of the vertical and horizontal members of the frames may be cast separately to be assembled into the complete frame at site. When the frame is cast in separate parts, one of the reinforcing bars of the vertical members of the frame

shall be kept projecting so as to tennon into the corresponding hole in the horizontal member. The holes in the horizontal member for taking the projecting reinforcement from the vertical members shall be slightly larger than the bar diameter to facilitate easy insertion of the projecting bars. After assembly at site, the holes shall be grouted with cement slurry of 1 cement : 2 coarse sand.

4.10.5 Mould

The mould for casting shall preferably be of steel to ensure better surface finish of the cast frame. Provision shall be made in the mould to accommodate fixing devices for hinges and the hold fasts. Where specified, suitable rebates may also be provided to act as plaster groove.

4.10.6 Protection and Curing

After casting in moulds, during setting and in first stage of hardening the concrete shall be protected from shocks, running or surface water and the harmful effect of frost, sunshine drying winds, and cold. The concrete shall be cured for at least 7 days unless special curing methods are adopted which shall conform to IS:6523.

The frames shall be matured before testing or dispatch for the following periods.

Type of cement used	Period
Ordinary Portland cement, Portland blast furnace slag cement Portland pozzolana cement	28 days
Rapid hardening cement (to be used with approval of the Engineer)	14 days

4.10.7 Arrangements for fixing of hinges to frames

Suitable arrangements for fixing hinges shall be provided in the frame by one of the following methods as directed (Ref. **Figures 4.6A to 4.6F**).

a) Hardwood fixture

Hardwood blocks of well seasoned teak or other suitable timber 150 mm long, 45 to 50 mm x 30 to 40 mm in cross section, one block for each of the hinge, shall be fixed in position with 6 mm mild steel bolts, nuts, and washers, after the frame has been cast, cured and matured. After tightening the nuts, the bolt heads and the butts shall be suitably covered with hard wood fillets, finished flush with concrete surfaces of the frame.

b) Hinge directly attached to frame. L Type flap hinge may be attached directly to

the frame with the help of 6 mm dia. mild steel bolts and nuts.

c) Hinge welded to frame.

The hinge may be welded to 3 mm thick mild steel flat embedded in a frame.

4.10.8 Arrangements for Door and Window Fixtures

Suitable arrangements shall be provided in the frame for receiving tower bolts, sliding bolts and other door and window fixtures as indicated.(See **Figure 4.6G**)

4.10.9 Fasteners

Arrangements for fixing the frames with hold fasts or metallic fasteners shall be provided in vertical members of frames as specified. In case of door frame, there will be 3 Nos. Hold fasts and in case of window, there will be 2 Nos. Hold fasts on each vertical member in contact with the

opening where the frame is to be fixed. Holes to accommodate 10 mm dia bolts to be fixed to Hold fasts and the nuts shall be left at appropriate locations. In case of windows wider than 1.20 mts the no of hold fasts or metallic fasteners in the vertical member should be increased to 3. Similarly if the height of doors or windows is more than 2.10 mts one additional unit should be provided for better stability.

4.10.10 Erection

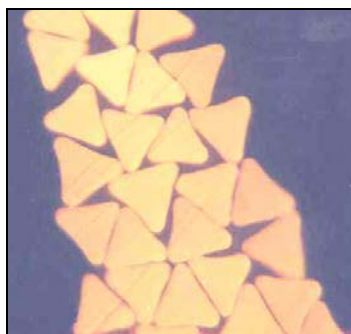
4.10.10.1 When a three piece frame is used, the vertical members shall be held in position with top member placed over them, the whole frame plumbed and firmly supported till the concrete around the hold fasts in the masonry has properly set and hardened. Cement and coarse sand mortar slurry 1:2 shall be used in grouting the joints between the vertical horizontal members of door frame. In case where four members are used, the bottom member shall be first placed in position and other erected on this base.

4.11 Use of Fibre reinforcement in plain cement concrete / RCC and plaster -

Due to inherent cement property, despite best curing efforts; micro-cracks develop in concrete and plaster due to plastic and early shrinkage during initial and final setting of concrete and plasters. These fine cracks elongate with age, increasing porosity of concrete and plastered surfaces and become a source for ingress of water resulting in seepage, leakage and development of wet patches.

Advancement in concrete technology has encouraged use of fibre reinforcement wherein the fibres act as secondary reinforcement to enhance durability and improve characteristics of concrete / cement work. Usage of Polyester Synthetic Triangular Fibres may be done in such cases. These fibres should be 100% Virgin Polymer (free of Iso Pthalic Acid). The brief Specifications of Polyester Synthetic Triangular Fibres for Plain Concrete, RCC & Cement Mortar are as below :

Description	Material	Shape	Length (mm)	Specific Gravity	Melting Point	Alkali Resistance
Plain Concrete	Polyester	Triangular	12 to 18	1.33 – 1.35	240 – 260° C	Excellent
RCC	Polyester	Triangular	12	1.33 – 1.35	240 – 260° C	Excellent
Plaster Mortar	Polyester	Triangular	6	1.33 – 1.35	240 – 260° C	Excellent



Cross-section of Triangular Polyester Fibre

1. In Batching Plant, Fibre to be dosed preferably alongwith aggregate.
2. In Site Mixer, Fibre is to be added after some water is put in mixer.
Then Sand, Cement & Aggregate can be added in any sequence.
4. In Manual Mix, Fibre is to be shaken into water container and then poured over dry mix concrete/mortar etc. and then mixed by spade.

Code Relevance : IS 456 Amendment no. 3, August 2007 is as below :

Dosage : 0.25 % By Cement Weight

Mixing Method : Fibre has water based dispersion.

Fibres : Fibres may be added to concrete for special applications to enhance properties for which specialist literature may be referred to.

ANNEXURE 4.1**NOTE ON THERMO MECHANICALLY TREATED BARS****1.0 Introduction**

Thermo Mechanically Treated (TMT) Bars is a recent technological advancement for production of high strength deformed steel bars for concrete reinforcement. In this process higher strength is obtained by thermo mechanical treatment, wherein the steel bars get intensive cooling immediately after rolling. Sudden reduction in temperature creates a hardened surface layer with the internal core still being hot. While further cooling in atmosphere, tempering takes place by the heat from the core. The process is expected to improve the properties of strength and ductility of the bars.

2.0 Advantage

Generally, the higher strength in steel can be obtained by increasing Carbon content, Micro alloying, Thermo Mechanical Treatment or cold Twisting. So far in India, cold twisting of bars was used extensively for production of high strength bars. These bars can easily be identified by the two main ribs being helical, whereas in hot rolled bars these ribs are straight. In the case of TMT Bars the higher strength is obtained by thermo mechanical treatment and the Carbon content also has been brought down leading to improved Ductility.

3.0 Properties

This steel is currently being produced in various grades by M/s. Steel Authority of India Ltd., (SAIL) M/s. Tata Steel and M/s. Rashtriya Ispat Nigam Ltd., The trade names for these bars are SAIL-TMT, TISCON-TMT and REBARS respectively. The grades, chemical properties and mechanical properties are indicated in Table A, B & C respectively.

TABLE - A
GRADES

SL	M/s Sail	M/s Tata Steel	M/s Rashtriya Ispat Nigam Ltd..	Yield Stress (0.2% proof Stress) Considering Equivalent As per IS:1786
1.	SAIL TMT 415	TISCON TMT 42	REBARS 415	415 N/MMF
2.	SAIL TMT 500	TISCON TMT 50	REBARS 500	500 N/MMF
3.	SAIL TMT 520			530 N/MMF

TABLE B
CHEMICAL COMPOSITION IN %

IS: – 1786 FE 415	SAIL TMT All Grades	TISCON TMT 42	TISCON TMT 50	(RINL) Rebars all Grades
Carbon	0.30 0.25	0.17	0.190	0.20
Sulphur	0.06 0.05	0.045	0.045	0.04
Phosphorus	0.06 0.05	0.045	0.05	0.05
Sulphur + Phosphorus	0.11 0.10	0.90	0.090	0.09

TABLE C
MECHANICAL PROPERTIES

	IS:-1786	SAIL - TMT			TISCON		VIZAG STEEL (RINL) REBARS	
Grade	Fe 415	415	500	550	TMT42	TMT50	Fe 415	Fe 500
Yield Strength	415	415	500	550	450	530	460	540
Tensile Strength	485	500	580	630	510	580	520	585
Elongation in %	14.5	22	20	18	20	18	20	18

4.0 Limitations

4.1 Standard Table of SP.16 (Design Aid to IS:456) can be used for utilizing these bars in the design process. However, there are limitations when it comes to using the strengths higher than 415 MPa in Earthquake prone areas. IS.13920 forbids using strengths higher than 415 MPa under following situations:-

- i) The structure is located in Seismic zone IV & V.
- ii) The structure is located in Seismic Zone III and has the importance factor (I) greater than 1.0.
- iii) The structure is located in Seismic Zone III and is an Industrial Structure.
- iv) The structure is located in Seismic Zone III and is more than 5 storey high.

4.2 While every care shall be taken to avoid mixing different types and grades of bars in the same structure members as main reinforcement to satisfy clause 25.1 of IS:456. Specific approval of the Engineer will be required in the exigency of more than one grade type being used in the same building.

4.3 This Note does not cover use of corrosion Resistant Steels (CRS) bars.

5.0 Identification

Care shall also be taken to properly identify these bars at site. The staff shall be specially trained for looking for identification marks on these bars. While ordering for TMT Bars, the Manufacturer should be specifically asked to advise on the methods of identification of different grades of their bars by way of identification marks on the bars and by colour code

ANNEXURE 4.2**GRADE CONCRETE****SAMPLING, STRENGTH TESTING AND ACCEPTANCE CRITERIA**

EXTRACTED FROM IS:456-2000

15. SAMPLING AND STRENGTH OF DESIGNED CONCRETE MIX**15.1 General:**

Samples from fresh concrete shall be taken as per IS: 1199 and cubes shall be made, cured and tested at 28 days in accordance with IS: 516.

15.1.1 In order to get a relatively quick idea of the quality of concrete, optional tests on beams for modulus of rupture at 72 ± 2 hours or at 7 days, or compressive strength tests at 7 days may be carried out in addition to 28 days compressive strength tests. For this purpose, the values should be arrived at based on actual testing. In all cases, the 28 days compressive strength specified in Table 2 shall alone be the criterion for acceptance or rejection of the concrete.

(Note:-Table 2 mentioned above is reproduced as Table 3.6 on "Grades of Concrete", Chapter 3 on Concrete Work, in terms of which the specified characteristic compressive strength at 28 days in N/mm^2 is 20 in case of M-20, 25 in case of M-25 and so on)

15.2 Frequency of sampling**15.2.1 Sampling Procedure -**

A random sampling procedure shall be adopted to ensure that each concrete batch shall have a reasonable chance of being tested that is, the sampling should be spread over the entire period of concreting and cover all mixing units.

15.2.2 Frequency

The minimum frequency of sampling of concrete of each grade shall be in accordance with the following :

Quantity of concrete in the work, m ³	Number of Samples
1-5	1
6-15	2
16-30	3
31-50	4
51 and above	4 plus one additional sample for each additional 50m ³ or part thereof.

NOTE - At least one sample shall be taken from each shift. Where concrete is produced at continuous production unit, such as ready-mixed concrete plant, frequency of sampling may be agreed upon mutually by suppliers and purchasers.

15.3 Test Specimen

Three test specimens shall be made from each sample for testing at 28 days. Additional samples may be required for various purposes such as to determine the strength of concrete at 7 days or at the time of striking the formwork, or to determine the duration of curing, or to check the testing error. Additional samples may also be required for testing samples cured by accelerated methods as described in IS: 9013. The specimen shall be tested as described in IS: 516.

15.4 Test Results of Sample

The test results of the sample shall be the average of the strength of three specimens. The individual variation should not be more than ± 15 percent of the average. If more, the test results of the sample are invalid.

16. ACCEPTANCE CRITERIA**16.1 Compressive Strength**

The concrete shall be deemed to comply with the strength requirements when both the following condition are met:

1. The mean strength determined from any group of four consecutive test results complies with the appropriate limits in col 2 of Table 11.

2. Any individual test result complies with the appropriate limits in col 3 of Table 11.

16.2 Flexural strength

When both the following conditions are met, the concrete complies with the specified flexural strength:

(a) The mean strength determined from any group of four consecutive test results exceeds the specified characteristic strength by at least 0.3 N/mm^2 .

(b) The strength determined from any test result is not less than the specified characteristic strength less 0.3 N/mm^2 .

16.3 Quantity of Concrete Represented by Strength Test Results

The quantity of concrete represented by a group of 4 consecutive test results shall include the batches from which the first and last samples were taken together with all intervening batches.

For the individual test result requirements given in col 2 of Table 11 or in item (b) of

16.2, only the particular batch from which the sample was taken shall be at risk.

Where the mean rate of sampling is not specified the maximum quantity of concrete that four consecutive test results represent shall be limited to 60 m^3 .

16.4 If the concrete is deemed not to comply pursuant to 16.3, the structural adequacy of the parts affected shall be investigated (see 17) and any consequential action as needed shall be taken.

16.5 Concrete of each grade shall be assessed separately.

16.6 Concrete is liable to be rejected if it is porous or honey combed; its placing has been interrupted without providing a proper construction joint, the reinforcement has been displaced beyond the tolerances specified; or construction tolerances have not been met. However, the hardened concrete may be accepted after carrying out suitable remedial measures to the satisfaction of the engineer-in-charge.

Table 11 Characteristic Compressive Strength Compliance Requirements

(Clauses 16.1 & 16.3)

Specified grade	Mean of the group of 4 Non-Overlapping Consecutive Test Results in N/mm^2	Individual Test Results in N/mm^2
(1)	(2)	(3)
M 15	$\geq f_{ck} + 0.825 \times \text{established standard deviation}$ (rounded off to nearest 0.5 N/mm^2) or $f_{ck} + 3 \text{ N/mm}^2$ whichever is greater.	$\geq f_{ck} \text{ N/mm}^2$
M 20 or above	$\geq f_{ck} + 0.825 \times \text{established standard deviation}$ (rounded off to nearest 0.5 N/mm^2) or $f_{ck} + 4 \text{ N/mm}^2$ whichever is greater	$\geq f_{ck} \text{ N/mm}^2$

(NOTE – In the absence of established value of standard deviation, the values given in Table 8 of IRC Concrete Bridge Code (Reproduced as Table 4.5 of this Chapter) may be assumed and attempt should be made to obtain results of 30 samples as early as possible to establish the value of standard deviation.)

ANNEXURE 4.3**ORDINARY CONCRETE – MANDATORY LAB TEST**

(Cube Test for Compressive Strength of Concrete)

A-0 One sample (consisting of six cubes 15 x 15 x 15 cm) shall be taken for every 20 cum or part thereof of concrete work, ignoring any part less than 5 cum or as often as considered necessary by the Engineer. The test of concrete cubes shall be carried out in accordance with the procedure as described below. A register of cubes shall be maintained at the site of work as prescribed in Annexure 4.5. The casting of cubes, concrete used for cubes and all other incidental charges such as curing, carriage to the testing laboratory shall be borne by the Contractor. The testing fee for the cubes, if any, shall also be borne by the Contractor.

A-1 Test procedure**A – 1.1 Mould**

The mould shall be of size 15 cm x 15 cm x 15 cm for the maximum nominal size of aggregate not exceeding 40 mm. For concrete with aggregate size more than 40 mm, size of mould shall be specified by the Engineer, keeping in view the fact that the length of size of mould should be about four times the size of aggregate.

The moulds for test specimens shall be made of non-absorbent material and shall be substantially strong enough to hold their form during the moulding of test specimens. They shall not vary from the standard dimensions by more than one percent. The moulds shall be so constructed that there is no leakage of water from the test specimen during moulding. All the cube moulds for particular site should, prior to use, be checked for accuracy in dimensions and geometric form and such test should at least be made once a year.

Each mould shall be provided with a base plate having a plane surface and made of non-absorbent material. This plate shall be large enough in diameter to support the moulds properly without leakage. Glass plates not less than 6.5 mm thick or plain metal not less than 12 mm thick shall be used for this purpose. A similar plate shall be provided for covering the top surface of the test specimen when moulded.

Note : Satisfactory moulds can be made from machine or steel castings, rolled metal plates or galvanized iron.

A.1.2 Sample of Concrete

Sample of concrete for test specimen shall be taken at the mixer or in the case of ready mixed concrete from the transportation vehicle discharge or as directed by the Engineer. Such samples shall be obtained by repeatedly passing a scoop or pail through the discharge stream of concrete. The sampling operation should be spread over evenly to the entire discharging operation. The samples thus obtained shall be transported to the place of moulding of the specimen. To counteract segregation, the concrete shall be mixed with a shovel until it is uniform in appearance. The location in the work of the batch of concrete thus sampled shall be noted for further reference. In case of paving concrete, samples shall be taken from the batch immediately after deposition of the sub-grade. At least five samples shall be taken from different portion of the pile and these samples shall be thoroughly mixed before being used to form the test specimen. The sampling shall be spread as evenly as possible throughout the day. When wide changes occur during concreting, additional samples shall be taken if so desired by the Engineer.

A.1.3. Preparation of Test Specimens

The interior surfaces of the mould and base plate shall be lightly oiled before the concrete is placed in the mould. The samples of concrete obtained as described under the test specimen shall be immediately moulded by one of the following methods as indicated below:-

When the job concrete is compacted by manual methods, the test specimen shall be moulded by placing the fresh concrete in the mould in three layers, each approximately one third of the volume of the mould. In placing each scoopful of concrete the scoop shall be moved around the top edge of the mould as the concrete there slides from it, in order to ensure a uniform distribution of concrete within the mould. Each layer shall be pounded 35 times with 16mm rod, 60 cm in length, bullet pointed at the lower end. The strokes shall be distributed in uniform manner over the cross section of the mould and shall penetrate into underlying layer. The bottom layer shall be pounded through its depth. After the top layer has been rodded, the surface of the concrete shall be

struck off with a trowel and covered with a glass plate at least 6.5 mm thick or a machined plate. The whole process of moulding shall be carried out in such a manner as to preclude the alteration of water-cement ratio of the concrete by loss of water, either by leakage from the bottom or overflow from the top of the mould.

When the job concrete is placed by vibration and the consistency of the concrete is such that the test specimens cannot be properly moulded by hand rodding as described above, the specimens shall be vibrated to give a compaction corresponding to that of the job concrete. The fresh concrete shall be placed in mould in two layers, each approximately half the volume of the mould. In placing each scoopful of concrete the scoop shall be moved around the top edge of the mould as the concrete there slides from it, in order to ensure a symmetrical distribution of concrete within the mould. Either internal or external vibrators may be used. The vibration of each layer shall not be continued longer than is necessary to secure the required density. The internal vibrators shall vibrate only the layer to be compacted. In compacting the first layer, the vibrators shall not be allowed to rest on the bottom of the mould. In placing the concrete for top layer there should be no mortar loss during vibrations. After vibrating the second layer enough concrete shall be added to bring level above the top of the mould. The surface of the concrete shall then be struck off with a trowel and covered with a glass or steel plate as specified above. The whole process of moulding shall be carried out in such a manner as to preclude the alteration of water-cement ratio of the concrete by loss of water, either by leakage from the bottom or over flow from the top of the mould.

A 1-4 Curing and Storage of Specimen

In order to ensure reasonably uniform temperature and moisture conditions during the first 24 hours for curing the specimen and to protect them from damage, moulds shall be covered with wet straw or gunny sacking and placed in a storage box so constructed and kept on the work site that its air temperature when containing concrete shall remain 22°C to 33°C, Other suitable

means which provide such a temperature and moisture conditions may be used.

NOTE:- It is suggested that the storage box be made of 25 mm dressed tongued and grooved timber, well braced with battens to avoid warping. The box should be well painted inside and outside and should be provided with a hinged cover and padlock.

The test specimen shall be removed from the moulds at the end of 24 hours and stored in a moist condition at a temperature within 24°C to 30°C until the time of test. If storage in water is desired, a saturated lime solution shall be used.

A – 1.5 Testing

The specimens shall be tested in accordance with procedure as described below:-

(a) The tests shall be made at an age of concrete corresponding to that for which the strengths are specified.

(b) Compression tests shall be made immediately upon removal of the concrete test specimen from the curing room i.e. the test specimen shall be loaded in damp condition. The dimensions of the test specimens shall be measured in mm accurate to 0.5 mm.

(c) The metal bearing plates of the testing machine shall be placed in contact with the ends of the test specimens. Cushioning materials shall not be used. In the case of cubes, the test specimen shall be placed in the machine in such a manner that the load is applied to sides of the specimens as cast. An adjustable bearing block shall be used to transmit the load to the test specimen. The size of the bearing block shall be the same or slightly larger than that of test specimen. The upper or lower section of the bearing block shall be kept in motion as the head of the testing machine is brought to a bearing on the test specimen.

(c) The load shall be applied axially without shock at the rate of approximately 140 kgs. per/ Sq_cm per minute. The total load indicated by the testing machine at failure of test specimen shall be recorded and the unit compressive strength is calculated in kg per sq_cm using the area computed from the measured dimensions of the test specimen. The type of failure and appearance of the concrete shall be noted.

ANNEXURE 4.4**REGISTER OF WORK TEST OF CONCRETE**

(7 days Test)

(a) Name of work	Concrete mix.(By volume)	Compressive strength in kg/cm ² on 7 days
(b) Name of contractor	1:1 ¹ / ₂ :3	175
(c) Agreement No	1:2:4	140
(d) Sample No.		
(e) Identification mark		
(f) Portion of work and quantity represented by sample.		
(g) Date and time of casting cube		
(h) Proportion of mix		

- Due date of test
- Actual date of test
- Minimum Strength
 - Maximum strength
 - Average strength of three cubes
 - Difference between 3a and 3 b
 - Difference in % age in terms of average strength
i.e. $3b-3a \times 100 =$

3c
- Specified compressive strength of concrete mix used

Cube No

REGISTER OF WORK TEST OF CONCRETE

(28 days Test)

(a) Name of work	Concrete mix.(By volume)	Compressive strength in 28 days Kg/cm ²
(b) Name of contractor	1:1 ¹ / ₂ :3	265
(c) Agreement No	1:2:4	210
(d) Sample No.		
(e) Identification mark		
(f) Portion of work and quantity represented by sample.		
(g) Date and time of casting cube		
(h) Proportion of mix		

- Due date of test
- Actual date of test
- Actual compressive strength of cubes
(Min. number of cubes to be tested-three)
 - Minimum strength
 - Maximum strength
 - Average strength of three cubes
- Specified compressive strength of concrete mix used

Cube No.

RECOMMENDED LIST OF TESTS ON MATERIALS AND WORKS

Material	Test	Field/ Lab.	Test Procedure	Minimum quantity of material for carrying out test	
Reinforced Cement Concrete (Ordinary Concrete)	(a) Slump Test	Field / Lab	Annexure 3.5 of Chapter 3	(i) 5 cum in case of column. (ii) 20 cum for slabs, beams and connected columns. (iii) 20 cum for other R.C.C. Work for all other small items and where R.C.C. done in a day is less than 5 cum test may be carried out as required by the Engineer	(i) Every 5 cum or part thereof. (ii) Every 20 cum or part thereof. (iii) -do-
	(b) Cube Test	Lab	Annexure 4.3	(i) 5 cum in case of column. (ii) 20 cum for slabs, beams and connected columns. (iii) 20 cum for other R.C.C. Work for all other small items and where R.C.C. done in a day is less than 5 cum test may be carried out as required by the Engineer	(i) Every 5 cum or part thereof. (ii) Every 20 cum or part thereof. (iii) -do-

Material	Test	Field/ Lab	Test Procedure	Minimu m quantity of material for carrying out test	Frequency of Testing	
					For consign-ment below 100 tonnes.	For consignment over 100 tonnes
Steel for Reinforc ement in RCC	Mild Steel and Medium Tensile Steel Bars					
	(a) Nominal Mass					
	(b)Tensile test	Lab/Field	IS: 1732		(i) Under 10 mm dia: one sample for each 25 t or part thereof.	(i) Under 10 mm dia, one sample for each 40 t or part thereof.
	(c) Bend test	Lab/Field	I.S:1608		(ii) 10mm to 16mm dia:one sample for each 35 t or part thereof	ii)10mm to 16mm dia, one sample for each 45 t or part thereof
	High Strength Deformed Steel Bars	Lab/Field	IS: 1599	As prescrib ed in IS: 1786	iii) Over 16mm dia: one sample for each 45 t or part thereof	iii) Over 16mm dia: one sample for each 50 t or part thereof
	(a) Nominal Mass					
	(b)Tensile test					
	(c)Bend Test	Lab/Field	I.S:1786			
	(d) Rebend Test	Lab/ Field	I.S:1608			
		Lab/Field	IS: 1599			
		Lab/Field	IS: 1786			

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FIGURE 4.1 A
SKETCH SHOWING U-TYPE HOOK FOR REINFORCEMENT

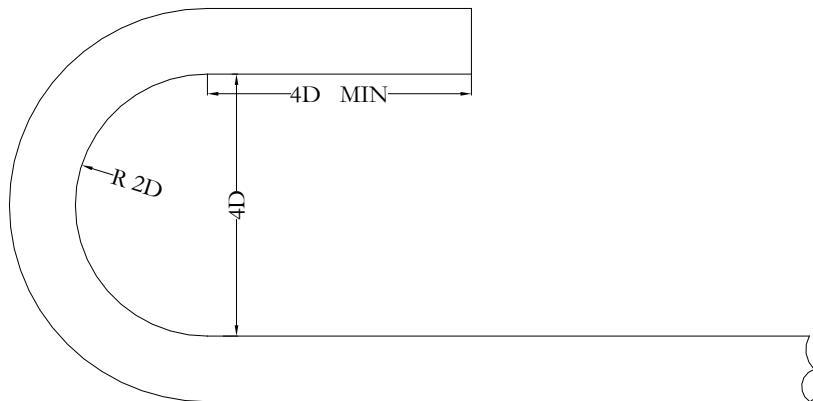


FIGURE 4.1 B
SKETCH SHOWING BENDS FOR REINFORCEMENT

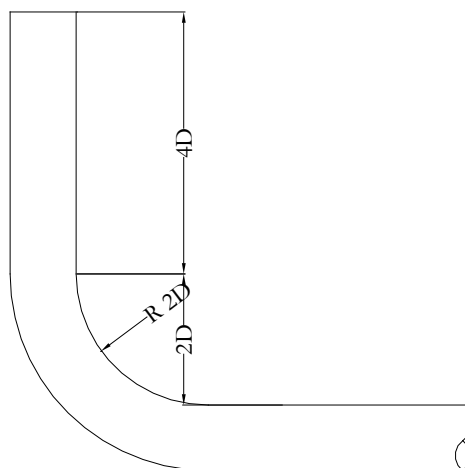
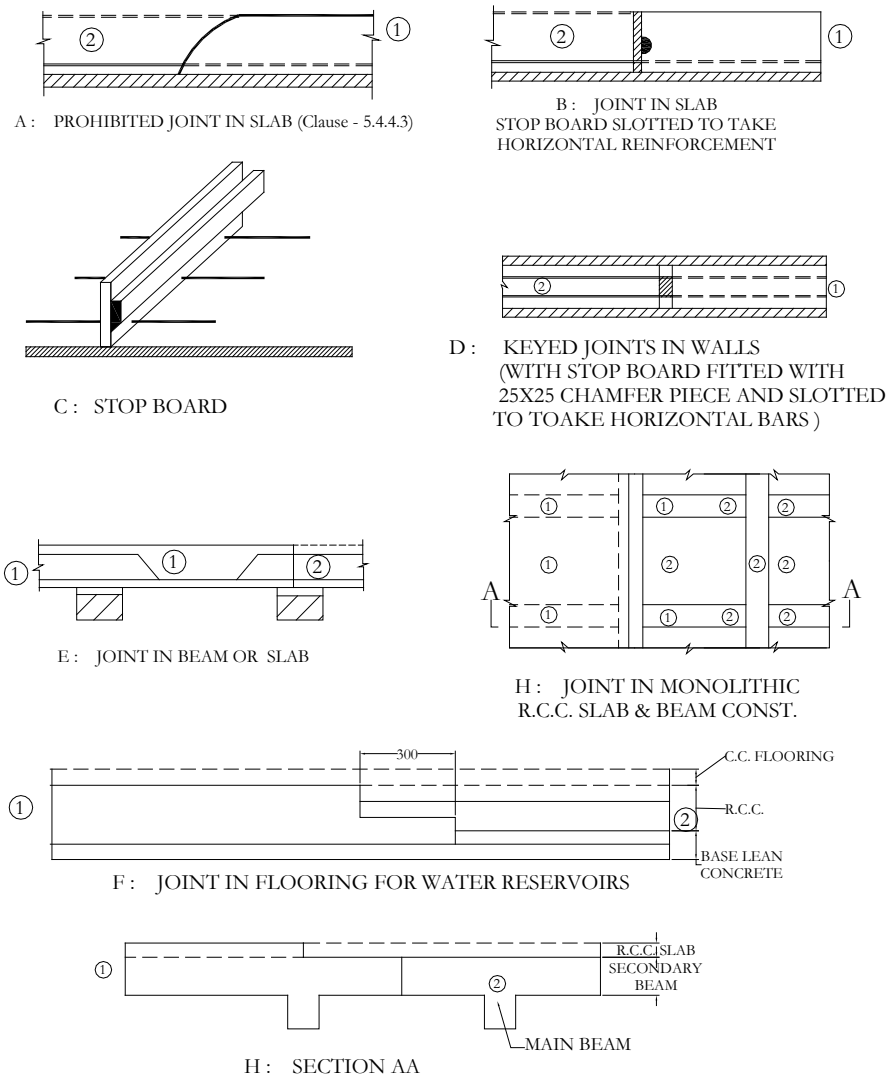


FIGURE 4.2

CONSTRUCTION JOINT AT VARIOUS LOCATIONS



- 1 : REPRESENTS FIRST PLACING OF CONCRETE.
2 : REPRESENTS SUBSEQUENT PLACING OF CONCRETE.

ALL DIMENSIONS ARE IN MM
DRAWINGS NOT TO SCALE

FIGURE 4.3 A & 4.3 B
DETAIL OF EXPANSION JOINTS IN VARIOUS LOCATIONS

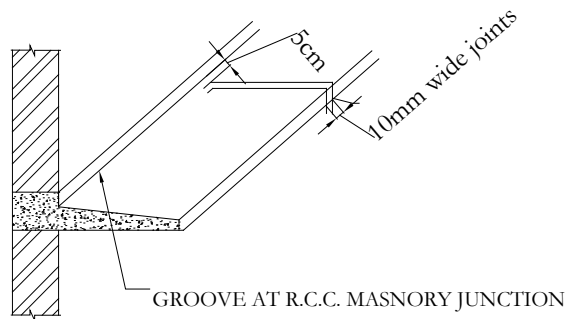


FIGURE 4.3 A : EXPANSION JOINTS IN LONG SUN SHADE

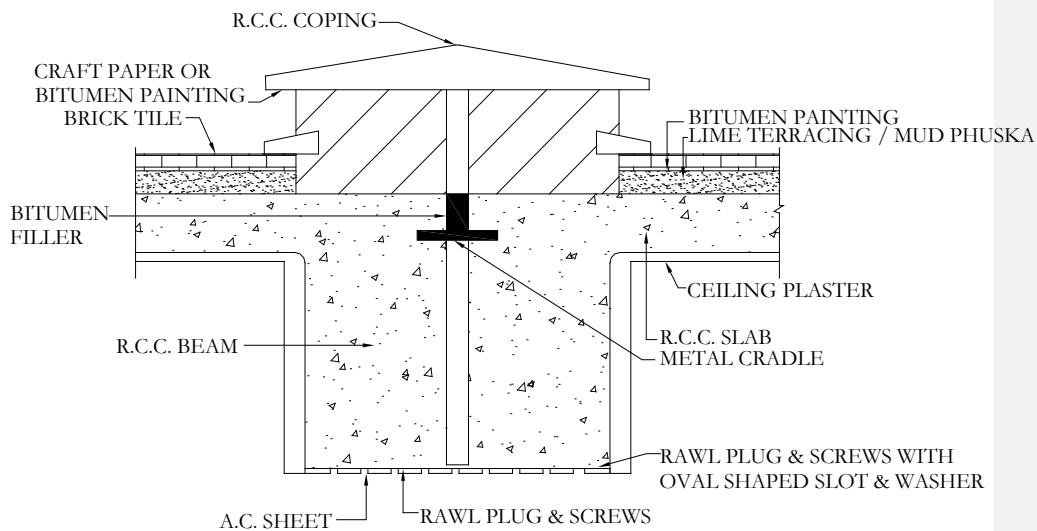


FIGURE 4.3 B : DETAILS OF RAISED TYPE EXPANSION JOINT AT ROOF

FIGURE 4.3C to 4.3E

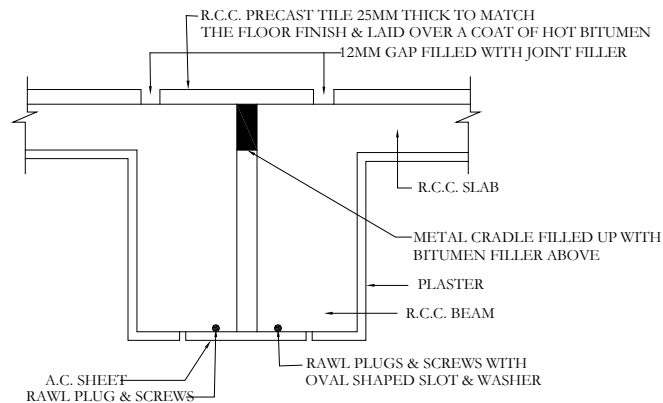


Fig 4.3C :Typical Details of Expansion joint at Floor

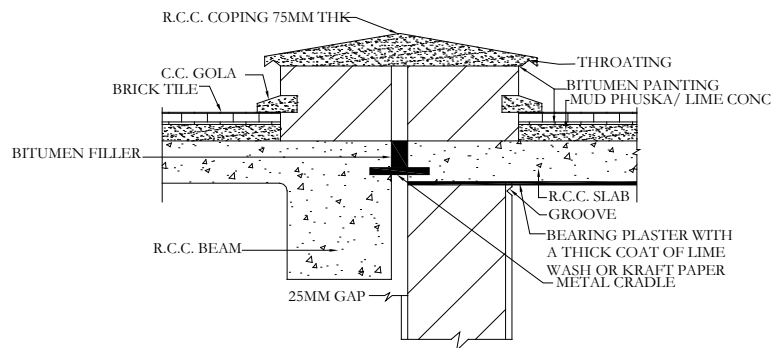


FIGURE 4.3 D :Typical Details of Expansion joint at wall & Beam Junction

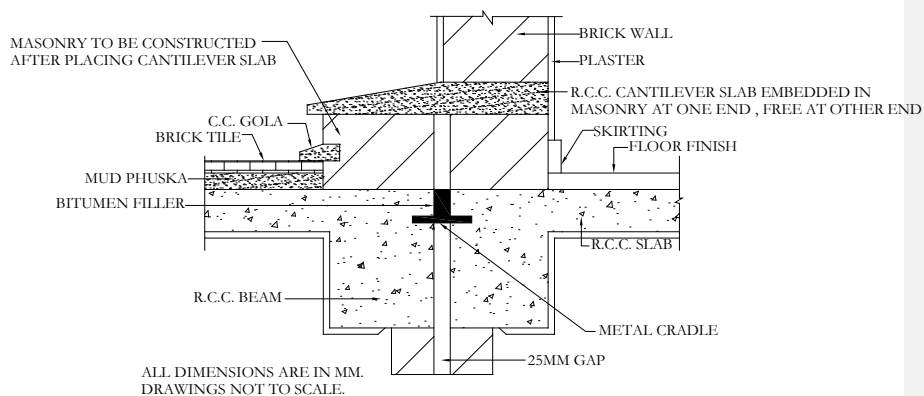


FIGURE 4.3 E :Typical Details of Expansion joint at Roof & Floor Junction

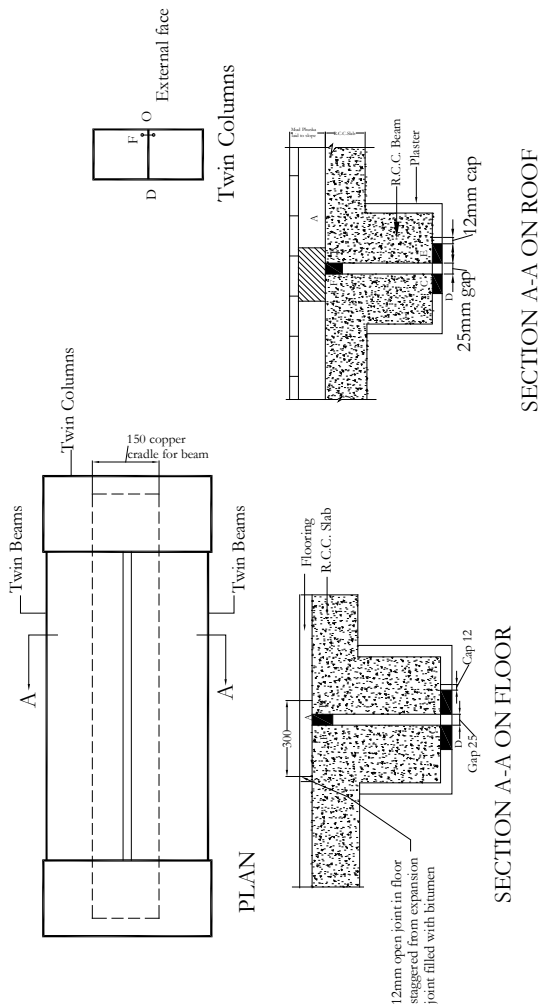


FIGURE 4.3 (F) TWIN BEAM WITH TWIN COLUMNS

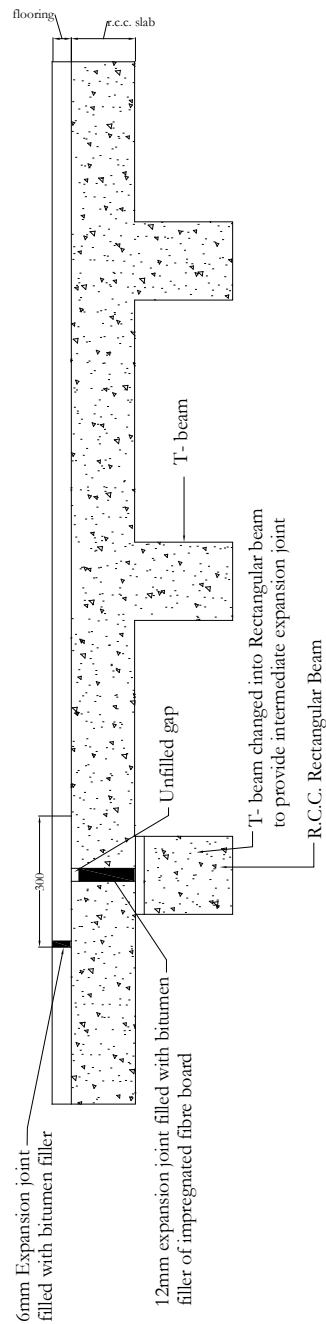


Figure 4.3 (G) Slab & T-Beam construction of Long Length

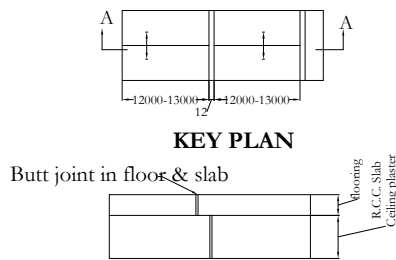


Figure 4.3 (H) Long Verandah Slab

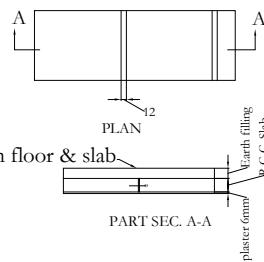


Fig 4.3 (I) Long -Water Reservoir Slab

- A Hot bitumen painting @ 1.7kg/sqm
- B Bitumen filler
- C Raw Plugs & 50mm screws @ 300mm c/c.
- D Asbestos sheet 150mm wide or P.V.C. sheet.
- E Raw Plugs & screws with oval shaped slot & washers @ 300 mm c/c.
- F Copper cradle

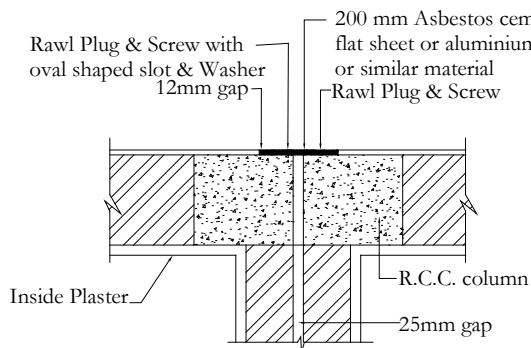


Fig 4.3 J
Typical Detail of Expansion Joint Covering
on Outer Face of Columns (Plan)

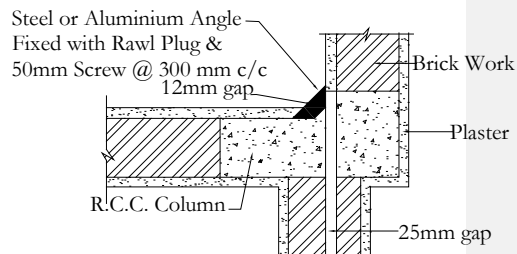


Fig 4.3 K
Typical Detail of Expansion Joints
at corner column

ALL DIMENSIONS ARE IN MM

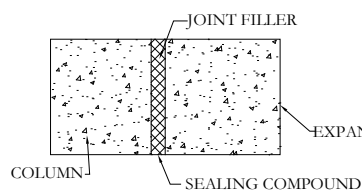


Fig 4.3 L
Typical Details of Expansion
Joint at Isolated Twin Columns

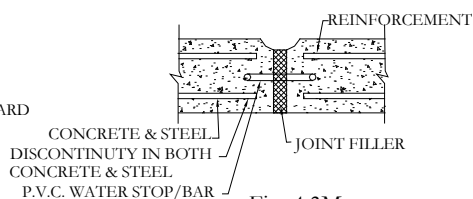
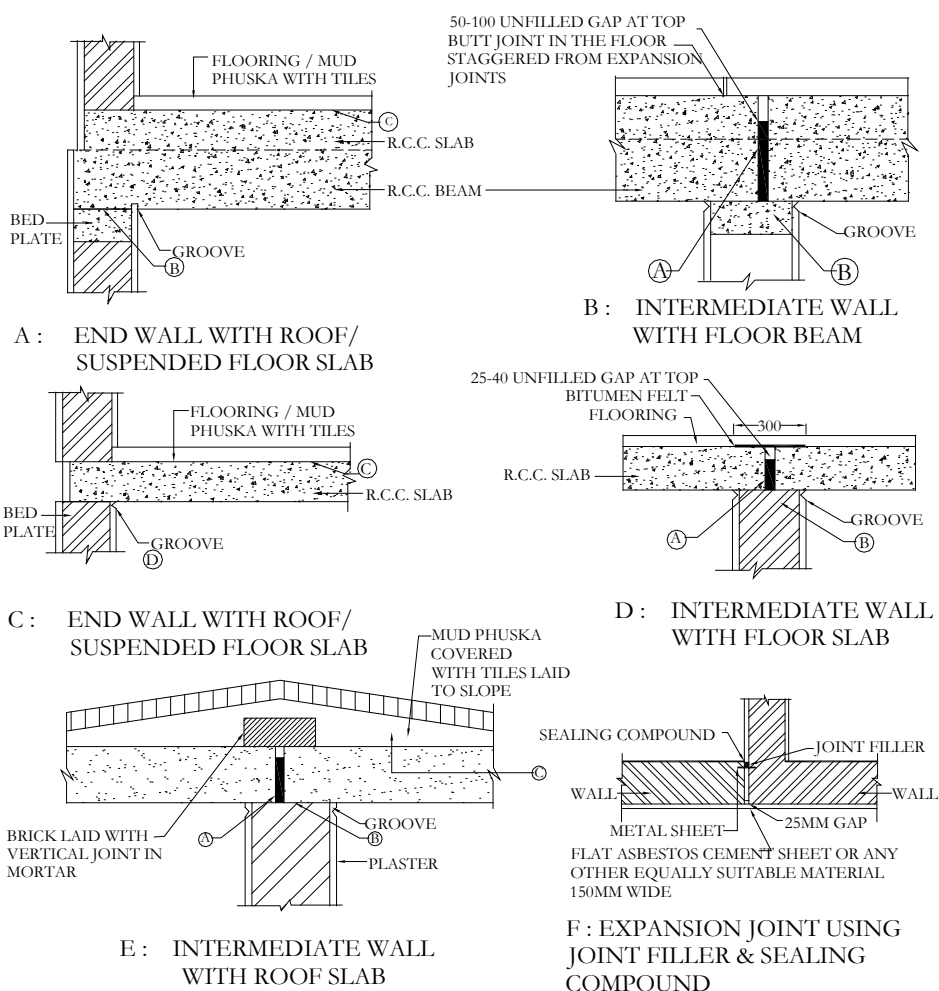


Fig 4.3M
Expansion Joint Subjected to Water
Pressure (for water Tanks)

Fig 4.3N



- A 12MM EXPANSION JOINTS FILLED WITH BITUMEN FILLER OR IMPREGNATED FIBRE.
B 6MM CEMENT PLASTER 1:3 (1C:3F:SAND) FINISHED WITH A FLOATING COAT OF NEAT CEMENT AND A THICK COAT OF LIME WASH OR LAID WITH KRAFT PAPER.
C HOT BITUMEN PAINTING @ 1.7KG/SQM IN CASE OF ROOF SLAB/BEAM
D HOT BITUMEN PAINTING @ 1.7KG/SQM BELOW BRICK WALL ONLY ON SUSPENDED FLOOR BEAM/SLAB

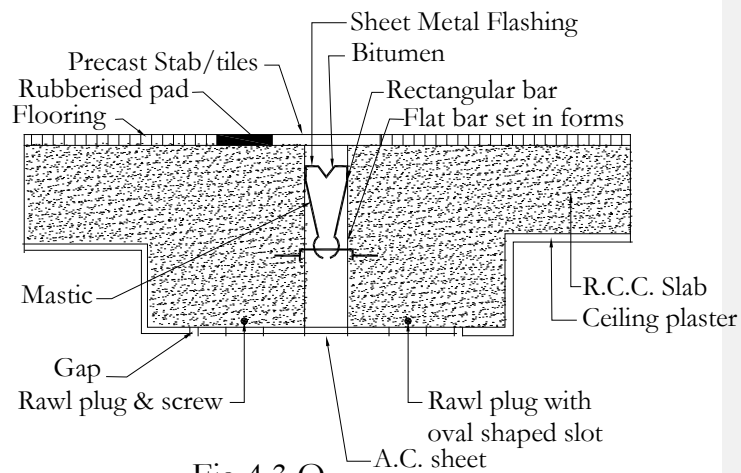


Fig 4.3 O
Seismic Separation at Floor Level

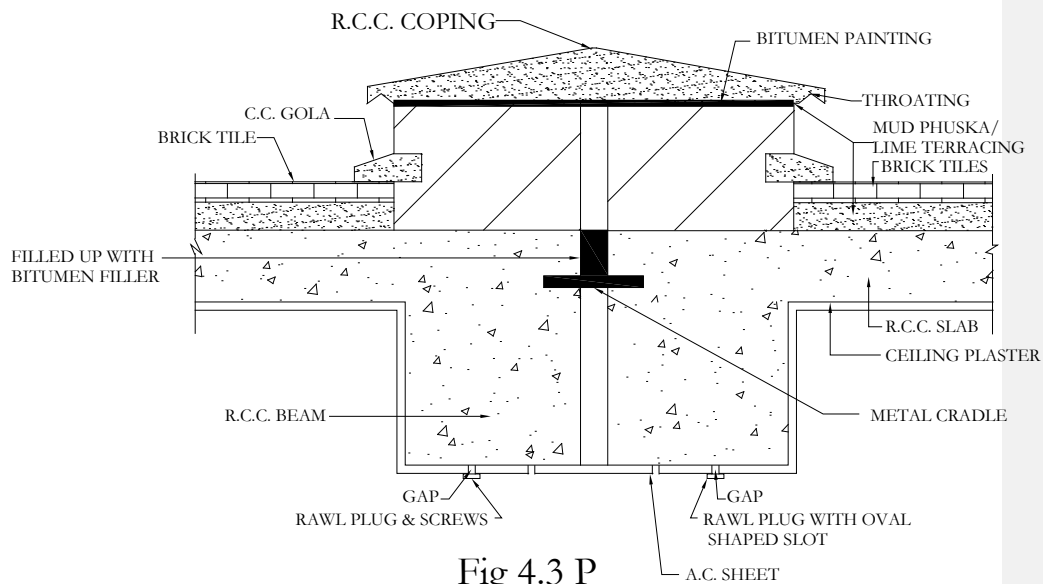
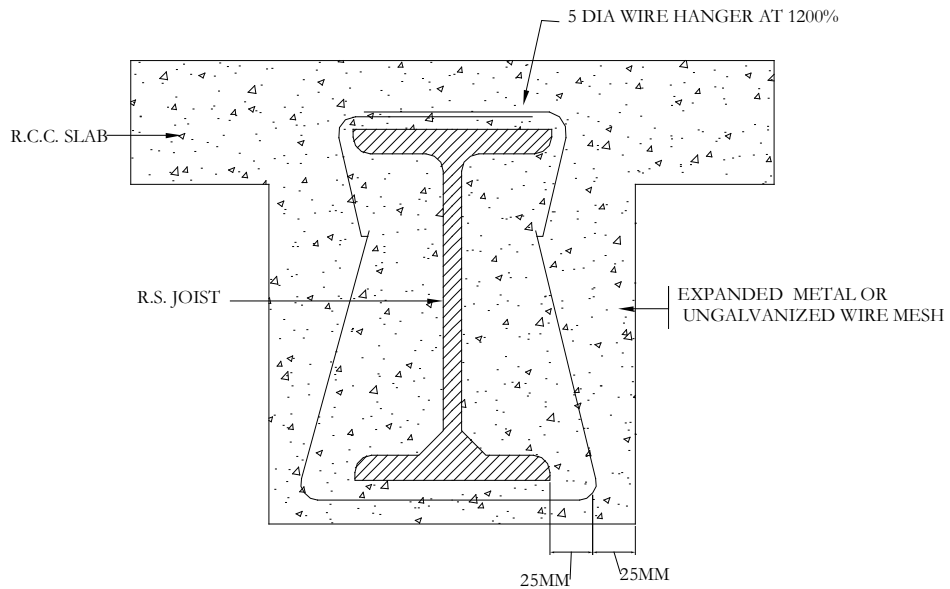


Fig 4.3 P
Seismic Separation Joints detail at Roof

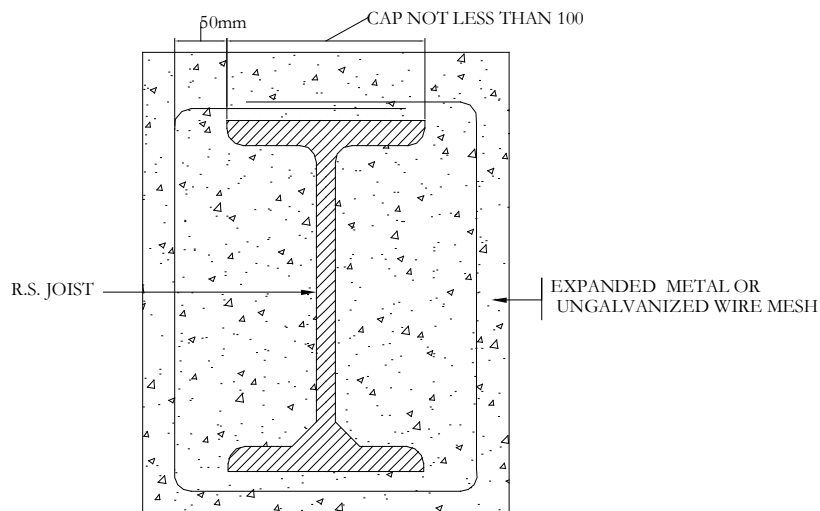
ALL DIMENSIONS ARE IN MM
DRAWINGS NOT TO SCALE

FIGURE 4.4B

ENCASING STEEL BEAM WITH SLAB



ENCASING STEEL COLUMN



Normally Cement Concrete 1:2:4 (1 Cement :2 Coarse Sand :
4 Graded Stone Aggregate 12.5 Nominal Size) shall be used.

ALL DIMENSIONS ARE IN MM.
DRAWINGS NOT TO SCALE.

FIGURE 4.5A to 4.5C

PRECAST R.C.C. DOOR - WINDOW FRAMES

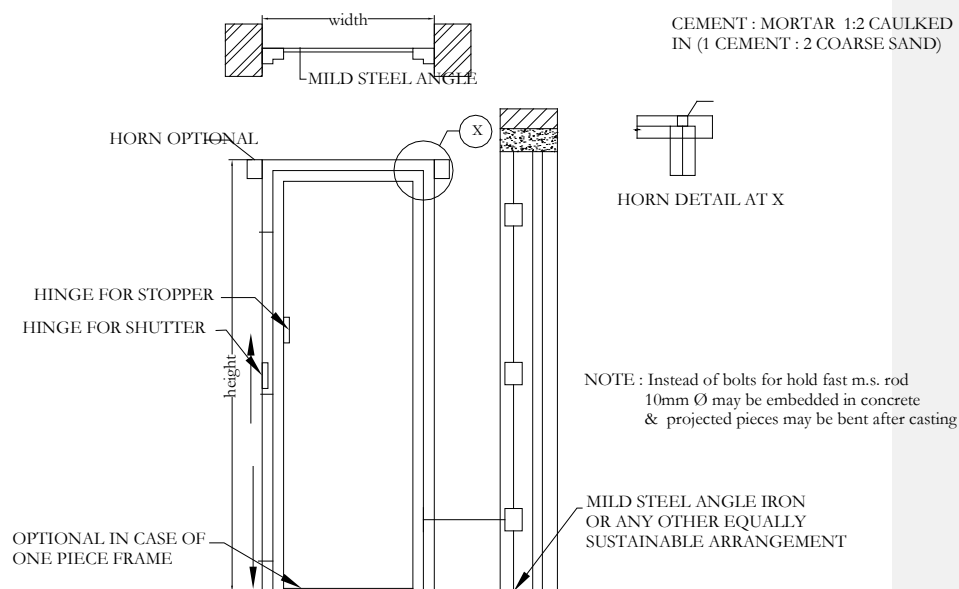


Fig 4.5A :Overall Dimensions of Precast Reinforced Concrete Door Frame

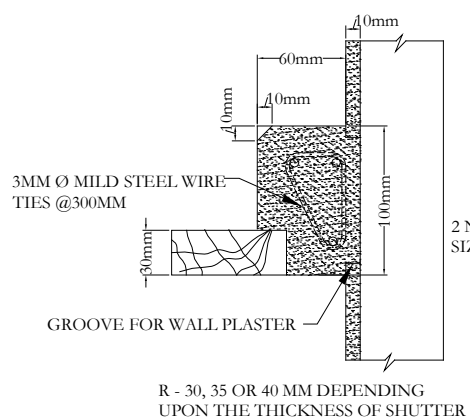


Fig 4.5 (B) : Cross Section of Precast Reinforced Concrete Door & Window Frame Showing Reinforcement

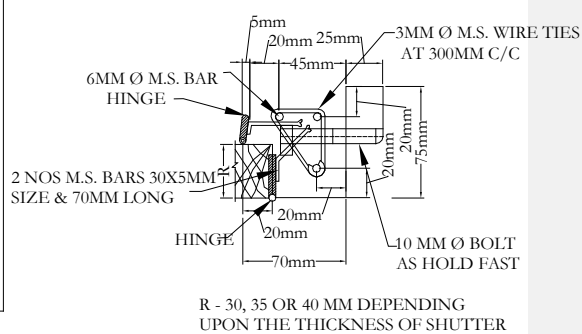
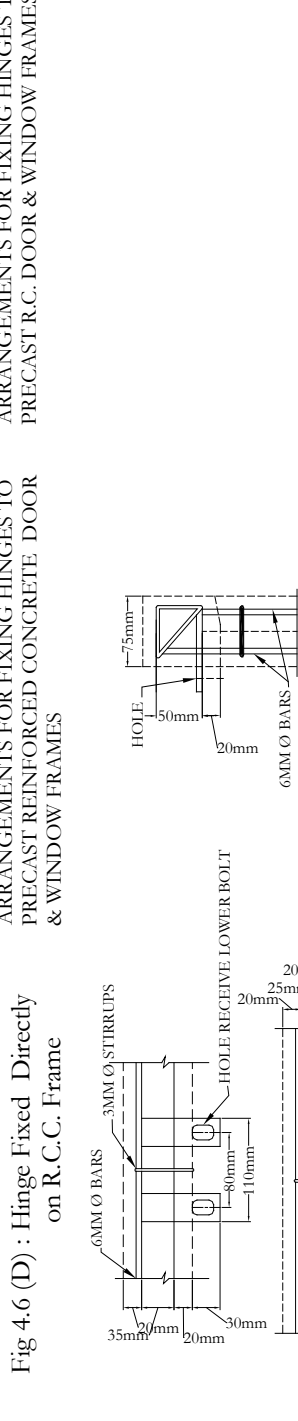
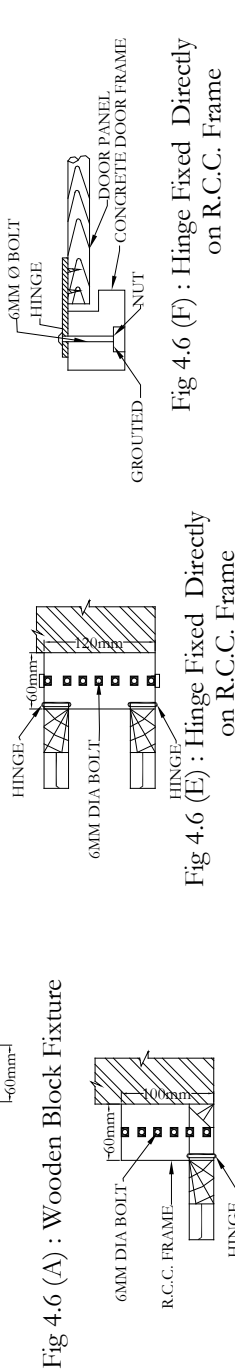
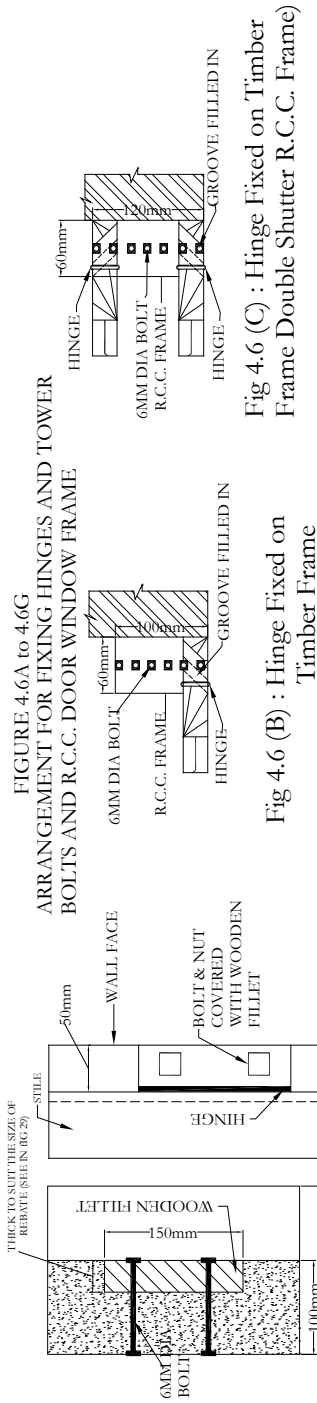


Fig 4.5 (C) : Alternative Details of Precast reinforced /concrete Door & Window Frame Showing Arrangement for Reinforcement, Hold fast & Hinges



ALL DIMENSIONS ARE IN MM.
DRAWINGS NOT TO SCALE.

Fig 4.6 (G) : Method of fixing Tower Bolts to R.C.C. Frames

Chapter 5

Brick Work

5.0. TERMINOLOGY

Arrises : The edges of a brick are formed by the inter section of the plain surfaces of the brick. The edges thus formed are called arrises. The arrises should be free from any damage and be sharp and square.

Bond : The arrangement of the bricks in successive courses to tie the brick work together both longitudinally and transversely. The arrangement is usually designed to ensure that no vertical joint of one course is exactly over the one in the next course above or below it, and there is greatest possible amount of overlap.

Bed : When the brick is laid flat the lower surface of the brick is called the bed.

Bed Joint : Horizontal joint in brick work or masonry with a layer of mortar (see Fig. 5.1A).

Closer : Any portion of a brick used in constructing a wall, to close up the bond next to the end brick of a course (See Fig.5.2A to 5.2D for Closers of different types and the purposes for which they are used).

Coping or Weathering : The cover applied over or the geometrical form given to a part of structure to enable it to shed rain water.

Corbel : A cantilever projecting from the face of wall to form a bearing (See Fig. 5.1D).

Cornice : Horizontal or ornamental feature projecting from the face of a wall (See Fig. 5.1D).

Course : A layer of bricks including bed mortar.

Cross joint : A joint other than a bed joint normal to the wall face.

Efflorescence : A powdery incrustment of salts left by evaporation. This may be visible on the surface or may be below surface. In the latter case, this is termed as crypto Efflorescence.

Frog : Indentation of depth 10 to 20mm on one of the flat sides of Hand moulded bricks of 90mm or 70mm height, with shape and size conforming to Figures referred to in Para 5.2 of IS 1077. No Frogs need to be provided in Bricks of 40mm height as well as those made by extrusion process.

Header : A brick laid with its length across the wall. (See Fig. 5.1A)

Indenting : The process of leaving recesses into which future work can be bonded.

Jamb : The part of the wall at the side of an opening.

Joint : A junction of bricks.

Jointing : The operation of finishing joints as the masonry work proceeds.

Lap : Lap is a horizontal distance between the joint of stretcher course with header course in case of brickwork in English Bond. For a good brick work the length of the lap should be equal to atleast one fourth of the length of brick. (See Fig.5.1A)

Perpends : The vertical joints of the bricks on header course and stretcher course are called as perpends. These perpends should be one above the other in alternate course. (See Fig.5.1A)

Pier : A thickened section forming integral part of the wall placed at intervals along the wall primarily to increase the stiffness of the wall or to carry a vertical concentrated load. The thickness of a pier is the over all thickness including the thickness of the wall, or when bonded into one leaf of a cavity wall the thickness obtained by treating this leaf as an independent wall (see Fig.5.1B).

Pillar : Pillar means a detached masonry support. This can be rectangular, circular, elliptical etc. In case of rectangular pillar, the breadth shall not exceed three times the thickness and thickness itself shall not exceed more than thrice the length of brick (see Fig.5.1C).

Quoin : An external corner in brick work, the term may also denote the brick used to form the quoin. (see Fig.5.1A)

Scaffolding : A temporary erection of timber or steel work used in the construction, alteration, demolition or repairs of a building to support or to assist in the hoisting or lowering of workmen, their tools and materials.

Sill : A brick work forming the lower boundary of door or window opening (see Fig.5.1D).

Spandrel : The space between the haunches and the road decking of an arch.

Strecher : A brick laid with its length in the direction of the wall. (see Fig.5.1A)

String course : A horizontal course projecting from a wall usually introduced at every floor level or windows or below parapet for imparting architectural appearance to the

structure and also keeping off the rain water (see **Fig.5.1D**).

Template : A pattern of sheet metal used as a guide for setting out specific section and shape.

Tooththing : When a brick wall has to be terminated and then continued after a considerable time, the wall is terminated vertically but to secure bondage with the new construction, alternate layer bricks are projected beyond the face of termination, and this projection of alternate bricks is called tooththing.

Wall Joint : A joint parallel to the wall face.

5.1. BRICKS/BRICK TILES/BRICK BATS

5.1.1 General : Bricks used in the masonry may be of the following types:

(a) **Common burnt clay bricks** : They shall conform to IS:1077 shall be hand moulded or machine moulded. They shall be free from nodules of free lime, visible cracks, flaws, warpage and organic matter, have a frog 100 mm in length 40 mm in width and 10 mm to 20 mm deep on one of its flat sides. Bricks made by extrusion process and brick tiles may not be provided with frogs. Each brick shall be marked (in the frog where provided) with the manufacturer's identification mark or initials.

(b) **Fly Ash Lime Bricks** : The Fly Ash Lime Bricks (FALG Bricks) shall conform to IS.12894. Visually the bricks shall be sound, compact and uniform in shape free from visible cracks, warpage, flaws and organic matter. The bricks shall be solid and with or without frog on one of its flat side.

Fly Ash : Fly ash shall conform to grade 1 or grade 2 of IS. 3812.

Note : This item will be operated only for load bearing structure up to 2 storeys and for non-load bearing walls 23 cms thick for multi-storeyed building. Fly ash used as replacement of sand shall not have more than 12% loss on ignition when tested.

Sand : Deleterious materials, such as clay and silt in the sand shall preferably be less than 5%.

Lime : Lime shall conform to class 'C' hydrated lime of IS:712.

Additives : Any suitable additive considered not detrimental to the durability of bricks may be used.

(c) **Clay fly Ash Bricks** : The clay fly ash bricks shall conform to IS.13757. The bricks shall be sound, compact and uniform in shape and colour. Bricks shall have smooth rectangular faces with sharp and square corners. The bricks shall be free from visible cracks, flaws, warpage, nodules of free lime and organic matter. The bricks shall be hand or machine moulded. The bricks shall have frog of 100 mm in length 40 mm width and 10 to 20 mm deep on one of its flat sides. If made by extrusion process may not be provided with frogs. Fly ash shall conform to grade I or grade II of IS 3812.

(d) **Tile Brick** : The bricks of 4 cm height shall be moulded without frogs. Where modular tiles are not freely available in the market, the tile bricks of F.P.S. thickness 44 mm (1.¾ ") shall be used unless otherwise specified.

(e) **Brick Bats** : Bricks bats shall be obtained from well burnt bricks. The bats shall be stacked in rectangular heaps, not less than one metre height. One cubic metre of bats shall be considered as equal to 265 Non modular bricks of size 230 x 110 x 70mm. On stack measurement shrinkage shall be deducted at 20% of the gross quantity.

(f) **Jhama Bricks** : These are over burnt bricks and as a result discoloured and distorted in shape. They are, therefore, normally unfit for good brick work.

5.1.2 Dimensions

The bricks may be modular or non-modular. Sizes of both types of bricks/tiles shall be as per **Table 5.1**. While use of modular bricks/tiles is recommended, non-modular (FPS) bricks/tiles can also be used where so specified. Non-modular bricks/tiles of sizes other than the sizes mentioned in **Table 5.1** may also be used where specified.

Table 5.1
STANDARD SIZES

(BASED ON PARA 6.1.1 & 6.1.2 OF IS 1077)

TYPES OF BRICKS/TILES	LENGTH L (mm)	WIDTH W (mm)	HEIGHT H (mm)
Modular Bricks	190	90	90
Modular tile bricks	190	90	40
Non-Modular bricks	230	110	70
Non- Modular Tile Bricks	230	110	44

Special Bricks for obtaining proper Bond arrangement and Modular dimensions for the Brickwork with the non-modular sizes	70	110	1/3 Length of Brick

5.1.3. Classification - Bricks/Brick tiles shall be classified on the basis of their minimum

compressive strength as given in **Table 5.2** below -

Table 5.2

(CLASSES OF COMMON BURNT CLAY BRICKS BASED ON TABLE 1 OF IS 1077)

Class Designation	Average compressive strength	
	Not less than	
	N/mm ²	kgf/cm ² (Approx.)
12.5	12.5	(125)
10	10.0	(100)
7.5	7.5	(75)
5	5.0	(50)
3.5	3.5	(35)

The bricks shall have smooth rectangular faces with sharp corners and shall be uniform in colour and emit clear ringing sound when struck.

5.1.4 Sampling and Tests

5.1.4.1 Samples of bricks shall be subjected to the following tests:

- Dimensional tolerance.
- Water absorption.
- Efflorescence.
- Compressive strength.

5.1.4.2 Sampling: For carrying out compressive strength, water absorption, efflorescence and dimensional tests, the samples of bricks shall be taken at random according to the size of lot as given in **Table 5.3**. The sample thus taken shall be stored in a dry place until tests are made. For the purpose of sampling, the following definition shall apply.

(a) **Lot:** A collection of bricks of same class and size, manufactured under relatively similar conditions of production. For the purpose of sampling a lot shall contain a maximum of 50,000 bricks. In case a consignment has bricks more than 50,000 of the same classification and size and manufactured under relatively similar conditions of production, it shall be divided into lots of 50,000 bricks or part thereof.

(b) **Sample:** A collection of bricks selected for inspection and/or testing from a lot to reach the decision regarding the acceptance or rejection of the lot.

(c) **Defective:** A brick failing to meet one or more of the specified requirements.

5.1.4.3 The samples shall be taken as below:

(a) **Sampling from a Stack:** When it is necessary to take a sample from a stack, the stack shall be divided into a number of real or imaginary sections and the required number of bricks drawn from each section. For this purpose bricks in the upper layers of the stack shall be removed to enable units to be sampled from places within the stack.

Note: For other methods of sampling i.e. sampling in motion and sampling from lorries or trucks, IS.5454 may be referred.

(b) **Scale of sampling and criteria for conformity for visual and dimensional characteristics:-**

(i) **Visual characteristics :** The bricks shall be selected and inspected for ascertaining their conformity to the requirements of the relevant specification. The number of bricks to be selected from a lot shall depend on the size of lot and shall be in accordance of Col.1 and 2 of **Table 5.3** for visual characteristics in all cases and dimensional characteristics if specified for individual bricks. All the bricks selected above in accordance with Col.1 and 2 of **Table 5.3** shall be examined for visual characteristics. If the number of defective bricks found in the sample is less than or equal to the corresponding number as specified in Col.3 of **Table 5.3** the lot shall be considered as satisfying the requirements of visual characteristics; otherwise the lot shall be deemed as not having met the visual requirements.

(ii) **Dimensional Characteristics:** The number of bricks to be selected for

inspecting the dimensions and tolerance shall be in accordance with Col.1 and 4 of **Table 5.3**. These bricks will be divided into groups of 20 bricks at random and each of the group of 20 bricks thus formed will be tested for all the dimensions and tolerances.

A lot shall be considered having found meeting the requirements of dimensions and tolerance if none of the groups of bricks inspected fails to meet the specified requirements.

TABLE 5.3
SCALE OF SAMPLING AND PERMISSIBLE NUMBER OF DEFECTIVES FOR VISUAL AND DIMENSIONAL CHARACTERISTICS

No. of bricks in the lot	For characteristics specified for individual bricks		For dimensional characteristics for group of 20 bricks
	No. of bricks to be selected	Permissible no. of defective in the sample	No. of bricks to be selected
2001-10000	20	1	40
10001-35000	32	2	60
35001-50000	50	3	80

(Note : In case the lot contains 2000 or less bricks the sampling shall be as per decision of the Engineer).

(c) Scale of Sampling and Criteria for Physical Characteristics: The lot which has been found satisfactory in respect of visual and dimensional requirements shall be next tested for physical characteristics like compressive strength, water absorption,

efflorescence as specified in relevant material specifications. The bricks for this purpose shall be taken at random from those already selected above. The number of bricks to be selected for each of these characteristics shall be in accordance with relevant columns of **Table 5.4**.

TABLE 5.4
SCALE OF SAMPLING FOR PHYSICAL CHARACTERISTICS

Lot size	Sample size for compressive strength, water absorption and efflorescence	Permissible No. of defectives for efflorescence
2001-10000	5	0
10001-35000	10	0
35001-50000	15	1

(Note : In case the lot contains 2000 or less bricks, the sampling shall be as per decision of the Engineer).

A lot shall be considered having satisfied the requirements of physical characteristics if the conditions stipulated here in are all satisfied.

(a) From the test results for compressive strength, the average shall be calculated and shall satisfy the requirements specified in relevant material specification.

(Note : In case any of the test result for compressive strength exceeds the upper limit for the class of bricks, the same shall be limited to the upper limit of the class for the purpose of averaging.)

(b) Wherever specified in the material specification, the compressive strength of

any individual bricks tested in the sample shall not fall below the minimum average compressive strength specified for the corresponding class of brick by more than 20 percent.

(c) From the test results for water absorption, the average for the bricks in the sample shall be calculated and shall satisfy the relevant requirements specification in material specification.

(d) The number of bricks failing to satisfy the requirements of the efflorescence specified in the relevant specification should not be more than the permissible no. of defectives given in Col.3 of **Table 5.4**.

5.1.4.4 Dimensional tolerances : The dimensions of modular and Non modular

bricks when tested as described above as per procedure described in **Annexure 5.1** shall be within the following limits per 20 bricks. Refer Para 6.2 of IS 1077 for details.

Modular Size Bricks and Tile Bricks

Length 372 to 388 cm (380 ± 8 cm)

Width 176 to 184 cm (180 ± 4 cm)

Height 176 to 184 cm (180 ± 4 cm) for 90 mm high bricks

Height 76 to 84 cm (80 ± 4 cm) for 40 mm high tile bricks

Non-Modular Size Bricks and Tile Bricks

Length 452 to 468 cms (460 ± 8 cm)

Width 216 to 224 cms (220 ± 4 cm)

Height 136 to 144 cms (140 ± 4 cm) For 70mm high bricks

Height 84 to 92 cms (88 ± 4 cm) For 44 mm high Tile Bricks

5.1.4.5 Compressive strength: The bricks, when tested in accordance with the procedure laid down in **Annexure 5.2** shall have a minimum average compressive strength for various classes as given in **Table 5.2**. The compressive strength of any individual brick tested shall not be fall below the min, compressive strength specified for the corresponding class of brick.

5.1.4.6 Water absorption: The average water absorption of bricks when tested in accordance with the procedure laid down in **Annexure 5.3** shall be not more than 20% by weight upto Class 12.5 and 15% by weight for higher classes.

5.1.4.7 Efflorescence: The rating of efflorescence of bricks when tested in accordance with the procedure laid down in **Annexure 5.4** shall be not more than moderate upto Class 12.5 and slight for higher classes.

5.1.5 Perforated Building Bricks

Perforated Bricks are light in weight and provide better thermal insulation as compared to common bricks. They are commonly used in walls and partitions. The area of perforations shall be between 30 percent and 45 percent of the total area of the corresponding face of the bricks. The perforations shall be uniformly distributed over the surface and may be of rectangular or circular shape. The area of each perforation shall not exceed 500 mm². The thickness of any shell shall not be less than 15 mm and of any web not less than 10mm. IS 2222 may be referred to further details on general quality, dimensions and tolerances, compressive strength, water absorption,

efflorescence, warpage, sampling and criterion of conformity and marking.

5.2 BRICK WORK

5.2.1. Classification - The brick work shall be classified as per the class designation of bricks used **Table 5.2** may be referred to.

5.2.2. Mortar

The mortar for the brick work shall be as specified in **Annexure 26.7 of Chapter 26 on "Mortars"** and conform to accepted standards. Lime shall not be used where reinforcement is provided in brick work.

5.2.3. Soaking of Bricks

Bricks shall be soaked in water before use for a period for the water to just penetrate the whole depth of the bricks. Alternatively bricks may be adequately soaked in stacks by profusely spraying with clean water at regular intervals for a period of not less than six hours. The bricks required for masonry work using mud mortar shall not be soaked. When the bricks are soaked they shall be removed from the tank sufficiently early so that at the time of laying they are skin-dry. Such soaked bricks shall be stacked on a clean place where they are not again spoiled by dirt, earth etc.,

Note : I. The period of soaking may be easily found at site by a field test in which the bricks are soaked in water for different periods and then broken to find the extent of water penetration. The least period that corresponds to complete soaking will be the one to be allowed for in construction work.

Note : II. If the bricks are soaked for the required time in water that is frequently changed the soluble salt in the bricks will be leached out, and subsequently efflorescence will be reduced.

5.2.4. Laying

5.2.4.1. Bricks shall be laid in English Bond unless otherwise specified. English Bond is shown in **Figures 5.3A to 5.3D**. In figure 5.3C isometric view of another popular Bond Double flemish bond is shown for comparison. The appearance on the face in Double Flemish Bond is more uniform than in English Bond and requires less number of facing bricks. But in strength, it is considered inferior to English Bond. For brick work in half brick wall, bricks shall be laid in stretcher bond. Half or cut bricks shall not be used except as closer where necessary to complete the bond. Closers in such cases, shall be cut to the required size and used near the ends of the wall. Header bond shall

be used preferably in all courses in curved plan for ensuring better alignment.

Note : Header bond shall also be used in foundation footings unless thickness of walls (width of footing) makes the use of headers impracticable. Where thickness of footing is uniform for a number of courses, the top course of footing shall be headers. In case of foundations offsets shall be preferably left over the layer laid in header.

5.2.4.2. All loose materials, dirt and set lumps of mortar which may be lying over the surface on which brick work is to be freshly started, shall be removed with a wire brush and surface wetted. Bricks shall be laid on a full bed of mortar, when laying. Each brick shall, be properly bedded and set in position by gently pressing with the handle of a trowel. Its inside face shall be buttered with mortar before the next brick is laid and pressed against it. Joints shall be fully filled and packed with mortar such that no hollow spaces are left inside the joints.

5.2.4.3. The walls shall be taken up truly in plumb or true to the required batter where specified. All courses shall be laid truly horizontal and all vertical joints shall be truly vertical. Vertical joints in the alternate course shall come directly one over the other. Quoins, Jambs and other angles shall be properly plumbed as the work proceeds. Care shall be taken to keep the perpend properly aligned within the maximum permissible tolerances given below.

- (a) Deviation from vertical within a storey shall not exceed 6 mm per 3 m height.
- (b) Deviation in verticality in total height of any wall of building more than one storey in height shall not exceed 12.5 mm.
- (c) Deviation from position shown on plan of any brick work shall not exceed 12.5 mm.
- (d) Relative displacement between load bearing walls in adjacent storey intended to be in vertical alignment shall not exceed 6 mm.

A set of tools comprising of wooden straight edge, Masonic spirit levels, square, 1 metre rule line and plumb shall be kept on the site of work for every 3 masons for proper check during the progress of work.

5.2.4.4. All quoins shall be accurately constructed and the height of brick courses shall be kept uniform. This will be checked using graduated wooden straight edge or storey rod indicating height of each course including thickness of joints. The position of damp proof course, window sills, bottom of lintels, top of the wall etc., along the height of

the wall shall be marked on the graduated straight edge or storey rod. Acute and obtuse quoins shall be bonded, where practicable in the same way as square quoins. Obtuse quoins shall be formed with squint showing three quarters brick on one face and quarter brick on the other.

5.2.4.5. The brick work shall be built in uniform layers. No part of the wall during its construction shall rise more than one metre above the general construction level. Parts of wall left at different levels shall be raked back at an angle of 45 degrees or less with the horizontal. Toothing shall not be permitted as an alternative to raking back. For half brick partition to be keyed into main walls, indents shall be left in the main walls.

5.2.4.6. All pipe fittings and specials, spouts, hold fasts and other fixtures which are required to be built into the walls shall be embedded, as specified, in their correct position as the work proceeds unless otherwise directed by the Engineer.

5.2.4.7. Top courses of all plinths, parapets, steps and top of wall below floor and roof slabs shall be laid with brick on edge, unless specified otherwise. Brick on edge laid in the top courses at corner of walls shall be properly radiated and keyed into position to form cut corners as shown in **Fig.5.3B**. Where bricks cannot be cut to the required shape to form cut corners, cement concrete 1:2:4 (1 cement:2 coarse sand: 4 graded stone aggregate 20 mm nominal size) equal to thickness of course shall be provided in lieu of cut bricks.

5.2.4.8. Bricks with Frogs shall be laid with frog down if the frog is 2cm deep. If it is 1 cm deep, the bricks may be used either frog down or up. For the bricks to be laid with frog down, the frog shall be filled with mortar before placing the bricks in position.

5.2.4.9. In case of walls one brick thick and under, one face shall be kept even and in proper plane, while the other face may be slightly rough. In case of walls more than one brick thick, both the faces shall be kept even and in proper plane.

5.2.4.10. To facilitate taking service lines later without excessive cutting of completed work, sleeves (to be paid separately) shall be provided, where specified, while raising the brick work. Such sleeves in external walls shall be sloped down outward so as to avoid passage of water inside.

5.2.4.11. Top of the brickwork in coping and sills in external walls shall be slightly tilted. Where brick coping and sills are projecting

beyond the face of the walls, drip course/throating (to be paid separately) shall be provided where indicated.

5.2.4.12. Care shall be taken during construction that edges of jambs, sills and projections are not damaged. In case of rain, new built work shall be covered with gunny bags or tarpaulins so as to prevent the mortar from being washed away. Damage, if any, shall be made good to the satisfaction of the Engineer.

5.2.4.13. Vertical reinforcement in the form of bars (MS or high strength deformed bars), considered necessary at the corners and junctions of walls and jamb opening doors, windows etc., shall be encased with cement mortar not leaner than 1:4 (1 cement : 4 coarse sand) or cement concrete mix as specified. The reinforcement shall be suitably tied, properly embedded in the foundation and at roof level. The dia. of bars shall not be less than 8 mm and concrete grade shall be minimum 1:3:6 (1 cement : 3 coarse sand : 6 graded stone aggregate 20 mm nominal size).

5.2.4.14. In retaining walls and the like, where water is likely to accumulate, weep holes, 50 to 75 mm square shall be provided at 2 m vertically and horizontally unless otherwise specified. The lowest weep hole shall be at about 30 cm above the ground level. All weep holes shall be surrounded by loose stones and shall have sufficient fall to drain out the water quickly.

(Note: Work of providing such loose stones will be payable extra).

5.2.4.15. Work of cutting chases, wherever required to be made in the walls for housing G.I. pipe, CI pipe or any other fixtures shall be carried out in various locations as per guidelines given below:-

(a) Cutting of chases in one brick thick and above load bearing walls.

(i) As far as possible services should be planned with the help of vertical chases. Horizontal chases should be avoided.

(ii) The depths of vertical chases and horizontal chases shall not exceed one-third and one-sixth of the thickness of the masonry respectively.

(iii) When narrow stretches of masonry (or short length of walls) such as between doors and windows, cannot be avoided they should not be pierced with openings for soil pipes or waste pipes or timber joints, etc., Where there is a possibility of load concentration, such narrow lengths of walls shall be checked for stresses and high strength

bricks in mortar or concrete walls provided, if required.

(iv) Horizontal chases when unavoidable should be located in the upper or lower one-third of height of storey and not more than three chases should be permitted in any stretch of a wall. No continuous horizontal chase shall exceed one metre in length. Where unavoidable, stresses in the affected area should be checked and kept within the permissible limits.

(v) Vertical chases should not be closer than 2 metres in any stretch of a wall. These shall be kept away from bearings of beams and lintels. If unavoidable, stresses in the affected area should be checked and kept within permissible limits.

(vi) Masonry directly above a recess, if wider than 30 cm horizontal dimension should be supported on lintel. Holes in masonry may be provided up to 30 cm width and 30 cm height without any lintel. In the case of circular holes in the masonry, no lintel need be provided for holes up to 40 cm in diameter.

(b) Cutting of chases in half brick load bearing walls: No chase shall be permitted in half brick load bearing walls and as such no recessed conduits and concealed pipes shall be provided with half brick thick load bearing walls.

(c) Cutting of chases in half brick non-load bearing walls: Services should be planned with the help of vertical chases. Horizontal chase should be provided only when unavoidable.

5.2.4.16 Pilasters : These shall be so set out to avoid a broken bond.

5.2.4.17 Openings : a) The depths of reveals and rebates, shall, where practicable conform to standard brick sizes to avoid cutting of bricks and thereby weakening the masonry. The arrangement of bonds at Quoins and at jambs of openings shall be symmetrical.

(b) Openings shall be of such size and so spaced in walls as to reduce the cutting of bricks to minimum. The width of openings shall, as far as possible, be a multiple of width of brick.

In the external walls, it is desirable to rebate the sills, jambs and heads of openings so as to form a barrier for rainwater. The sill may be sloped slightly to allow the rain water to drain off.

5.2.4.18 Parapets and Copings

(a) The parapets and copings shall be of thickness such that their base covers the junction of roof slab and wall which shall be further effectively treated against possible leakage of rain water. Normally a cement lime mortar 'gola' /cement concrete gola or fillet is done. **Figure 5.4** maybe seen for details.

(b) Coping may be of stone, concrete, brick or terracota. It is to be throated underside of the projections. The top of the coping shall be slightly sloped to allow water to drain off.

5.2.4.19 Brick work in Mud Mortar:-

a) Unless otherwise specified, all Brickwork in mud mortar shall have the top 30 cm of walls and partitions as well as 30 cm alround door, window and other openings built in cement mortar.

b) Thickness of Joints shall not exceed 12mm.

5.2.5. Joints

5.2.5.1 The thickness of all types of joints including brick wall joints and cross joints shall be such that four courses and three joints taken consecutively shall measure as follows:-

(i) In case of modular bricks conforming to IS.1077 specification for common burnt clay buildings bricks, equal to 39 cm.

(ii) In case of non-modular bricks, it shall be equal to 31 cm.

Note: Specified thickness of joints shall be of 1 cm. Deviation from the specified thickness of all joints shall not exceed one-fifth of specified thickness i.e. 8 mm -12 mm.

5.2.5.2 Finishing of Joints: The face of brick work may be finished flush or by pointing. In flush finishing either the face joints of the mortar shall be worked out while still green to give a finished surface flush with the face of the brick work or the joints shall be squarely raked out to a depth of 1 cm while the mortar is still green for subsequently plastering. The faces of brickwork shall be cleaned with wire brush so as to remove any splashes of mortar during the course of raising the brick work. In pointing, the joints shall be squarely raked out to a depth of 1.5 cm while the mortar is still green and raked joints shall be brushed to remove dust and loose particles and well wetted, and shall be later refilled with mortar to give ruled finish. Some such finishes are 'flush', 'weathered', "keyed", "tucked" and "Raked" as shown in **Figure 5.5**.

5.2.6. Curing

The brick work shall be constantly kept moist on all faces for a minimum period of seven days. Brick work done during the day shall be suitably marked indicating the date on which the work is done so as to keep a watch on the curing period.

5.2.7. Scaffolding

Scaffolding shall be strong to withstand all dead, live and impact loads which are likely to come on them. Scaffolding shall be provided to allow easy approach to every part of the work.

5.2.7.1. Single Scaffolding : Where plastering, pointing or any other finishing has been indicated for brick work, single scaffolding may be provided, unless otherwise specified. In single scaffolding, one end of the put-logs /pole shall rest in the hole provided in the header course of brick masonry. Not more than one header for each put-log/pole shall be left out. Such holes shall not be allowed in the case of pillars, brick work less than one metre in length between the openings or near the structural member supported by the walls. The holes for put-logs/poles shall be made good with brick work and wall finishing as specified.

5.2.7.2. Double Scaffolding : Where the brick work or tile work is to be exposed and not to be finished with plastering etc., double scaffolding having two independent supports, clear of the work, shall be provided.

5.2.8. Measurements

5.2.8.1. Brick work shall be measured in cubic metres unless otherwise specified. Any extra work over the specified dimensions shall be ignored. Dimensions shall be measured correct to the nearest 0.01 m i.e. 1 cm. Areas shall be calculated to the nearest 0.01 sqm and the cubic contents shall be worked out to the nearest 0.01 cum.

5.2.8.2. Brick work shall be measured separately in the following stages:

- (a) In foundation and plinth
- (b) From Plinth level to floor two levels
- (c) Beyond floor two level above plinth level for every additional floor or part thereof

Note : (1) Brick work in parapet walls, mummy, lift machine room and water tanks constructed on the roof upto 1.2 m height above roof shall be measured together with the corresponding work of the floor next below.

(2) Plinth Level:- For the purpose of measurement for masonry in plinth and foundation and for masonry in super-

structure, the plinth level shall be determined as given below:

- i) For buildings: Ground floor level or 1.2 metres above GL whichever is lower.
- ii) For abutments, piers & return walls of culverts & bridges, walls of water reservoirs and basements - Floor level
- iii) For retaining walls where floor level is not determinate: 1.2 metres above average ground level or bed level
- iv) For breast walls: Formation level
- v) For platform walls: Formation level

5.2.8.3. No deductions or additions shall be done and no extra payment made for the following:

- (a) Ends of dissimilar materials (that is, joists, beams, lintels, posts, girders, rafters, purlins, trusses, corbels, steps etc.) up to 0.1 m^2 in section.
- (b) Opening up to 0.1 m^2 in area (see Note).
- (c) Wall plates, bed plates and bearing of slabs, chhajjas and the like, where thickness does not exceed 10 cm. and bearing does not extend over the full thickness of walls:
- (d) Cement concrete blocks as for hold fasts and holding down bolts.
- (e) Iron fixtures, such as wall ties, pipes up to 300 mm diameter and hold fasts for doors and windows.
- (e) Chases of section not exceeding 50 cm. in girth; and
- (f) Bearing portion of drip course, bearing of moulding and cornice.

Note : i) In calculating area of an opening, any separate lintel or sills shall be included with the size of the opening but end portions of lintel shall be excluded. Extra width of rebated reveals, if any, shall also be excluded.

ii) Where minimum area is defined for deduction of an opening, void or both, such areas shall refer only to opening or void within the space measured.

5.2.8.4. Walls half brick thick and less shall each be measured separately in square metres stating thickness.

5.2.8.5. Walls beyond half brick thickness shall be measured in multiples of half brick which shall be deemed to be inclusive of mortar joints. For the sizes of bricks specified in 5.1.2 half brick thickness shall mean 100 mm for modular and 115 mm for non-modular bricks.

Where fractions of half brick occur due to architectural or other reasons, measurement shall be as follows:-

- (a) up to $\frac{1}{4}$ th brick – actual measurements and
- (b) Exceeding $\frac{1}{4}$ th brick-full half bricks.

5.2.8.6. String courses, projecting pilasters, aprons, sills and other projections shall be fully described and measured separately in running metres stating dimensions of each projection.

5.2.8.7. Square or rectangular pillars shall be measured separately in cubic metres in multiple of half brick.

5.2.8.8. Circular pillars shall be measured separately in cubic metres as per actual dimensions.

5.2.8.9. Brick work curved on plan including cut brick corners, splays, reveals and cavity walls shall be measured like the brick work in straight walls and shall include all cutting and wastage of bricks, tapered vertical joints and use of extra mortar, if any. Brick work curved on plan to a mean radius not exceeding six metres shall be measured separately and extra shall be payable over the rates for brick work in straight walls. Nothing extra shall be payable if the mean radius of the brick work curved in plan exceeds six metres.

5.2.8.10. Tapered walls shall be measured as normal walls and extra payment shall be allowed for making tapered surface for brick work in walls.

5.2.8.11. Brick work with brick tiles shall be measured and paid for separately.

5.2.9. Rate

The rate shall include the cost of materials and labour required for all the operations described above except the vertical reinforcement and its encasement in cement mortar or cement concrete. The rate shall also include the following:

- (a) Raking out joints or finishing joints flush as the work proceeds;
- (b) Preparing tops of existing walls and the like for raising further new brick work;
- (c) Rough cutting and waste for forming gables, splays at eaves and the like;
- (d) Leaving holes for pipes up to 150 mm dia. and encasing hold fasts etc in masonry.
- (e) Rough cutting and waste for brick work curved in plan and for backing to stone or other types of facing.
- (f) Embedding in ends of beams, joists, slabs, lintels, sills, trusses etc.,

(g) Bedding wall plates, lintels, sills, roof tiles, corrugated sheets etc., in or on walls if not covered in respective items;

(h) Leaving chases of section not exceeding 50 cm in girth or 350 sq.cm. in cross-section; and

(i) Brick on edge courses, cut brick corners, splays reveals, cavity walls, brick works curved on plan to a mean radius exceeding six meters.

5.3. BRICK WORK IN ARCHES (REFER FIGURE 5.6)

5.3.1 General : The detailed specifications for brick work mentioned in Para 5.2 shall apply, in so far as these are applicable. Arch work shall include masonry for both gauged as well as plain arches. In gauged arches, cut or moulded bricks shall be used. In plain arches, uncut bricks shall be used.

Brick forming skew-backs shall be dressed or cut so as to give proper radial bearing to the end voussoirs. Defects in dressing of bricks shall not be covered by extravagant use of mortar, nor shall the use of chips or bats etc., be permitted.

The bricks of the spandrel wall at their junctions with the extrados of the arch shall be cut to fit the curvature of the arch.

5.3.2 Circular Arches

These shall be either (a) plain arches, and shall be built in half brick concentric rings with break joints, or (b) gauged arches built with bricks cut or moulded to proper shape. The arch work shall be carried up from both ends simultaneously and keyed in the center. The bricks shall be flush with mortar and well pressed into their positions so as to squeeze out a part of their mortar and leave the joints thin and compact. All joints shall be full of mortar and thickness of joints shall not be less than 5 mm nor more than 15 mm.

After the arch is completed, the haunches shall be loaded by filling up the spandrels up to the crown level of the arch. Care shall be taken to load the haunches on two sides of the spandrels.

When the arch face is to be pointed (and not plastered), the face bricks shall be cut to proper shape or moulded, so as to have the joints not more than 5 mm thick. These shall be laid with radial joints to the full depth of the arch.

5.3.3 Flat Arches

These shall be gauged arches of brick cut or moulded to proper shape. The extrados shall be kept horizontal and the intrados shall

be given slight camber of 1 in 100 of the span. The center of the arch from which joints shall radiate, shall be determined by the point of the inter-section of the two lines drawn from the ends of the arch at the springing level and at 60° to horizontal.

In flat arches, bricks shall be laid with radial joints to the full depth of arch and voussoirs breaking joints with each other. The arch work shall be carried up from both ends simultaneously and keyed in the center. The thickness of the joints shall not exceed 5 mm. Flat arches may be used for the sake of appearance but for purpose of carrying loads of the wall above, these shall be used in conjunction with relieving arches/ lintels placed below.

5.3.4 Centering and Shuttering

The centering and shuttering for the arch shall be got approved by the Engineer before the arch work is started. It shall be strong enough to bear the dead load of the arch and the live loads that are likely to come upon it during construction, without any appreciable deflections.

The shuttering shall be tightened with hard wood wedges or sand boxes, so that the same could be eased without jerks being transmitted to the arch. The sequence of easing the shuttering shall be got approved from the Engineer. The shuttering shall be struck within 48 hours of the completion of the arch but not before 24 hours. This shall be done after the spandrel has been filled in and the arch loaded. The centering shall not, however, be struck for atleast two weeks after completion of the arch and that too only with the permission of the Engineer.

5.3.5 Measurements

The length of the arch shall be measured as the mean of the extrados and intrados of the arch correct to a cm. The thickness of the arch shall be measured in multiples of the half brick. The breadth in the direction of the thickness of wall shall be measured as specified. The cubical contents shall be calculated in cubic metre, correct to two places of decimal.

For arches exceeding 6 m. in spans extra payment shall be made on the actual area of the soffit for additional cost of centering including all strutting, bolting, wedging, easing, striking and its removal.

5.3.6 Rate

The rate is inclusive of the cost of the materials and labour required for all the operations described above.

5.4. HALF BRICK WORK

5.4.1 General:- Brick work in half brick walls shall be done in the same manner as described above in para 5.2.4 except that the bricks shall be laid in stretcher bond. When the half brick work is to be reinforced as will be required in case of half brick wall in water tanks or long lengths of half brickwork, 2 Nos. M.S. bars normally of 6 mm dia. shall be embedded in every third course. The dia of bars shall not in any case exceed 8 mm. These shall be securely anchored at their end where the partitions end. The free ends of the reinforcement shall be keyed into the mortar of the main brick work to which the half brick work is joined. The mortar used for reinforced brick work shall be rich dense cement mortar of mix 1:4 (1 cement : 4 coarse sand). Lime mortar shall not be used. Over-laps in reinforcement, if any shall not be less than 30 cm.

The mortar interposed between the reinforcement bars and the brick shall not be less than 5 mm. The mortar covering in the direction of joints shall not be less than 15 mm.

5.4.2 Measurement :

The length and height of the wall shall be measured correct to a cm. The area shall be calculated in sqm. Where half brick wall is joined to the main walls of one brick or greater thickness, measurements for half brick wall shall be taken for its clear length from the face of the thicker wall.

5.4.3 Rate

The rate includes the cost of the materials and labour involved in all the operations described above except reinforcement which is to be paid for separately.

5.5 BRICK TILE WORK

5.5.1 General : The work shall be done in the same manner as described in para 5.2.4. except that Brick Tile shall be used instead of bricks. The measurement and rate shall be same as specified under para 5.2.

5.6 HONEY COMB BRICK WORK

5.6.1 General : The brick honeycomb work shall be done with specified class of brick, laid in specified mortar. All joints and edges shall be struck flush to give an even surface.

The thickness of the brick honey comb work shall be half-brick only, unless otherwise specified. Openings shall be equal and alternate with half brick laid with a bearing of 2 cm on either side. —

5.6.2 Measurements

The length and height shall be measured correct to a cm. Area shall be calculated in square metres correct to two places of decimal. Honeycomb openings shall not be deducted.

5.6.3 Rate

The rate includes the cost of materials and labour involved in all the operations described above.

5.7 JOINING OLD BRICK WORK WITH NEW BRICK WORK

5.7.1 General : (a) In case the height of the bricks of old as well a new work is same, the old work shall be toothed to the full width of the new wall and to the depth of a quarter of brick in alternate courses. In case the height of the bricks is unequal, then the height of each course of new work shall be made equal to the height of the old work by adjusting thickness of horizontal mortar joints in the new wall. Where necessary, adjustments shall be made equal to thickness of old wall by adjusting the thickness of vertical joints.

(b) For joining new cross wall to old main wall, a number of rectangular recesses of width equal to the thickness of cross wall, three courses in height and half a brick in depth shall be cut in the main walls. A space of the three courses shall be left between two consecutive recesses. The new cross wall shall be bonded into the recesses to avoid any settlement.

(c) Joining of old brick work with the new brick work shall be done in such a way that there shall not be any hump or projection at the joint.

5.7.2 Measurements

The height and thickness of vertical face in contact with new work shall be measured to the nearest 0.01 m and shall be calculated to the nearest 0.01 sqm.

5.7.3 Rate

The rate includes the cost of labour and materials involved in all the operations described above.

5.8 MOULDING AND CORNICES

5.8.1 General : (a) The specifications described under Para 5.2 shall apply in so far these are applicable. Mouldings and cornices shall be made with bricks as specified for brick work. The bricks shall be cut and dressed to the required shape as shown in the architectural drawings.

(b) Cornices shall not ordinarily project by more than 20 cm and this projection shall be obtained by projecting each brick course by not more than one-fourth brick length. For cornices projecting more than 20 cm and requiring more than quarter brick projection, metal cramps shall be used and paid for separately.

5.8.2 Corbelling : Corbel is the term given to a brick or series of bricks which project from a wall. Corbelling is done to thicken a wall or form a decorative feature. Corbelling shall be brought roughly to shape by plastering with the specified mortar. When the mortar is still green, the mouldings shall be finished straight and true with the help of metal templates.

5.8.3. Curing and Protection

The mouldings and cornices shall be cured for at least seven days. These shall be protected from the effects of sun and rain by suitable covering and also from damage during the execution of the work.

5.8.4. Measurements

For the purpose of measurements, the sectional periphery of mouldings and cornices (excluding the portion in contact with wall) shall be measured in centimeters and length in metres as shown in **Figure 5.7**. The girth and length shall be measured correct to a cm., No deduction shall be made from the masonry of wall for the bearing of the moulding and cornices.

5.8.5 Rate

The rate includes the cost of materials and labour involved in all the operations described above.

5.9 BRICK WORK UNDER WATER OR FOUL POSITIONS

5.9.1 General : Brick Work Under following conditions shall be measured separately for payment of extra over and above the quantity measured and paid under para 5.2.8.

- i) Work in or under water/or liquid mud;
- ii) Work in or under foul positions

5.10 EXPOSED BRICK WORK

5.10.1 Facing Bricks

The facing bricks made from suitable soils shall be free from cracks, flaws, nodules of free lime, warpage and organic matter. These shall be thoroughly burnt and shall have plane rectangular faces with parallel sides and sharp straight right angled edges. Facing bricks shall have uniform colour and even texture. Unless otherwise specified, facing bricks shall be machine moulded. Selected hand moulded bricks may also be used as facing bricks where specified. As far as possible, total requirement of facing bricks for a work, shall be arranged from the same kiln. Bricks with chipped edges and broken corners shall not be used.

5.10.2 Dimensions and Tolerances

The standard sizes of machine moulded facing bricks shall be as specified in para 5.1.2.

Permissible tolerances shall be as under :

	Dimension (mm)		Tolerance (For Machine moulded bricks) mm
	Modular	Non Modular	
Length	190	230	± 3
Width	90	110	± 1.5
Thickness	40	44	± 1.5

Note : Tolerance and dimensions for selected hand moulded bricks ± 4 mm in length and ± 3 mm in width and thickness.

5.10.3. Sampling - As per paras 5.1.4.2 and 5.1.4.3.

5.10.4 Physical Requirements

Facing bricks shall be of class designation 7.5 unless otherwise specified. Average compressive strength shall not be less than 7.5 N/mm², water absorption shall not exceed 20 percent by weight and

efflorescence rating shall be nil when tested in accordance with the procedure laid down and tolerance in dimensions shall be checked as per the procedure laid down in **Annexure 5.1**.

Mortar, Soaking of Bricks and laying shall be as specified in paras 5.2.2, 5.2.3. and 5.2.4. respectively.

5.10.5. Joints : Joints in the exposed brick work shall be truly horizontal and vertical and kept uniform with the help of wooden or steel

strips. The thickness of joints shall be as per 5.2.5.1.

5.10.6. Curing and Scaffolding : Curing and scaffolding shall be as specified in paras 5.2.6. and 5.2.7 respectively.

5.10.7. Measurements

Exposed brick work in face using machine moulded and selected hand moulded bricks shall be measured separately and the measurement shall be as specified in para 5.2.8.

5.10.8. Rate

The rates shall be as specified in para 5.2.9. and shall also include the following:

- (a) Labour for selecting bricks and wastage of bricks where use of selected hand moulded brick is specified.
- (b) Leaving uniform horizontal and vertical grooves of specified depth and providing joints of required thickness using wooden or steel strips as the work proceeds.

5.11. CAVITY WALL

5.11.1. General : (a) It is a wall comprising of two leaves, each leaf being built of masonry units and separated by a cavity so as to provide an air space within the wall and tied together with metal ties or bonding units to ensure that two leaves act as one structural unit as shown in **Figure 5.8**. The width of the cavity shall not be less than 50 mm and not more than 115 mm. Each leaf of the cavity wall shall not be less than 75 mm thick, the space between the leaves being either left as cavity or filled with non-load bearing insulating and water proofing material.

(b) In building cavity walls of half brick-thickness, only stretcher bond shall be used, unless purpose made snap headers are available. When header bricks are cut and used, they are either likely to protrude into the cavity and form a ledge for mortar droppings to collect or they may be so short as to weaken the structure.

(c) At the base of the cavity wall, the foundations and basement shall be solidly constructed upto 300mm above the ground level. The air cavity shall begin not less than 200mm below the upper floor surface of the ground floor and the cavity shall be continued without interruption to the roof.

(d) The cavity shall be ventilated by air slots below the eaves level of the roof to the extent of 50 cm² for every 20 m² of the wall.

(e) At the points where the two leaves of party wall (see Para 5.11.6) come into contact, for example at windows and doors,

they shall be separated by a water tight membrane. Above lintels of doors and windows, a damp-proof membrane shall be inserted sloping downwards and outwards. At solid jambs, a vertical damp-proof course shall be inserted.

(f) The materials of leaves may be different masonry, concrete etc. The thicker leaf shall be arranged on the inside.

5.11.2 Metal Ties

These may be of galvanized iron, wrought iron, gun metal, brass, copper, stainless steel or any such corrosion resistant metal, made of flats 20 x 5 mm cranked or twisted at their mid point with ends split and fish tailed. The ties shall be built into horizontal bed joints during erection, placed sloping towards the exterior side to prevent water from flowing along it from outer to inner leaf side (For details refer **Figure 5.8**).

5.11.3 Bonding Units

These shall be preferably pre cast R.C.C. units having cross-section as shown in **Fig. 5.8**. Length of the Bonding units will be sum of thickness of both leaves plus width of cavity if the leaves are 75 mm or 115 mm. If the leaves are more than 115 mm thick, then the length of a unit will be 2 x 115 + width of cavity as shown in **Fig.5.8**. Pre cast RCC units shall be provided with 2 Nos. 6 mm mild steel reinforcement bars tied with 2 No. and 3 mm. Dia. (M.S. wire/hard drawn wire) cross bars (As shown in **Fig.5.8**) placed in the center of unit.

Cement concrete used in the bonding units shall not be leaner than 1:2:4.

(1 cement : 2 coarse sand : 4 graded stone aggregate 20 mm nominal size).

5.11.4 Spacing of Ties / Bonding Units

Metal ties/bonding units shall be spaced not more than 90 cm apart horizontally and 45 cm vertically and staggered in each course. Additional ties shall be used near openings. A minimum of 5 Ties/ m² of surface area of the wall shall be provided.

5.11.5 Restrictions

Cavity walls shall not normally be built more than 7.5 metres in height and 9 metres in length. Where larger lengths and heights are desired, the wall shall be divided into panels with strengthening measures such as pillars etc., Cavity shall be covered at the top with at least two courses of masonry unit and/or a coping over it.

Adoption of cavity walls is not recommended when heavy concentrated loads from beam, etc., are to be supported by walls.

5.11.6 Precautions

The following precautions shall be taken :

- a) Parapets- If the top of a hollow wall ends with a parapet, the cavity shall be carried to the full height of the wall or stopped at the roof flashing level;
- b) Eaves – If a roof projects over the top of the wall, the cavity shall be closed at the top;
- c) Party walls – In a hollow party wall, the top of a cavity wall shall be closed just above the uppermost ceiling level and the courses over shall be continued as in solid brickwork. A sound insulation material shall be interposed between the hollow wall and solid brick work.

5.11.7 Measurements and Rate

(a) Brick work in cavity walls shall be included and measured with general brick work. The width of the cavity shall not be measured. Skin of cavity wall, half brick thickness shall be measured as and paid as described in paras 5.2.8. and 5.4.

(b) The forming of the cavity shall be given in square metres stating the width of the cavity and shall include the metal ties/bonding unit specifying the numbers per square metre.

(c) Labour and material for closing cavities at the jambs, sills and heads of opening shall be as described and measured separately in running metres.

The item shall include use of device for keeping cavity clear and forming the requisite weep and vent holes and nothing extra on this account shall be payable.

5.12 BRICK DRIP COURSE

5.12.1 General : The brick drip course shall be laid above the junction of the roof with the wall to shield the cracks which may develop at these junctions. The upper corners of the projecting bricks shall be chamfered or rounded off with 8 cm radius. The transverse drip of throating about 1.3cm deep shall be cut on the under side of the projecting bricks. Specially moulded bricks shall be used for the brick course. Where moulded bricks are not available, bricks cut to shape shall be permitted.

5.12.2 Measurements : The drip course shall be measured in running metres correct to a cm and no deduction shall be made from the masonry of walls for the bearing portion of the drip course.

5.12.3 Rate : The rate includes the cost of all materials and labour required for the drop course as stated above but excludes the cost

of the lime concrete gola made at the junction of the wall and the terrace in mud phuska terraced roofs.

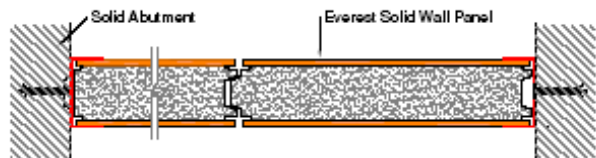
5.13 SOLID WALL PANELS

50 mm thick solid wall panels are sandwich panels made out of FRACC and non asbestos wall boards. These should be provided with tongue and groove joining system to facilitate rapid construction. The 50 mm thick solid wall panels should adhere to following sizes and properties :

1. Sizes : (i) 3000 x 600 mm
(ii) 2700 x 600 mm
(iii) 2400 x 600 mm

Or size can be modified according to the site requirement.

2. Thickness : 50 mm (thickness of FRCC : 42 mm & thickness of board on both faces 2 x 4 mm = 8 mm)
3. Weight : 42.8 kg/m²
4. Edge Profile : Square or (bevelled edge)
5. Axial compressive : 46.1 kg/cm² Strength
6. Tensile strength : 0.35 N/mm²



ANNEXURE 5.1

TEST FOR DIMENSIONAL TOLERANCE OF BRICKS

A-1 Sampling As per paras 5.1.4.1. to 5.1.4.3.

A.2 Procedure : All the blisters, loose particles of clay and small projections shall be removed from the surface of bricks. Each specimen of 20 bricks shall then be arranged upon a level surface successively in contact with each other and in straight line as described in A.4. The overall length of the assembled bricks (20 Nos) shall be measured with a steel tape sufficiently long to measure the whole row at one stretch.

A.3. Tolerance : The actual dimensions of bricks when tested as described in A-2 shall be within the limits per 20 bricks as stipulated in Para 5.1.4.4.

A-4 Criteria for conformity : A lot shall be considered conforming to the requirements of dimensions and tolerances if all the groups of bricks are tested and meet the specified requirements as per clause 5.1.4.4.

ANNEXURE 5.2**TEST FOR COMPRESSIVE STRENGTH OF BRICKS** (Refer IS 3495 (Part 1))

B.1. Specimen : Five whole bricks shall be taken from the samples as specimens for this test. Length and width of each specimen shall be measured correct to 1 mm.

B.2. Apparatus The apparatus consists of compression testing machine, the compression plate of which shall have a ball seating in the form of portion of a sphere the center of which shall coincide with the center of the plate.

B-3 Procedure

(a) Pre-conditioning : Unevenness observed in the bed faces should be removed by grinding to provide two smooth and parallel faces. The specimen shall be immersed in the water for 24 hours at 25° to 29°

(b) Any surplus moisture shall then be allowed to drain at room temperature. The frog of the bricks if it exists should be filled flush with mortar 1:3 (1 Cement: 3 clean coarse sand of grade 3 mm and down) and shall be kept under damp jute bags for 24 hours and after that these shall be immersed in clean water for three days.

After removal from water, the bricks shall be wiped out of any traces of moisture.

(b) Actual Testing: Specimen shall be placed with flat faces horizontal and mortar filled face upward between three 3 ply plywood sheets each of thickness 3 mm and carefully centered between plates of the testing machine. Plaster of Paris can also be used in place of plywood sheets to ensure a uniform surface.

Load shall be applied carefully axially at uniform rate of 14 N/mm² per minute till the failure of the specimen occurs.

B-4 Reporting the Test Results: The compressive strength of each specimen shall be calculated in N/ mm² as under:-

Compressive Strength :

$$= \frac{\text{Maximum load at failure (in N)}}{\text{Area of Specimen (in sq. mm)}}$$

For the purpose of calculating the average compressive strength, Compressive strength of all the individual bricks comprising the sample shall be averaged and reported. In terms of Para C 3.1.3 of Annexure C on Clause 2.3 of Part 2 Brick work and Block work of Chapter 4 of BIS Hand Book on Building Construction practices, if the compressive strength of any brick tested exceeds the specified value (refer Para 5.1.3), that result may be taken into account in reporting the results.

B-5 Criteria for conformity : A lot shall be considered having satisfies the requirements of average compressive strength if it satisfied the minimum average compressive strength specified in Para 5.1.3 for the corresponding class of brick tested. The compressive strength of any individual brick tested shall not fall below the minimum compressive strength specified for the corresponding class of bricks by more than 20%.

ANNEXURE 5.3**TEST FOR WATER ABSORPTION OF BRICKS** (Refer IS 3495 (Pt.2))

C-1 No. of Specimen : Five whole bricks shall be taken from samples as specimen for this test.

C.2. Apparatus : A balance required for this test shall be sensitive to weigh 0.1 per cent of the weight of the specimen.

C.3. Procedure

(a) Pre-conditioning : The specimen shall be allowed to dry in a ventilated oven at a 110° C to 115° C till it attains a substantially constant weight. If the specimen is known to be relatively dry, this would be accomplished in 48 hours, if the specimen is wet, several additional hours may be required to attain constant weight. It shall be allowed to cool at room temperature. In a ventilated room, properly separated bricks will require four hours for cooling, unless electric fan passes air over them continuously in which case two hours may suffice.

The cooled specimen shall be weight and marked as W1. A warm specimen shall not be used for this purpose.

(b) Actual Testing : Specimen shall be completely dried before immersion in the

water. It shall be kept in clean water at a temperature $27^{\circ}\text{C} \pm 2^{\circ}\text{C}$ for 24 hours. Specimen shall be wiped out of the traces of water with a damp cloth after removing from the water and then shall be weighed within three minutes after removing from water. Weight is marked as W2.

C-4 Reporting the Test Results : The water absorption of each specimen shall be calculated as follows and the average of five tests shall be reported.

$$\text{Water Absorption} = \frac{(W2-W1) \times 100}{W1}$$

C-5 Criteria for Conformity : A lot shall be considered having satisfied the requirements of water absorption if the average water absorption is as stipulated in Para 5.1.4.6.

ANNEXURE 5.4

TEST FOR EFFLORESCENCE OF BRICKS

(Refer IS 3495 (Pt.3))

D-1 No. of Specimen : Five whole bricks shall be taken as specimen for this test.

D-2 Apparatus : Apparatus required for this test shall be a shallow flat bottom dish containing distilled water of size 180X180X40 mm deep if of square shape or 200 mm dia X 40mm deep if circular. (As per IS-3495)

D-3 Procedure (actual testing) : The brick shall be placed vertically in the dish with 2.5 cm immersed in the water. The room shall be warm (20°C to 30°C) and well

ventilated. The bricks should not be removed until it absorbs whole water. When the whole water is absorbed and the brick appears to be dry, place a similar quantity of water in that dish and allow it to evaporate as before. The brick shall be examined after the second evaporation.

D-4 Reporting the Test Results : The rating to efflorescence in ascending order shall be reported as 'NIL', 'SLIGHT', 'MODERATE', 'HEAVY' or 'SERIOUS' in accordance with the following:-

(a) NIL : When there is no perceptible deposit of efflorescence.

(b) SLIGHT: When not more than 10 per cent of the area of the brick is covered with a thin deposit of salts.

(c) MODERATE: When there is heavier deposit and covering up to 50% of the area of the brick surface but unaccompanied by powdering or flaking of the surface.

(d) HEAVY: When there is a heavy deposit of salts covering 50% or more of the brick surface but unaccompanied by powdering or flaking of the surface.

(e) SERIOUS: When there is heavy deposit of salts, accompanied powdering and/or flaking of the exposed surface and tending to increase in the repeated wetting of the specimen.

D-5. Criteria for Conformity : A lot may be considered having satisfied the requirements of efflorescence if the permissible number of defectives depending on lot size is not more than that specified in Table 5.4 and the efflorescence is not beyond "moderate" for bricks upto Class 12.5 and not beyond "slight" for higher classes of bricks.

RECOMMENDED LIST OF TESTS ON MATERIALS

Material	Clause	Test	Field/ Laboratory Test	Test Procedure	Minimum quantity of material carrying out test	Frequency of testing
Bricks/ Brick Tiles	5.1.4.1 to 5.1.4.7	Testing of Bricks/Brick Tiles for dimensions, compressive strength, water absorption and efflorescence	Laboratory	ANNEXURES 5.1 to 5.4	As per Tables 5.3 and 5.4	--

BRICK WORK - FIGURES EXPLAINING SOME
ITEMS REFERRED TO

FIGURE 5.1 A to 5.1 D

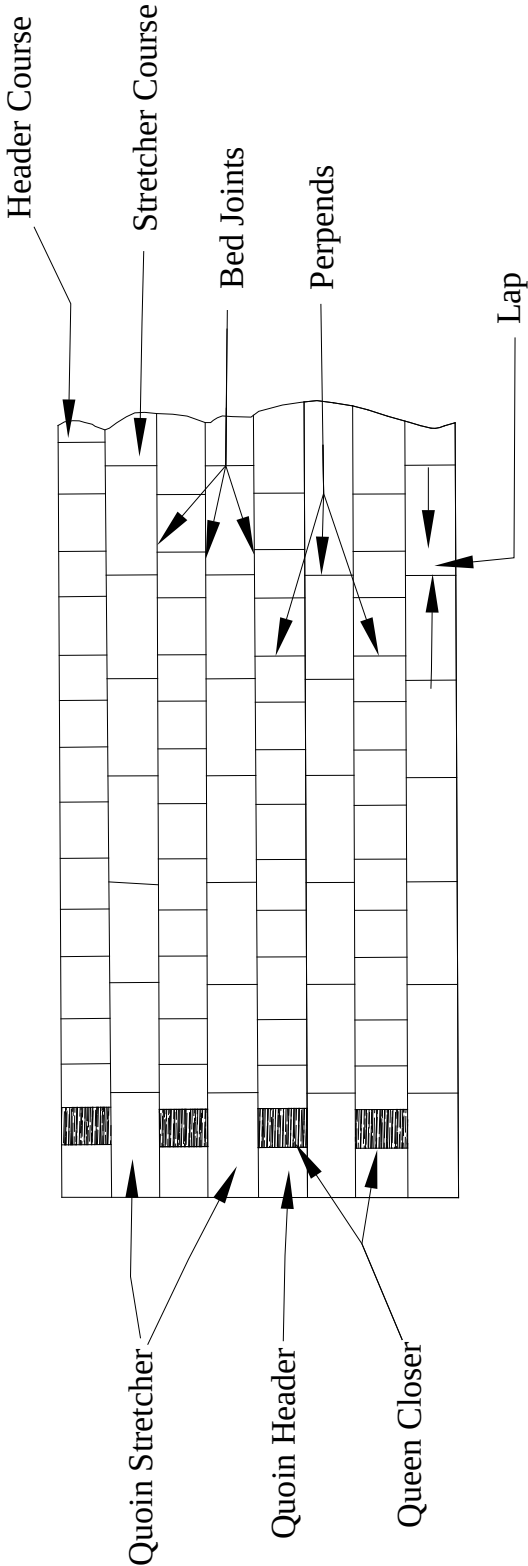


FIGURE 5.1 A

CLOSERS USED IN BRICK WORK

FIGURE 5.2 A to 5.2D

(a) Queen Closer: A solid brick is cut longitudinally in two equal parts and the above half brick is called queen closer. Instead of cutting the brick longitudinally we can cut the same breadth wise in quarter lengths and in that case two closers one from each face will have to be used. However , a single piece is preferable. The queen closer is normally placed next to quoin header.

(b) King Closer: While doing work on jambs during the fixing of doors or windows, brick bats are freely used to get the satisfactory arrangement of mortar joints. At such places one can use these closers very conveniently. The king closer is obtained by cutting half portion of header face and half portion of stretcher face in a triangular position, as shown in Fig. 5.2 B

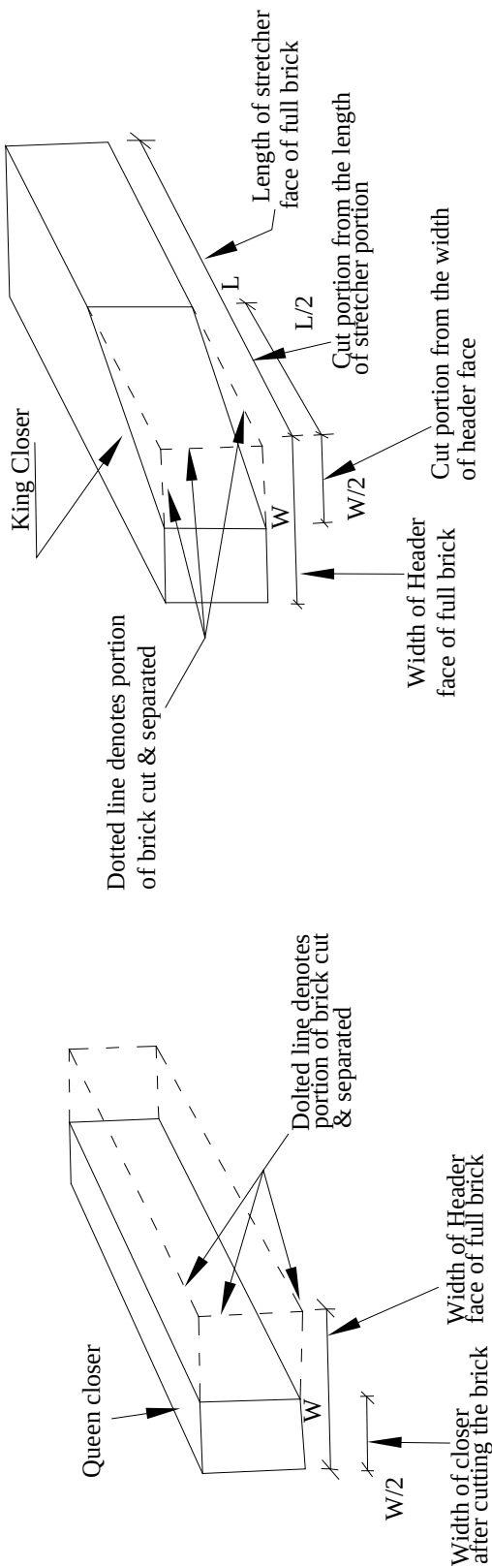


FIGURE 5.2 B King closer

Queen closer

FIGURE 5.2 A

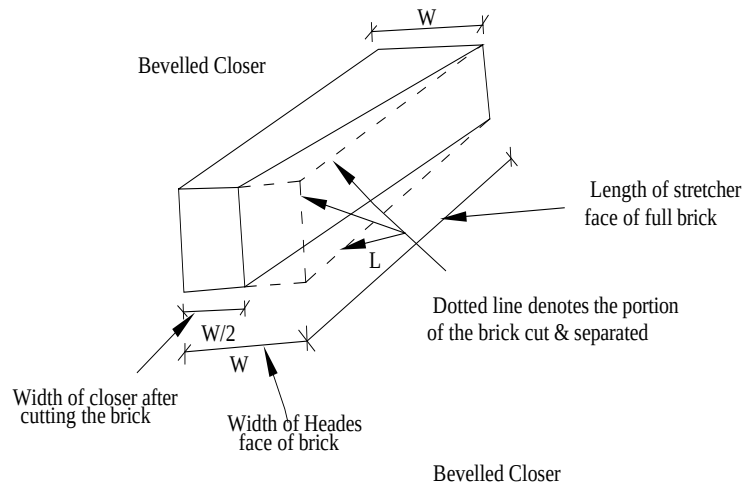
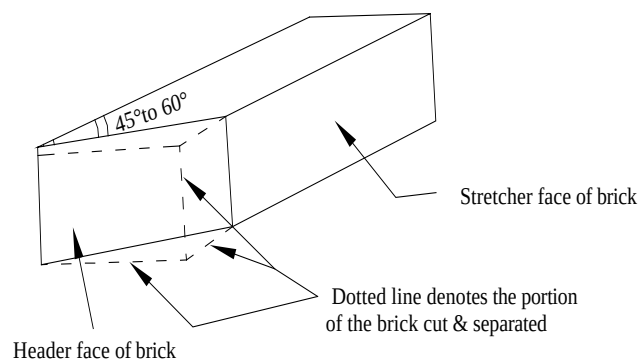


FIGURE 5.2 C

Bevelled Closer. To construct splayed brick work the use of bevelled closer which appears as closer at one face and a header at other face is most convenient.

The bevelled closer is obtained by cutting a triangular portion of the brick, from half the width of the brick to the end of length side as shown in fig. 5.2 C



Mitred Closer

FIGURE 5.2 D

Mitred Closer. When a wall is being closed at corners or near pillars the necessity of closer arises. The solution is to use regular closers and these closers are called mitred closers. These closers are made by cutting a triangular portion of the brick through its width at an angle of 45° to 60° with the length of the brick as shown in Fig. 5.2 D

FIGURE 5.1 B

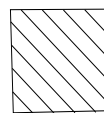
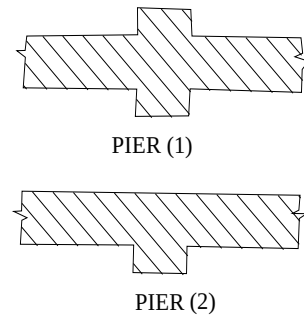


FIGURE 5.1 C

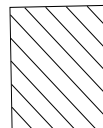
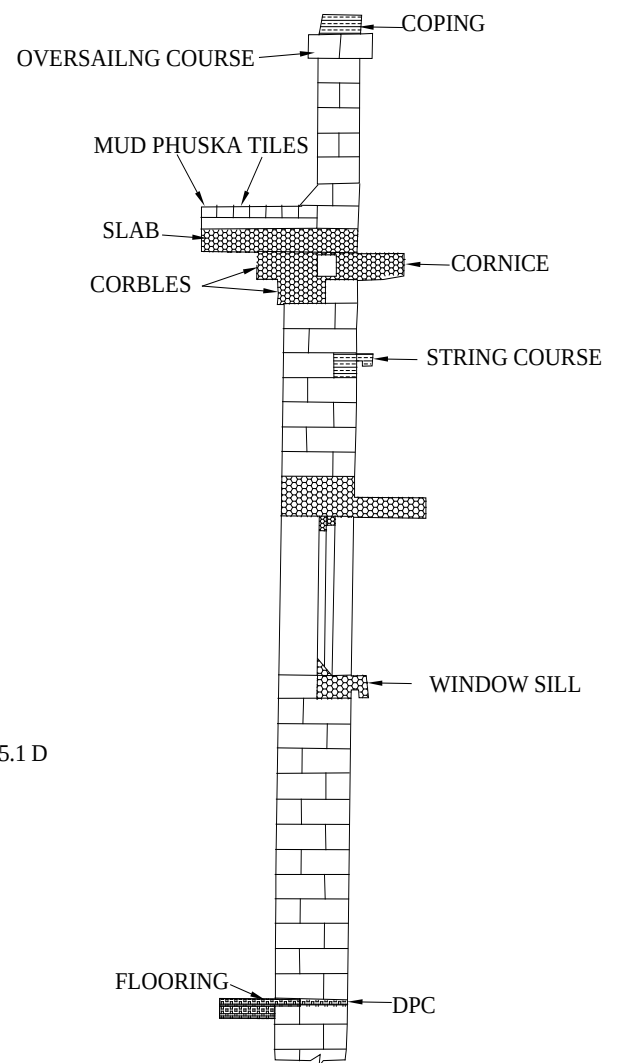


FIGURE 5.1 D

PILLARS

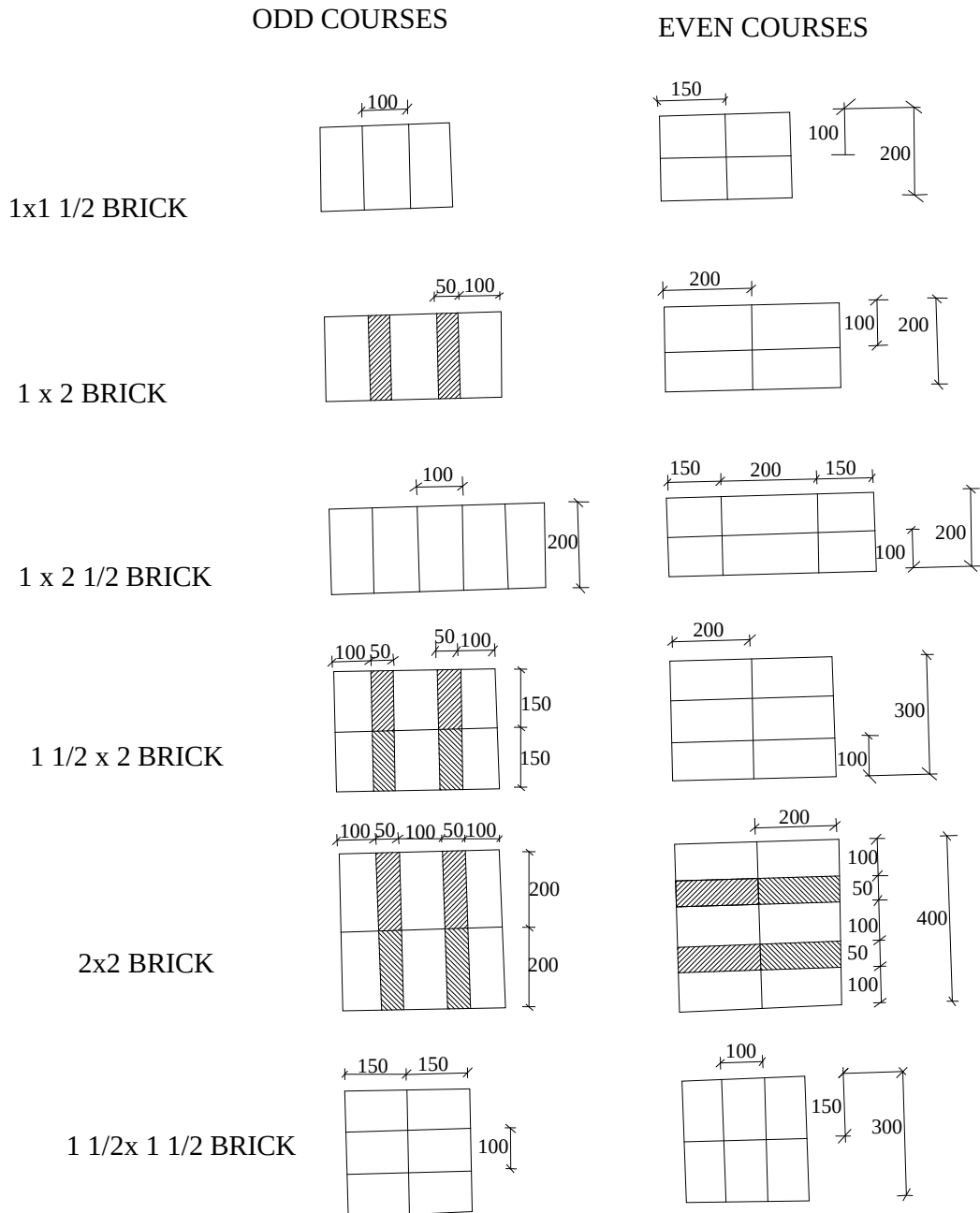


TYPICAL SECTION OF BRICK WALL

Note: IN RECTANGULAR WALLS THE BREADTH SHALL NOT EXCEED THREE TIMES THE THICKNESS AND THICKNESS ITSELF SHALL NOT EXCEED MORE THAN THREE BRICKS

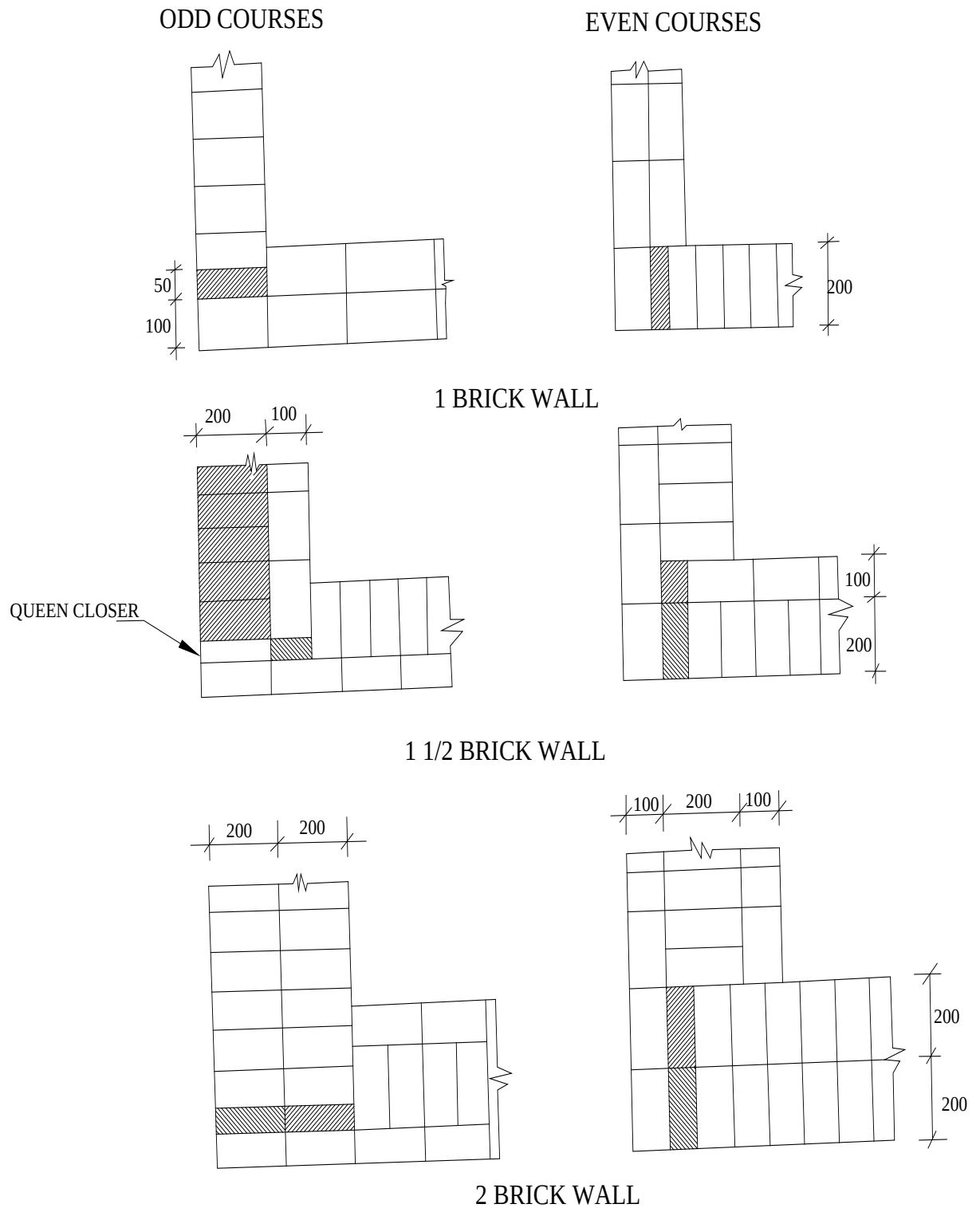
- 5.3 A English bond - Brick Pillars of different sizes
 5.3 B English Bond - Brick walls of different thickness
 5.3 C Double Flemish Bond - Brick wall 1 1/2 Brick thick - Isometric view
 5.3 D English Bond - Brick wall 1 Brick thick - Isometric view

BRICK PILLARS
 FIGURE 5.3 A to 5.3D



All dimensions are in mm
 Drawings not to scale

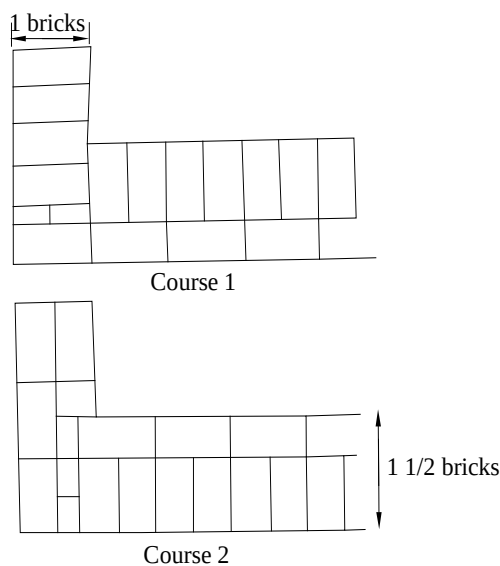
FIGURE 5.3 A



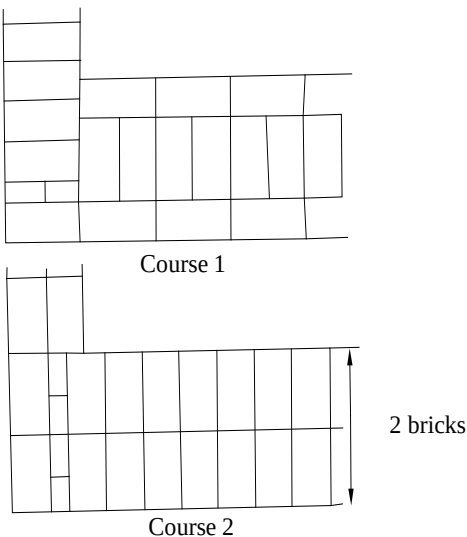
All dimensions are in mm
Drawings not to scale

Figure 5.3 B

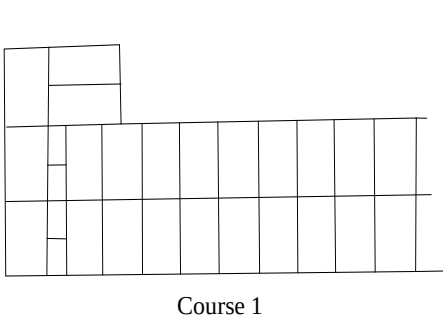
Figure 5.3 B
CONTD



1 BRICK WALL JOINING
1 1/2 BRICK WALL

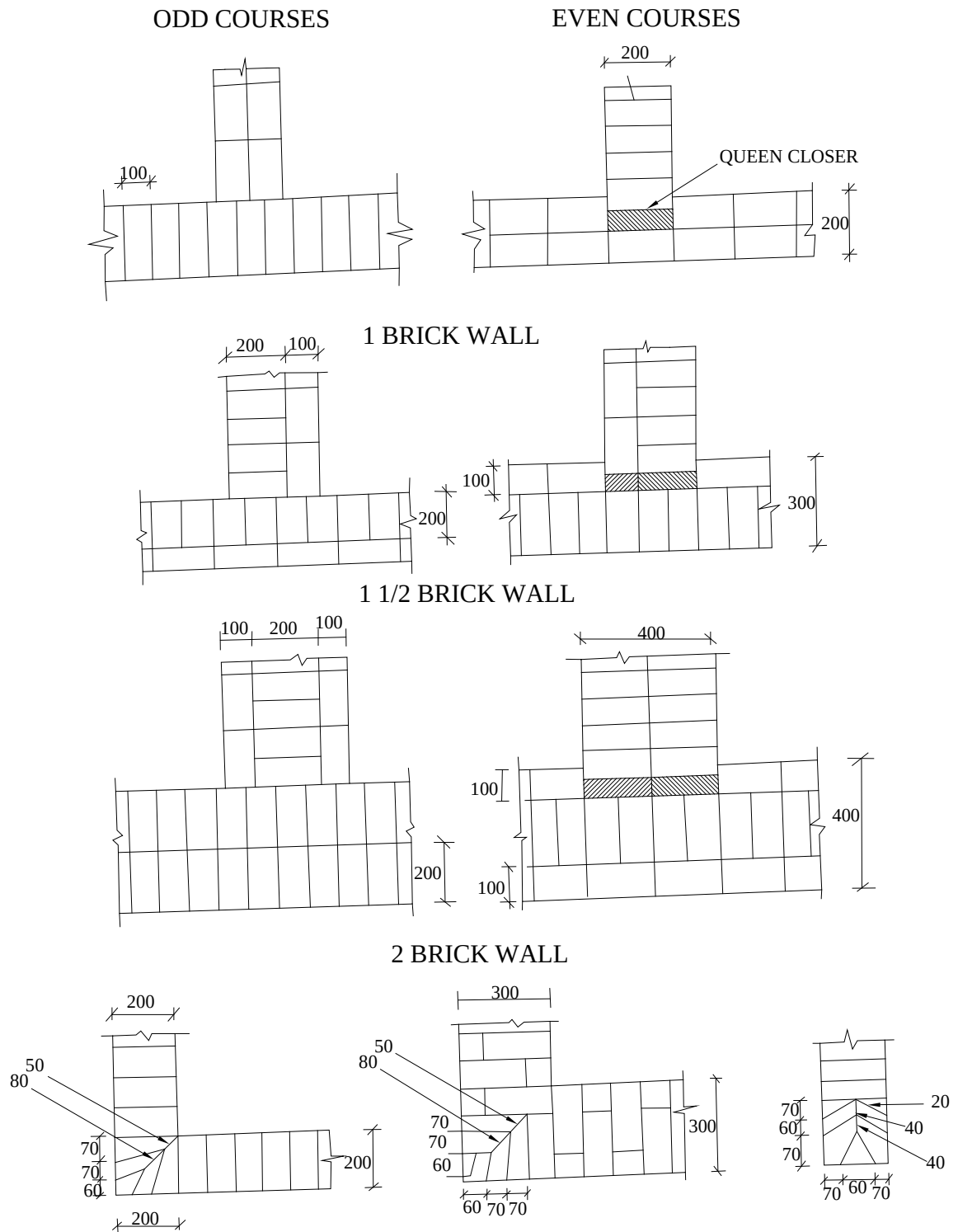


1 BRICK WALL JOINING
2 BRICK WALL



1 1/2 BRICK WALL JOINING
2 BRICK WALL

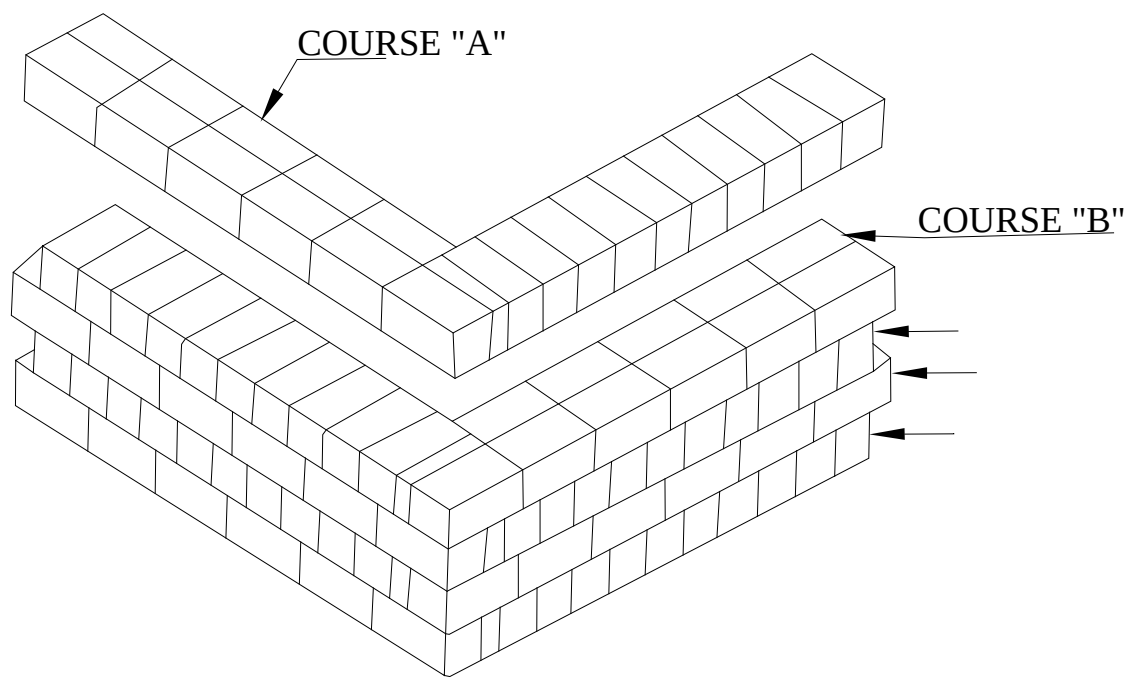
Figure 5.3 B
CONTD



All dimensions are in mm
Drawings not to scale

CUT BRICK CORNER

ENGLISH BOND



DOUBLE FLEMISH BOND
FIG 5.3 C

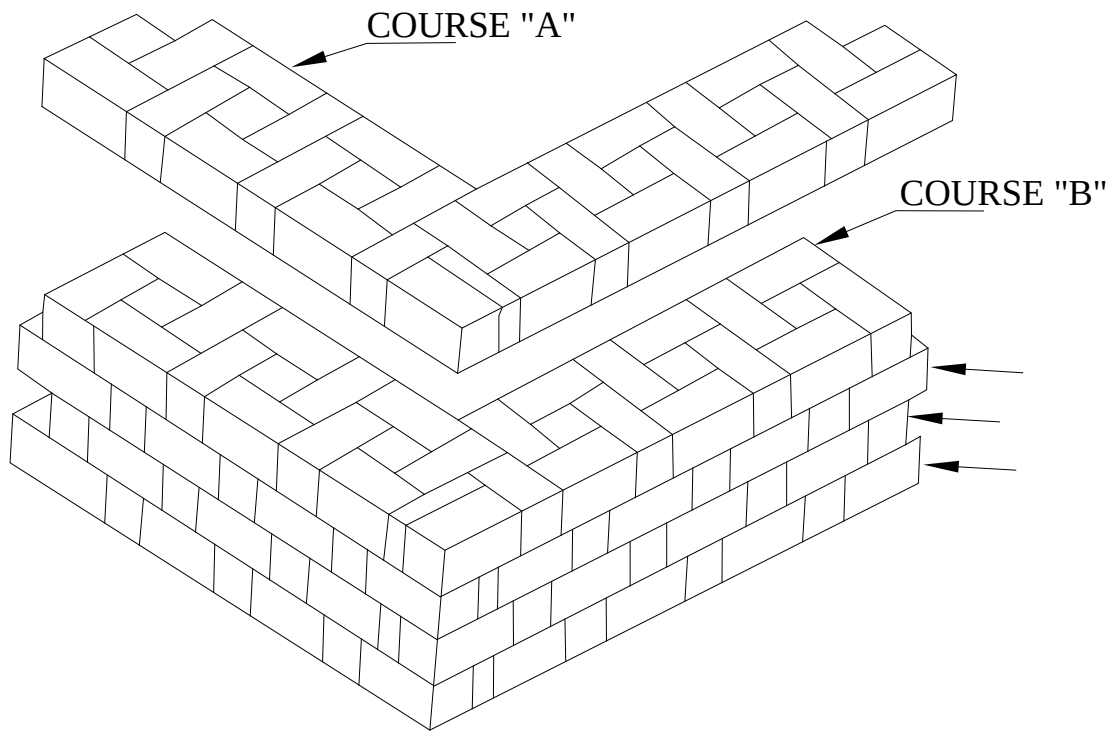
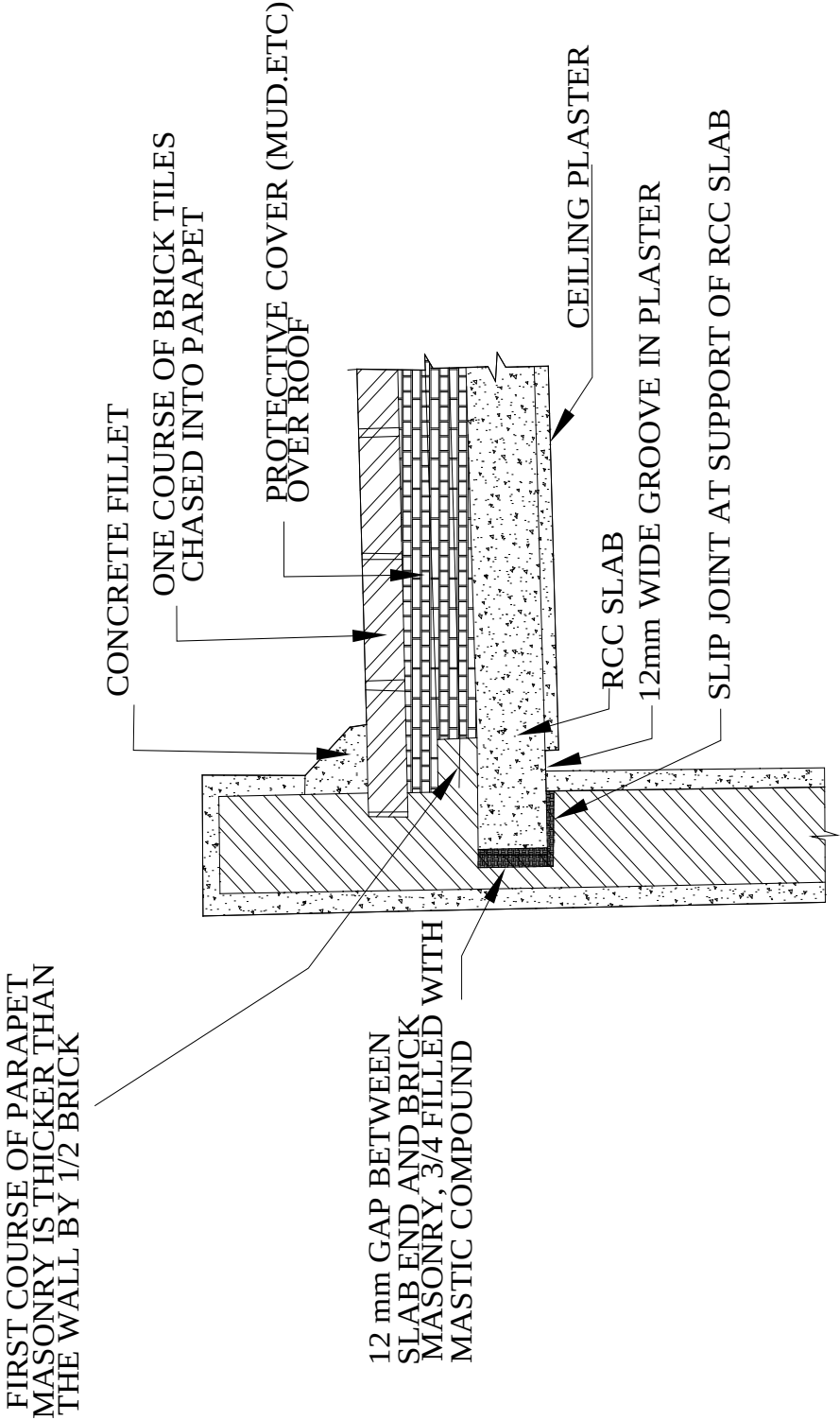


FIG 5.3 D

CONSTRUCTIONAL DETAIL OF BEARING OF RCC ROOF SLAB
OVER A MASONRY WALL

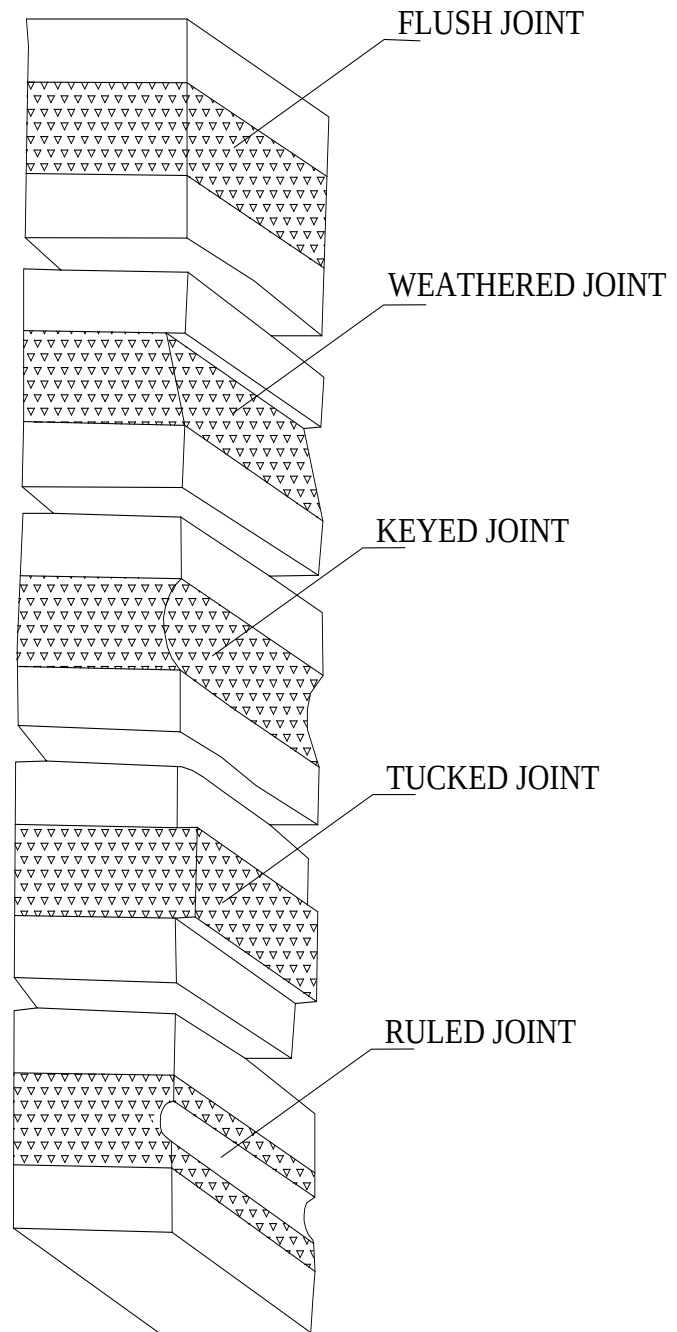
FIGURE 5.4



SECTION

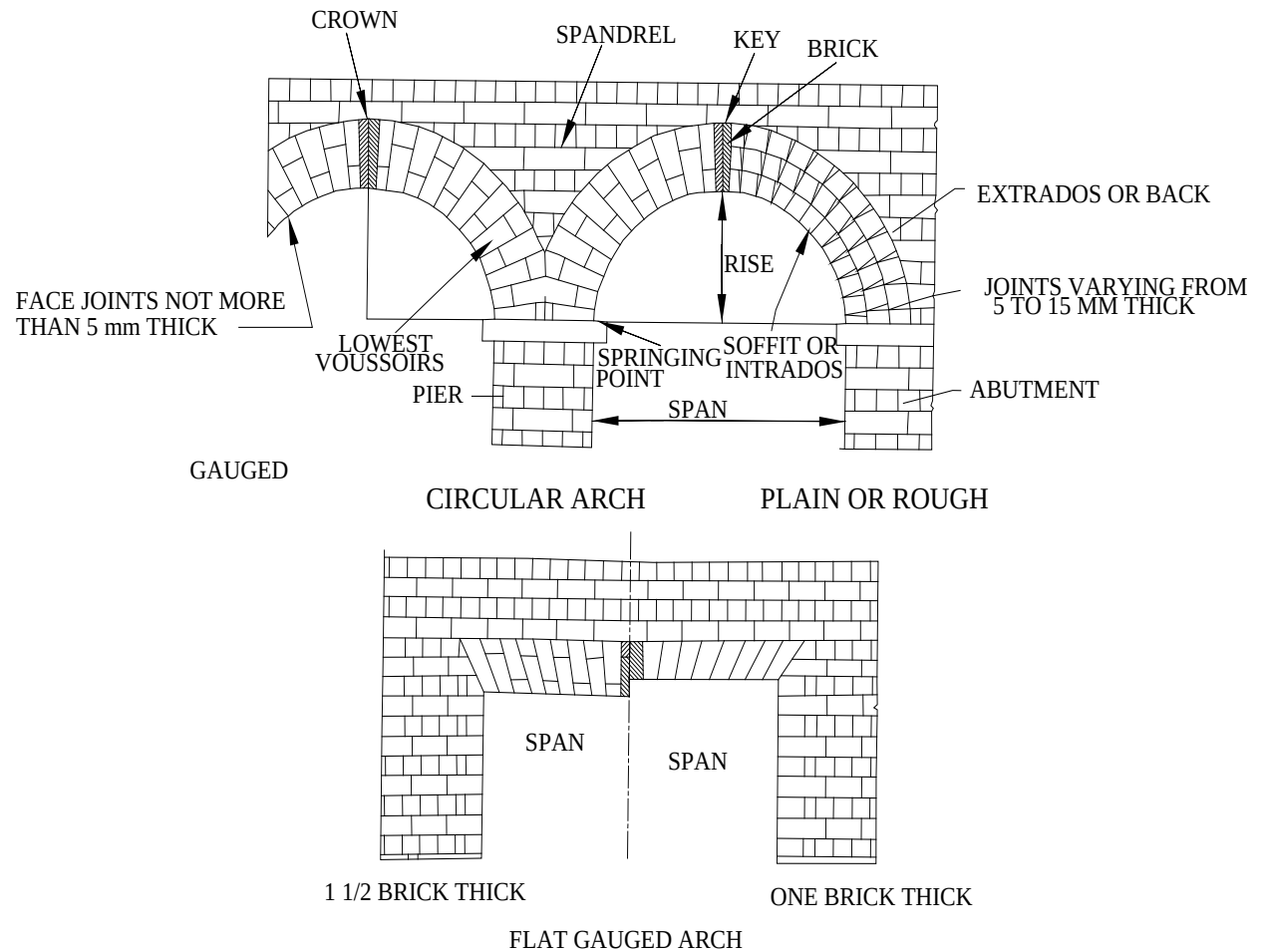
DIFFERENT TYPES OF POINTING FINISHES FOR BRICK WORK

FIGURE 5.5



BRICK WORK IN ARCHES

FIGURE 5.6



Brick work in Arches (Clause 6.3)

Note : Common Terminology

Voussiors - Individual Wedge- shaped bricks.

Rise - Vertical distance between the springing line and highest point of soffit

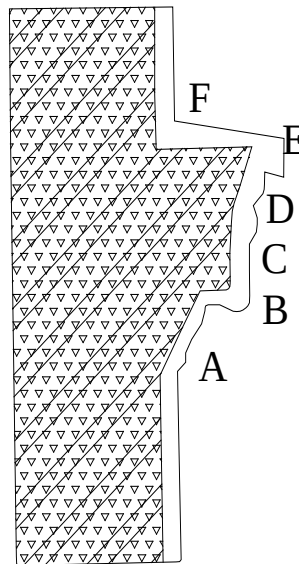
Haunch - Lower part of the Arch from springing line to midway of the crown

Bed joints : Joints between voussiors

Label course : An extra course built around the Extrados of the arch, usually projecting on the face, giving the arch extra depth without cutting the bricks.

MOULDINGS AND CORNICES

FIGURE 5.7

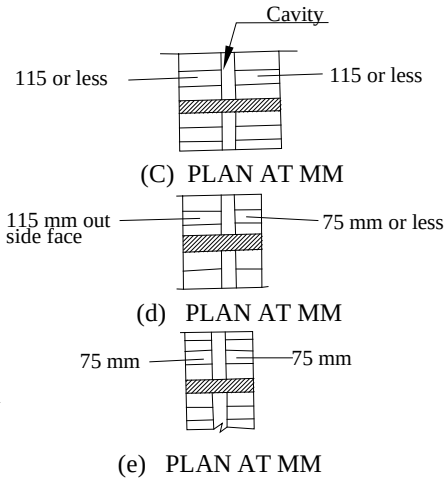
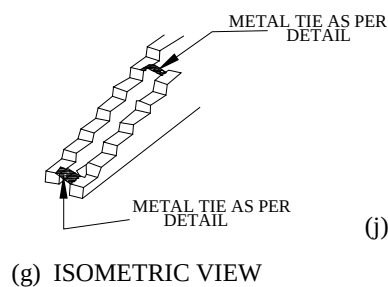
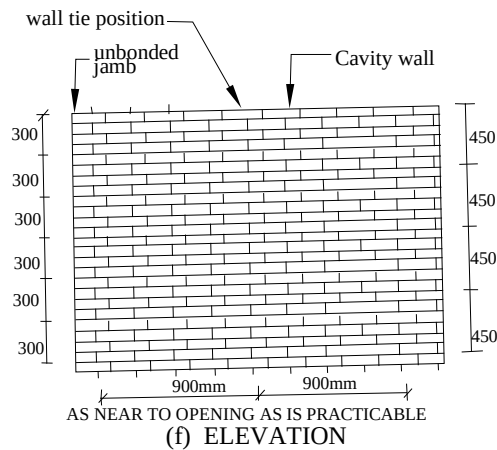
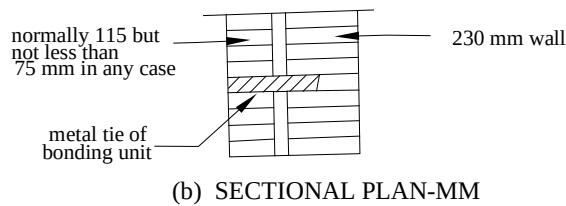
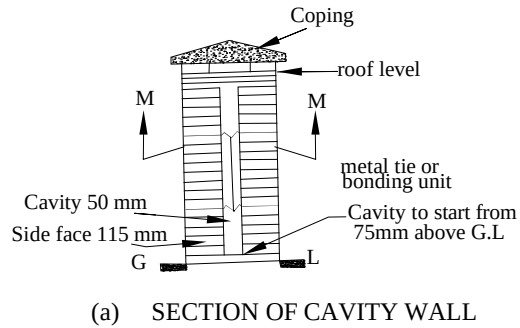


Notes

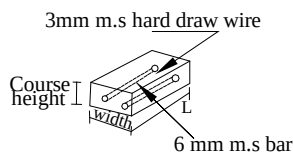
1. The sectional periphery Curve ABCDEF to be measured and paid
2. Length FA shall not be measured.

BRICK WORK IN CAVITY WALLS

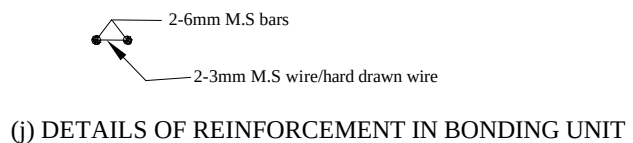
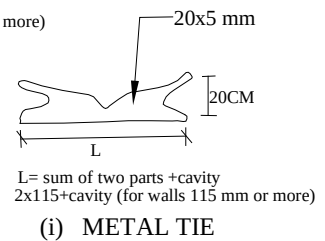
FIGURE 5.8



- Note:
- (1) Only one of the alternatives, a, b, c, d or e shall be applicable in each case
 - (2) Ties shall be placed sloping towards exterior side.



$L = \text{thickness of walls} + \text{cavity}$
 $2 \times 115 + \text{cavity}$ (for walls 115 mm or more)



Chapter 6

Stone Work

6.0 TERMINOLOGY & PROPERTIES OF STONE

6.0.1 Terminology

Ashlar : Stone masonry using dressed block of given dimensions having faces perpendicular to each other and laid in courses.

Bed Joint: The joint where one stone presses on another for example, a horizontal joint in a wall or radiating joint between the voussoirs of arch (**Fig. 6.1A/1 & 6.1A/3 and 6.9**).

Hollow (Open and closed cavity) block

A concrete masonry unit with any one of the external dimensions greater than the corresponding dimension of a brick and having one or more large holes or cavities which either pass through the block (open cavity) or do effectively pass through the block (closed cavity) and having the solid material between 50% and 75% of the total volume of the block calculated from the over-all dimensions.

Solid Block

A concrete masonry unit with external dimensions greater than corresponding dimensions of a brick and having solid material not less than 75% of the total volume of the block calculated from over all dimension.

Bond : An inter-locking arrangement of structural units in a wall to ensure stability.

Bond Stone (Through stone): Selected long stone used to hold a wall together transversely (**Fig.6.2**).

Corbel : Stone bonded well into the wall with part of it projecting out of the face of wall to form a bearing surfaces.

Cornice : A horizontal moulded projection which crowns or finishes either a wall, any horizontal division of wall, or any architectural feature (**Fig. 6.1A/3**).

Cramp : A small piece of metal or the hardest or toughest stone procurable sunk in mortices and fixed across joints as additional ties. The ends of metal cramps are bent at right angles and stone cramps are dovetailed (**Fig.6.1A/2**).

Course : A layer of stones in wall including the bed mortar.

Dowels : Dowels are small sections of metal, stone or pebbles bedded with mortar in corresponding mortice in bed or side joint of adjacent stones (**Fig.6.1A/1**).

Jamb : The part of the wall at the side of an opening.

Joggle : A key between the stones by providing a groove in one stone to take a corresponding concealed projection in the edges on the other stone (**Fig.6.1A/2**).

Natural Bed : The planes of stratification that occur in a sedimentary rock.

Parapet : A solid or pierced guard wall for flat stone terrace or balcony (or a bridge) or a curb wall at the lower part of a pitched roof which is exposed to atmosphere on face back and top (**Fig.6.1A/3**).

Quoin : A quoin is the external angle of wall or building. The term is also applied to stone specially selected and neatly dressed for forming such angle.

Random : Random or irregular size and shapes.

Reveal : The part of the jamb between the frame and the arise.

Rubble Masonry : Masonry built of stones either irregular in shapes as quarried or squared and only hammer dressed and having comparatively thick joints. As far as possible, stones for rubble masonry shall be angular.

Skewback : Sloping surface against which the springing of an arch rests (**Fig. 6.9**).

Spandrel : Space between the haunches below the decking level (**Fig. 6.9**).

String Course : A horizontal band, plain or moulded, usually projecting slightly from the face of wall (**Fig.6.1A/3**).

Surfacing or Dressing of Stones : The stones are dressed to have different surfaces as indicated in definitions below.

Template or Bed Block : A block of stone or concrete bedded on a wall to distribute the pressure from a concentrated load.

Self Faced Surfaces : Surfaces of stones used for roofing, flooring, lintels etc., as obtained from quarry.

Squared Back Surface : Means the surface shall be dressed back at right angles to the face of the stone.

Chisel Drafted Margin : The dressing done with a drafting chisel in narrow strips of width generally 2 to 5 cm. Chisel drafted margin shall be punch dressed.

Hammer Dressed Surface : A hammer dressed stone shall have no sharp and irregular corners and shall have a comparatively even surface so as to fit well in masonry. Hammer dressed stone is also known as hammer faced, quarry faced and rustic faced. The bushing from the general wall face shall not be more than 40 mm on exposed face and 10 mm on faces to be plastered (**Fig.6.1B/1**).

Rock Faced Surface : A rock face stone shall have a minimum of 25mm wide chisel drafted margin at the four edges, all the edges being in the sample plane.

Rough Tooled Surface : A rough tooled surface shall have a series of bands, made by means of plane chisel 4 to 5 cm wide, more or less parallel to tool marks all over the surface. These marks may be either horizontal, vertical or at an angle of 45 deg. as directed. The edges and corners shall be square and true. The depth or gap between the surface and straight edge, held against the surface shall not be more than 3mm. (Rough tooled stones are used where fairly regular plane faces are required for masonry work.)

Punched Dressed Surface : A rough surface is dressed by means of punch chisel to show series of parallel ridges. The depth of gap between the surface and a straight edge held against the surface shall not exceed 3 mm (**Fig.6.1B/2**). Punched dressed stones are used where even surfaces are required.

Close Picked Surface : A punched stone is further dressed by means of point chisel so as to obtain a finer surface, ridges, or chisel marks left over being very tiny. The depth of gap between the surface and a straight edge kept over the surface shall not exceed 1.5 mm (**Fig.6.1B/3**).

Fine Tooled Surface : Close picked surface is further dressed so that all the projections are removed and fairly smooth surface is obtained. The surfaces shall have 3 to 4 lines per centimeter width depending on the degree of hardness of stone and degree of fineness required (**Fig.6.1B/4**). This type of dressing is commonly adopted for ashlar work.

Polished Surface : Surfaces having a high gloss finish. Polishing of stones shall be done by rubbing them with suitable abrasive, wetting the surface where necessary with water. Alternatively polishing of stones shall be done by holding them firmly on the top of revolving table to which some abrasive material like sand or carborundum is fed. The final polishing shall be performed by rubber or felt, using oxide of lime (called by trade name as putty powder) as a polishing medium.

Moulded: Cut to profile of a moulding with punched dressed surfaces, unless otherwise specified.

6.0.2 Properties of Stone :

6.0.2.1 Crushing Strength of Stones

This shall be as indicated in **Table 6.1**. Test for crushing or compressive strength shall be carried out as prescribed in IS 1121 (Part 1).

TABLE 6.1
CRUSHING STRENGTH OF STONE

TYPE OF STONE	MIN. CRUSHING STRENGTH N/mm ² (kgf/cm ²)
Granite	100 (1000)
Basalt	40 (400)
Lime Stone (except very soft stones)	20 (200)
Sandstone	30 (300)
Marble	50(500)
Quartzite	80 (800)
Laterite (Block)	3 (30)

6.0.2.2 Durability :

Requirements have been indicated in Para 6.1.1. Petrographic examination of stones may be done as per IS 1123 which helps in identifying natural stones.

6.0.2.3 Sizes : Normally stones used shall be small enough to be lifted and placed by hand. Unless otherwise indicated, the length of stones for stone masonry shall not exceed three times the height and breadth of base

shall not be greater than three fourth the thickness of the wall , or not less than 15 cm. The height of stone may be upto 30 cm.

6.0.2.4 Selection of Stones :

In selection of stones, the situation where it is to be used shall be considered. **Table 6.2** gives the recommended use of common types of stones.

Table 6.2

Type of Stone	Use
1. Dense stone like granite, gneiss	a) Masonry work submerged in water b) Masonry below plinth level or in contact with soil
2. Granite, quartzite	Masonry work exposed to smoke or chemical fumes
3. Sand stone	Fire resistant masonry
4. Soft stone like marble, sandstone	For carved ornamental work, arches, veneers etc.

6.0.2.5 Type of Stone Masonry

The following Types are in common use

- Random Rubble Masonry – Uncoursed and brought to course & Dry Coursed Rubble Masonry.
- Coursed Rubble Masonry - First and Second sorts
- Ashlar Masonry – Plain, Special
- Stone veneering.
- Laterite Stone Masonry / Slate Stone Masonry

6.0.2.6 Laying of Stones – General requirements

a) The stones should be laid so that the pressure is always perpendicular to the bed. The courses shall be built perpendicular to the pressure which the masonry will bear. In case of battered walls, the base stone and the plane courses shall be at right angles to the batter.

b) In the case of coursed rubble masonry, if the heights of the courses vary, the largest stone shall be placed in the lowest course; the thickness of courses shall also decrease gradually to the top. Vertical joints shall be staggered as far as possible. Bell shaped bond stones or headers shall not be used. All the necessary chases for joggles, dowels and cramps should be formed in the stones before hand.

c) Sufficient transverse bonds should be provided by the use of bond stones extended from the front to the back of the wall and from outside wall to the interior of thick wall and in the latter case bond stones shall overlap each other in their arrangement.

At all angular junctions, the stones at each alternate course shall be well bonded into the respective courses of adjacent wall.

d) Where there is break in the masonry work, the masonry shall be raked in

sufficiently long steps for facilitating jointing of old and new work. The stepping of the raking shall not be more than 45 deg. to the horizontal. Walls and pillars shall be carried up truly plumb or as to the specified batter.

e) No work shall be done above 1m from the ground level or the floor level as the case may be, without the aid of suitable scaffolding.

6.0.2.7 Fixing of Door & window Frames

Where door and window frames are to be fixed in the opening, hold fasts embedded in concrete block replacing a stone block may be used.

6.0.2.8 Bearing of floors, Roofs and Joints

Corbels or brackets shall be provided for resting of joists. Beams carrying heavy loads shall be supported by templates of concrete stone.

6.0.2.9 Jointing and Pointing

All joints shall be full of mortar. Pointing may be avoided. If unavoidable, raking is to be done and types of pointing shall be as for brick work.

6.0.2.10 Weather protection and Curing

Stone masonry laid in cement or lime mortar shall be protected during construction from rain and frost by suitable cover. The masonry shall be kept wet on all the faces for a period of 7 days after construction. In case of masonry work, with lime mortar, it is desirable that the work, after every height of 1.5m or less, shall be allowed to set for atleast 2 days before starting further construction over it. Stone masonry laid in mud mortar shall not be watered but shall be protected during construction from rain or from uneven drying.

6.0.2.11 Weep holes are generally to be provided in abutments, wings and returns

and other earth retaining structures, as shown on the drawings or as directed by the Engineer. These shall be formed either by building in pipes of suitable size or by leaving holes of the required size through the masonry, with a proper fall from the back of the wall to the front. No extra payment shall be made for forming weep holes and no deduction will be made from the masonry for the gaps for weep holes

6.1 RANDOM & UNCOURSED RUBBLE MASONRY (Refer Figure 6.2)

(Note : This para describes basically Random or Uncoursed Rubble Masonry. A slight improvement in uncoursed Rubble Masonry is to bring it to course at vertical intervals of 30cm to 90 cms. Paras 6.1.3 and 6.1.4 may be referred to for details.)

6.1.1. Stone

The stone shall be of the type specified such as granite, trap, limestone, sand stone, quartzite etc., and shall be obtained from the

quarries, approved by the Engineer. Stone shall be hard, sound, durable and free from weathering decay and defects like cavities, cracks, flaws, sand holes, injurious veins, patches of loose or soft materials and other similar defects that may adversely affect its strength and appearance. As far as possible stones shall be of uniform colour, quality or texture. Generally stone shall not contain crystalline silica or chalk, mica and other deleterious materials like iron-oxide, organic impurities etc.,

Normally Stones with round surface shall not be used.

The compressive strength of common types of stones shall be as per **Table 6.1** and the percentage of water absorption shall generally not exceed 5% for stones other than those specified in **Table 6.3**. For laterite this percentage is 12%.

Table 6.3
MAX. WATER ABSORPTION OF STONES

Type of stone	Maximum Water Absorption percentage by weight
Granite	0.5
Basalt	0.5
Lime stone (Slab & Tiles)	0.15
Sand Stone (Slab & Tiles)	2.5
Marble	0.40
Quartzite	0.40
Laterite (Block)	12

Note : Test for water absorption shall be carried out as laid down in IS:1124.

6.1.2. Size of Stones

Normally stones used should be small enough to be lifted and placed by hand. Unless otherwise indicated, the length of stones for stone masonry shall not exceed three times the height and the breadth or base shall not be greater than three-fourth the thickness of wall, or not less than 15 cm. The height of stone may be up to 30 cm.

6.1.3. Categories of RR Masonry:- Random Rubble Masonry shall be un-coursed (**Figure 6.2**) or brought to courses as specified in Para 6.1.4 Un-coursed random rubble masonry shall be constructed with stones of sizes as referred to in para 6.1.2. and shapes picked up random from the stones brought from the approved quarry. Stones having sharp corners or round surfaces shall, however, normally not be used.

6.1.4. RR Masonry brought to course : Random rubble masonry brought to the course is similar to un-coursed random rubble masonry except that the courses are roughly leveled at intervals varying from 30 cm to 90 cm in height according to the size of stones used.

6.1.5. Dressing

Each stone shall be hammer dressed on the face, the sides and the bed. Hammer dressing shall enable the stones to be laid close to neighbouring stones such that the face shall not project more than 40 mm on the exposed face and 10 mm on the face to be plastered.

Mortar :

The mortar used for joining shall be as specified and should conform to IS 2250 (Refer **Chapter 26 on "Mortar"**)

6.1.6. Laying

All stones shall be wetted before use. Each stone shall be placed close to the stones already laid so that the thickness of the mortar joints at the face is not more than 20 mm. Face stones shall be arranged suitably to stagger the vertical joints and long vertical joints shall be avoided. Stones for hearting or interior filling shall be hammered down with wooden mallet into position and firmly bedded in mortar. Chips or spalls of stones may be used for filling of interstices between the adjacent stones in hearting and these shall not exceed 20% of the quantity of stone masonry. To form a bond between successive courses plum stones projecting vertically by about 15 to 20 cm shall be firmly embedded in the hearting at the interval of about one metre in every course. No hollow space shall be left anywhere in the masonry.

The masonry work in wall shall be carried up true to plumb or to specified batter.

Random rubble masonry shall be brought to the level courses at plinth, window sills, lintel and roof levels. Leveling shall be done with concrete comprising of one part of the mortar as used for masonry and two parts of graded stone aggregate of 20 mm nominal size.

The masonry in structure shall be carried uniformly. Where the masonry of one part is to be delayed, the work shall be raked back at an angle not steeper than 45° .

6.1.7. Bond Stones

Bond or through stones running right through the thickness of walls, shall be provided in walls up to 60cm thick and in case of walls above 60 cm thickness, a set of two or more bond stones overlapping each other by at least 15 cm shall be provided in a line from face of the wall to the back. Details may be seen in **Figure 6.4**.

In case of highly absorbent types of stones (porous lime stone and sand stone etc..) single piece bond stones may give rise to dampness. For all thicknesses of such walls, a set of two or more bond stones overlapping each other by at least 15 cm shall be provided. Length of each such bond stone shall not be less than two-third of the thickness of the wall.

Where bond stones of suitable lengths are not available pre-cast cement concrete block 1:2:4 (1 cement : 2 coarse sand : 4 graded stone aggregate 20 mm nominal size) of cross section not less than 225 square centimeters and length equal to the thickness of wall shall be used in lieu of bond stones. This shall however be applicable only in masonry below ground level and

where masonry above ground level is finally required to be plastered.

At least one bond stone or a set of bond stones shall be provided for every 0.5 sqm of the area of wall surface. All bond stones shall be marked suitably with paint as directed by the Engineer.

6.1.8. Quoin and Jamb Stones

The quoin and jamb stones shall be of selected stones neatly dressed with hammer or chisel to form the required angle. Quoin stones shall not be less than 0.01 cum. in volume. Height of quoins and jamb stones shall not be less than 15 cm. Quoins shall be laid header and stretcher alternatively.

6.1.9. Joints

Stones shall be so laid that all joints are fully packed with mortar and chips. Face joints shall not be more than 20 mm thick.

The joints shall be struck flush and finished at the time of laying, when plastering or pointing is not to be done. For the surfaces to be plastered or pointed, the joints shall be raked to a minimum depth of 20 mm when the mortar is still green.

6.1.10. Scaffolding

Single scaffolding having one set of vertical support shall be allowed. The supports shall be sound and strong, tied together by horizontal pieces, over which the scaffolding planks shall be fixed. The inner end of the horizontal scaffolding member may rest in a hole provided in the masonry. Such holes, however, shall not be allowed in pillars under one metre in width or near the skew back of arches. The holes left in masonry work for supporting scaffolding shall be filled and made good with cement concrete 1:3:6 (1 Cement: 3 coarse sand : 6 stone aggregate 20 mm nominal size).

6.1.11. Curing

Masonry work in cement or composite mortar shall be kept constantly moist on all faces for a minimum period of seven days. In case of masonry with fat lime mortar, curing shall commence two days after laying of masonry and shall continue for at least seven days thereafter.

6.1.12. Protection

Green work shall be protected from rain by suitable covering. The work shall also be suitably protected from damage, mortar dropping and rain during construction.

6.1.13. Measurements

6.1.14.1. The length, height and thickness shall be measured correct to a cm. The thickness of wall shall be measured at joints

excluding the bushing. Only specified dimension shall be allowed; anything extra shall be ignored. The quantity shall be calculated in cubic metre nearest to two places of decimal.

6.1.14.2. The work under the following categories shall be measured separately:-

- (i) From foundation to plinth level
 - (a) Work in or under water and or liquid mud,
 - (b) Work in or under foul positions.
- (ii) From plinth level to two floor levels.
- (iii) From two floor levels above plinth level for every additional floor or part thereof.
- (iv) Stone masonry in parapet shall be measured together with the corresponding item in the wall of the storey next below.

6.1.14.3. No deduction shall be made nor extra payment made for the following:-

- (a) Ends of dissimilar materials (that is joists, beams, lintels, posts, girders, rafters, purlins, trusses, corbels, steps etc.) up to 0.1 sqm in section.
- (ii) Openings each up to 0.1 sqm in area. In calculating the area of openings, any separate lintels or sills shall be included along with the size of opening but the end portions of the lintels shall be excluded and the extra width of rebated reveals, if any, shall also be excluded.
- (iii) Wall plates and bed plates, and bearing of chhajjas and the like, where the thickness does not exceed 10 cm and the bearing does not extend over the full thickness of the wall.

Note : The bearing of floor and roof shall be deducted from wall masonry.

- (iv) Drain holes and recesses for cement concrete blocks to embed hold-fasts for doors, windows, etc.,
- (v) Building in masonry, iron fixture, pipes up to 300mm dia, hold fasts of doors and windows etc.,
- (vi) Forming chases in masonry each up to section of 360 sq.cm.

6.1.14.4 Masonry (excluding fixing brick work) in chimney breasts with smoke or air flues not exceeding 20 sq.dm. (0.20 sq.m.) in sectional area shall be measured as solid and no extra payment shall be made for pargetting and coring such flues. Where flues exceed 20sq.dm. (0.20 sq.m.) sectional area deduction shall be made for the same and pargetting and coring flues shall be

measured in running metres stating size of flues and paid for separately.

6.1.14.5 Apertures for fire places shall not be deducted and no extra payment made for splaying of jambs, throating and making arch to support the opening.

6.1.14.6 Square or Rectangular Pillars: These shall be measured as walls, but extra payment shall be allowed for stone work in square or rectangular pillars over the rate for stone work in walls. Rectangular pillar shall mean a detached masonry support rectangular in section, such that its breadth does not exceed two and a half times the thickness.

6.1.14.7 Circular Pillars (Columns): These shall be measured as per actual dimensions, but extra payment shall be allowed for stone work in circular pillars over the rate for stone work in walls. The diameter as well as length shall be measured correct to a cm.

6.1.14.8 Tapered wall shall be measured net, as per actual dimensions and paid for as other walls.

6.1.14.9 Curved Masonry: Stone masonry curved on plan to a mean radius exceeding 6 metres shall be measured and included with general stone work. Stone work circular on plan to a mean radius not exceeding 6 metres shall be measured separately and shall include all cuttings and waste and templates. It shall be measured as the mean length of the wall.

6.1.15 Rate

The rate shall include the cost of materials and labour required for all the operations described above and shall include the following :

- (a) Raking out joints for plastering or pointing done as a separate item, or finishing flush as the work proceeds.
- (b) Preparing tops and sides of existing wall for raising and extending.
- (c) Rough cutting and waste for forming gables, cores, skew backs or spandrels of arches, splays at eaves and all rough cutting in the body of walling, unless otherwise specified.
- (d) Bond stones or cement concrete bond blocks.
- (e) Leading and making holes for pipes etc.,
- (f) Bedding and pointing wall plates, lintels, sills, etc., in or on walls, bedding roof tiles and corrugated sheets in or on walls.
- (g) Building in ends of joists, beams, lintels, etc.

6.2. COURSED RUBBLE MASONRY – FIRST SORT (Figure 6.3)

6.2.1 General:- Coursed Rubble Masonry is generally of First Sort or second sort. Squared Rubble Masonry is an inferior variety of coursed Rubble Masonry and a Note on this may be seen in **Figure 6.3**.

6.2.2 Stone - Shall be as specified in para 6.1.1.

6.2.3 Size of Stones - Shall be as specified in para 6.1.2.

6.2.4 Dressing

Face stones shall be hammer dressed on all beds and joints so as to give them approximately rectangular block shape. These shall be squared on all joints and beds. The bed joint shall be rough chisel dressed for at least 8 cm back from the face, and side joints for at least 4 cm such that no portion of the dressed surface is more than 6 mm from a straight edge placed on it. The bushing on the face shall not project more than 4 cm as an exposed face and one cm on a face to be plastered. The hammer dressed stone shall also have a rough tooling for minimum width of 2.5 cm along the four edges of the face of the stone, when stone work is exposed.

6.2.5 Mortar

The mortar for jointing shall be specified and shall conform to IS 2250. Refer to **Chapter 26 on Mortar**.

6.2.6 Laying

All stones shall be wetted before use. The walls shall be carried up truly plumb or to specified batter. All courses shall be laid truly horizontal and all vertical joints shall be truly vertical. The height of each course shall not be less than 15 cm nor more than 30 cm.

Face stones shall be laid with alternate headers and stretchers. No pinning shall be allowed on the face. No face stone shall be less in breadth than its height and at least one-third of the stones shall tail into the work for length not less than twice their height.

The hearting or the interior filling of the wall shall consist of stones carefully laid on their proper beds in mortar with chips and spalls of stone being used where necessary to avoid thick beds of joints of mortar and at the same time ensuring that no hollow spaces are left anywhere in the masonry. The chips shall not be used below the hearting stone to bring these up to the level of face stones. The use of chips shall be restricted to the filling of interstices between the adjacent

stones in hearting and these shall not exceed 10% of the quantity of stone masonry.

The masonry in a structure shall be carried up uniformly but where breaks are unavoidable, the joints shall be raked back at an angle not steeper than 45°, Toothing shall not be allowed.

6.2.7 Bond Stones

Shall be as specified in para 6.1.8. except that a bond stone or a set of bond stones shall be inserted 1.5 to 1.8 metres apart, in every course.

6.2.8 Quoins

The quoins shall be of the same height as the course in which these occur. These shall be at least 45 cm long and shall be laid as stretchers and headers alternately. These shall be laid square on the beds, which shall be rough-chisel dressed to a depth of at least 10 cm. In case of exposed work, these stones shall have a minimum of 2.5 cm wide chisel drafts at four edges, all the edges being in the same plane.

6.2.9 Joints

All bed joints shall be horizontal and all side joints vertical. All joints shall be fully packed with mortar. Face joints shall not be more than one cm thick.

When plastering or pointing is not required to be done, the joints shall be struck flush and finished at the time of laying. Otherwise, joints shall be raked to a minimum depth of 20 mm by raking tool during the progress of work, when the mortar is still green.

6.2.10 Curing etc.:- Curing, scaffolding, measurements and rates shall be as specified under Para 6.1.

6.3 COURSED RUBBLE MASONRY – SECOND SORT (Figure 6.3)

6.3.1. Stone: Shall be as specified in para 6.1.1.

6.3.2. Size of Stones : Shall be as specified in para 6.1.2.

6.3.3. Dressing

Shall be as specified in para 6.2.4 except that no portion of dressed surface shall exceed 10 mm from a straight edge placed on it.

6.3.4. Mortar

The mortar for jointing shall be as specified and shall conform to IS 2250. Refer to **Chapter 26 on Mortar**.

6.3.5. Laying

Shall be as specified in para 6.2.6 except that the use of chips shall not exceed 15% of the quantity of stone masonry and stone, in each course, need not be of the same height but not more than two stones shall be used in the height of a course.

6.3.6. Bond Stone, Quoins

Shall be as specified in paras 6.2.7 and 6.2.8 respectively.

6.3.7. Joints

All bed joints shall be horizontal and all side joints vertical. All joints shall be fully packed with mortar. Face joints shall not be more than 2 cm thick.

When plastering or pointing is not required to be done, the joints shall be struck flush and finished at the time of laying. Otherwise the joints shall be raked to a minimum depth of 20 mm by raking tool during progress of work, when the mortar is still green.

6.3.8. Curing, Scaffolding, measurement and rates: Shall be as specified.

6.4. PLAIN ASHLAR MASONRY (Figure 6.5)

6.4.1. General : Stone shall be of the type specified. It shall be hard, sound, durable and tough, free from cracks, decay and weathering and defects like cavities, cracks, flaws, sand holes, veins, patches of soft or loose materials etc., Before starting the work, the contractor shall get the stones approved by the Engineer.

6.4.2. Size of Stones

Normally stones used should be small enough to be lifted and placed by hand. The length of the stone shall not exceed three times the height and the breadth on base shall not be greater than three-fourth of the thickness of wall nor less than 15 cm. The height of stone may be up to 30 cm.

6.4.3. Dressing

Every stone shall be cut to the required size and shape, so as to be free from waviness and to give truly vertical and horizontal joints. In exposed masonry, the faces that are to remain exposed in the final position and the adjoining faces to a depth of 6 mm shall be fine chisel dressed so that when checked with 60 cm straight edge, no point varies from it by more than 1 mm. The top and bottom faces that are to form the bed joints shall be chisel dressed so that variation from 60 cm straight edge at no point exceeds 3 mm. Faces which are to form the vertical joints should be chisel dressed so that variation at any point with 60 cm straight edge does not exceed 6mm. Any vertical

face that is to come against backing of masonry shall be dressed such that variation from straight edge does not exceed 10 mm. All angles and edges that are to remain exposed in the final position shall be true, square, and free from chippings.

A sample of dressed stone shall be prepared for approval of the Engineer. It shall be kept at the work site as a sample after being approved.

6.4.4. Mortar

The mortar for jointing shall be as specified and should conform to IS 2250. Refer to **Chapter 26 on Mortar.**

6.4.5. Laying

All stones shall be wetted before placing in position. These shall be floated on mortar and bedded properly in position with wooden mallets without the use of chips or under pinning of any sort.

The walls and pillars shall be carried up truly plumb or to batter as shown in drawings. All courses shall be laid truly horizontal and all vertical joints shall be truly vertical.

In case of ashlar work without backing of brick work or coursed rubble masonry, face stone shall be laid headers and stretchers alternately unless otherwise directed. The headers shall be arranged to come as nearly as possible in the middle of stretchers above and below. Stone shall be laid in regular courses of not less than 15 cm in height and all the courses shall be of same height, unless otherwise specified.

For ashlar facing with backing of brick work or coursed rubble masonry (**Fig.6.6**) face stone shall be laid in alternate courses of headers and stretchers unless otherwise directed. Face stone and bond stone course shall be maintained throughout. All connected masonry in a structure shall be carried up nearly at one uniform level throughout, but where breaks are unavoidable, the joints shall be made in good long steps so as to prevent cracks developing between new and old work. Bond stone provided in the masonry shall be payable in the item of Ashlar masonry. Neither any deduction will be made from the brick masonry for embedding the bond stone in the backing nor any extra payment shall be made for any extra labour involved in making holes in brick masonry backing.

When necessary, jib crane or other mechanical appliances shall be used to hoist the heavy pieces of stones and place these into correct positions, care being taken that the corners of the stone are not damaged.

Stone shall be covered with gunny bags, before tying or rope is passed over it, and it shall be handled carefully. No piece which has been damaged shall be used in work.

6.4.6. Bond Stones

Shall be as specified in para 6.1.8.

6.4.7. Joints

All joints shall be full of mortar. These shall be not more than 6 mm thick. Face joints shall be uniform throughout and a uniform recess of 20 mm depth from face shall be left with the help of the steel plate during the progress of work.

6.4.8. Pointing

All exposed joints shall be pointed with mortar as specified. The pointing when finished shall be sunk from stone face by 5 mm or as specified. The depth of mortar in pointing work shall not be less than 15 mm.

6.4.9. Curing

Masonry work in cement or composite mortar shall be kept constantly moist on all faces for a minimum period of seven days. In case of masonry with fat lime mortar, curing shall commence two days after laying on masonry and shall continue for at least seven days thereafter.

6.4.10. Protection

Green work shall be protected from rain by suitable covering. The work shall also be suitably protected from damage, mortar dropping and rain during construction.

6.4.11. Scaffolding

Double scaffolding having two sets of vertical supports shall be provided. The supports shall be sound and strong, tied together with horizontal pieces over which scaffolding planks shall be fixed.

6.4.12. Measurements

The finished work shall be measured correct to a centimeter in respect of length, breadth and height. The cubical contents shall be calculated in cubic metre nearest to two places of decimal.

6.4.12.1 No deduction nor any extra payment shall be made for the following:-

- (i) Ends of dissimilar materials (that is joists, beams, lintels, posts, girders, rafters, Purlins, trusses, corbels, steps etc.) up to 0.1 sqm. in section.
- (ii) Openings up to 0.1 sqm. in area. In calculating the area of opening, any separate lintels or sills shall be included along with the size of the opening but the end portion of the lintels shall be excluded and extra width of

rebated reveals, if any, shall also be excluded.

(iii) Wall plates and bed plates and bearing of chhajja and the like, where the thickness does not exceed 10 cm and the bearing does not extend over the full thickness of the wall.

Note: The bearing of floor and roof slabs shall be deducted from wall masonry.

(iv) Drainage holes and recesses left for cement concrete blocks to embed hold-fasts for doors and windows.

v) Building in the masonry iron fixture and pipes up to 300mm diameter.

Stone walling in chimney breasts, chimney stacks, smoke or air flues not exceeding 0.20 sqm. in sectional area shall be measured as solid and no extra measurement shall be made for pargetting and coring such flues. Where flues exceed 0.20 sqm. in sectional area, deduction shall be made for the same and pargetting and coring flues paid for separately.

6.4.12.2. Square, Rectangular or Circular Pillars: Shall be measured and paid for as walls, but extra payment shall be allowed for such pillars and columns over the rate for stone work in walls.

Rectangular pillars shall mean a detached masonry support, rectangular in section, such that its breadth shall not exceed two and half times the thickness.

6.14.2.3. Curved Stone Work:- Stone work curved on a plan to a mean radius exceeding six metres shall be measured net and included with general stone work. Stone work curved in plan to a mean radius not exceeding six metres shall be measured separately and extra payment shall be allowed and shall include all cutting and waste and templates. It shall be measured as the mean length of wall.

6.4.13. Rate

The rate shall include the cost of materials and labour required for all the operations described above. Stone facing or wall lining up to and not exceeding 8 cm thickness shall be paid for under "Stone work for wall lining etc., (Veneer work)". The stone work of thickness exceeding 8 cm shall be paid under relevant items of work.

6.5. OTHER TYPES OF ASHLAR (ORDINARY) MASONRY (Refer Figures 6.7A to 6.7E)

6.5.1 Punched Ashlar Masonry (Refer Figure 6.7A)

6.5.1.1 Stone - Shall be as specified in para 6.4.1.

6.5.1.2 Size of Stone - Shall be as specified in para 6.4.2.

6.5.1.3 Dressing

Shall be as specified in para 6.4.3 except that the faces exposed in view shall have a fine dressed chisel draft 2.5 cm wide all round the edges and shall be rough tooled between the drafts, such that the dressed surface shall not be more than 3 mm from a straight edge placed over it.

6.5.1.4 Other Details

The specifications for mortar, laying and fixing, bond stone, joints, pointing, curing, protections, scaffolding, measurements and rates shall be same as specified in para 6.4.

6.5.1.5 Ashlar Rock faced (see Figure 6.7B)

a) Dressing shall be as for Plain Ashlar except that the exposed faces of the stone between the drafts shall be left rough as the stone comes from the quarry; but no rock face or bushing shall project more than 75mm from plane of drafts.

b) Other requirements shall be as for Plain Ashlar.

6.5.1.6 Ashlar Rough Tooled (see Figure 6.7C)

a) The dressing of the stone shall be similar to plain ashlar except that the face exposed to view shall have a fine chisel draft 25mm wide round the edges and shall be rough tooled between the draft such that the dressed surface shall not deviate more than 3mm from the straight edge placed over it.

b) Other requirements shall be as for Plain Ashlar.

6.5.1.7 Ashlar Chamfered (see Figure 6.7D)

a) The dressing shall be as for Plain Ashlar except that it shall be levelled off to 45 deg. for a depth of about 25mm or more as specified.

b) Other requirements shall be as for Plain Ashlar.

6.5.1.8 Ashlar Block in Course (see Fig. 6.7E)

a) The stones are dressed all squared and laid to fine joints; the faces being usually hammer dressed. The stones selected may be of larger size than plain ashlar.

b) The other requirements are as for Plain Ashlar except that the courses vary between 200-250 mm in thickness. This type of masonry is therefore superior to coursed rubble masonry.

6.6 MOULDED, SUNK, CARVED ASHLAR MASONRY (Refer Figure 6.8)

6.6.1 Stone

Shall be as specified in para 6.4.1.

6.6.2 Dressing

a) Every stone shall be cut to the required size and shape and chisel dressed on all beds and joints so as to be free from any waviness and to give perfectly vertical, horizontal, radial or circular joints with adjoining stones, as the case may be. The dressed surface shall not be more than 3 mm from a straight edge placed on it. The face shall be gauged, cut, chamfered, grooved, rebated, sunk or plain moulded and fine tooled as shown in the working drawings. The joints 6 mm from the face shall also be fine tooled so that a straight edge laid along it is in contact with every point. It shall be the finest surface which can be given to a stone with the chisel and without rubbing.

b) In case of sunk or moulded masonry, the corner stone shall be dressed at true right angles or true to the shape as specified, the corners being straight and vertical.

c) For Arches (see Fig.6.9), dome or circular work (see Fig.6.8) the stone shall be dressed to required wedge shape so that joints shall be truly radial.

6.6.2.1 Ashlar Arches

a) Every stone shall be cut to the required size and shape and chisel dressed on all beds and joints as stipulated in Para 6.6.2 (a) and (c) above.

b) An elevation of the arch shall be drawn out on lime or cement plaster on the ground, and voussiors of different width according to the stone to be used marked thereon. Sheet templates shall then be cut out and the stones well dressed to the templates to a uniform and fine finish. This will ensure the voussiors having sides radial to the centre, and the upper and lower surfaces cut concentric.

c) All visible angles and edges shall be true, square and free from chippings as stipulated in Para 6.6.2 (a) above.

d) Centering : All arches shall be formed on a well constructed centering. The centering shall be so designed and shall have such a profile that with the full weight of the work on it, the correct curvature and form of the arch indicated in the drawings are obtained, and shall be of such form and dimensions as are approved by the Engineer.

Where timber centering is used all the ribs shall be of such class of timber, as the Engineer shall approve and they shall be properly jointed and fastened at the joints of all segments, ties and struts with suitable fixtures on each side and the centres shall be provided in such numbers and be used in such sets as in the opinion of the Engineer, will ensure the various works being carefully constantly and continuously carried on. Steel Centering shall be preferred to Timber centering.

In any structure of more than three spans, there shall always be sufficient sets of centres to allow taking up work on the number of arches specified by the Engineer and in any case not less than four spans shall be completely centered at one time. Where there are three spans or less, all the spans shall be completely centered before the building of any of the arches is commenced and the building of the several arches shall be simultaneously executed as directed. The centering for groined arches shall be specially constructed as directed. In erecting the ribs of centering, proper allowance must be made for settlement and

the lagging boards for every length will be required to be gauged to a uniform thickness and their upper surface shall be formed true to the proper curvature and kept perfectly clean. All arches and other works must be left true to the curvature and form indicated in the drawings. All centres for skew arches shall be constructed and set on the square. The Engineer will determine the period during which the sets of centering shall remain fixed after arches are keyed and no centering shall be eased or struck without the authority from the Engineer.

The centering shall be wedged in position so that it can be "eased" as soon as the arch has been turned and the haunches filled in.

6.6.3 Striking of Centres and application of load:

The centres should not be struck before one week after the completion of the arch and then too only with the permission of the Engineer. After completion of any portion of the masonry of an arch bridge, the following minimum periods of time shall be allowed to elapse before loads as specified below may be imposed on that portion of the masonry.

Class of Cement	50% of designed load	75% of designed load	Full designed load
i) Ordinary cement mortar and concrete	7 days	14 days	28 days
ii) Rapid hardening cement mortar and concrete	5 days	10 days	28 days

The expression "load" means the total calculated load with the appropriate impact allowance specified for the speed at which the load is permitted to run.

The above periods shall be suitably increased where the mean air temperature is less than 16 deg. C

6.6.4 Ashlar Pillars:- Pillars if made in ashlar, shall be in blocks well dressed on all sides. Unless not obtainable, these shall be at least 75 cm deep and shall be built with 'Khaddi' (Gypsum or sweet lime) or cement. 'Khaddi' should be mixed with red colour so that its whiteness is not noticed when it has set.

6.6.5 Ashlar Stone lintels (Pataos)

The exposed faces shall be well dressed and other surfaces rough dressed with chisel. If the lintels are wider than 23cm, they may be made in two pieces joined together with gypsum with the vertical joint at the centre of the width. The pieces shall invariably be

clamped together with metal clamp, and if the upper surface of the 'patao' has to take roofing, this surface shall be dressed to take the slope of the 'Patti'. Under no circumstances horizontal joints are to be allowed.

6.6.6 Moulded, sunk, carved Ashlar masonry :

Dressing:- Every stone shall be cut to the required size and shape and chisel dressed on all beds and joints so as to be free from any waviness and to give perfectly vertical, horizontal, radial, or circular joints with adjoining stones as the case may be. The dressed surface shall not be more than 3mm from a straight edge placed on it. The face shall be gauged, cut, chamfered, grooved, rebated, sunk, or plain moulded and fine tooled as shown in the working drawings. The joints 6mm from the face shall also be fine tooled so that the straight edge laid along it is in contact with every point. It shall

be finest surface which can be given to a stone with chisel and without rubbing.

In case of sunk or moulded masonry the corner stone shall be dressed at true right angles or true to the shape as specified. The corners being straight and vertical.

For arch, dome, or circular work stone shall be dressed to required wedge shape so that joints shall be truly radial.

Samples : The full size lay out of the moulding etc., shall be prepared on platform from which sheet templates shall be cut and the stone dressed to templates to a uniform and fine finish. All the visible angles and edge shall be true square and free from chippings. A sample of dressed stone shall be prepared for approval and it shall be kept as sample after being approved by the Engineer.

In case of ashlar moulded and carved columns a full size model of the required moulding, carving etc., shall be prepared in plaster of paris and kept at site of work as sample work after being approved by the Engineer. The stones shall be moulded and carved in accordance with the approved model to a uniform and fine finish.

6.6.7 Other Details

Shall be as specified in paras 6.4.4., 6.4.5. and 6.4.7 to 6.4.11.

6.6.8 Centering and Shuttering for arch dome and circular moulded work

Centering and shuttering required for arch, dome or circular moulded work shall be constructed as directed by the Engineer. The stipulations for centering and shuttering for Arch work indicated in Para 6.6.2.1 shall be adopted for dome and circular moulded work as applicable.

6.6.9 Measurement

The dimensions of the circumscribing rectangles of the dressed stone used in the work shall be measured correct to a cm and cubical contents shall be calculated in cubic metres, nearest to two places of decimal.

6.6.9.1. In case of sunk or moulded work the measurements for the work shall be taken course by course. The plain stone used in conjunction with sunk or moulded stone shall be measured and paid for under the relevant item of stone work.

6.6.9.2. Sunk or moulded work in rectangular, square and circular pillars, moulded cornices and string courses shall be measured under stone work sunk or moulded but extra payment shall be allowed over the general work in each case. No such

extra payment shall be allowed for moulded string and plinth course.

6.6.9.3 In case of arch dome or circular moulded work for arches exceeding six meters in clear span extra payment for additional cost of centering shall be made on the actual area of soffit including strutting, bolting, wedging, easing, stripping and removal.

6.6.10 Rate

The rate includes the cost of all materials and labour involved in all the operations described above, including centering and shuttering for arch, dome or circular moulded work.

6.7 STONE VENEERING WORK (Figure Nos. 6.10, 6.11 & 6.12)

6.7.1 General:- Stone lining up to 8 cm shall be treated as veneering work and lining of greater thickness as plain Ashlar Masonry.

6.7.2 Stone

Shall be as specified in para 6.4.1.

The stone shall be cut into slabs of required thickness along the planes parallel to the natural bed of stone.

6.7.3 Dressing

Shall be as specified in para 6.4.3. except that dressing at the back shall not be done, so as to ensure better grip with hearting or backing. The dressed slabs shall be of the thickness as specified, with permissible tolerance of ± 2 mm.

6.7.4 Mortar

Mortar for fixing shall be as specified and should conform to IS 2250. Refer to **Chapter 26 on "Mortar"**.

6.7.5 Laying

The stone shall be wetted before laying. They shall then be fixed with mortar in position without the use of chips or underpinning of any sort.

6.7.5.1 Where so desired, the adjoining stones shall be secured to each other by means of copper pins 75 mm long and 6 mm diameter or as specified.

6.7.5.2 Further the stones shall be secured to the backing by means of cramps. The material for cramps shall have high resistance to corrosion under conditions of dampness and against the chemical action of mortar or concrete in which cramps are usually embedded. Cramps shall be of 25mm x 6mm and 30 cm long in case of backing of stone masonry walls and brick masonry walls thicker than 230mm. In case

of backing with brick masonry walls 230mm or less thick or RCC members, cramps shall be of 25 x 6 mm and length as per requirement, made out of gun metal or any other metal specified in para 6.7.5.6. Generally the outer length of cramp in half brick work backing shall be 115mm and in one brick work backing it shall be 150mm. Typical shape and details of cramps for such backing are indicated in **Figure 6.11** for general guidance. This can be modified as directed by the Engineer if so, required at site. Cramps shall be spaced not more than 60 cm horizontally. Alternatively the stone may be secured to the backing by means of stone dowels 10 x 5 x 2.5 cm as per shape indicated in **Fig.6.10** and the adjoining stones secured to each other by means of gun metal cramps or copper pins of the specified size. Minimum one cramp/stone dowel shall be used to secure one slab to the backing.

6.7.5.3 Cramps may be attached to the sides (see **Fig.6.12A, 6.12B**) or top and bottom (see **Fig.6.12C to F**) or sides, top and bottom (see **Fig.6.12 G & H**). The minimum number of cramps required for fixing facing unit to the wall are illustrated in **Fig.6.12** The actual number of cramps and their sections, however, shall be as per requirements of design to carry the loads.

6.7.5.4 Where cramps are used to hold the unit in position only, the facings shall be provided with a continuous support on which the stones rest at the ground level and other storey levels, the support being in the form of projection from or recess into the concrete floor slab, or a beam between the columns or a metal angle attached to the floor slab or beams. These supports shall preferably be at vertical intervals not more than 3.5 m apart and also over the heads of all openings. Such supports shall also be provided where there is transition from thin facings below to thick facings above.

6.7.5.5 Alternatively cramps may be used to hold the units in position and in addition to support the units thus transferring the weight of the units to the backing. Such cramps should be properly designed as per IS: 4101 (Part.1.).

6.7.5.6 The cramps may be of gun metal or copper alloyed with zinc, tin, nickel, lead and/or stainless steel.

6.7.5.7 The pins, cramps and dowels shall be laid in cement mortar 1:2 (1 Cement : 2 fine sand) and their samples got approved by the Engineer and kept at site.

6.7.5.8 The walls shall be carried up truly plumb. All courses shall be laid truly horizontal and all vertical joints truly vertical. The stones shall break joints on the face for at least half the height of the course, unless otherwise shown in the drawings. The stones shall be laid in regular courses not less than 20 cm height and all the stones shall be of the same height unless otherwise specified. No stone shall be less in length than one and a half times its height unless otherwise specified.

6.7.5.9 As far as possible the backing shall be carried up simultaneously with the face work. In case of reinforced cement concrete backing, the lining shall be secured to the backing after it has set and got cured. The cramps shall be fixed in concrete at the required positions, while laying.

6.7.6 Joints

The joints shall be done with composite cement lime mortar 1:1:6 (1 Cement: 1 lime putty: 6 fine sand) or as specified.

All joints shall be full of mortar. Special care shall be taken to see that the groundings for veneer work are full of mortar. If any hollow groundings are detected by tapping the face stones, these shall be taken out and re-laid. The thickness of joints shall be as small as possible, not exceeding 5 mm. For a close but jointed facing, the thickness shall not exceed 1.5 mm. The face joints shall be uniform throughout.

Where joint filler or compound is to be used, the joints shall be raked out to a depth of at least 25 mm after the mortar in the joints has set sufficiently and the filler or compound applied. The joints may be subsequently finished with a mortar suited to the appearance of the work. It is preferable to use joint sealing compounds where the facings are exposed to heavy rain fall and winds and their selections would depend upon local experience and availability of joint sealing compounds. In their absence only masonry mortars 1:1:6 (1 Cement : 1 lime putty: 6 sand) or as specified which have proved to be successful from local exposure conditions shall be used.

6.7.7 Other details

Specifications for pointing, curing, protections and scaffolding shall be as specified under Para 6.4.

6.7.8 Measurements

The length and breadth of the finished work shall be measured in metres correct to cm.

The area should be calculated in sq. metre correct to two places. of decimal.

The veneering work curved on plan shall be measured as plain work, but extra payment shall be allowed for radii not exceeding six metres on external face. For radius beyond six metres the work shall be measured as plain work only, even if the face may have to be dressed to curve. In case of plain slabs of geometrical shape other than square or rectangle or plain slabs of irregular shape, the dimensions of the circumscribing rectangle of the dressed slab used in the work shall be measured.

6.7.9 Rate

The rate includes the cost of materials and labour involved in all the operations described above, except for the cost of providing and fixing pins, dowels, and metal cramps and ledges and supports, which shall be paid for separately unless otherwise stipulated in the item of work.

6.8 STONE CHHAJJA (Figure 6.13)

6.8.1. General:- Stone slabs shall be hard, sound and durable. These shall be chisel dressed on all faces which are exposed to view and rough dressed at other surfaces. Angles shall be true and edge lines straight. The finished thickness shall be as stipulated with permissible tolerance of ± 2 mm. The length of stone slabs in chhajja shall not be less than 60 cm unless otherwise specified.

6.8.2. Construction details:- In case of sloping chhajja, the stone shall be sloped as specified. It shall have minimum bearing of 20 cm measured horizontally on the wall and the bearing shall also be similarly sloped. Each slab shall have a hole in the center of the bearing area through which the anchoring M.S. holding down bolt shall pass. The holding down bolts shall be 12 mm in diameter and shall be bent at right angles at its lowest end and buried horizontally for at least 7 cm in a joint 30 cm below the bearing surface. Each holding down bolt shall be secured at top by suitable washer and nut.

The chajjas shall be provided with cove supports and where cove is in brick masonry, it shall project out from the wall as under:

45 cm wide chajja, cove projection 15 cm; depth of cove 3 courses.

60 cm wide chajja, cove projection 20 cm; depth of cove 4 courses.

75 cm wide chajja, cove projection 25 cm; depth of cove 5 courses.

90 cm wide chajja, cove projection 30 cm; depth of cove 6 courses.

6.8.3. In case of horizontal chhajja, the stone shall be fixed horizontally with a slight outer slope of about 1 cm. It shall have minimum bearing of 15 cm on the wall. Holding down bolts shall be provided, only where so specified.

6.8.4. Pointing

The joints shall be pointed with 1:2 cement mortar (1 Cement: 2 stone dust /crushed stone sand) with an admixture of pigment to match the stone shade and properly cured.

6.8.5. Other Details

Specifications for curing, protections and scaffolding shall be as specified under Para 6.4.

6.8.6. Measurements

The length and breadth of the finished work shall be measured correct to a cm. The area of chhajja projecting beyond the wall shall be calculated in sqm. correct to two places of decimal.

In case of sloping chhajja, the sloping breadth shall be measured, the area of chhajja projecting beyond the wall shall be calculated in sqm. correct to two places of decimal.

6.8.7. Rate

The rate shall include the cost of all materials and labour involved in all the operations described above. Anchoring the coves shall be deemed to be included in the rate only when it is so stipulated in the description of the item.

6.9. SHELVES, COPING, PLAIN CORNICES, STRING COURSES ETC.,

6.9.1. Stones

Stone shall be of uniform colour and texture and of the kind as stipulated.

6.9.2. Dressing

The exposed faces and sides of shelves shall be chisel dressed such that the dressed surface shall not be more than 3 mm from a straight edge placed on it. All visible angles and edges shall be free from chippings, The surfaces to be buried in the masonry shall be rough dressed.

6.9.3. Laying

These shall be laid in mortar of specified mix and fixed as shown in drawing or as directed by the Engineer.

6.9.4. Other Details

Specifications for pointing, curing, protections and scaffolding shall be as specified under Para 6.4.

6.9.5. Measurements

6.9.5.1. Shelves: The length and breadth shall be measured inclusive of bearings correct to a cm. The thickness shall be as specified with permissible tolerance of ± 2 mm. The area shall be calculated in sqm. correct to two places of decimal.

6.9.5.2. Copings: The dimensions of the circumscribing rectangles of the dressed stones as used in work shall be measured correct to a cm. The cubical contents shall be calculated correct to two places of decimal in cum.

6.9.5.3 Plain Cornices, String Courses and Plinth Courses: The length, breadth and depth of the stone including bearing shall be measured correct to a cm. The cubical contents shall be calculated correct to two places of decimal in cum.

6.9.5.4. No deduction shall be made from the masonry of wall for the bearing of stone shelves, cornices and string courses.

6.9.6. Rate

The rate shall include the cost of all materials and labour required in all the operations described above.

6.10. STONE JALI

6.10.1. General:- Stone shall be as specified in para 6.4.1.

Dressing and Fixing

The stone shall be cut in to slabs of required thickness so as to make jali of the specified thickness. The jali shall be cut as per pattern shown on the drawings. All exposed faces shall be fine tooled to a uniform and smooth finish. Fixing shall be done with the adjoining work in grooves, rebates etc., as shown in the drawing or as directed by the Engineer. A tolerance of ± 2 mm shall be allowed in the specified thickness of the jali.

6.10.2. Measurements

The length and breadth of the stone forming the jali including its borders shall be measured correct to a cm and the area shall be calculated in square metres nearest to two places of decimal.

6.10.3. Rate

It includes the cost of labour and materials required for all the operations described above, it also includes the cost of making grooves or rebates in the adjoining work for fixing jali.

6.11. LATERITE STONE MASONRY

6.11.1. Dressing

Laterite stones shall be hammer dressed into rectangular blocks so that all faces are free from waviness and unevenness, and the edges are true and square. The least thickness/breadth shall be not less than height. The length shall generally be equal to twice the breadth, unless otherwise specified.

6.11.2. Laying

The dressed stones shall be laid in regular courses of not less than 15cm height. All courses in the masonry shall be of the same height unless otherwise directed. The stones shall be laid in alternate header stretcher fashion, with alternate courses of headers and stretchers or in any other suitable fashion as directed. The vertical joints shall break by at least 65 mm. No specific corner stones are necessary. Quoin may be provided, where so indicated.

6.11.3. Joints

All bed joints shall be truly vertical, the thickness of joints shall not exceed 15 mm. Each stone shall be carefully laid in place with joints completely filled with mortar. Where no plastering or pointing is required to be done, the joints shall be struck flush as the work proceeds. In other cases, joints shall be raked square to minimum depth of 15 mm by a raking tool during the progress of work while the mortar is still green.

6.11.4. Scaffolding, Curing and Protection

Provisions in para 6.4 shall apply.

6.11.5. Measurement and Rates

Provisions in para 6.4 shall apply.

6.12. SLATE STONE MASONRY

6.12.1 General:- Slate stone shall be obtained from the approved quarry, as indicated, and shall not be less than 6 cm thick. Slate stones shall be carefully hammered down into place with wooden mallet and firmly bedded with mortar. Chips and spalls shall be wedged in order to avoid thick bed joints of the mortar. Spalls and pinnings may show on face. Thickness of mortar in beds and joints shall not exceed 25 mm. No face work shall be provided.

6.12.2 Construction details:- Slate stone masonry shall be built un-coursed. Walls should be leveled up at the top of plinth, sill and lintel level of openings and at top with minimum amount of chips and spalls. For walls up to 45 cm thick, 25% of face area

shall be of bond stones. For walls over 45 cm thick, 10% of the face area shall be of bond stones. Quoin and jambs stones shall be laid headers and stretchers alternately.

6.12.3 Scaffolding, Curing and Protection

These shall be as specified in para 6.4.

6.12.4 Measurement and Rate

These shall be as specified in para 6.4.

6.13. DRY COURSED RUBBLE MASONRY

6.13.1 General:- This sort of wall is particularly suitable for breast and retaining walls as in hill Railways and roads.

6.13.2 Foundations:- The foundations, if in moorum, should be carried down to a depth of from 60 to 90 cm below the hill slope at the outer side, and filled in with the largest blocks of stone available, carefully laid and packed in by hand with stones of smaller size. The bed of the foundation shall be excavated at right angles to the face batter and not horizontally.

6.13.3 Stones:- The stones used should be of the largest and best description procurable in the locality and roughly hammer dressed, so as to secure as large bedding surfaces as possible. When laid, all hollows round them should be tightly packed with smaller stones.

6.13.4 Laying:- The stones must be laid on their natural or quarry bed at right angles to the face batter in regular courses. Each course is to be built with proper bond and break of joints with course below. The front and rear faces of the wall shall be similar and equally well bonded with the hearting. The stones must be laid as headers as far as possible with their largest "bed" downwards. All stones in one course need not be of the same height but not more than two stones shall be used to make the full height of the course between two headers, having full depth. No course shall be of greater height than the one below it.

6.13.5 Bond Stones:- Bond stones, atleast 90.0 cm or for full thickness of wall, if wall is less than 90.0 cm in thickness shall be provided in each course at 150 to 180 cm apart on the face of the work, and continued through the whole width, overlapping each other by 23 cms, so as to tie the front and rear faces of the work together. These bond stones shall be of the full height of the course in the facing, atleast as broad as they are high, and of the greatest length readily procurable.

6.13.6 Filling:- The filling in behind the wall shall be done with waste or smaller stones,

carefully packed and rammed and carried up simultaneously with the building of the face. The filling of earth should be avoided and necessary arrangements for drainage kept.

6.13.7 Thickness and Batter:- The thickness and batter of walls shall be as specified in the drawings or as ordered by the Engineer. Generally for retaining ordinary earth fill without surcharge, the top wall should not be less than 60 cm wide and the batter in front not steeper than 1 in 3 (Keeping back vertical). The thickness at the top and the batter on the face may be increased at the discretion of the Engineer. For walls higher than 450 cms the top width may be suitably increased or only top built in dry masonry, the rest being masonry in mortar.

6.13.8 Long Walls:- Long lengths of dry rubble walls should be suitably divided into panels separated from one another by short lengths of walls (150 to 210cm) long built in mortar at intervals of, say 600 to 900 cm in order to confine subsequent damage if any, only to the panels affected.

6.14. PRE CAST CONCRETE STONE BLOCKS MASONRY

6.14.1 Terminology

For the purpose of this section of specifications, the following definitions shall apply:

6.14.1.1 Block Density – The density calculated by dividing the mass of a block by the over all volume including holes or cavities.

6.14.1.2 Stone Spalls – Broken stone pieces of varying sizes obtained by breaking the natural river boulders or quarry stones.

6.14.1.3 Concrete Stone Masonry Block – A pre cast cement concrete solid block having stone spalls in it (25-30 percent of block volume) and cement concrete with dense stone aggregate and sand. It is 100% solid.

6.14.1.4 Stone Face Exposed Block – A concrete stone masonry block where the stone spalls are exposed at one of its face. In the face, which forms the exposed wall face, the wall gets the texture of stone surface exposed.

6.14.2 Dimensions and Tolerances

Concrete stone masonry block is a solid block and shall be referred to by its nominal dimensions. The term 'nominal' means that the dimensions include the thickness of the

mortar joint. Actual dimensions shall be 10 mm short of the nominal dimensions.

The nominal dimensions of concrete stone masonry block shall be as follows:-

Length	300 mm
Height	150 mm and
Width	100,150 and 200 mm

In addition, blocks shall be manufactured in one-third, half, two-third and three quarters of the full length.

The nominal dimensions of the units are so designed that taking into account the thickness of mortar joints, they will produce wall lengths and heights which will conform to the principles of modular co-ordination.

Blocks of other nominal dimensions may also be made if so directed by the Engineer.

6.14.3 Provision of reinforcement:- For accommodating vertical reinforcement required in earthquake resistant construction, special blocks of half width and with semi-circular recess in it (see **Fig.6.14**) shall be used. The dimensions shown in the Figure are suitable for 200 mm thick wall. Similar blocks shall be made for walls of thickness greater than 200 mm.

6.14.4 Tolerances:- The maximum variation in the length of the units shall not be more than ± 5 mm and maximum variation in height and width of units not more than ± 3 mm.

6.14.5 Construction Details:- Subject to the tolerances specified in para 6.14.4 the faces of blocks shall be flat and rectangular, opposite faces shall be parallel, and all arises shall be square. The bedding surfaces shall be at right angles to the faces of the blocks.

6.14.6 Blocks with Special Faces

Blocks with special faces shall be manufactured and supplied as specified in the Schedule item or agreement.

6.14.7 Classification

Concrete stone masonry blocks shall be classified according to their average compressive strength as given in **Table.6.5** below Para 6.14.13.4.

6.14.8 Materials

6.14.8.1 Cement: cement complying with any of the following Indian Standards may be used at the discretion of the Engineer IS: 269, 455, 1489, 6909, 8041 & 8043. (Refer **Chapter 26 on Mortar**)

6.14.8.2 When cement conforming to IS: 269 is used, replacement of cement by fly-ash conforming to IS: 3812 may be permitted

up to a limit of 20%.. However, it shall be ensured that blending of fly-ash with cement is as intimate as possible, to achieve maximum uniformity.

6.14.8.3 Stone Spalls: The stone spalls shall be of size ranging from 50 to 250 mm in dimension. The stone spalls shall be hard, sound, round in shape, durable, free from decay and weathering. These shall not be flaky. The spalls shall have rough surface for better bond with cement concrete. Good quality stones, such as granite, sand stone and basalt shall be used. Slate shale or any other soft and flaky stone shall not be used. The spalls shall be obtained from approved quarry or by breaking river boulder. Larger size shall be broken into the required sizes and shall be stacked into two categories.

(a) 100 mm and above; and

(b) Below 100 mm.

6.14.8.4 Aggregates: The aggregates used in the manufacture of block shall be clean and free from all deleterious matter, and shall conform to the requirements of IS: 383.

Maximum size of the coarse aggregate shall be 10 mm. Sand used in the manufacture of blocks shall be well graded, clean and free from deleterious matter, and shall conform to the requirements of IS: 383. Besides it shall have fine particles 15 to 20% passing 300 micron I.S. Sieve and 5 to 15% passing 150 micron I.,S. Sieve.

It is recommended that the fineness modules of the combined aggregate shall be between 3.6 and 4.

6.14.8.5 Fly-ash conforming to IS: 3812 may be used for part replacement of fine aggregate up to a limit of 20%.

6.14.9 Manufacture

Blocks may be manufactured either at construction site or in factory on a central casting platform using steel moulds with or without surface vibration for compaction of cement concrete.

6.14.9.1 Mould: Moulds shall be fabricated using mild steel plates and mild steel angles for stiffening the plates.

The moulds shall be either fixed type (bolt with four side walls fixed at corners, and top and bottom open) or split type.

Split type may be either individual or gang mould type. Where the compaction of the concrete is done manually, the mould may be either fixed type or split type. When the compaction of the blocks is done with surface vibrator, the mould shall be only split type (individual or gang mould).

6.14.10 Mix

6.14.10.1 The cement concrete mix for concrete stone masonry blocks shall not be richer than one part by volume of cement to 9 parts by volume of combined fine and coarse aggregates, and shall not be leaner than one part by volume of cement to 13 parts by volume of combined fine and coarse aggregates.

6.14.10.2 In case of blocks where compaction is done manually, concrete mix of medium consistency (10 – 12 mm slump) shall be used in order to enable proper compaction and de-moulding. The consistency of the mix should be such that it may form a lump when compressed in the hand without free water being visible.

6.14.10.3 In case of blocks where compaction is done by external vibrator, concrete mix of very low consistency (zero slump) shall be used in order to vibrate and compact the concrete under pressure.

6.14.10.4 Mixing: Concrete shall normally be mixed in a mechanical mixer unless otherwise permitted by the Engineer. In case of hand mixing 10% extra cement shall be used without any extra payment.

Mixing shall be continued until there is a uniform distribution of the materials, and the mass is uniform in colour and consistency.

6.14.11 Placing and Compaction

Depending upon the size of the stone spalls, these shall be used either in one layer or in two layers. When used in two layers, large size spalls of 100 mm and above shall be placed in the bottom and concrete poured all round and at top, and shall be tamped manually. Second layer of stone spalls of size 50 mm and above shall be placed over the first layer, and again concrete is poured all round and up to 20 to 30 mm above the top level of mould.

6.14.11.1 Depending upon the size of block, the average volume of stone spalls used should generally be between 25 to 30%. However, in no block, it shall be less than 20% of the volume of block.

6.14.11.2 Each stone spall shall have a minimum space of about 15 to 20 mm around it. For blocks with exposed stone texture, the stone spalls shall touch the surface of the mould.

6.14.11.3 Blocks may be compacted manually as well as mechanically. In case of manual compaction, the concrete laid after the first layer of stone spalls shall be tamped with mason's tool and again it shall be

tamped with suitable tampers and compacted from top and finally struck off level with trowel.

In case of mechanical compaction, the mould shall be filled up to overflow, vibrated and mechanically tamped using external vibrator and struck off level.

6.14.11.4 De-moulding shall be done 5 to 10 minutes after compaction. In case of fixed type mould it shall be pulled up with side handles while pressing down the block with the plate at top with thumb. In case of split type mould, the sides shall be removed first and the partition plates (gang mould) shall be pulled up subsequently.

6.14.11.5 After de-moulding, the blocks shall be protected until they are sufficiently hardened to permit handling without damage.

6.14.12 Curing

The blocks hardened shall then be cured in a curing water tank or in a curing yard and shall be kept continuously moist for at least 14 days.

6.14.12.1 Drying – After curing, the blocks shall be dried for a period of two or four weeks depending upon weather before being used on the work. The blocks shall be allowed to complete their initial shrinkage before they are laid in a wall.

6.14.13 Physical Requirements

6.14.13.1 General: – All blocks shall be sound and free from cracks or other defects which may interfere with the proper placing of the unit or impair the strength or performance of the construction.

6.14.13.2 Where blocks are to be used in exposed wall construction, the face or faces that are to be exposed shall be free of chips, cracks or other imperfections, except that not more than 5% of a consignment may contain slight cracks or small chipping.

6.14.13.3 Dimensions: The overall dimensions of the blocks when measured as given in Appendix A of IS: 12440 (IS Code on Precast Concrete Masonry Blocks) shall be in accordance with para 6.14.2 subject to the tolerances mentioned therein.

6.14.13.4 Compressive Strength: The minimum compressive strength at 28 days, being the average of eight blocks, and the minimum compressive strength at 28 days of individual blocks, when tested in the manner described in Appendix B of IS: 12440 (IS Code or Precast Concrete Stone Masonry Blocks) shall be as prescribed in **Table.6.5**.

TABLE 6.5
COMPRESSIVE STRENGTH OF CONCRETE STONE MASONRY BLOCKS

Class Designation	Minimum average compressive strength on blocks N/mm ²	Minimum strength of individual blocks N/mm ²
5	5.0	3.5
6	6.0	4.2
7	7.0	5.0
9	9.0	6.3
10	10.0	7.5

* For 100 mm wide blocks (for 100mm thick walls) the minimum strength may be 3.5 N/mm².

6.14.13.5 Water Absorption: The water absorption being the average of three blocks, when determined in the manner prescribed in Appendix C of IS: 12440 shall be not more than 6% by mass.

6.14.14 Tests

6.14.14.1 Tests as described in Appendix A of IS: 12440 shall be conducted on samples of blocks selected according to the sampling procedure given in para 6.14.14.2 to ensure conformity with the physical requirements laid down in para 6.14.13.

6.14.14.2 A sample of 15 blocks shall be taken from a lot of 5000 or part thereof manufactured under similar conditions of the same size and batch.

6.14.15 Criteria for Conformity

6.14.15.1 The lot shall be considered as conforming to the requirements of the specification if the conditions mentioned in paras 6.14.15.3 & 6.14.15.4 are satisfied.

6.14.15.2 Number of blocks with dimensions outside the tolerance limit and/or with visual defects, among those inspected shall be not more than two.

6.14.15.3 For compressive strength, the mean value determined shall be greater than or equal to the minimum limit specified in para 6.14.13.4.

6.14.15.4 For water absorption the mean value determined shall be equal to or less than maximum limit specified in para 6.14.13.5.

6.14.16 Laying

The laying of pre cast concrete stone block masonry shall be as per para 6.15.8.

6.15 HOLLOW AND SOLID CONCRETE BLOCK MASONRY

6.15.1 Hollow and solid concrete blocks

They shall conform to the requirements of IS:2185. "Specification for hollow and solid concrete blocks" except with regard to the mix of cement concrete and sizes of aggregates which shall be as indicated. Hollow blocks shall be sound, free from cracks, broken edges, honey combing and other defects that would interfere with the proper placing of block or impair the strength or performance of construction.

6.15.2 Dimensions and Tolerances

6.15.2.1 Concrete masonry building units shall be made in sizes and shapes to fit different construction needs. They include stretcher, corner, double corner or pier, jamb, header, bull nose, and partition block and concrete floor units.

6.15.2.2 Concrete Block-hollow (open or closed cavity) or solid shall be referred to by its nominal dimensions.

The nominal dimensions of concrete block shall be, as follows:-

Length: 400, 500 or 600 mm

Height: 200 or 100 mm

Width: 50, 75, 100, 150, 200, 250 or 300 mm

In addition, blocks shall be manufactured in half lengths of 200, 250 or 300 mm to correspond to the full lengths.

The maximum variation in the length of the units shall be not more than ± 5 mm and maximum variation in height and width of unit, not more than ± 3 mm.

6.15.3 Classification

6.15.3.1 Hollow (open and closed cavity) Concrete Blocks

The hollow (open and closed cavity) concrete blocks shall conform to the following three grades:

(a) Grade 'A' – These are used as load bearing units and shall have a minimum block-density of 1500 kg/m³. These shall be manufactured for minimum average

compressive strengths of 3.5, 4.5, 5.5 and 7.0 N/mm²

respectively at 28 days (see **Table 6.6**).

(b) Grade 'B' – These are also used as load bearing units and shall have a block density less than 1500 kg/ m³ but not less than 1000 kg/m³. These shall be manufactured for minimum average compressive strengths of 2.0, 3.0 and 5.0 N/mm²

respectively at 28 days (see **Table 6.6**).

(c) Grade 'C' - These are used as non-load bearing units and shall have a block-density less than 1500 kg/m³ but not less than 1000/ m³. These shall be manufactured for

minimum average compressive strength of 1.5 N/mm² at 28 days (see **Table 6.6**).

(d) Grade 'D' – The solid concrete blocks are used as load bearing units and shall have a block density not less than 1800 kg/ m³. These shall be manufactured for minimum average compressive strengths of 4.0, and 5.0 N/mm² respectively at 28 days (see **Table 6.6**).

6.15.4 Physical Requirements

6.15.4.1. Compressive Strength: the average crushing strength of eight blocks, when determined in accordance with IS: 2185 shall be not less than that specified in Table given below:-

TABLE 6.6
PHYSICAL REQUIREMENTS OF HOLLOW AND SOLD CONCRETE BLOCKS

Type	Grade	Density of Block kg/ m ³	Minimum Average Compressive Strength of Units N/mm ²	Minimum Strength of Individual Units N/mm ²
(1)	(2)	(3)	(4)	(5)
Hollow (open & closed cavity) load bearing unit	A(3.5) A(4.5) A(5.5) A(7.0)	Not less than 1500	3.5 4.5 5.5 7.0	2.8 3.6 4.4 5.6
	B(2.0) B(3.0) B(5.0)	Less than 1500 but not less than 1000	2.0 3.0 5.0	1.6 2.4 4.0
Hollow (open & closed cavity) non-load bearing unit	C(1.5)	Less than 1500 but not less than 1000	1.5	1.2
Solid load bearing units	D(4.0) D(5.0)	No less than 1800	4.0 5.0	3.2 4.0

6.15.4.2 Drying Shrinkage: The drying shrinkage of the blocks (average of three blocks) when unrestrained, shall be determined in accordance with IS:2185 and shall not exceed 0.1 per cent.

6.15.4.3 Moisture Movement: The moisture movement (average of three blocks) when determined in the manner described in IS:2185 shall not exceed 0.09 percent.

6.15.4.4 Water Absorption: The water absorption (average of three blocks) when determined in the manner described in

IS:2185 shall be not more than 10 percent by mass.

6.15.4.5 Face shells and webs shall increase in thickness from the bottom to the top of the unit. Depending upon the core moulds used, the face shells and webs shall be flared and tapered or straight tapered, the former providing a wider surface for mortar. The thickness of the face shell and web shall be not less than the values given in **Table 6.7**.

TABLE 6.7
MINIMUM FACE SHELL AND WEB THICKNESS

Nominal Block width mm	Face shell Thickness Min. mm	Thickness of Web Min. mm	Total Web Thickness per Course in any 200 mm length of Walling Min.mm
(1)	(2)	(3)	(4)
100 or less	25	25	25
Over 100 to 150	25	25	30
Over 150 to 200	30	25	30
Over 200	35	30	38

6.15.4.6 Subject to the tolerances specified in para 6.15.2.2 and the provisions of para 6.15.4.7 the face of masonry units shall be flat and rectangular, opposite faces shall be parallel, and all arises shall be square. The bedding surfaces shall be at right angles to the faces of the blocks.

6.15.4.7 Blocks with special faces shall be manufactured and supplied as directed by the Engineer.

6.15.5 Curing and Drying

The blocks shall be cured in an immersion tank or in a curing yard and shall be kept continuously moist for at least 14 days. When the blocks are cured in an immersion tank, the water of tank shall be changed at least every four days.

After curing, the blocks shall be dried in shade before being used on the work. They shall be stacked with voids horizontal to facilitate through passage of air. The blocks shall be allowed to complete their initial shrinkage before they are laid in wall.

6.15.6 Construction of Masonry

For single storeyed buildings, the hollows of blocks in foundation and basement masonry shall be filled up with sand and only the top foundation course shall be of solid blocks. But for two or more storeyed buildings, solid concrete blocks shall be used in foundation courses, plinth and basement walls, unless otherwise indicated. If hollow blocks are used, their hollows shall be filled up with cement concrete 1:3:6 using 12.5 mm nominal size aggregates.

6.15.7 Wetting of Blocks

Blocks need not be wetted before or during laying in the walls. In case the climate condition so require, the top and the sides of the blocks may only be slightly moistened so as to prevent absorption of water from the mortar and ensure the development of the required bond with the mortar.

6.15.8 Laying

6.15.8.1 Blocks shall be laid in mortar, as indicated and thoroughly bedded in mortar, spread over the entire top surface of the previous course of blocks to a uniform layer of not less than 10 mm and not more than 12 mm in thickness.

All courses shall be laid truly horizontal and all vertical joints made truly vertical. Blocks shall break joints with those above and below for not less than quarter of their length. Pre-cast half length closers (and not cut from full size blocks) shall be used. For battered faces, bedding shall be at right angles to the face unless otherwise directed. Care shall be taken during construction to see that edges of blocks are not damaged.

6.15.8.2 Mortar

(a) Hollow concrete blocks shall be embedded with a mortar which is relatively weaker than the mix used for making blocks in order to avoid formation of cracks. A rich or strong mortar tends to make a wall too rigid thus localizing the effects of movements due to temperature and moisture variations, resulting in cracking of blocks. The recommended proportion of mortar measured by volume is given in **Table 6.8**.

Table 6.8 Mix Proportions of Mortar for Hollow Concrete Blocks

SL	Type of Work	Normal Masonry (Cement: Lime: Sand)	Reinforced Masonry (Cement: Sand)
1	Normal Work	1:1:9 to 10	1:7 to 8
2	Exposed to severe conditions; high intensity of loads; pilasters; heavily loaded lintels and beams	1:1:6 to 7	1:4 to 5
3	Partitions of 10cm	1:1:7 to 8	1:5 to 6

Note : All mortars shall have a slump of 75 mm.

(b) Light weight blocks shall be embedded with a mortar mix, the strength of which is lower than mix for making blocks, to avoid formation of cracks. A 1:2:9 cement, lime, sand mortar may generally be used; for high intensity of load it shall be 1:1:6. Autoclaved blocks shall be embedded in mortar as specified in **Table 6.8**.

6.15.8.3 Concrete used for filling hollow concrete block masonry when reinforced shall be 1 cement, 2 ½ sand and 3 coarse aggregate of size ranging from 4.75 mm to 10mm. The water cement ratio shall not exceed 0.6. When cells exceed 100mm on the narrower side, the proportion of mix shall be 1 cement, 2 ½ sand, 3 ½ coarse aggregate for reinforced concrete and 1:3:6 for plain concrete.

6.15.8.4 Thickness of Walls:- (a) For load bearing masonry built with hollow concrete blocks, the thickness of walls shall not be less than the values as obtained from IS 1905.

(b) Light weight block in load bearing masonry for external walls in framed construction shall not be less than 200mm thick. However, if they are suitably braced by lateral or vertical supports, the thickness can be 100mm. Non-load bearing hollow block walls shall be not less than 100mm thick.

(c) Autoclaved block walls in framed construction shall also be as per (b), except that for load bearing work, the minimum thickness shall be 200mm; however it can be reduced to 150mm if properly braced.

6.15.8.5 Lateral Support

Walls made of blocks shall have vertical or horizontal lateral supports at right angles to the face of the wall. Cross walls, pilasters or buttress walls shall provide the lateral support.

6.15.9 Provisions for Door and Window Frames

A course of solid concrete block masonry shall be provided under door and window openings or a 10 cm thick pre-cast concrete sill block under windows. The solid course shall extend for at least 20 cm beyond the opening on either side. For jambs of very large doors and windows either solid units are used or the hollows shall be filled in with concrete of mix 1:3:6 using 12.5 mm nominal size aggregate.

6.15.10 Provisions for Roof

The course immediately below the roof slab shall be built with solid blocks. The top of the roof course shall be finished smooth with a layer of cement and coarse sand mortar 1:3, 10 mm thick and covered with a thick coat of white wash or crude oil, to ensure free movement of slab.

6.15.11 Intersecting Walls

When two walls meet or intersect and the courses are to be laid up at the same time, a true masonry bond between at least 50% of the units at the intersection is necessary. When such intersecting walls are laid up separately, pockets with 20 mm maximum vertical spacing shall be left in the first wall laid. The corresponding course of the second wall shall be built into these pockets.

6.15.12 Piers

The top course of block in the pier shall be built in solid blocks. Hollow concrete block shall not be used for isolated piers, unless their hollows are specified to be filled with cement concrete.

6.15.13 Fixtures etc. Fixtures, fittings, etc. shall be built into the masonry in cement and coarse sand mortar 1:3 while laying the blocks where possible. Hold fasts shall be built into the joints of the masonry during laying.

Holes, chases, sleeves, opening etc., of the required size and shape shall be formed in the masonry with special blocks while laying for fixing pipes, service lines, passage of water etc., After service lines, pipes etc., are fixed, voids left, if any, shall be filled up with cement concrete 1:3:6 (1 cement: 3 coarse sand: 6 stone aggregate 20 mm nominal size) and neatly finished.

6.15.14 Finishes

Rendering shall not be done to the walls when walls are wet. Joints for plastering or pointing as specified shall be raked to a depth of 12 mm.

Joints on internal faces, unless otherwise indicated, shall be raked for plastering. If the internal faces of masonry are not to be plastered the joints shall be finished flush as the work proceeds or pointed flush where so indicated.

6.15.15 Avoidance of Crack formation

6.15.15.1 General:- One of the main problems faced in a structure constructed with hollow or cellular type blocks is development of cracks. The cracks may arise from alteration in length, curvature or orientation due to load settlement, thermal

expansion or changes in moisture content. By taking preventive measures such cracks can be avoided.

6.15.15.2 Preventive measures

Preventive measures to avoid cracks have been explained in detail in Chapter 4 masonry, Section 3 Construction Practices – Block work Para 6 Avoidance of Crack formation of Bureau of Indian Standards “Hand Book on Building Construction

Practices (Excluding Electrical Works) Special Publication SP 62 (S&T), 1997. The same may be referred to for dealing with specific issues. Some of the measures dealt with include provision of Bonded beams and studs used as structural members or provision of horizontal joint reinforcement which serves the same purpose as Bonded beams.

FIGURES EXPLAINING SOME OF THE ITEMS REFERRED TO IN

FIGURE 6.1 A & 6.1 B

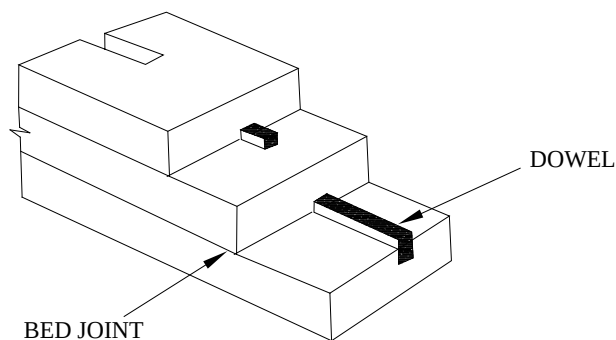


Fig. 6.1 A/1 : Dowel Joint

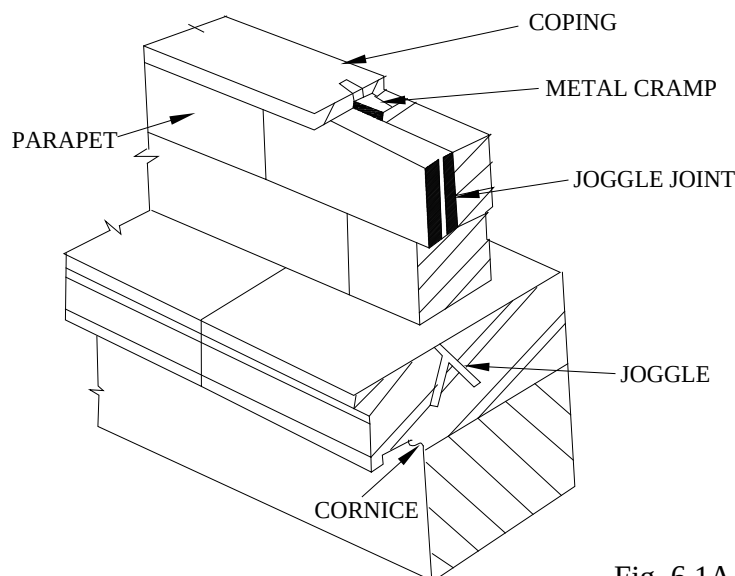


Fig. 6.1A/2 Joggle joint

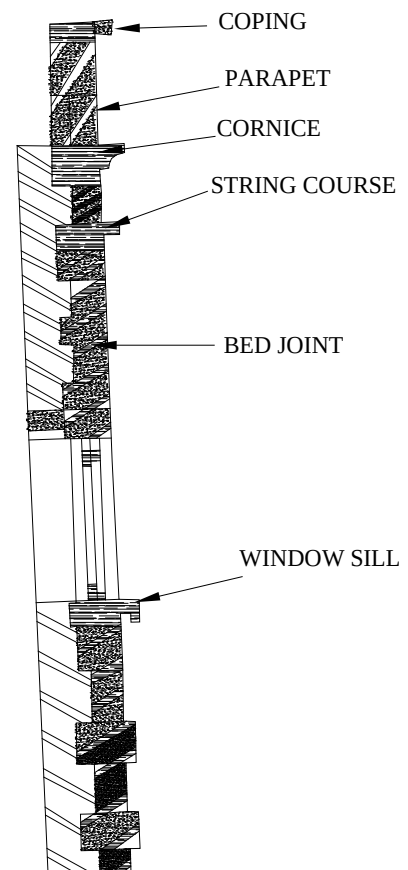


Fig. 6.1A/3 Section of Ashlar with Brick Backing

FIGURE 6.1 B

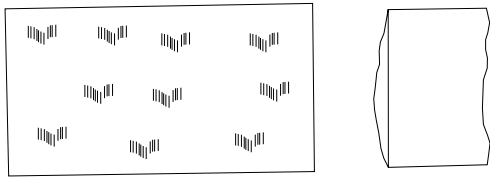


Fig. 6.1B/1 Hammer Dressed Stone Surface

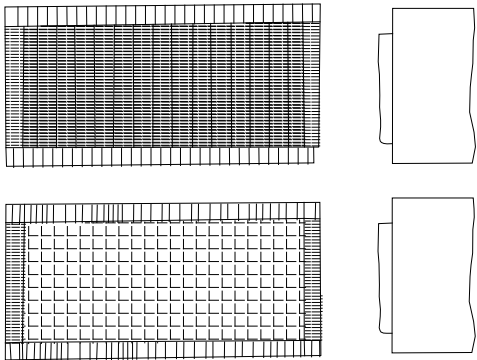


Fig.6.1 B/2 Punched Stone Face Surface
(Chisel drafted)

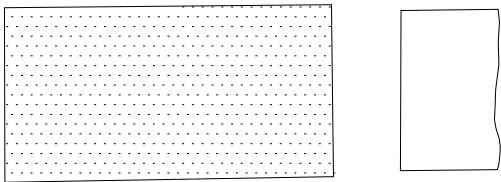


Fig.6.1 B/3 Close Picked Stone Surface

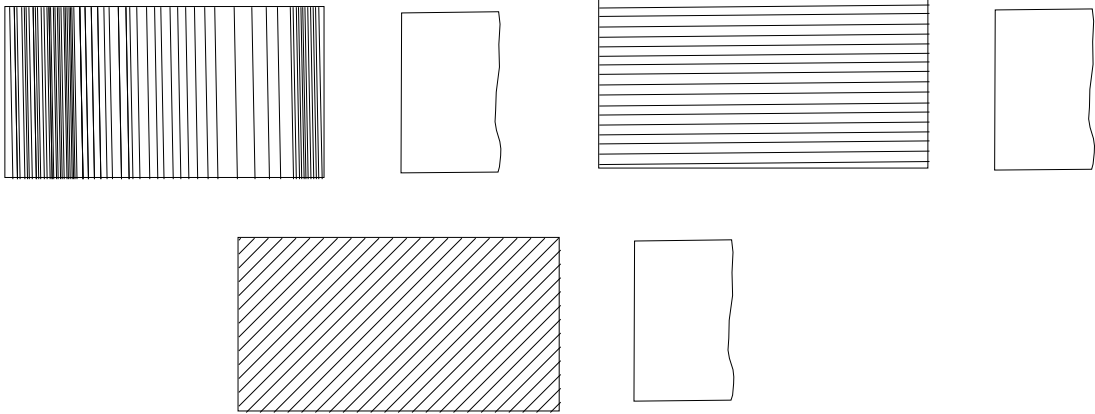
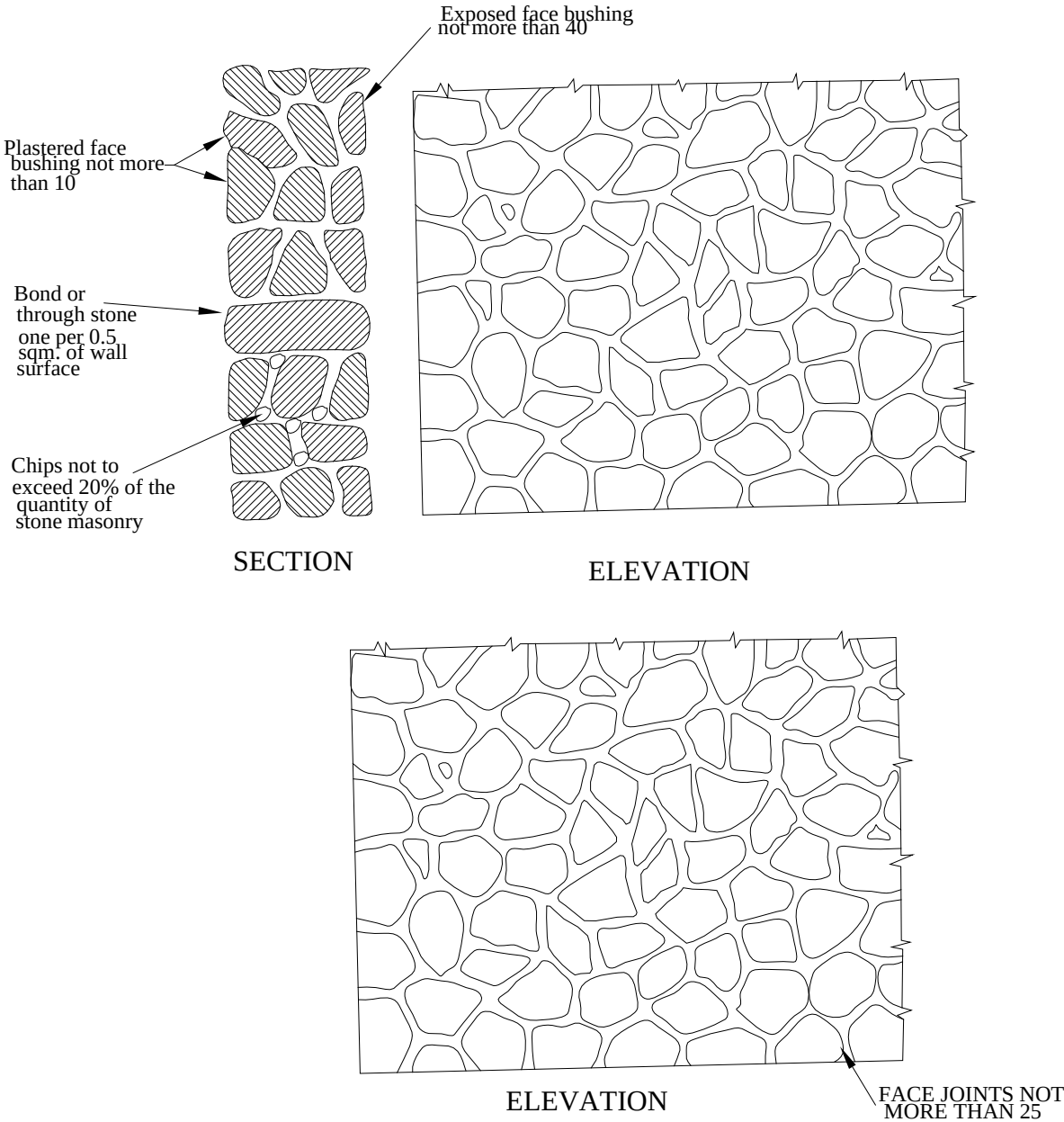


Fig.6.1 B/4 Fine Tooled Stone Surface

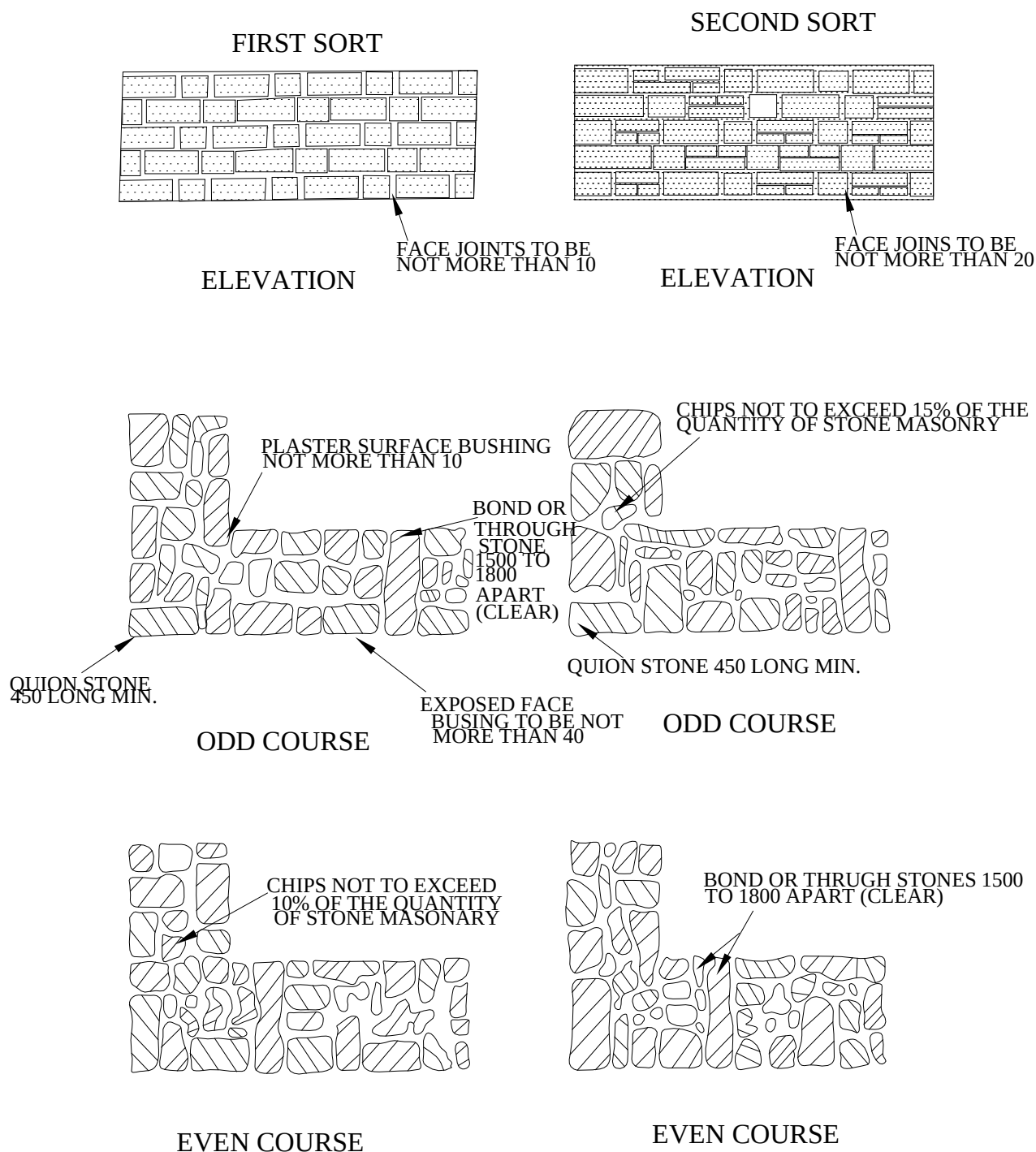
RANDOM RUBBLE MASONRY UNCOURSED

FIGURE 6.2



RUBBLE MASONRY - COURSED

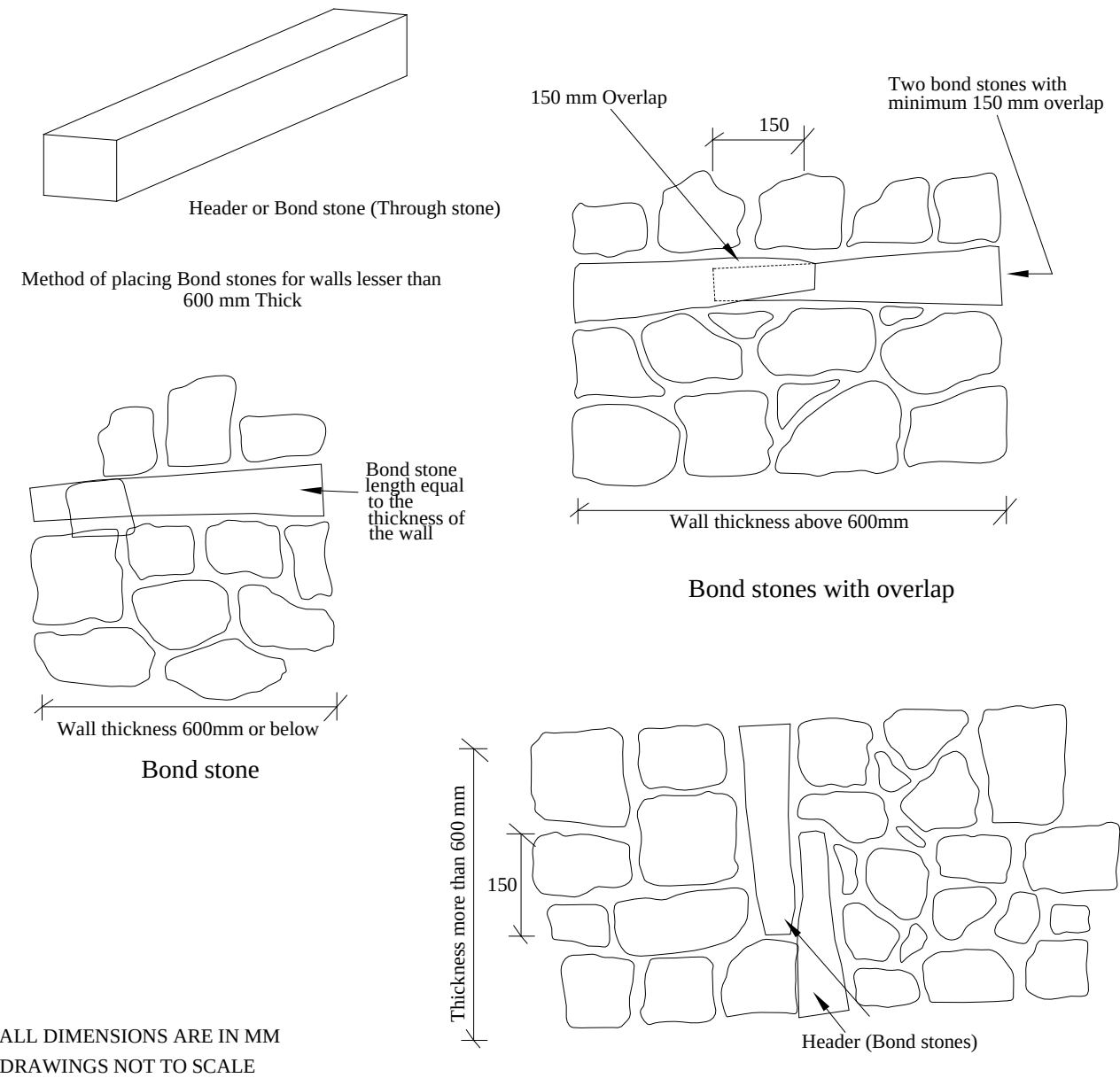
FIGURE 6.3



Note : Squared Rubble Masonry is the same as Coursed Rubble Masonry except that the stones need not be coursed throughout. The stones can be of height between 10 cm and 20 cm with a small proportion of smaller stones to fill gaps in between main stones. All stones shall be laid with horizontal bed joints. Headers shall be provided at the rate of atleast one per sqm of wall face. The work shall be brought up level throughout at every 1m of height.

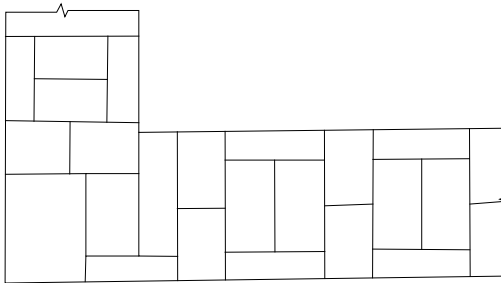
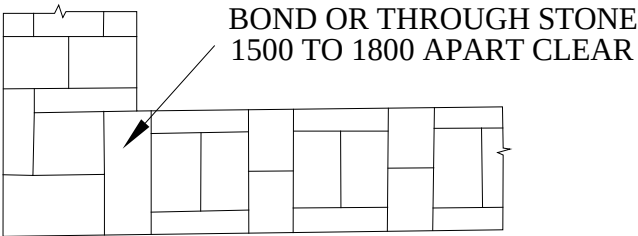
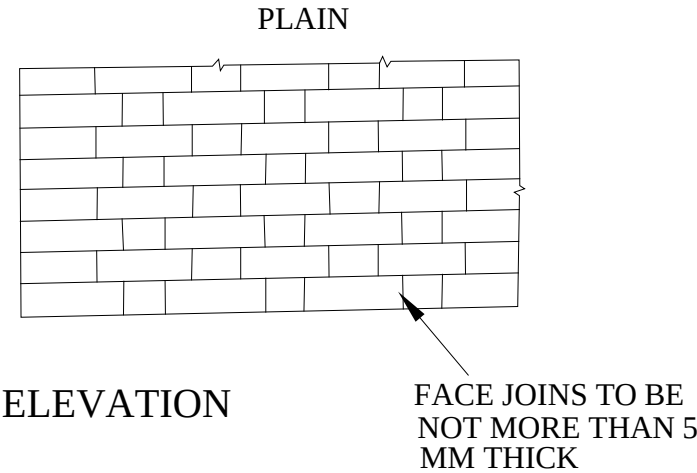
RANDOM RUBBLE MASONRY - DIFFERENT METHODS OF PROVIDING HEADER (BOND STONES) IN A STONEWALL

FIGURE 6.4



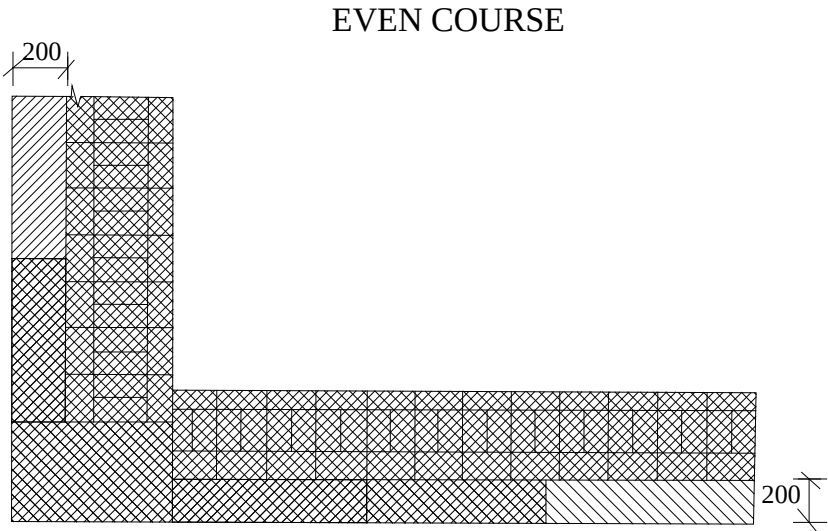
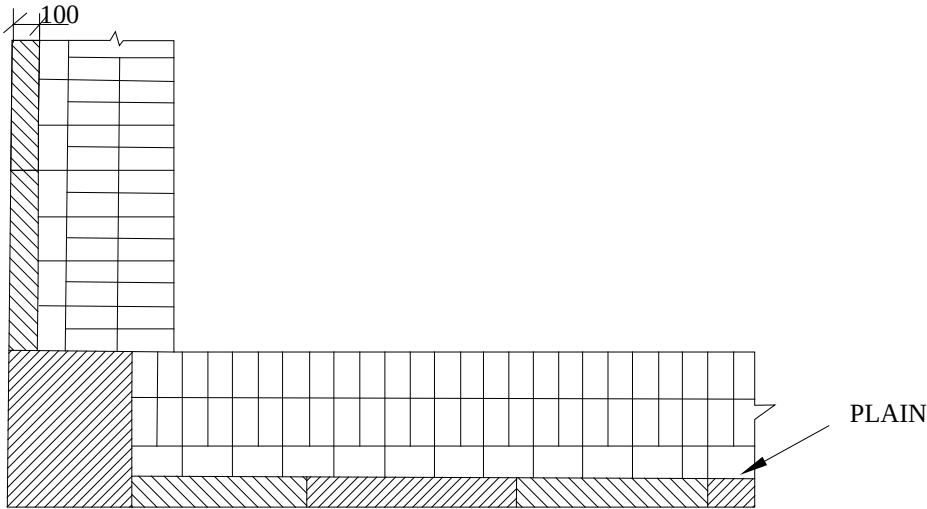
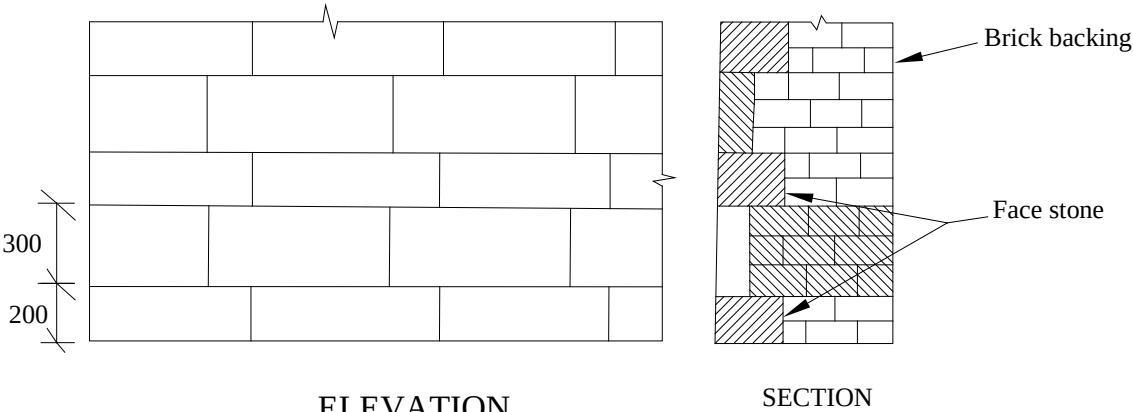
ASHLAR STONE MASONRY - PLAIN

FIGURE 6.5



ASHLAR STONE MASONRY - BRICK BACKING

FIGURE 6.6

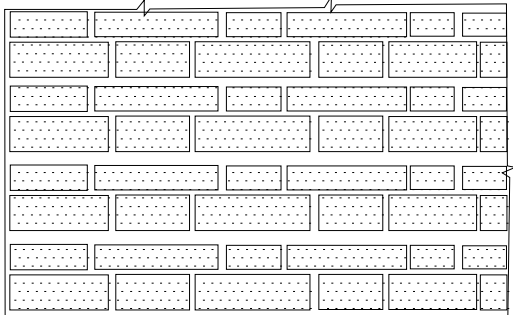


ALL DIMENSIONS ARE IN MM
DRAWINGS NOT TO SCALE

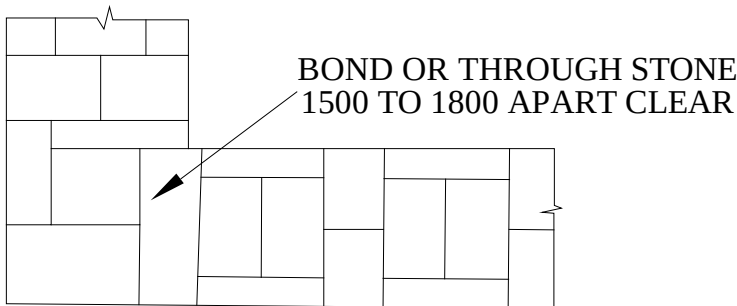
ODD COURSE

PUNCHED ASHLAR MASONRY
FIGURE 6.7 A

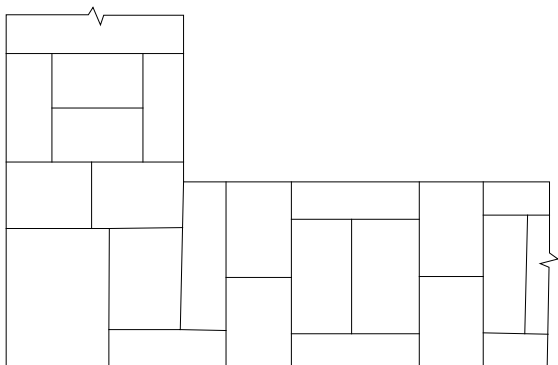
PUNCHED (ORDINARY)



ELEVATION



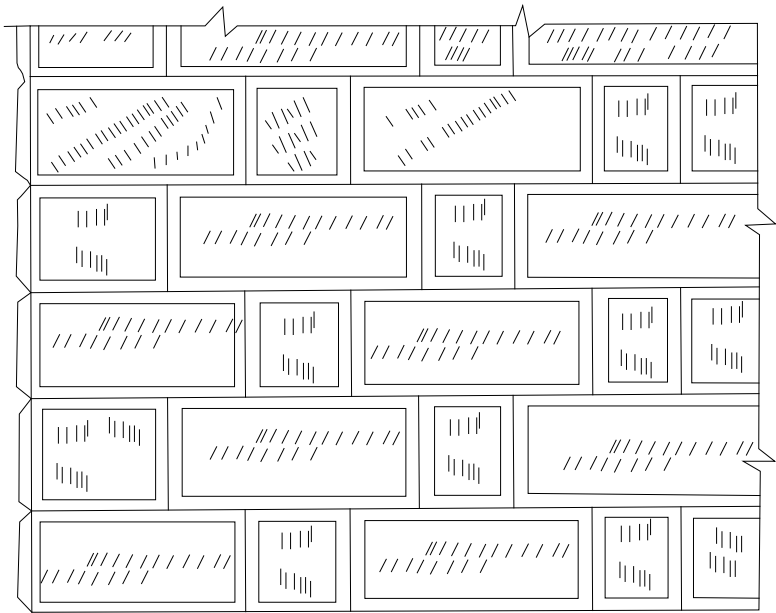
ODD COURSE



EVEN COURSE

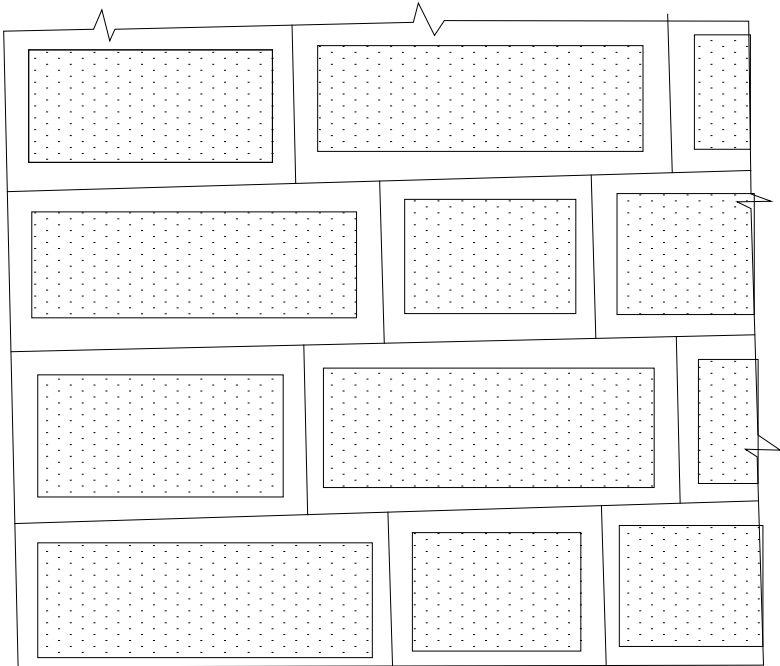
ASHLAR - ROCK FACED

FIGURE 6.7 B



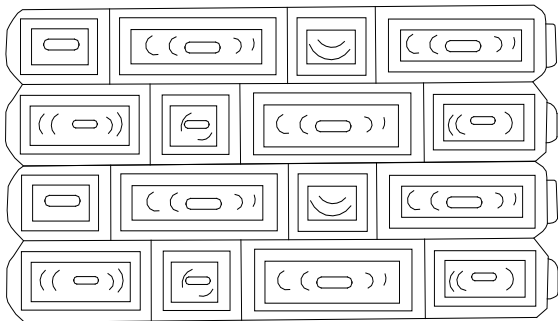
ASHLAR - ROUGH TOOLED

FIGURE 6.7 C



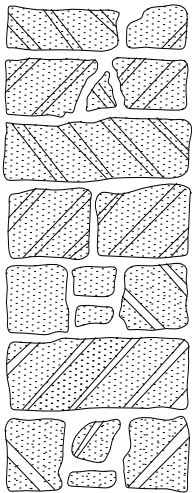
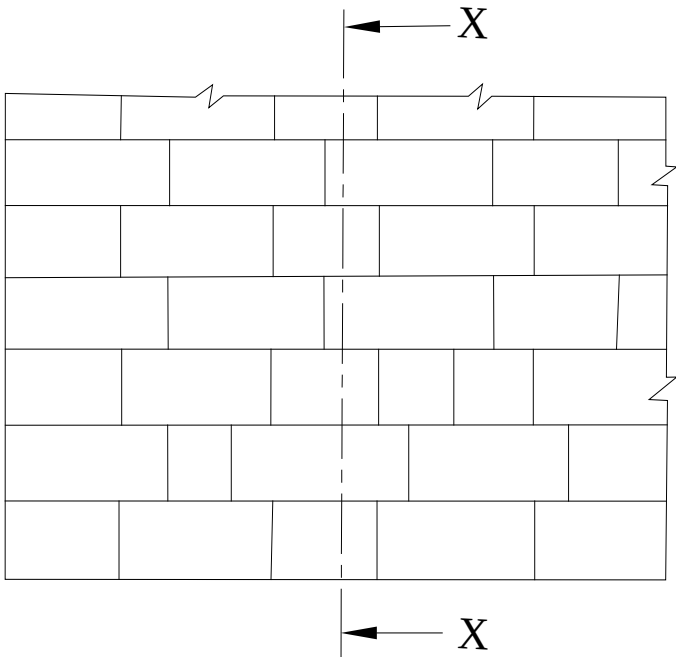
ASHLAR - CHAMFERED

FIGURE 6.7 D



ASHLAR - BLOCK IN COURSE

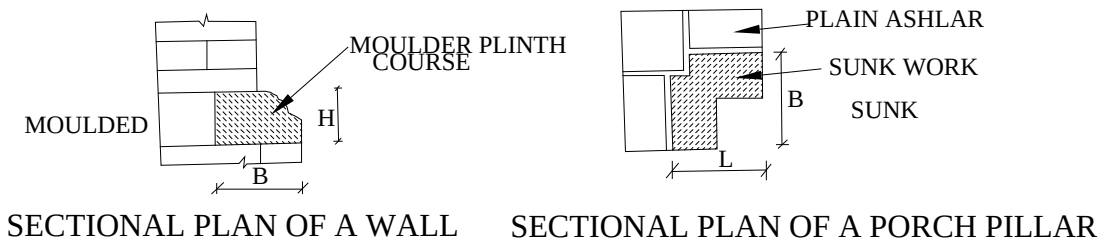
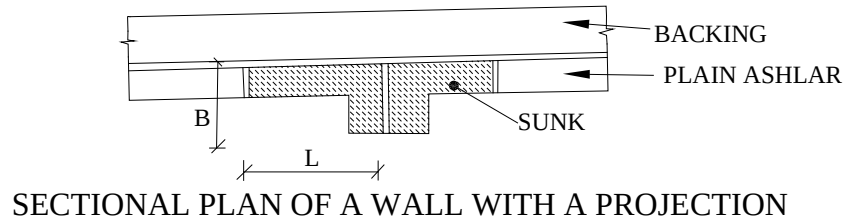
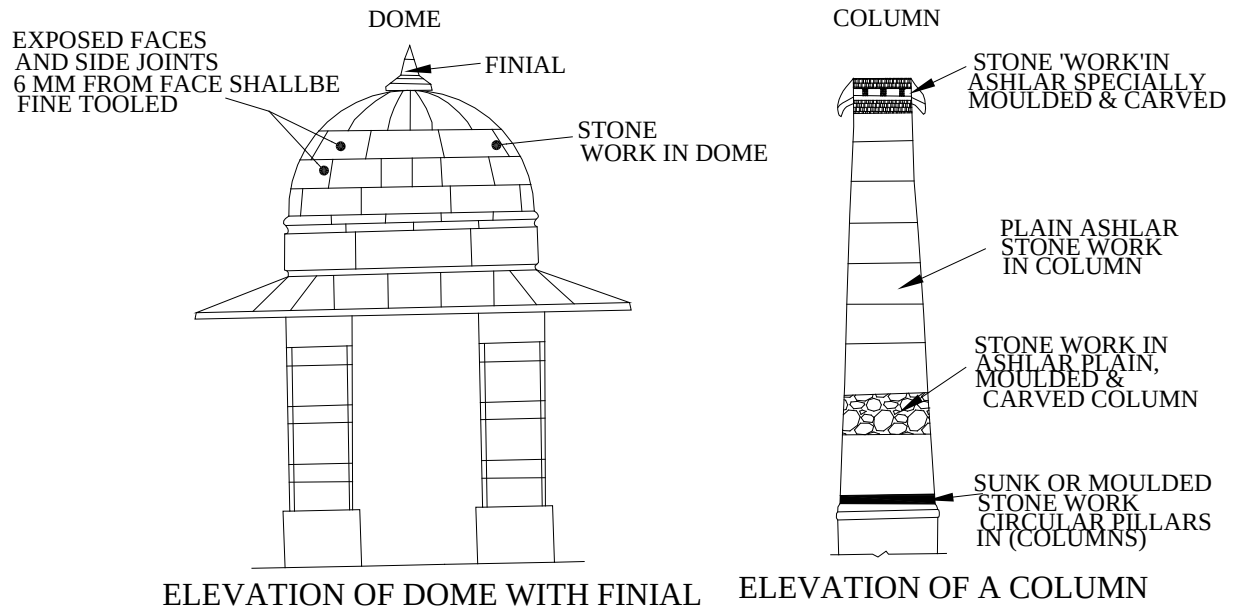
FIGURE 6.7 E



SECTION XX

MOULDED SUNK, CURVED ASHLAR MASONRY

FIGURE 6.8

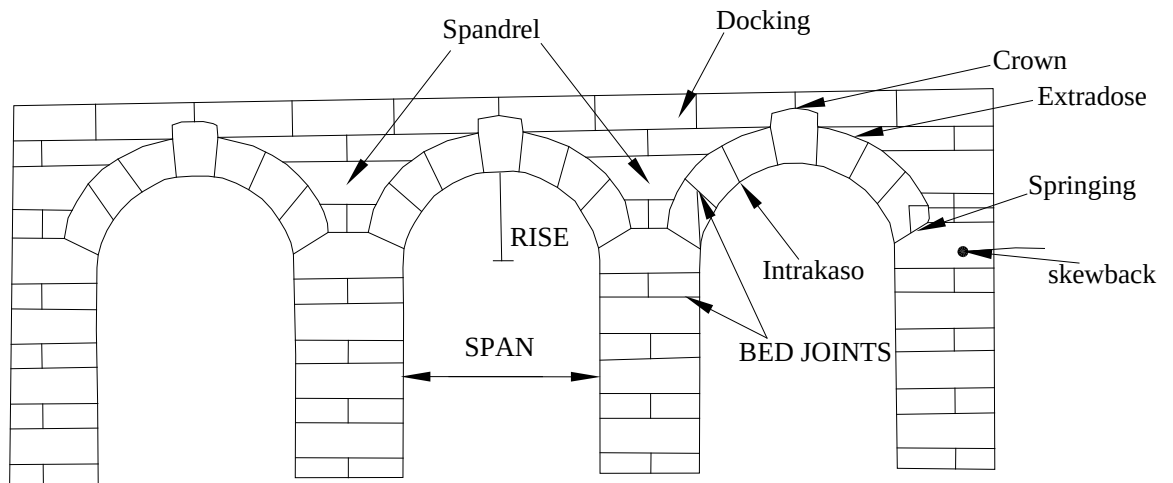


Note: Sunk or moulded stone work shown shaded, to be measured as $1 \times b \times h$

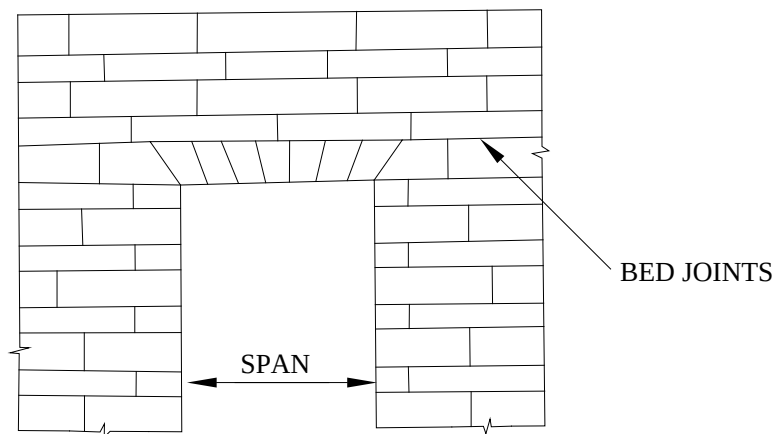
ALL DIMENSIONS ARE IN MM
DRAWINGS NOT TO SCALE

STONE WORK IN ARCHES - ASHLAR MASONRY

FIGURE 6.9



CIRCULAR ARCH

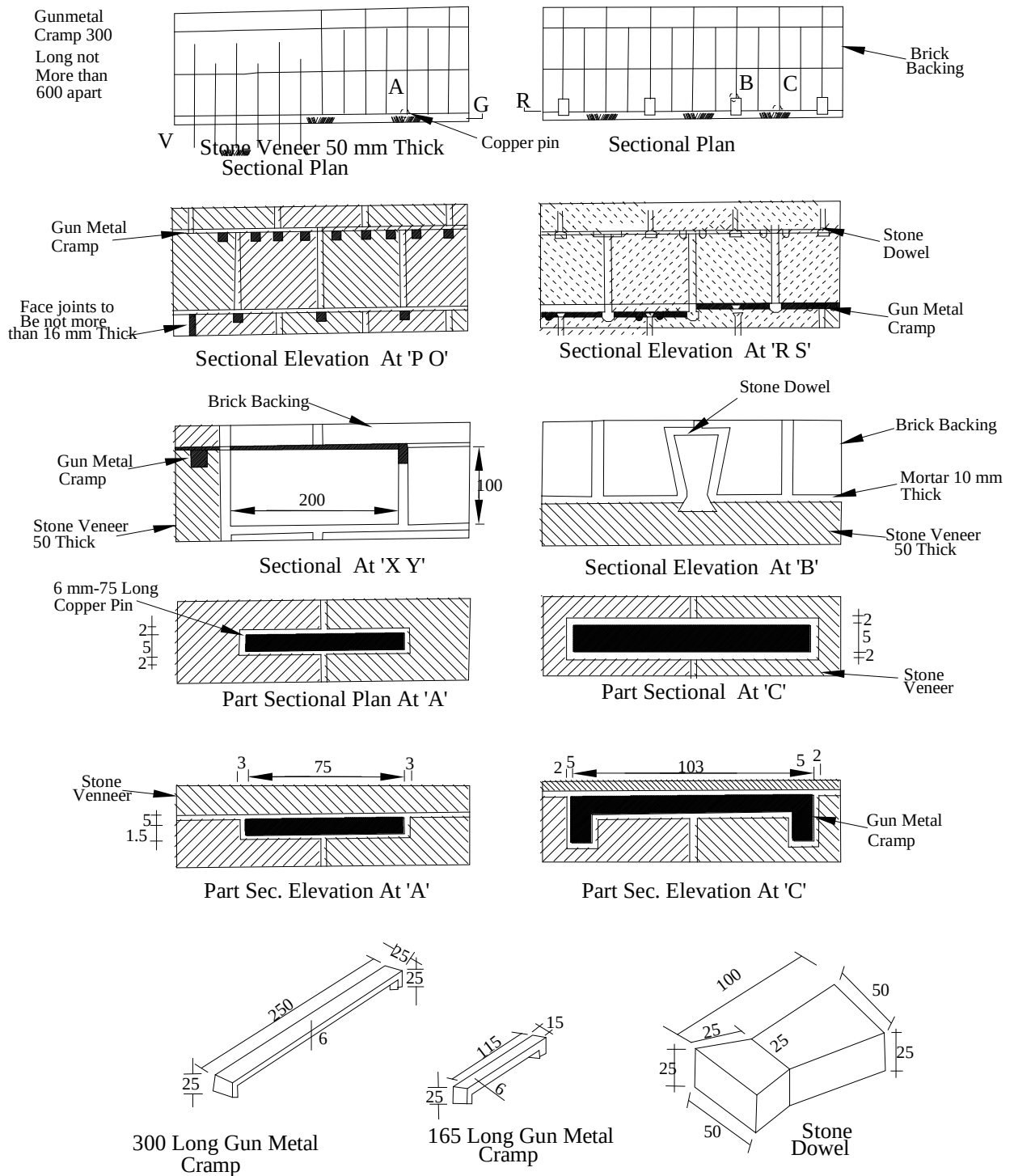


FLAT ARCH

ALL DIMENSIONS ARE IN MM
DRAWINGS NOT TO SCALE

STONE VENEERING - GENERAL FIXING ARRANGEMENTS

FIGURE 6.10



ALL DIMENSIONS ARE IN MM
DRAWINGS NOT TO SCALE

STONE VENEERING - TYPICAL FIXING ARRANGEMENTS

FIGURE 6.11

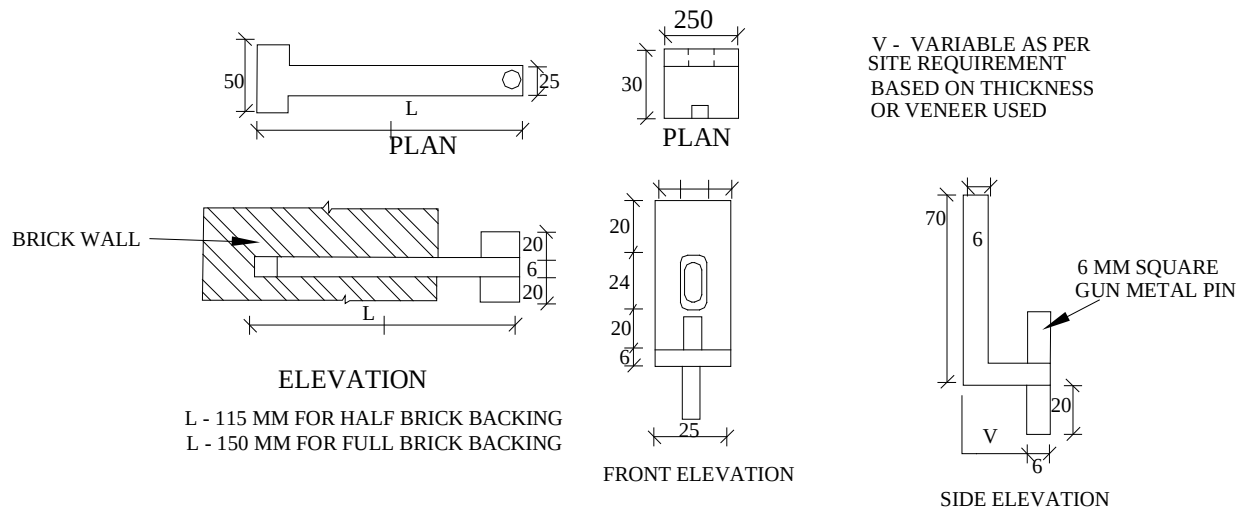


Fig. 6.11: Cramp for Brick Backing

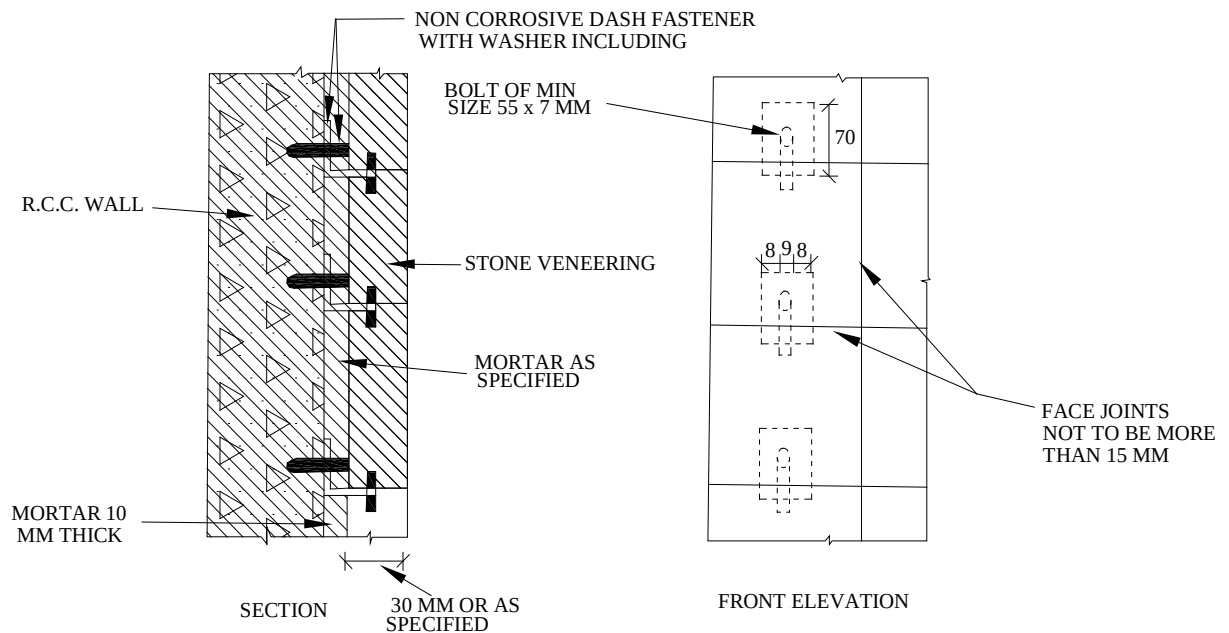


Fig. 6.11 : Cramp for R.C.C. Work Backing

ALL DIMENSIONS ARE IN MM
DRAWINGS NOT TO SCALE

STONE VENEERING - GENERAL ARRANGMENT AND CRAMPS

FIGURE 6.12

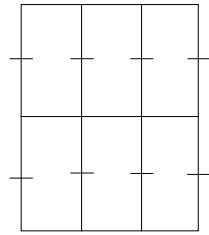


Fig 6-12 A

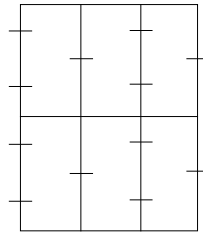


Fig 6-12 B

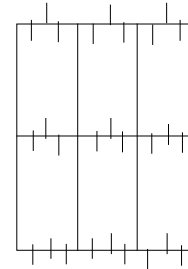


Fig 6-12 C

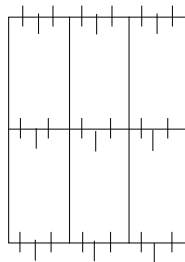


Fig 6-12 D

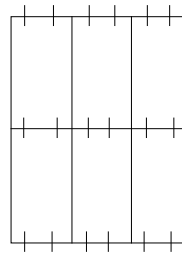


Fig 6-12 E

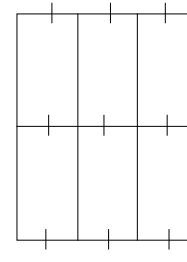


Fig 6-12 F

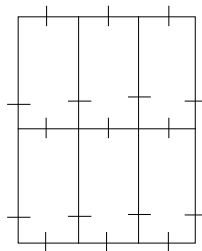


Fig 6-12 G

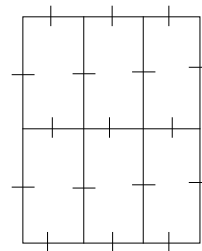


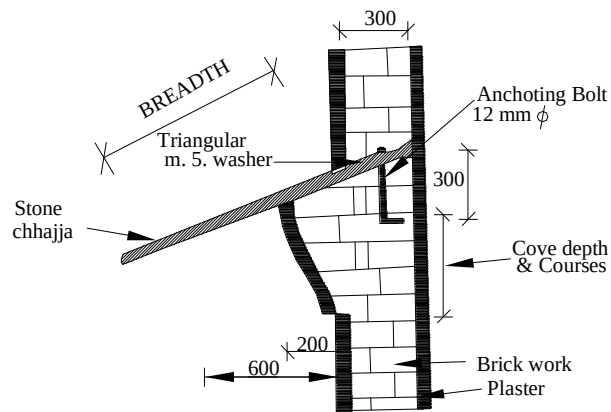
Fig 6-12 H

NOTE : CRAMPS ARRANGMENT IS SHOWN ABOVE FOR VENEERINGS WITH LONGER SIDES
VERTICAL FOR VENEERINGS HAVING THE LONGER SIDES HORIZONTAL CRAMPS
WOULD BE ARRANGED TO SUIT THE ALTERED POSITIONS

ALL DIMENSIONS ARE IN MM
DRAWINGS NOT TO SCALE

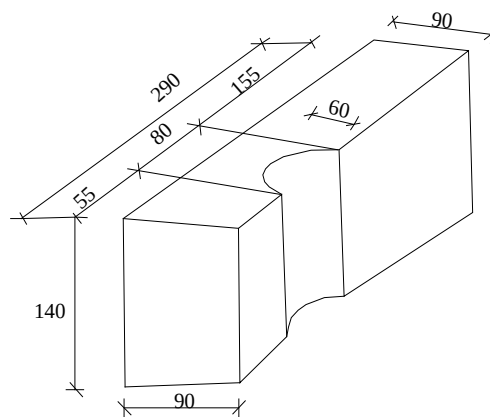
STONE CHHAJJAS

FIGURE 6.13



SPECIAL BLOCK FOR EMBEDDING VERTICAL STEEL REINFORCEMENT

FIGURE 6.14



ALL DIMENSIONS ARE IN MM
DRAWINGS NOT TO SCALE

Chapter 7

Wood Work

7.0 TERMINOLOGY

Ballies : Thin round poles usually without bark.

Beam : A structural timber generally long in proportion to its width and thickness and used for supporting load primarily by its internal resistance to bending.

Block Board : A Board having a core made up of strips of wood, each not exceeding 25 mm in width, laid separately or glued or otherwise joined to form a slab which is glued between two or more outer veneers with the direction of the grain of the core blocks running at right angles to that of the adjacent outer veneers.

Core : The inner layers of a composite wood product.

Cross Band : A general term indicating a transverse layer of veneer or veneers in composite wood products.

Decorative Veneers : Veneers having attractive appearance due to figure, colour, grain, lustre etc.

Hard Wood : A conventional term used to denote the wood obtained from broad-leaved trees. It has no relationship to the physical properties of hardness or strength. On account of the confusion this word might cause, its use is discouraged.

Freeze Rail : Horizontal member, mortised or otherwise secured to the stiles of a door, provided just below the free panel; usually provided for decorative purposes in the uppermost portion of the door.

Joint : A prepared connection for joining adjacent pieces of wood, veneer, etc.,

Dovetail Joint : A joint at the corner of two pieces in such a way that the notches made in one are fitted exactly into projections of corresponding size and shape made in the other. There are various kinds of dovetail joints for instance, lapped dovetail joint, wedge shaped dovetail joint, etc., joined in a way which will resist withdrawal except in the direction in which it was assembled (**FIGURE 7.1A**)

Mitred Joint : A joint between two members at an angle which bisects the joining angle; usually the joining faces are cut at 45°C to form a right angle (**FIGURE 7.1B**)

Mortise and Tenon Joint : A joint in which the reduced end (tenon) of one member fits

into the corresponding slot (mortise) in another member (**FIGURE 7.1C**).

Tongue and Groove Joint : A joint in which a tongue is provided on edge of one member to fit into a corresponding groove on the other (**FIGURE 7.1D**).

Knot : Base of a branch or limb embedded in the tree which becomes visible when it is cut.

Diameter of a Knot : The maximum distance between two points farthest apart on the periphery of a round knot, on the face where it becomes visible. In the case of a spike or splay knot, the maximum width of the knot visible on the face on which it appears shall be taken as its diameter.

Muntin : Small horizontal or vertical dividing bars within basic frame work of a window, or door subdividing and supporting the glass panes or panels of doors.

Particle Board : A board manufactured from particles of wood or other ligno-cellulose material, for example, flakes, granules, shavings, slivers, splinters agglomerated, formed and pressed together by use of an organic binder together with one or more of the agents, such as heat, pressure, moisture and a catalyst.

Particle : Distinct particle or fraction of wood, or other ligno-cellulose material produced mechanically for use as the aggregate for making a particle board. This may be in the form of flake, granule, shaving, splinter and sliver.

Plywood : A board formed of three or more layers of veneers cemented or glued together, usually with the grain of adjacent veneers running at right angles to each other.

Rebate : A recess along the edge of a piece of timber to receive another piece or a door, sash or a frame.

Sapwood : The outer layers of the log, which in the growing tree contain living cells and feed material. The sapwood is usually lighter in colour, and is readily attacked by insects and fungi.

Seasoning : A process involving the reduction of moisture content in timber under more or less controlled conditions towards or to an amount suitable for the purpose for which it is to be used.

Seasoned Timber : Timber whose moisture content has been reduced to the specified minimum, under more or less controlled processes of drying.

Structural Timber : Timber used in framing and load bearing structures or timber used or intended for use in buildings where strength is the primary consideration.

7.1 TIMBER

a) IS 4970 on "Key for identification of commercial Timbers" gives ready guidance to the purchasing organisations to determine whether the Timber supplied is actually of the species stipulated. IS 4970 contains diagnostic features of 60 species of Timber both Softwood and Hardwood. IS 4970 covers a simply operated Punched Card key for the field identification of the commercial Timber based on their general properties and anatomical characteristics visible under a hand lens.

b) IS 12806 on "Indian Timbers for Door and Windows Shutters and Frames – Classification" covers 109 species recommended for shutters and 69 for frames and gives guidance for selection of appropriate Timbers species for the purpose envisaged. The classification of species in IS 12806 is based on strength coefficient, appearance and texture, durability and treatability, weight, retention of shape, refractoriness to seasoning, ease of working etc of Timber. IS 12896 also lays down the general requirements of quality, seasoning, moisture content and preservative treatment for timber. It does not however cover the species suitable for flush doors.

c) Timber is classified as under :

- (i) Teak wood
- (ii) Deodar wood
- (iii) Non-coniferous timbers other than teak
- (iv) Coniferous timber other than deodar.

The timber shall be free from decay, fungal growth, boxed heart, pitch pockets or streaks on the exposed edges, splits and cracks. The timber shall be graded as first grade and second grade on the basis of the permissible defects in the timber as given in **ANNEXURE 7.1**. For both the grades, knots should be avoided over a specified limit.

7.1.1 Teak Wood (*Tectona granolis*)

It is of outstanding merit in retention of shape and durability. The heart wood is one of the most naturally durable woods of the world. It usually remains immune to white ant attack and insect attack for very long periods. It is,

however, not always immune from fungus attack (rot). Taken as a whole, good quality teak is very durable. It is relatively easy to saw and work. It can be finished to a fair surface and takes polish well. It is generally used for making furniture and all important timber constructions.

7.1.1.1. Superior Class Teak Wood such as Balharsha, Malabar and Dandeli

Individual hard and sound knot shall not be more than 12 mm in diameter and the aggregate area of all the knots shall not exceed half percent of the area of the piece. It shall be close grained.

7.1.1.2 First Class Teak Wood :

Individual hard and sound knot shall not be more than 25 mm in diameter and the aggregate area of all the knots shall not exceed one percent of the area of the piece.

7.1.1.3 Second Class Teak Wood :

Individual hard and sound knot shall not be more than 40 mm in diameter and the aggregate area of all the knots shall not exceed one and a half percent of the area of the piece. Wood shall be generally free from sapwood, but traces of sapwood may be allowed.

7.1.2 Sal Wood (*Shoera Robusta*)

Sal is about 30 percent heavier than teak, 50 percent harder, and about 20 to 30 percent stronger. In shock resistance it is about 45 percent above teak. Its heart wood is a naturally durable wood, and usually remains immune to attack by white ants and fungi for a long period, while its sapwood is very perishable and should not be used. Well dried sal is not a really easy wood to saw and work. It is a rough constructional wood than a carpentry timber. No individual hard and sound knot shall exceed 25 mm in diameter and the aggregate area of all the knots shall not exceed 1% of the area of the piece. It can be used for a variety of purposes, such as for frames of doors and windows, beams, rafters, flooring, piles, bridging, tool handles, tent pegs etc.

7.1.3 Kail Wood (*Pinus Wallichiana*)

Kail wood is not a very durable wood. But it is easy to saw and work and is usually very popular in workshops. It can be brought to a fine smooth surface, but is more suitable for paint and enamel finishes than for polish work. It is useful for joinery works, constructional work, light furniture and house fittings.

7.1.4.1 First Class Kail Wood

No individual hard and sound knot shall be more than 25 mm in diameter and the aggregate area of all the live knots shall not exceed 1.5 percent of the area of the piece. Wood shall be generally free from sapwood, but traces of sapwood may be allowed.

7.1.4.2 Second Class Kail wood

No individual hard and sound knot shall be more than 40 mm in diameter and the aggregate area of all the live knots shall not exceed 1.5 percent of the area of the piece. Wood shall be generally free from sapwood, but traces of sapwood may be allowed.

7.1.5 Other Species

The following species of timber can also be used for various activities of building construction. The information regarding their availability and use is given in **Table 7.1**. The chief characteristics of the species are given below: -

7.1.5.1 Khair (*Acacia Catechu* Wild)

The heart wood is very durable and is seldom attacked by white ants and fungi. It is an extremely strong and very hard and rough timber and a some what difficult timber to saw and machine, especially if the wood is old and dry. Stiff tools should be used in machining and turning. It finishes and polishes extremely well. It is used for posts in house construction, tool handles, tool bodies etc.

7.1.5.2 Babul (*Acacia Nilotica* SSP Indica)

Its functions and uses are similar to those described in 7.1.5.1.

7.1.5.3 Haldu (*Andina Cordifolia*)

Haldu is a fairly hard and strong wood. It is about 10 percent harder than teak but slightly weaker in transverse strain, elasticity and compression. It is a very easy wood to saw and machine. It also finishes very easily and takes polish remarkably well. It cannot be dovetailed because it breaks away. It is commonly used for door and window frames, floor boards, turning, carvings, furniture, panelling and house hold fitments.

7.1.5.4 Mango (*Mangifera Indica*)

It is a very sturdy wood when seasoned and it is as good as teak in this respect but is not a very durable wood in exposed positions. It is very liable to fungal staining and decay and is not immune to white ant attack. It receives preservative treatment well. It can be easily finished to smooth surface. Its chief uses are for cheap furniture, planking, floor and ceiling boards.

7.1.5.5 Chir (*Pinus Flexburghi*)

Chir is not a very durable wood unless treated with preservative. It is easy to saw and is usually popular in workshops. It can be brought to a fine smooth surface, but is more suitable for paint and enamel finishes than for polish work. It is used for construction work and house fitments.

7.1.5.6 Hollock (*Terminalia myriocarpa*)

Hollock is not a very durable wood unless properly treated. It can be readily treated with wood preservatives. It can be finished to fairly good surface, but needs careful filling before it is polished. It is used for house building in the form of scantlings, beams, rafters and planking. It also makes up into excellent furniture.

7.1.5.7 Benteak (*Largerstroemia Lanceolata*)

Benteak is very close to teak in strength. It is suitable for all constructional purposes and is not prone to fungus attack. It is finished to a fine smooth surface and takes a good polish. It is used for house building, furniture, carriage building and general carpentry.

7.1.5.8 Gamari (*Gmelina Arborea*)

Gamari is lighter and not so strong as teak. It is a durable wood but not immune to white ants attack for a very long period if placed in the ground. It is used for making furniture, panelling and other general utility and domestic purposes. It is a good wood for patterns.

7.1.5.9 Bahera (*Terminalia Bellirica* Roxb)

Seasoned wood is considerably immune to attack of fungus and insect. It can be treated fairly readily with wood preservatives. It is an easy wood to saw but difficult to bring to a smooth surface. It is used for rafters and boards. It is mainly used for ply wood work.

7.1.5.10 Bijasal (*Ptrocarpus Marsupium*)

It is a timber of natural durability above the average. It can be brought to a good finish and with ample filling, takes a good polish. Its chief use is for building purposes. It is also used for furniture.

7.1.6 Moisture Content

Control on moisture content of timber is necessary to ensure its proper utility in various climatic conditions. For specifying permissible limit of moisture content in the timber the country has been divided into four climatic zones as per **ANNEXURE 7.2**. In each of the zones, maximum permissible limit of moisture content of timber for different uses, when determined in

accordance with the procedure laid down in **ANNEXURE 7.3** shall be as per **Table 7.2**.

7.1.6.1 Tolerance on Moisture Content

Average Moisture content of all the samples from a lot shall be within + 3 percent and moisture content of individual samples within + 5 percent of maximum permissible

moisture content specified in **Table 7.2**. These tolerances are the absolute values over the percentage moisture content for Sl. Nos. 1 & 2 of **Table 7.2**. No tolerance on moisture content is permitted for Sl. Nos. 3 and 4 of **Table 7.2**.

TABLE 7.1 : SPECIES OF TIMBER

SL	Botanical Name	Trade Name	Average unit wt Kg/m ³	Availability				
				North Zone	East Zone	Central Zone	West Zone	South Zone
1.	Tectona granolis linnf	Teak	640	-	Y	X	X	X
2.	Acacia Catechiu Wild	Khair	1010	X	X	X	Y	Y
3.	Acacia Arabica Wild	Babul	785	X	X	X	Y	Z
4.	Andina Cordifolia Roxb HK.1.	Haldu	675	X	-	-	-	X
5.	Cedrus Deodars D Don	Deodar	545	X	-	-	-	-
6.	Magnifera Indica Linn	Mango	690	X	X	Y	Y	X
7.	Pinus Flexburgi	Chir	575	X	-	-	-	-
8.	Pinus Wallichiam Wall	Kail	515	X	-	-	-	-
9.	Shorea Robusta Gaertn.	Sal (U.P.)	881	X	X	X	-	-
10.	Terminalia Myrioecarpa Heurcket Muell Arg.	Hollock	610	-	X	-	-	-
11.	Lagerstroemia Lanceolata Wall	Benteak	675	-	-	-	Y	X
12.	Gamelinc Arborea Linn	Gamari	515	Y	Y	Y	Z	Y
13.	Terminalia Bellirica Roxb.	Bahera	801	X	X	X	Y	X
14.	Pterocarpus Marsupium Roxb	Bijasal	800	-	X	X	Y	Y

Note The average unit wt. is at 12 per cent moisture content.

AVAILABILITY : The territories comprising India, Sikkim and Bhutan have been divided into five zones, which cover roughly the following areas :

NORTH ZONE : Jammu and Kashmir, Punjab, Himachal Pradesh, Delhi, Uttar Pradesh and Rajasthan

EAST ZONE : Assam, Manipur, Tripura, West Bengal, Bihar, Orissa, Sikkim, Bhutan, Andamans, North East Frontier Agency and Nagaland.

CENTRAL ZONE : Madhya Pradesh, Vidharbha areas of Maharashtra State and the North East Part of Andhra Pradesh (Godavari delta area).

WEST ZONE : Maharashtra State (Except Vidharbha areas) Gujarat and North West Part of Karnataka.

SOUTH ZONE : Tamil Nadu, Andhra Pradesh (Except the Godavari delta area), Kerala and Karnataka (except North West Part)

The availability of timbers is categorized under three classes as indicated below :

X – Most common, 1415 m³ (1000 tonnes) and more per year.

Y – Common 355 m³ (250 tonnes) to 1415 m³ (1000 tonnes) per year and

Z – Less common, below 355 m³ (250 tonnes) per year.

TABLE 7.2 Maximum Permissible Moisture Content of Timber

SL	Use	Maximum Moisture Content Per cent			
		Zone I	Zone II	Zone III	Zone IV
1.	Beams, Rafters & Posts	12	14	17	20

2.	Doors and windows (a) 50 mm and above thickness (b) Thinner than 50 mm	10	12	14	16
3.	Flooring strips	8	10	10	12
4.	Furniture & cabinet making	10	12	14	15

7.1.7 Seasoning of Timber

The process of drying timber under controlled conditions is called seasoning of timber. Timber shall be either air seasoned or kiln – seasoned and in both cases moisture content of the seasoned timber shall be as specified in **Table 7.2**. Unless otherwise specified, air seasoned timber shall be used. Kiln seasoning of timber, where specified, shall be done as per IS : 1141 in a plant approved by the Engineer.

7.1.8 Preservation of Timber

Preservative treatment does not improve basic properties of timber but gives varying degree of protection against deterioration due to attacks by fungi, termites, borers and marine organisms. Preservative treatment, where specified, shall be done using Oil type, Organic solvent type or Water soluble type preservative. Oil type preservatives shall be used if the timber is not required to be polished or painted. Before preservative treatment, the timber shall be sawn and seasoned. All surfaces exposed after treatment, except due to planing, shall be thoroughly brushed with the preservation before jointing. Preservative treatment of timber shall be done as per IS: 401 in a plant approved by the Engineer.

7.1.9 Precautions against Decaying

- i) The contractor must in all cases obtain orders of the Engineer regarding the time at which he shall do painting, oiling, tarring, or otherwise treating wood work. The best time for painting wood work is when humidity is at its lowest.
- ii) When the end of a beam or any wood work is buried in masonry or brick work, an air space of 6mm shall be left at the end, sides and top.
- iii) Timber buried in the ground should be charred and well coated with tar. Also the ends of all beams, etc. which will be embedded in walls and the sides of timber which will abut against or rest on walls must be treated with boiling coal tar or any other protective mixture, approved by the Engineer.

7.2.1 Timber

Timber panels shall be preferably made of timber of large width. The minimum width and thickness of a panel shall be 150 mm and 15 mm respectively. When made from more than one piece, the pieces shall be joined with a continuous tongue and groove joint,, glued together and reinforced with metal dowels. The grains of timber panels shall run along the longer dimensions of the panels. The panels shall be designed such that no single panel exceeds 0.5 square metre in area.

7.2.2A Plywood for General Purposes (Refer IS 303)

7.2.2A.1 Definition Plywood boards are formed by gluing and pressing three or more layers of veneers with the grains of adjacent veneers running at right angles to each other.

7.2.2A.2 Materials Any species of timber may be used for plywood manufacture. The veneers shall be either rotary cut or sliced and shall be sufficiently smooth to permit an even spread of adhesive. Adhesive used for bonding the veneers in different grades of plywood shall be the corresponding type of adhesive as specified in IS 848. Extenders conforming to IS 1508 may be used with the synthetic resin adhesive subject to certain conditions.

7.2.2A.3 Grades and Types Plywood for general purposes shall be of the following two grades, depending on the bond strength developed by the adhesive used for bonding.

- a) Boiling water resistant or BWR Grade
- b) Moisture resistant or MR Grade

Plywood for general purposes of Grade BWR or MR shall be classified into three types AA, AB and BB depending on the quality of the surface. Quality requirements of Type A surface will be superior to those of Type B as stipulated in Table 1 of IS 303. Similarly permissible defects in Type A will be lesser than in Type B as given in Table 2 of IS 303. The better quality surface shall be called "face" and the opposite side called "back". Type AA means both face and back of Quality A. Type AB means face of quality

7.2 PANELLING MATERIAL

A and back of Quality B. Type BB means both face and back of Quality B.

7.2.2A.4 Dimensions, Thickness and Tolerances - Normal dimensions are of width 1200mm and length 2400mm,

2000mm and 1800mm; width 900mm and length 2100mm and 1800mm. Thickness of Plywood panes shall be as in **Table 7.3** below.

TABLE 7.3

No. of Ply	Thickness (mm)	No. of Ply	Thickness (mm)
3 Ply	3,4,5,6	9 Ply	12,15,16,19
5 Ply	5,6,8,9	11 Ply	19,22,25
7 Ply	9,12,15,16	Above 11 Ply	As ordered

Tolerances in Length + 6mm; - 0 mm
 Width + 3mm; - 0 mm
 Thickness Less than 6mm $\pm 10\%$
 6mm and above $\pm 5\%$

Thickness of all veneers shall be uniform within a tolerance of $\pm 5\%$. Corresponding veneers on either side of the central ply and those of face and back veneers shall be of species having similar physical and mechanical properties. Grain directions in the various plies shall conform to the requirements indicated in sub-clause 7.2.3 of IS 303. In all cases the grain on both faces of the assembly boards shall run in the same direction.

7.2.2A.5 Testing

Sampling shall be governed by Clause 10 of IS 303 and Testing by Clause 11. The requirements to be complied with are indicated in Sub clauses 11.2, 11.3 and 11.4. Retest if required shall be done as given in Subclause 11.5.

7.2.2B Veneered Decorative Plywood (Refer IS: 328)

7.2.2B.1 Definitions - Decorative Plywood is used in paneling work in buildings for furniture and for general interior decoration. The Plywood may be with ornamental veneers on one or both faces.

7.2.2B.2 Materials - Plywood when used in the manufacture of veneered decorative plywood of MR and BWR Grade shall be MR and BWR Type conforming to IS: 303. Adhesive for bonding veneers shall be MR and BWR type synthetic resin conforming to IS: 848 for MR and BWR Grade veneered decorative plywood. Decorative veneer shall be rotary cut or sliced and shall have a thickness of not less than 0.3 mm and not more than 1-0 mm

Veneers forming any one ply and the corresponding ply on the opposite side of the

central plane of plywood shall be of the same species of timber and of the same nominal thickness except in case of faces where they shall be of such thickness and strength as to balance each other.

7.2.2B.3 Grades and Types Decorative plywood shall be of the grade BWR (Boiling Water Resistant) and MR (Moisture Resistant). In each grade there shall be two types I and II with requirements as indicated in Clause 7 of IS 1328. Type I is of superior quality compared to type II.

7.2.2B.4 Dimensions and Tolerances

Normal supply shall be of size 2400 mm x 1200 mm; 2100 mm x 1200 mm; 1800 mm x 1200 mm; 2100 mm x 900 mm and 1800 mm x 900 mm. Thickness 3 mm, 4 mm, 6 mm, 9 mm, 12 mm, 19 mm, 25 mm.

Tolerance in length + 6 mm; - 0 mm
 Width + 3 mm; - 0 mm

Thickness Less than 6 mm $\pm 10\%$
 6 mm and above $\pm 5\%$

7.2.2B.5 Testing

Sampling and Criteria for conformity shall be as stipulated in Clause 10 of IS 1328. Tests and requirements to be complied with shall be as given in Clause 11 of IS 1328.

7.2.3A Particle Board for General purposes – Medium Density (Refer. IS 3087)

7.2.3A.1 Definition

Medium density Particle Boards are made of wood and/ or other lignocellulosic materials formed and pressed together under heat and pressure by use of an organic binder together with one or more additive like wax preservative etc. Board may be of Extruded type or Flat pressed type. In Extruded type, particles of wood and/or lignocellulosic materials are mixed with resin and the mix is pressed and forced through an extrusion hot plate press with the particle oriented

considerably in a direction at right angles to direction of extrusion. In flat press type, the mix is pressed in a parallel plate hot press or continuous band type of press. In Graded Particle Board there is gradual density gradient from the outer surface to the centre of the board across the thickness. Multilayer Particle Board is a board made of more than three layers of like material in which particles of different shapes and sizes may be used in different layers.

7.2.3A.2 Classes and Types

	<u>Class</u>	<u>Designation</u>
	<u>Grade</u>	
	Flat pressed single layer	
--	FPS	
	Flat pressed – three layer,	
	Multilayer and graded	I
	FPT-1	
--do--		
II	FPT-2	
	Extrusion pressed, solid	--
	XPS	
	Extrusion pressed, Tubular	
--	XPT	

7.2.3A.3 Materials

Timber : Any species of wood and/or other lignocellulosic material may be used.

Adhesive : Synthetic resin conforming to IS 848 shall be used. But for FPT-1 and FPT-2 only BWR or BWP type adhesive has to be used.

7.2.3A.4 Dimensions and Tolerances

The Standard sizes (length and widths) will be as stipulated in Clause 8.1 of IS 3087. Thickness shall be 6 mm, 9 mm, 12 mm, 15 mm, 20 mm, 25 mm, 30 mm, 35 mm, 40 mm and 45 mm.

7.2.3A.5 Tolerances

Tolerances in length & width will be as in Clause 8.3 of IS 3087. In thickness it will be $\pm 5\%$.

7.2.3A.6 Testing

Sampling and inspection will be as per Clause 10 of IS: 3087; Testing as per Clause 11 and Physical & Mechanical properties to be complied with by Flat pressed single layer, Flat pressed three layer. Multilayer and graded Extrusion pressed solid (XPS) and Extrusion pressed Tubular (XPT) shall be as in Table-1 of IS: 3087.

7.2.3B Veneered Particle Board (Refer IS: 3097)

7.2.3B.1 Grades and Types

Veneered Particle Boards are of two Grades I and II, with Grade-I being superior to Grade-II. Each of the Grades shall be of four types.

- Type-1 Solid core with general purpose type veneers on both faces.
- Type-2 Solid core with decorative veneer on one or both faces.
- Type-3 Tubular core with general purpose type veneers on both faces.
- Type-4 Tubular core with decorative veneer on one or both faces.

7.2.3B.2 Materials

i) **Particle Board** : Should conform to IS: 3087.

ii) **Veneer** : To be either sawn or rotary cut or sliced and of smooth surface. Face veneers of decorative type particle board should conform to Type-I of IS 1328. Face and cross band veneers of general purpose type should conform to Type A or B of IS: 303.

iii) **Adhesive** : For Grade-I Particle Board BWP or BWR type of IS: 848 should be used. For Grade-II MR type of IS: 848 shall be used.

7.2.3B.3 Manufacture

Veneered Particle Board shall be made by either glueing particle boards between the veneers or alternatively between two sheets of plywood. The total thickness of skin of either side shall not exceed 5 mm. Lipping, if provided shall be internal with a total depth not less than 22 mm and thickness same as that of Particle Board Core, made out of well seasoned Timber batten. Lipping may also be of suitable veneer glued to the edges.

7.2.3B.4 Dimensions and Tolerances

Length and width shall conform to clause 7.3 of IS: 3097. Thickness can be 6, 10, 12, 20, 25, 30, 35, 40, 45 and 50 mm. Tolerances shall be as specified in Clause 7.4 of IS: 3097 and for Thickness it is $\pm 5\%$.

7.2.3B.5 Testing

Sampling shall be as per Clause 8 of IS: 3097 and Tests and Accepting Criteria as per Clause-9.

7.2.3C Prelaminated Particle Board (Refer IS: 12823)

7.2.3C.1 Definition :

Prelaminated Particle Board to IS: 12823 is a Particle Board laminated on both surfaces by

Synthetic resin impregnated base papers under the influence of heat and pressure or with finished foils under the influence of pressure or pressure and heat depending upon the type of binder used.

7.2.3C.2 Materials

Particle Board used as the core shall be synthetic resin bonded flat pressed three layer or multi layer or graded Particle Board conforming to IS:3087. Impregnated Base paper shall be printed or plain coloured base paper impregnated in a suitable resin. Impregnated overlay is an absorbent Tissue paper. Finished foil shall be synthetic resin based surfacing film with one face fully finished. Adhesive will be any suitable synthetic resin.

7.2.3C.3 Grades and Types

Prelaminated Particle boards are available in two grades – Grade I and Grade II corresponding to the two Grades of Particle Board under IS: 3087. Each Grade consists of four types, Type-1, Type-II, Type-III and Type-IV depending upon the abrasion resistance of the prelaminated surface. Type-I is useful for flooring application, Type-II for horizontal application like cash counters and restaurant Table tops, Type-III for normal horizontal application like office Table tops and domestic furniture Tops and Type-IV for vertical application like panelling, partitioning and for false ceiling. Designation of different Types shall be PLB followed by two numbers, First number 1 stands for Grade-1 and 2 for Grade-2. Serial number 1,2,3,4 stands respectively for Types 1,2,3, & 4.

7.2.3C.4 Finish

The finish of the paper over laid board depends on the surface of the type used. Common surface finishes are glossy, matt textured (soft, swede, wood pore and leather) etc., The surface finish of the foil finished boards depends on the original finish of the foil used.

7.2.3C.5 Dimensions and Tolerance

They shall conform to Clause 8.1 (Amendment No.5) of IS: 12823. Prelaminated Particle Boards are available in Thickness ranging from 6 mm to 45 mm Tolerance in thickness ± 5 percent and in the dimensions as given in Clause 8.2 of IS: 12823.

7.2.3C.6 Testing

Sampling and inspection shall conform to Clause 9. Testing of samples shall be done as stipulated in Clause-10 of IS:12823. Physical and Mechanical properties should

conform to the figures in Table 1 of IS Code 12823.

7.2.4 Laminated Veneer Lumber (Refer IS: 14616)

7.2.4.1 Definition

Reconstituted ligno-cellulosic products like Plywood Particle Board, Fibre Board etc. are substitutes of wood for use as panels for partitions, shelves, toppings, decking etc. For load bearing applications as complete wood substitute, products like Laminated Veneer Lumber (LVL) have been developed and are reconstituted ligno-cellulosic products with the fibre oriented along a specific direction. LVL is a structural composite made by laminating veneers 1.5 mm to 4.2 mm thick, with suitable adhesive and with the grain of veneers in successive layers aligned along the longitudinal (length) dimension of the composite.

7.2.4.2. Materials

Veneers shall be obtained from logs grown in plantation such as rubber wood, eucalyptus, acacia etc. Adhesive will be of BWP Grade conforming to IS: 848. Preservatives shall be compatible with the adhesive.

7.2.4.3. Dimensions

Dimension of LVL will include margin for dressing and finishing not exceeding 3 mm in width and thickness, and 12 mm in length.

7.2.4.4. Testing

Sampling and Testing shall be done as stipulated in Clause 9 of IS: 14616. The physical and mechanical properties shall conform to the requirements stipulated in Table 1 of IS: 14616.

7.2.5 Hard Board (Refer IS 1658)

7.2.5.1. Hard boards are generally classified into the following three types according to their method of manufacture, density and other related mechanical and physical properties.

(a) Medium hard board: A homogenous fibre building board having a density exceeding 480 kg / m^3 but not exceeding 800 kg / m^3 .

(b) Normal hard board: A homogenous fibre building board having a density exceeding 800 kg / m^3 but not exceeding 1200 kg / m^3 .

(c) Tempered hard board: Hard board which has been further treated in the course of manufacture to increase its density, strength and water resistance.

7.2.5.2. The hard board used for paneling of door shutters, shall be of tempered quality. The thickness of hard board paneling used shall not be less than 12 mm in case of

single panels shutter and 10 mm in case of two or more panel shutter. The hard board shall be regular and, unless otherwise specified shall have square edges. The lengths of the two diagonals of the board shall not differ by more than ± 3 mm per metre length of the diagonal. The tolerance on length and width shall be ± 3 mm and on thickness ± 0.3 mm.

7.2.5.3 Workability

The hard boards shall not crack, split or chip when drilled, sawed or nailed perpendicular to the surface.

7.2.5.4 Finish

The boards shall be of uniform thickness subject to tolerance stated above. They shall be free from warp. The surface shall be flat, free from cracks and lumps and of natural colour. At least one face shall be smooth.

7.2.6 Block Board (Refer IS 1659)

7.2.6.1. Block Boards have a solid core made up of uniform strips of wood each not exceeding 25 mm in width, laid separately, or spot glued or otherwise joined to form a slab which is glued, between two or more outer veneers, with the direction of the grain of the core block running at right angles to that of adjacent veneers. In any one block board, the core strips shall be of one species of timber only. Face veneers may be decorative or commercial on both faces or decorative on one face and commercial on the other. Block boards shall be Grade 1 (Exterior Grade) as per IS : 1659. Both surfaces of the boards shall be sanded to a smooth finish.

7.2.6.2 Adhesives

The adhesives used for bonding shall be BWP type synthetic resin conforming to IS: 848 for Grade I block boards.

7.2.6.3 Thickness and Tolerance

Block boards are available in thickness ranging from 12 to 50 mm. Tolerance in thickness shall be $\pm 5\%$ for boards up to and including 25 mm thick and $\pm 2.5\%$ for boards above 25 mm thickness. Each board shall be of uniform thickness.

7.2.6.4 Testing

The samples tested shall meet the requirements of physical and mechanical properties of block boards specified in I.S. code 1659. No. of samples depending on the lot size shall conform to IS 1659.

7.2.6.5. Type of face veneers, thickness and grade of block boards shall be as specified. Unless otherwise stated, grade 1

(exterior grade) block boards bonded with BWP Type Synthetic resin shall be used.

7.2.7 Asbestos Cement Board (Refer IS 2096)

This should conform to IS : 2096. The material used in the manufacture of asbestos cement building boards shall be composed of an inert aggregate consisting of clean asbestos fibre cemented together by ordinary Portland cement, rapid hardening and low heat Portland cement, or blast furnace slag cement. No organic or inorganic materials shall be added to the composition. Pigments which are embodied in the asbestos cement for colouring purpose shall be of permanent colours and shall conform to the requirements. The thickness of the asbestos cement board used for paneling shall not generally be less than 6.5 mm in case of single panels shutters and 5 mm in case of two or more panel shutter. Asbestos cement building boards shall be of two classes, namely 'A' and class B. The thickness of class A shall be 6.5 mm and for class 'B' 5 mm. The tolerance on thickness shall be ± 0.5 mm.

7.2.8A Medium Density Fibre Board (MDF) (Refer IS 12406)

7.2.8A.1 Definition

Medium Density Fibre Board is a panel product manufactured from lignocellulosic fibres combined with synthetic resin or other suitable binder. The specific gravity of the product will be 0.6 to 0.9 by application of process of heat and pressure. Inter fibre bond is substantially created by binder.

7.2.8A.2 Types

MDF shall be of one type only that is flat pressed single layer. It may be of two Grades designated as under:

Solid Board Grade I SBG I

Solid Board Grade II SBG II

Grade I Boards may be used in "Hazard Class I" Environment with relative humidity less than or equal to 70% so that equilibrium moisture content of MDF will not be more than 15% as well as in "Hazard Class 2" Environment with relative humidity more than 70% so that the equilibrium moisture content of MDF will not be more than 20%. Grade II MDF can be used in "Hazard Class I" Environment only.

7.2.8A.3 Material

i) Wood - Any species of wood or other lignocellulosic material may be used.

ii) Adhesive - Any suitable type can be used so that MDF conforms to the requirements in Table 1 of IS 12406.

iii) Sizing material - Paraffin was dissolved in mineral spirit or emulsified with water.

7.2.8A.4 Manufacture

Should be carried out as described in Clause 6 of IS 12406.

7.2.8A.5 Dimensions and Tolerances

Standard Lengths and widths of MDF shall be as given in Clause 8.1 of IS 12406. Thickness will be 6, 9, 12, 15, 18, 22, 25, 30, 35 and 40mm. Tolerance shall be as given in Clause 8.2. In thickness it will be ± 0.3 mm.

7.2.8A.6 Testing

Sampling and Inspection will conform to Clause 10 and Testing of Samples to Clause 11 of IS 12406. The Physical and Mechanical requirements to be satisfied shall be as given in Table 1 of IS 12406.

7.2.8B Prelaminated Medium Density Fibre Board (Refer IS 14587)

7.2.8B.1 Definition

Prelaminated MDF Board to IS 14587 is a Fibre Board laminated on both surfaces by synthetic resin impregnated base papers with or without impregnated overlay under the influence of heat and pressure.

7.2.8B.2 Materials

Fibre Board shall conform to IS 12406. Impregnated base paper will be a printed or plain coloured paper impregnated in any suitable synthetic resin. Impregnated overlay paper will be a highly absorbent tissue paper impregnated in a suitable resin.

7.2.8B.3 Grades and Types

Prelaminated M.D.F. Board shall be of two Grads I and II corresponding to IS 12406. Grade I is generally preferred for use. Each of the Grades shall be of four Types I, II, III or IV classified by the surface abrasion characteristic defined in Table 1 of IS 14587. Type I will be useful for flooring application; Type II for horizontal application like

restaurant table tops; Type III for normal horizontal application like Office Table Top and domestic furniture and Type IV for vertical applications like panelling, partitioning and for false ceiling.

7.2.8B.4 Dimensions and Tolerances

They shall conform to IS 12406.

7.2.8B.5 Testing

Provisions in IS 14587 Clause 9 on "Sampling and Inspection" and Clause 10 on "Testing of Samples" will apply on Physical and Mechanical properties. The test results should conform to the figures stipulated in Table 1 of IS 14587.

7.2.9 Sheet Glass, Frosted Sheet Glass

7.2.9.1 Sheet glass shall be flat, transparent and clear as judged by the unaided eye. It may, however, possess a slight tint when viewed edgewise. Sheet glass shall be of Selected Quality (SQ) or Ordinary Quality (OQ) as per IS: 2835. Glass shall be free from cracks. Unless otherwise specified, ordinary quality sheet glass shall be used.

7.2.9.2 Dimensions

Nominal thickness and range of thickness of sheet glass shall be as per **Table No.7.4**. Tolerance on cut sizes (length and width) shall be ± 2.0 mm.

TABLE 7.4 : Thickness and Weight of Sheet Glass

Nominal Thickness (mm)	Range of Thickness (mm)	Weight (kg/sqm)
4.0	3.8 to 4.2	10.0
5.0	4.7 to 5.3	13.5

7.2.9.3 Sheet glass of 4 mm nominal thickness weighing not less than 10 kg/sqm shall be used for glass panel of area up to 0.5 sqm. For panel exceeding 0.5 sqm in area, the nominal thickness of the glass to be used shall be as specified.

7.2.9.4 Different Types of Glasses used for Doors, Windows and Ventilators are detailed below.

1. Clear Window glass	It is a thin transparent flat glass. Its thickness varies from 2.5 to 7.5mm.
2. Prism glass	It has prism shaped ribs which deflect light. These prisms are provided at different angles.
3. Plate glass	It is also a plain flat transparent glass, 3 to 6mm thick; fitted in the windows of luxurious buildings
4.Quartz glass	The glass transmits ultra-violet rays and is used in hospitals
5.Processed glass	The various types available in the market under this type of glass are ground glass, chipped one process and chipped two process. Some are used for providing privacy, they diffuse light. Others transmit maximum light.

6. Frosted glass	This glass is made by grinding off the polished surface by a sand blast. It is used to reduce heat and glare. It is also referred to as Ground glass/ Translucent glass and is used mainly in toilets and other places where vision is to be obstructed.
7. Wire glass	A mesh or wire is embedded in the glass for strengthening it.
8. Bullet proof glass	This is manufactured with laminated plate glass. The glass breaks under impact but does not turn into pieces.
9. Pinhead glass	This is also called perforated glass. Perforations are made in sheet or plate glass with the help of rollers or by providing a series of ribs to produce diffusion. It is used for the same purposes as frosted glass.

7.2.10 Wire Cloth (Wire Gauze)

7.2.10.1 Wire Cloth which shall generally conform to IS: 1568 shall be regularly woven with equally spaced galvanized mild steel wires in both warp and weft directions. The

wire cloth shall be properly selvaged by one or more wires in each edge.

7.2.10.2 Mesh - Average width of aperture and the nominal diameter of the wire shall be as under:

Average width of Aperture mm	Nominal dia of wire mm
1.40	0.63
1.18	0.56
1.00	0.50

7.2.10.3 Width of aperture and dia of wire of wire cloth shall be as specified. Unless otherwise stated, wire cloth of 1.40 mm average aperture width woven with 0.63 mm nominal dia galvanized mild steel wire shall be used.

7.2.10.4 Fly-proof wire cloth (aperture 1.40 mm) is generally provided in Kitchen and dining areas while wire cloth of smaller aperture is used in mosquito proof shutters.

7.2.11 Gypsum Board

Gypsum Board is formed by enclosing and bonding together a core gypsum plaster (a calcium sulphate mineral) with or without fibre between two sheets of highly durable paper. The gypsum boards shall be non-resonant, dimensionally stable and possess flame retardant qualities. The boards shall conform to IS : 2095 and gypsum plaster shall conform to IS : 2547. The surfaces of the board shall be true and free from imperfection that would render the board unfit for use with or without decoration.

7.2.11.1 Types - Gypsum plaster boards are classified according to their use.

7.2.11.2 Gypsum Wall Board with Reduced Water Absorption Rate

These boards have additives of the core and/or the paper liners to reduce the water absorption rate. They may be suitable for special applications in buildings where reduced absorption properties are required

to improve the performance of the board. Unless stated otherwise, decoration may be applied to the face.

7.2.11.3 Gypsum Wall Board with Improved Core Cohesion at High Temperatures

These boards have mineral fibres and/or other additives in the gypsum core to improve core cohesion at high temperatures. They have a face suitable for direct decoration.

7.2.11.4 Gypsum Plaster Base Board

These boards have a face suitable to receive gypsum plaster and may be perforated during primary manufacture.

7.2.11.5 Gypsum Plaster Base Board with Improved Core Cohesion at High Temperatures

These boards have mineral fibres and/or other additives in the gypsum core to improve core cohesion at high temperatures. They have a face suitable to receive gypsum plaster and may be perforated during primary manufacture.

Physical Requirements

7.2.11.6 Dimensions

The width, Length and thickness of the boards shall be as given in **Table 7.5**. The lengths of the two longitudinals of the boards shall not differ by more than ± 3 mm per metre length of the diagonal.

TABLE 7.5 Dimensions of Gypsum Plaster Boards

Type of Board	Width in mm	Length in mm	Thickness mm
Wall Board	600, 900 and 1200	1800 to 3600 in steps of 100 mm	9.5, 12.5 and 15
Base Board	400 and 900	1200, 1500 and 1800	9.5 and 12.5

7.2.11.7 Tolerance The tolerance on dimension shall be as given in **Table 7.6** below: -

TABLE 7.6
TOLERANCES IN GYPSUM BOARDS

Type	Tolerance in mm on		
	Width	Length	Thickness
Gypsum Wall Board	0 to – 5	0 to – 6	± 0.6
Gypsum Base Board			
(a) Non-perforated	0 to – 8	0 to – 6	± 0.6
(b) Perforated	0 to - 8	0 to - 10	± 0.6

7.2.11.8 Transverse Strength - Breaking load for gypsum plaster boards, shall be in accordance with **Table 7.7** given below:-

TABLE 7.7 Breaking Load of Gypsum Plaster Boards

Type of Board	Thickness (mm)	Breaking load, Transverse direction (N)	Min. Longitudinal Direction (N)
(1)	(2)	(3)	(4)
Plaster Board	9.5	140	360
	12.5	180	500
	15.0	220	650
Base Board	9.5	123	180
	12.5	165	235

7.2.12 Coir Veneer Board (Refer IS 14842)

7.2.12.1 Definition

Coir Veneer Board to IS 14842 is manufactured with a combination of coconut fibre needled felt, veneer and jute fibre with Kraft paper. Coconut fibre needled felt can be used as core / cross bands or as outer skins formed with jute fibres and kraft paper. The composite ply should be a balanced construction on either side of central ply. The blended mass of glued fibres is laid to form a mat which is pre-needled.

7.2.12.2 Materials

Coconut fibre, jute and kraft paper shall be as stipulated in Clause 5 of IS 14842. Adhesive shall conform to BWR/MR of IS:- 848 for BWR/MR Grade of Boards. Any species of Timber may be used for the manufacture of veneers which shall be either rotary cut or sliced. Alum, wax resin or other adhesive may be introduced in the agglomerate for coir veneer Board prior to forming primarily to increase water resistance.

7.2.12.3 Grades

Coir Veneer Board for general purposes shall be of Boiling Water Resistant (BWR) Grade or Moisture Resistant (MR) Grade.

7.2.12.4 Dimensions and Tolerance

Dimensions of Boards shall be as stipulated in Clause 8.2 of IS 14842. The thickness of Veneer Board shall be 3mm, 4mm, 5mm, 6mm, 9mm, 12mm, 16mm, 18mm, 20mm and 25mm. The thickness shall be uniform with a tolerance of 5 percent for 6mm and above and 10 percent for thickness less than 6mm. Tolerance for other dimensions shall conform to Clause 8.4 of IS 14842.

Testing
Sampling shall be done as per Clause 10 of IS 14842 and Tests as stipulated in Clause 11. The physical and Mechanical qualities shall conform to the requirements indicated in Sub clauses 11.1 to 11.4 of IS 14842. Retest if required shall be carried out as stipulated in Sub clause 11.5.

7.3 DOOR, WINDOW AND VENTILATOR FRAMES

Extracts from IS 4021-1995 on Timber, Door, Windows & Ventilator Frames are at **Annexure 7.4.**

7.3.1. Timber : Timber for door, window and ventilators frames shall be as specified.

Timber shall be sawn in the direction of the grains. All members of a frame shall be of the same species of timber and shall be straight without any warp or bow. Frames shall have smooth, well-planed (wrought) surfaces except the surfaces touching the walls, lintels, sill etc., which may be left clean sawn. Rebates rounding or moulding shall be done before the members are jointed into frames. The depth of the rebate for housing the shutters shall be 15 mm, and the width of the rebates shall be equal to the thickness of the shutters. Timber Sections shall be dressed and planed to within the permissible tolerance from the full dimensions as below.

(a) Width

(b) Thickness

7.3.2. Joints

The frames shall have dovetail joints **Figure 7.1A**. The jamb posts shall be through tenoned in to the mortise of the transoms to the full thickness of the transome and the thickness of the tenon shall be not less than 2.5 cm. The tenons shall closely fit into the mortise without any wedging or filling. The contact surface of tenon and mortise before putting together shall be glued with polyvinyl acetate dispersion based adhesive conforming to IS: 4835 or adhesive conforming the WBP or MR grade of IS : 851 and pinned with 10 mm dia hard wood dowels, or bamboo pins or star shaped metal pins. The joints shall be at right angles when checked from the inside surfaces of the respective members. The joints shall be pressed in position. Each assembled door frame shall be fitted with a temporary stretcher and a temporary diagonal brace on the rebated faces.

7.3.3. Fixing of Frames

The frames shall be got inspected and approved by the Engineer before being painted, oiled or otherwise treated and before fixing in position. The surface of the frames abutting masonry or concrete and the portions of the frames embedded in floors shall be given a coating of coal tar. Frames shall be fixed to the abutting masonry or concrete with holdfasts or metallic fasteners as specified. After fixing, the jamb posts of the frames shall be plugged suitably and finished neat. Vertical members of the door frames shall be embedded in the floor for the full thickness of the floor finish and shall be suitably struttred and wedged in order to prevent warping during fixing. A minimum of three hold fasts shall be fixed on each side of door and window frames one at center point and other two at 30 cm from the top

and bottom of the frames. In case of window and ventilator frames of less than 1 Metre in height two hold fasts shall be fixed on each side at quarter point of the frames. Hold fasts and metallic fasteners shall be measured and paid for separately.

7.3.4 Measurements

Wood work wrought, framed and fixed shall be measured for finished dimension without any allowance for the wastage or for dimensions beyond specified dimension. However, in case of members having mouldings, roundings or rebates and members of circular or varying sections, finished dimensions shall be taken as the sides of the smallest square or rectangle from which such a section can be cut. Length of each member shall be measured over all to the nearest cm so as to include projection for tenons. Width and thickness shall be measured to the nearest mm and the quantity shall be worked out in unit of cubic decimeter in whole numbers.

7.3.5 Rate

The rate shall include the cost of material and labour involved in all the operations described above except the hold fasts or metallic fasteners which will be paid for separately.

7.4 FALSE CEILING AND PARTITION FRAMES

This work shall be done as specified in 7.3 except that the scantlings need not be planed unless otherwise specified.

7.5 TRUSSES

7.5.1 General:- The work shall be carried out as per detailed drawings and as directed by the Engineer. Specified timber shall be used. Sawing shall be truly straight and square, and in the direction of the grains. The scantlings shall be accurately planed smooth to the full dimensions with rebate roundings and mouldings shown in the drawings, before the same are framed. Patching or plugging of any kind shall not be permitted. A tolerance of $-2/+3$ mm shall be allowed in the finished cross sectional dimension.

7.5.2 Joints

Joints shall be simple, neat and strong. All mortise and tenon joints, mitred joints, scarfs etc., shall fit in fully and accurately without wedging or fillings. The joints shall be as per detailed drawings. Holes of correct sizes shall be drilled before inserting screws/bolts. Driving in screws with hammer is prohibited. Holes for bolts shall be of uniform diameter. The screws, bolts and nails shall be dipped

in oil before using. The heads of nails and screws shall be sunk and puttied or dealt with as instructed by the Engineer. The gauge and length of nails, screws and bolts shall be approved by the Engineer before using on works.

7.5.3 Shaping Form and Cutting

The wood sections, as specified or required, shall be straightened, cut square and to correct lengths. A fine accuracy shall be ensured in the fabrication of various members so that these can be assembled without being unduly strained or forced into position and when built up, shall be true to shape and free from twist, kinks, buckles or open joints.

7.5.4 Fabrication

As per drawing, a full size truss diagram shall first be drawn on a levelled platform. From this full size diagram, templates of all joints as for tenons, mortises, scarves etc., shall be made for use in the fabrication. The template shall be made to correspond to each member and place for holes for screws and bolts shall be marked accurately on them and drilled. The templates shall be laid on wooden members and the holes for screwing and bolting marked on them. The ends of the wooden members shall also be marked for cutting. The base of columns and the position of anchor bolts shall be carefully set out. Before fabrication of the truss, individual members shall be assembled together to ensure close abutting or lapping of the surfaces of the different members and fitted close together as per drawing.

7.5.5 Hoisting and Placing in position

The trusses shall be hoisted and placed in position carefully, without any damage to itself and other building work and injury to workman. The trusses shall be secured to walls by means of holding down bolts or as directed by the Engineer. The necessary mechanical appliances such as fitting tackle, winch etc., for hoisting the truss shall be used. The trusses shall be stayed temporarily till they are permanently secured in position and connected with each other by means of purlins. Holding down bolts, cleats used for purlins and bottom plates used for tie and rafter member shall be paid for separately. All beams and guides shall be bedded in wall plates with atleast 25cm bearing. All joints shall bear not less than 12mm on wall plates. Every purlin or batten supported on a wall shall have a bearing in the direction of its length equal to its own depth, subject to a minimum of 10 cm.

When the end of a beam or any wood work is buried in masonry or brickwork, an air space of 6mm shall be left at the ends, sides and top.

7.5.6 Surface Treatment

Wood work shall not be painted, oiled or otherwise treated before it has been approved by the Engineer. All portions of timber built into or against or close to masonry or concrete or buried in ground shall be given two coats of boiling coal tar. It is desirable to add to Coal Tar quick lime powder in proportion of 1 kg. of lime to 5 litre of Coal Tar. In place of Coal Tar, use of red lead paint or other approved wood primer shall be permitted. All junctions of rafters, purlins, beams and wall plates shall be painted with approved wood primer.

7.5.7 Precautions

As a precaution against fire, no wood work shall be fixed within 60 cm of a fire place or flue.

7.5.8 Measurements

Wood work shall be measured for finished dimensions. No allowance shall be made for dimensions supplied beyond those specified. Length of each piece shall be measured over all nearest to a cm, so as to include projections for tenons, scarves or mitres. Width and thickness shall be measured to the nearest cm. Cubical contents can be worked out in units of cubic decimeter in whole number.

7.5.9 Rate

The rate includes the cost of materials and labour involved in all the operations described above. Unless otherwise specified, iron fixtures such as bolts and nuts, M.S. steel plates, holding down bolts and staining, priming, painting or polishing of the work shall be paid for separately.

7.6 PANELLED GLAZED OR PANELLED AND GLAZED SHUTTERS

Extracts from IS Code 1003 Pts. 1 & 2 on Shutters are at **Annexures 7.5A & 7.5B)**

7.6.1 General:- Panelled or glazed shutters for doors, windows, ventilators and cupboards shall be constructed in the form of timber frame work of stiles and rails with panel inserts of timber, plywood, block board, veneered particle board, Prelaminated Particle Board, fibre board, Prelaminated Fibre Board, wire gauze or sheet glass. The shutters may be single or multi-panelled, as shown in the drawings or as directed by the Engineer. Timber for frame work, material for panel inserts and

thickness of shutters shall be as specified. All members of the shutters shall be straight without any large warp or bow and shall have smooth well planed face at right angles to each other. Any warp or bow shall not exceed 1.5 mm. The right angle for the shutter shall be checked by measuring the diagonals and the difference between the two diagonals should not be more than ± 3 mm.

7.6.2 Frame work

Figure 7.2 may be seen for the Terminology for various components.

7.6.2.1 Timber for stiles and rails shall be of the same species and shall be sawn in the directions of grains. Sawing shall be truly straight and square. The timber shall be planed smooth and accurate to the required dimensions. The stiles and rails shall be joined to each other by plain or haunched mortise and tenon joints and the rails shall be inserted 25 mm short of the width of the stiles. The bottom rails shall have double tenon joints and for other rails single tenon joints shall be provided. The lock rails of door shutter shall have its center line at a height of 800 mm from the bottom of the shutters unless otherwise specified. The thickness of each tenon shall be approximately one-third the finished thickness of the members and the width of each tenon shall not exceed three times its thickness.

7.6.2.2 Gluing of Joints

The contact surfaces of tenon and mortise shall be treated, before putting together, with

bulk type synthetic resin adhesive conforming to IS : 851 suitable for construction in wood or synthetic resin adhesive (Phenolic and aminoplastic) conforming to IS : 848 or polyvinyl acetate dispersion based adhesive conforming to IS : 4835 and pinned with 10 mm dia hardwood dowels or bamboo pins or star shaped metal pins; after the frames are put together and pressed in position by means of press.

7.6.2.3 Stiles and bottom rail shall be made out of one piece of timber only. Intermediate rail exceeding 200 mm in width may be out of one or more pieces of timber. The width of each piece shall be not less than 75 mm. Where more than one piece of timber is used for rails, they shall be joined with a continuous tongued and grooved joint glued together and reinforced with metal dowels at regular intervals not exceeding 200 mm.

7.6.3 Muntin & Glazing Bars:- Muntin and glazing bars where required shall be sub-tenoned to the maximum depth which the size of the member would permit or to a depth of 25 mm whichever is less. Unless otherwise specified the finished dimensions of the components of frame work of shutters shall be as given in **Table 7.8**. The tolerance on width of styles and rail shall be ± 3 mm. The tolerance in thickness will be ± 1 mm. The thickness of all components of frame work shall be the same as the thickness of the shutter. Tolerance on over all dimensions of the shutter shall be ± 3 mm.

TABLE 7.8 Dimensions of components of Frame Work

SL	Description	Width (mm)	Thickness (mm)
A. DOOR SHUTTERS			
(a)	Stile, top and freeze rail	100	35 or 40
(b)	Lock rail	150	35 or 40
(c)	Bottom rail	200	35 or 40
(d)	Muntin	100	35 or 40
(e)	Glazing bar	40	35 or 40
B. WINDOW, VENTILATOR CUPBOARD SHUTTES			
(a)	Stile, top and freeze rail	80	20, 25 or 30
(b)	Bottom rail	80	20, 25 or 30
(c)	Muntin	60	20, 25 or 30
(d)	Glazing bar	40	20, 25 or 30

7.6.4 Rebating

The shutters shall be single-leaf or double leaved as shown in the drawings or as directed by the Engineer. In case of double leaved shutters, the meeting of the stiles

shall be rebated by one-third the thickness of the shutter. The rebating shall be either splayed or square type as shown in **Figure 7.2**.

7.6.5 Panelling

The panel inserts shall be either framed into the grooves or housed in the rebate of stiles and rails. Timber, plywood, hard board and particle board panels shall be fixed only into grooves. The depth of the groove shall be 12 mm and its width shall accommodate the panel inserts such that the faces are closely fitted to the sides of the groove. Panel inserts shall be framed into the grooves of stiles and rails to the full depth of the groove leaving on space of 1.5 mm. Width and depth of the rebate shall be equal to half the thickness of stiles and rails. Glass panels, asbestos panels wire gauze panels and panel inserts of cupboard shutters shall be housed in the rebates of stiles and rails.

7.6.5.1 Timber Panels

Timber panels shall be preferably made of timber of large width; the minimum width and thickness of the panel shall be 150 mm. and 15 mm respectively. When made from more than one piece, the pieces shall be jointed with a continuous tongued and grooved joint glued together and reinforced with headless nails at regular intervals not exceeding 100 mm. Depth and thickness of such joint shall be equal to one-third of thickness of panel. The panels shall be designed such that no single panel exceeds 0.5 square metre in area. The grains of timber panels shall run along the longer dimensions of the panels. All panels shall be of the same species of timber unless otherwise specified. Tolerance permissible in thickness of Panel is $\pm 1.00\text{mm}$

7.6.5.2 Plywood Panels

Plywood boards used for paneling of shutters shall be BWR type or grade as specified in Para 7.2.2A & 7.2.2B. Each panel shall be a single piece of thickness, 9 mm for two or more panel construction and 12 mm for single panel construction unless otherwise specified.

7.6.5.3 Block Board Panels

Block board used for paneling of shutters shall be Grade I (Exterior Grade) bonded with BWR type synthetic resin adhesives as specified in 7.2.6. Each panel shall be a single piece of thickness 12 mm unless otherwise specified.

7.6.5.4 Veneered Particle, Board Panels / Prelaminated Particle Board Panels

Veneered Particle Board / Prelaminated Particle Board used for paneling of shutters shall be Exterior Grade I bonded with BWR type synthetic resin adhesives as specified in Paras 7.2.3B and 7.2.3C. Each panel shall

be a single piece of thickness 12 mm unless otherwise specified.

7.6.5.5 Fibre Board Panels / Prelaminated Fibre Board Panels

Fibre Board / Prelaminated Fibre Board used for paneling of shutters shall be Exterior Grade I bonded with BWP type synthetic resin adhesives as specified in Paras 7.2.8A & 7.2.8B. Each panel shall be a single piece of thickness 10 mm unless otherwise specified.

7.6.5.6 Wire Gauze Panels

Wire Gauze used for paneling of shutters shall be woven with 0.63 mm dia galvanized mild steel wire to form average aperture size of 1.40 mm as specified in 7.2.10. Wire gauze shall be securely housed into the rebates of stiles and rails by giving right angle bend turned back and fixed by means of suitable staples at intervals of 75 mm and over this wooden beading shall be fixed., The space between the rebate and the beading shall be fixed with putty to give a neat finish. Each wire gauze panel shall be a single piece, and the panels shall be so designed that no single panel exceeds 0.5 sqm. in area. However, care shall be taken to prevent sagging of wire gauge of panel by providing and fixing 20 x 20 mm square or equivalent beading to the external face in the required patterns as directed by the Engineer.

7.6.5.7 Glass Panels

Glass paneling (Glazing) shall be done with sheet/float glass of ordinary quality as specified in 7.2.9. Glazing in the shutters of doors, windows and ventilators of bath, WC and Lavatories shall be provided with frosted glass the weight of which shall be not less than 10 kg/sqm. Frosted glass panels shall be fixed with frosted face on the inside. Glass panels shall be fixed by providing a thin layer of putty conforming to IS : 419 applied between glass pane and all along the length of the rebate and also between glass panes and wooden beading. Putty can be prepared by mixing one part of white lead with three parts of finely powdered chalk and then adding boiled oil to the mixture to form a stiff paste and adding varnish to the paste at the rate of 1 litre of varnish to 18 kg. of paste. Fixing of glass panes without beading shall not be permitted. Glazing shall be done after the shutters have been primed and prepared for painting, so that wood may not draw oil out of putty. Typical arrangement of glazing is at **Figure 7.3**. For external glazed doors and windows, the beadings should be fixed on the outside. No

glazing is to be considered complete until all stains have been removed from the surface of the glass and wood work. No glass is to be inserted in frames until the frames have been primed and prepared for painting etc, so that the putty may adhere properly.

7.6.5.8 Finish

Panels of shutters shall be flat and well sanded to a smooth and level surface.

7.6.6 Beading

Beadings in panelled shutter shall be provided where specified in architectural drawings or directed by the Engineer. Each length of beading shall be of single piece. Joints at the corners shall be mitred and exposed edges shall be rounded. Beading shall be fixed with headless nails at 75 mm intervals. For external shutters, the beading shall be fixed on the outside face.

7.6.7 Machine/Factory made Shutters

Machine made shutters, where specified, shall be procured from an approved factory. For machine made shutters, operations like sawing, planing, making tongue and tenons, cutting grooves, mortises and rebates, drilling holes and pressing of joints shall be done by suitable machines. Machine made shutters shall be brought to the site fully assembled but without any priming coat. Panel inserts of sheet glass and wire gauge, may, however, be fixed at site.

7.6.8 Fixing of Shutters

For side hung shutters of height upto 1.2 m each leaf shall be hung on two hinges at quarter points and for shutters of height more than 1.2 m each leaf shall be hung on the hinges one at the center and the other two at 200 mm from the top and bottom of the shutters. Top hung and bottom hung shutters shall be hung on two hinges fixed at quarter points of top rail or bottom rail. Centre hung shutter shall be suspended on a suitable pivot in the center of the frame. Size and type of hinges and pivots should be as specified. Flap of hinges shall be neatly counter sunk into the recesses cut to the exact dimensions of flap. Screws for fixing the hinges shall be screwed in with screw driver and not hammered in. Unless otherwise specified, shutters of height more than 1.2 Metres shall be hung on butt hinges of size 100 mm and for all other shutters of lesser height butt hinges of size 75 mm shall be used. For shutters of more than 40 mm thickness butt hinges of size 125 x 80 x 4 mm shall be used. Continuous (piano) hinges shall be used for fixing cup-board shutters where specified.

7.6.9 Fittings

Fittings shall be provided as per schedule of fittings decided by the Engineer. **Annexure 7.6** gives for guidance the schedule of fittings and screws usually provided. Cost of providing and fixing shutter shall include cost of hinges and necessary screws for fixing the same. All other fittings shall be paid for separately. The fittings shall conform to specifications laid down in 7.21.

7.6.10 Wooden Cleats and Blocks

Wooden cleats and blocks shall be fixed to doors and windows as directed by the Engineer, as per size and shape approved by him. These are included in the cost of providing and fixing the shutters.

7.6.11 Measurements

Frame work and panelling shall be measured separately.

7.6.11.1 Frame Work of Shutters

The overall length and width of the frame work of the shutters shall be measured nearest to a cm in fixed position (overlaps not to be measured in case of double leaved shutters) and the area calculated in square metres correct to two places of decimal. No deduction shall be made to form panel openings or louvers. No extra payments shall be made for shape, joints and labour involved in all operations described above.

7.6.11.2 For panelling of each type or for glazed panel, length and width of opening for panels inserts or glazed panels shall be measured correct to a cm before fixing the beading and the area shall be calculated to the nearest 0.01 sqm. The portions of the panel inserts or glazed panel inside the grooves or rebates shall not be measured for payment.

7.6.12 Rate

Rate includes the cost of materials and labour involved in all the operations described above. The frame work and paneling of each type or glazed panels shall be paid separately. The rate for frame work includes the cost of butt hinges and necessary screws as specified in 7.6.9. However, extra payment shall be made for providing moulded beading where specified. Nothing extra shall be paid for plain beading as stated in 7.6.6 when specified in drawing.

7.7A Wooden Flush Door Shutters (Cellular and Hollow Core Type) (Plywood Face Panels) (Refer IS 2191 Pt.1)

7.7A.1 Types and Designation

Cellular or Hollow Core flush door shutters may be of the decorative type or non-decorative (paintable) type. Abbreviations to be used are Cellular Decorative CD; Cellular Non Decorative CN; Hollow Decorative HD and Hollow Non decorative HN.

7.7A.2 Sizes, Thickness and Tolerances

Extracts from Clause 4 on "Sizes" from IS 2191 Pt. 1 are enclosed as **Annexure 7.7**. Sketch representing the dimensions is at **Figure 7.4A**.

7.7A.3 Materials

7.7A.3.1 Timber

Timber (Species, quality, preservative treatment) shall conform to stipulations in Clause 5.1 of IS 2191 Pt.1. For Stiles, rails and lipping only hard wood species shall be used. Moisture content in timber shall be not more than 12% when tested as per IS 1708.

7.7A.3.2 Plywood

Commercial Plywood used in Flush door shutters shall be BWR Grade of Type AB conforming to IS 303. Decorative Plywood should conform to BWR Grade Type II to IS 1328.

7.7A.3.3 Cross Band - Should conform to BWR Grade Plywood to IS 303.

7.7A.3.4 Face Veneers

Commercial face veneer should conform to BWP Grade Plywood to IS 303. Decorative face veneer should conform to BWR Grade I to IS 1328.

7.7A.3.5 Adhesive - Adhesive used shall be phenol formaldehyde synthetic resin conforming to BWR Type of IS 848.

7.7A.3.6 Particle Board

Particle Board used for the core of the Flush Shutters shall be either Flat pressed or extrusion pressed type conforming to IS 3087 using Phenol Formaldehyde adhesive.

7.7A.4 Construction

7.7A.4.1 Cellular Core (Refer Figure No.7.4B)

Timber frames for holding the core shall be constructed from stiles and top and bottom rails, each not less than 75mm wide including internal lippings where provided. The cellular core shall be of Type A or Type B described in sub clause 6.1 of IS 2197 (Pt.1). For Type A, Particle Board to IS 3087 or Hard Board to IS 1658 or Wooden battens or Plywood battens etc of not less than 25mm width will be used to provide voids of area not exceeding 25 cm^2 and total voids contents not exceeding 50% of Core Volume. For Type B Rolls, strips, Coils or

corrugations of veneer not less than 1mm thick and 100mm length will be used. Voids will be uniformly distributed throughout the core.

7.7A.4.2 Hollow Core (Refer Fig. No. 7.4C)

Timber frames for holding the core shall be constructed from stiles and top, bottom and minimum two intermediate rails each not less than 75mm wide including internal lipping where provided. In each segment, battens not less than 25mm wide shall be fixed in such a way that voids are distributed equally and the void area in any segment is less than 500 cm^2 . Battens may be replaced by suitable rolls or strips of veneers.

7.7A.4.3 Face Panels

The plywood forming the face panel shall be not less than 3mm in thickness in the case of cellular core shutters and not less than 6mm in thickness in the case of hollow core shutters except for 25mm thick shutters in which case 4mm thickness may be permitted. The thickness of face veneers in the plywood shall be between 0.5mm and 1.5mm for commercial veneers and 0.5mm and 1.0mm for decorative veneers.

7.7A.4.4 Lipping

Lipping where provided shall be internal (designated as edge band) or external as specified by the Purchaser. Joints shall not be permitted in the lipping. Edge band shall have a total depth of not less than 25mm. External lipping shall be solid and measure atleast 6mm on the face of the door.

7.7A.4.5 Rebating

In the case of double leaved shutters, the meeting of stils shall be rebated by one third thickness of shutter. Where lipping is provided, the depth of lipping at the meeting of stiles shall be not less than 35mm.

7.7A.4.6 Opening for Glazing

When required by the purchaser, opening provided shall be 25cm in height and 20cm in width. Bottom of opening shall be at a height of 140cm from the bottom of the shutter, Opening shall be lipped internally with solid timber.

7.7A.4.7 Venetian

This shall be provided where desired. Height of opening shall be 30 cm from the top of bottom rail. Width of opening shall provide for a clear space of atleast 75mm between the edge of the door and the venetian opening.

7.7A.5 Fittings -Shutters shall be shop prepared for taking mortice locks or latches as ordered.

7.7A.6 Testing

The tests to be carried out and the requirements to be complied with are as given in Clause 9 of IS 2191 Pt.1. Sampling and Criteria for conformity shall be as laid down in Clause 10 of IS 2191 Pt.1.

7.7A.7 Fixing - This shall be as specified in Para 7.6.8.

7.7A.8 Measurements

Length and width of the shutters shall be measured to the nearest cm in closed position covering the rebate of the frames but excluding the gap between the shutters and the frame. Overlap of two shutters shall be measured.

All work shall be measured net as fixed and area calculated in square metres to nearest

two places of decimal. No deduction shall be made for providing venetian opening and opening for glazing.

7.7A.9 Rate

The Rate shall include the cost of materials and labour involved in all the operations described above. Extra shall be payable for providing rebate in double leaved shutters.

7.7B Wooden Flush Door Shutters (Cellular and Hollow Core Types (Particle Board and Hard Board Face Panels) – (Refer Is 2191 Pt.2)**7.7B.1 Types and Designations**

Types and Designations shall be as under for Particle Board Face Panels.

CORE	TYPE		DESIGNATION
	Decorative or Non Decorative	Skin	
Cellular	D	Decorative Veneered Particle Board	CDPV
	ND	Unveneered Particle Board	CNP
	ND	Commercial Veneered Particle Board	CNPV
Hollow	D	Decorative Veneered Particle Board	HDPV
	ND	Unveneered Particle Board	HNP
	ND	Commercial Veneered Particle Board	HNPV

7.7B.2 Sizes, Thickness and Tolerances

Same as in Para 7.7A.2. Core shall conform to provisions in IS 2191 Pt.1.

7.7B.3 Materials

7.7B.3.1 Timber: Same as in Para 7.7A.3.1.

7.7B.3.2 Particle Board

Unveneered Particle Board for use with CNP and HNP should conform to IS 3087 using BWR Type Resin. Veneered Particle Board for use with Decorative type CDPV and HDPV as well as for Nondecorative type CNPV and HNPV should conform to the corresponding appropriate provisions in IS 3097.

7.7B.3.3 Fibre Board

For shutters with Fibre Hard Board face only tempered hard board conforming to IS 1658 shall be used.

7.7B.3.4 Adhesive

Phenol Formaldehyde of BWP Type conforming to IS 848 should be used.

7.7B.4 Construction

The relevant provisions in IS 2191 (Pt.2) will apply. For Face Panel, if unveneered Particle Board or Veneered Particle Board is used, the face panel shall not be less than 6mm thick in the case of cellular core flush doors and not less than 9mm thick in case of hollow core flush doors. If hard board is used the corresponding figures will be 4mm and 6mm. The Panel shall be glued under pressure on both faces of the core by the hot press process.

7.7B.5 Fittings - Para 7.7A.5 will apply.

7.7B.6 Testing - Para 7.7A.6 will apply.

7.7B.7 Fixing - Para 7.7A.7 will apply.

7.7B.8 Measurements - Para 7.7A.8 will apply.

7.7B.9 Rate - Para 7.7A.9 will apply.

7.7C WOODEN FLUSH DOOR SHUTTERS (Solid Core Type) (Plywood Face Panels) (Refer IS 2202 Pt.1)**7.7C.1 Types and Designations**

Solid Core flush door shutters may be of the decorative type or non decorative (paintable)

type as under depending on the type of Core.

SL	Core	Type	Designation
i)	Block Board	Decorative	BD
		Non Decorative	BN
ii)	Particle Board with or without Block Board	Decorative	PD
		Non Decorative	PN
iii)	Medium density Fibre Board with or without Block	Decorative	MD
		Non Decorative	MN

Board

7.7C.2 Size and Thickness - Same as in Para 7.7A.2

7.7C.3 Material - 7.7C.3.1 Timber Same as in Para 7.7A.3.1.

7.7C.3.2 Plywood

Commercial Plywood should conform to IS 710 for adhesive and grading with surface requirements to suit type AB of IS 303 for veneers. Decorative Plywood should conform to Type I of IS 1328.

7.7C.3.3 Cross band / Face Veneer

Cross band and commercial face veneer should conform to Marine Grade Plywood IS 710 for quality and IS 303 for veneers. Decorative face veneer should conform to Type I of IS 1328.

7.7C.3.4 Adhesive - It shall be Phenol Formaldehyde BWP Grade synthetic resin to conform to IS 848.

7.7C.3.5 Particle Board

Particle Board used for the core shall be either FPT-1 or XPS designation of IS 3087.

7.7C.3.6 Medium Density Fibre Board

MDF Board used for the core shall conform to Type EGSB of IS 12406.

7.7C.4 Construction

7.7C.4.1 Block Board Core (See **Figure 7.4D**)

A frame constructed of stiles and rails shall be provided for holding the core. Width of frame including lipping shall be 45mm to 75mm. Wooden strips to form to core shall not exceed 30mm in width. The strips of wood may be laid separately or spot glued or otherwise jointed to form a core which is glued between two or more outer veneers.

7.7C.4.2 Particle Board or Medium Density Fibre Board Core (See **Figure 7.4E**)

Frame shall be as mentioned in 7.7C.4.1 Particle Board / M.D.F.Board should be as given in Para 7.7C.3.5 and 7.7C.3.6 respectively.

7.7C.4.3 Particle Board or Medium Density Fibre Board with Block Board Core (Reg. **Figure 7.4F**)

Frame, Particle Board and M.D.F. Board shall be as indicated in Para 7.7C.4.2, Block Board shall conform to Para 7.7C.4.1 and should extend atleast 150mm from inner edge of the stiles on either side and the rest shall be particle board or MDF Board.

7.7C.4.4 Stiles and rails - They shall be one piece, without any joint.

7.7C.4.5 Face Panel - The Face Panel shall be formed by gluing on both faces of the core either plywood or cross board and face veneers by the hot press process. The thickness of the cross band as such or in the plywood shall be between 1mm and 3mm. The thickness of face veneer as such or in the plywood shall be between 0.4mm to 1.5mm for commercial veneers and 0.35mm to 1.0mm for decorative veneers, provided combined thickness of both is not less than 2.2mm.

7.7C.4.6 Lipping

Internal lipping shall have a total depth of not less than 25mm. External lipping shall be solid and shall measure atleast 4mm on the face of the door.

7.7C.4.7 Rebating

In the case of double leaved shutters, the meeting of stiles shall be rebated by 8mm to 10mm. Where lipping is provided, the depth of lipping at the meeting of stiles shall be not less than 30mm.

7.7C.4.8 Opening for glazing - Same as in 7.7A 9 except that the width may be 15cm or 20cm.

7.7C.4.9 Venetian

This shall be provided if ordered. The height of opening shall be 35cm from bottom of shutter. A clear space of atleast 7.5cm should be left between the edge of door and venetian opening.

7.7C.5 Fittings

Shutters shall be shop prepared for taking mortice locks or latches. Suitable blocks of wood may be provided for fixing the locks.

7.7C.6 Testing - The following Clauses of IS 2202 (Pt.1) will apply.

Clause 10 Tests

Clause 11 Requirements

Clause 12 Sampling and criteria for conformity

7.7C.7 Fixing - Para 7.7A.7 will apply.

7.7C.8 Measurements - Para 7.7A.8 will apply.

7.7C.9 Rate - Para 7.7A.9 will apply.

7.7D Wooden Flush Door Shutters (Solid Core Type) – (Particle Board and Hard Board Face Panel) (Refer IS 2202 Pt.2)

7.7D.1 Type and Designations

Solid Core flush door shutters with Particle Board face panels may be of decorative or non decorative (Paintable) type. The Designations based on the type of Core and type of face panel will be as under:

Core	Type		Designation
	Decorative or Non Decorative	Veneered or Unveneered Particle Board	
Block Board	Decorative Nondecorative Nondecorative	Veneered Unveneered Veneered (commercial)	BDPV BNP BNPV
Particle Board with or without Block Board	Decorative Nondecorative Nondecorative	Veneered Unveneered Veneered (Commercial)	PDPV PNP PNPV

7.7D.2 Sizes Thickness and Tolerance - Same as in Para 7.7A.2.

7.7D.3 Materials -

7.7D.3.1 Timber Same as in Para 7.7A.3.1.

7.7D.3.2 Particle Board for Face Panel

Unveneered To conform to IS 3087 and of appropriate Type

Veneered To conform to IS 3097 and of appropriate Type

7.7D.3.3 Fibre Hard Board for Face Panel

Tempered hard board should conform to IS 1658.

7.7D.3.4 Adhesive - Should be Phenol formaldehyde synthetic resin and should conform to BWP Type to IS 848.

7.7D.4 Construction

7.7D.4.1 Core - Paras 7.7C.4.1 to 7.7C.4.4 will apply.

7.7D.4.2 Face Panel

Face Panel shall be formed by gluing by the hot press process on both faces of the core. Particle Boards or veneered particles boards or Hardboard. The thickness of each face Panel of Particle Board shall be not less than 4mm and of hardboard not less than 3mm.

7.7D.5 Fittings - Para 7.7A.5 will apply.

7.7D.6 Testing - Provisions in Para 7.7C.6 will apply.

7.7D.7 Fixing - Para 7.7A.7 will apply.

7.7D.8 Measurements - Para 7.7A.8 will apply.

7.7D.9 Rate - Para 7.7A.9 will apply.

7.8. Battened and Framed Door and Window Shutters (Figure 7.5A)

7.8.1 General:- Specified timber shall be used, and it shall be sawn in the direction of the grains. Sawing shall be truly straight and square. The timber shall be planed smooth and accurate to the full dimensions; rebates, roundings and mouldings as shown in the drawings made before assembly. Patching or plugging of any kind shall not be permitted except as provided.

7.8.2 Dimensions:- Planks for battens shall be 20 mm thick unless otherwise specified and of uniform width of 75 mm to 100mm. These shall be planed and made smooth, and provided with minimum 12 mm rebated joints. The finished work with a tolerance of ± 1 mm in thickness and $\pm 1 \frac{1}{2}$ mm in width of battens etc., shall be accepted. The ends of battens shall be feather tongued into stiles and rails, which shall be provided with 12 mm groove to fit in the battens.

7.8.3 Fixing etc:- The specification for fixing wooden cleats and blocks, fittings and measurements shall be as described under 7.6.

7.8.4 Rate - It includes the cost of materials and labour involved in all the operations described above.

7.9 LEDGED AND BATTENED, OR LEDGED BRACED AND BATTENED DOOR AND WINDOW SHUTTER (FIGURE 7.5B & 7.5C)

7.9.1 General:- Provisions in Para 7.8.1 shall apply.

7.9.2 Dimensions:- Planks for battens shall be 20mm thick unless otherwise specified and of uniform width of 75 mm to 100 mm. These shall be planed and made smooth and provided with minimum 12 mm rebated

joints. The finished work with a tolerance of ± 1 mm in thickness and $\pm 1\frac{1}{2}$ mm in width of battens, ledges etc., shall be accepted. The ends of battens shall be feather tongued into style and rails, which shall be provided with 12 mm groove to fit in the battens.

7.9.3 Ledges and Braces

The battens shall be fixed together by 25 mm thick ledges and braces fixed to the inside face of door shutters with screws. The ledge shall be 175 mm wide and brace 125 mm wide unless otherwise specified. The braces shall incline downwards towards the side on which the door is hung as shown in **Figure 7.5C**. Edges and ends of ledges and braces shall be chamfered. Tee hinges shall be provided in ledges only. The finished work with a tolerance of ± 1 mm in thickness and $\pm 1\frac{1}{2}$ mm in width of battens, ledges etc., shall be accepted.

7.9.4 Fixing etc.:- The specifications for fixing wooden cleats, blocks, fittings and measurements shall be as described under 7.6.

7.9.5 Rate - It includes the cost of materials and labour involved in all the operations described above.

7.10 LEDGED BRACED AND BATTENED GARAGE DOOR SHUTTERS (FIGURE 7.5C & 7.5D)

7.10.1 General:- Para 7.8.1 will apply.

7.10.2 Battens:- Planks for battens shall be 20mm thick unless otherwise specified and of uniform width of 125 to 175 mm. These shall be planed and made smooth, and provided with minimum 12 mm rebated joints. The joint lines shall be chamfered. The finished work with a tolerance of ± 1 mm in thickness and $\pm 1\frac{1}{2}$ mm in width of battens etc., shall be accepted. Thickness of doors shall be the thickness of battens only and not the combined thickness of battens and braces.

7.10.3 Ledges and Braces

The battens shall be fixed together by 30 mm thick (unless otherwise specified), ledges and braces on the inside face of door shutter with minimum two numbers of 50 mm long wood screws per batten. The ledges shall be 225 mm and braces 175 mm wide, unless otherwise specified. The braces shall incline downwards towards the side on which the door is hung. Edges and ends of ledges and braces shall be chamfered.

7.10.4 Fittings and Fixing

Garage door shutter shall be fixed to the wall masonry with six pintle sets. Each set shall consist of a pin clamp of 50 x 6 mm flat iron 45 cm long, bent and forked at one end and provided with 20 mm dia. M.S. pin on the other end and 50 x 6 mm double strap 60 cm long. The pin shall be firmly riveted or welded to the pin clamps, the other end of which shall be embedded in masonry by means of cement concrete block 40 x 20 x 20 cm 1:2:4 mix (1 cement : 2 coarse sand : 4 graded stone aggregate 20 mm nominal size). These shall be so placed that the bottom pin shall face upwards and the top pin downwards, in order that the gate may not be removed by lifting over pins. The fixing shall be so done that the door shutter can open on the outside by 180°.

The double strap shall fit in the pin on one side and shall be fixed to the shutter at ledge on the other side with 4 bolts and nuts of 12 mm diameter. One hook and eye 450 mm size of mild steel shall be provided for each shutter to keep fixed in open position. A cement concrete block 15 x 10 x 20 cm in 1:2:4 (1 cement : 2 coarse sand : 4 graded stone aggregate 20 mm nominal size) mix shall be embedded in the floor at junction of two shutters so that the door shutters open only on the outside and not on the inside. An iron sliding bolt (aldrop) 450 x 16 mm in diameter shall be provided and fixed. Tolerance of ± 0.5 mm in diameter may be allowed.

7.10.5 Measurements

The over all length and width of the shutter shall be measured nearest to a cm in fixed position (overlaps not to be measured in case of double leaved shutters) and area calculated in square metres correct to two places of decimal. Rate of 450X16mm dia aldrop is included in the rate of shutters .

7.10.6 Rate - It includes the cost of materials and labour required for the operations described above. Nothing extra shall be paid for cement concrete blocks, nor anything deducted from the measurement of masonry of wall on account of cement concrete blocks etc.,

7.11 LOUVERED SHUTTERS

7.11.1 General:- Para 7.8.1 will apply.

7.11.2 Frames

Where the shutters have to be provided in the same frames as for the ordinary door or window, the thickness of the frame shall be increased by the specified thickness of the

shutters, which shall be paid for separately under the relevant items of work.

7.11.3 Stiles and Rails - It shall be as specified in 7.6.

7.11.4 Venetians

The panel space shall be fitted with Venetians which shall be 12 mm thick, unless otherwise specified. The venetian blades shall slope down towards the outside at angle as shown in the drawings and shall be fixed in stiles. These shall overlap each other by about half of their widths. The Venetians may be of fixed or movable type as specified. The finished work with a tolerance of ± 1 mm in thickness and $\pm 3/2$ mm in width of battens etc., shall be accepted.

7.11.5 Fittings etc:- The specification for fittings, wooden cleats and blocks and measurements shall be as specified under 7.6.

7.11.6 Rate

It includes the cost of materials and labour involved in all the operations described above. The rate for frame work includes the cost of butt hinges and necessary screws as specified in 7.6.8. The rate for venetian/louvers shall include the cost of beading if specified.

7.12 LOUVERS FIXED TO FRAMES

7.12.1 General:- The louvers shall be of wood, glass, AC sheet or any other material as specified.

7.12.2 Fixing -

These shall be fixed in grooves of minimum of 1.25 mm depth, made in the frame. The venetian blades shall slope down towards the outside at an angle of 45° or as shown in the drawings. These shall overlap each other by about half of their widths.

7.12.3 Measurements

The width and height of the clear opening shall be measured to the nearest cm and area calculated in square metre correct to two places of decimal for the purpose of payment.

7.12.4 Rate - The rate is inclusive of the cost of materials and labour required for all the operations described above.

7.13 WIRE GAUZE FLY PROOF SHUTTERS

7.13.1 General:- Para 7.8.1 will apply.

7.13.2 Stile and Rails

The specifications shall be as described under 7.6.2.3. The stiles and rails shall be

given a rebate to receive the wire gauze which shall form the panels.

7.13.3 Wire Gauze

This shall unless specified otherwise conform to para 7.2.10 and 7.6.5.6. The wire gauze shall be bent at right angles in the rebates of stiles and rails, turned back and fixed tight with blue tacks at about 75 mm centres, fixed alternately in the two faces of the rebates. Over this, wooden beading shall be fixed with beads or small screws at about 75 mm centers.

The space between the beading and rebates, where the wire gauze is bent, shall be neatly finished with putty, so that the end of the wire gauge may not be visible.

7.13.4 Fixing etc:- Fixing Fittings, Wooden cleats, blocks and Measurement shall be as specified under 7.6.

7.13.5 Rate - This includes the cost of materials and labour involved in all the operations described above, and as specified under 7.6.

7.14 PANELLED PARTITIONS

7.14.1 Frames:- Wooden frames shall be made as per detailed drawings or as directed by the Engineer and paid for separately, unless otherwise specified.

7.14.2 Partitions:- The space between the frame work shall be filled in with panelled or glazed partitions of wood, asbestos sheet, masonite or as specified. The specifications under Para 7.6 shall apply to wooden partitions except that those shall be fixed in the rebates of the frame with screws. Asbestos, hard board, plywood or other specified sheets shall be similarly fixed in the rebates of the frame with screws and wooden beading.

7.14.3 Measurements:- The partitions shall be measured in Sqm. within the rebates of the frames. The width and height of partitions shall be measured correct to a cm.

7.15 SHELVES

7.15.1 General:- Shelves and vertical partitions of cupboards shall be of timber planks fibre board, particle board, block board or veneered / prelaminate particle board as specified. Thickness and type of planks or boards shall be as specified. Each shelf shall be a single piece and vertical partitions between two consecutive shelves shall be without any joint. Exposed edge of boards having particle board core shall be sealed with 3 mm thick single piece teak wood strips of width equal to the thickness of board with headless pins. The arrangement

of shelves and vertical partitions shall be as per drawings or as directed by the Engineer.

7.15.2 Fixing

Planks for shelves shall be planed on all faces and edges. In case of boards they shall be sawn to the required size truly straight and square. Timber battens 25 x 40 mm unless otherwise specified shall be planed smooth and fixed inside the cupboard with wooden plugs and screws. Shelves shall be fixed to the battens and vertical portions shall be held in position by fixing them to the battens and shelves using screws. Teakwood strips for edge sealing of the boards shall be planed smooth and fixed with headless nails. Tolerance in width shall be ± 1.5 mm and in thickness 1 mm.

7.15.3 Measurements

Length and width of shelves and vertical partitions shall be measured correct to a cm separately for each type of board stating its thickness. Area shall be calculated correct to 0.01 sqm.

7.15.4 Rate

It includes the cost of materials and labour required for all the operations described above.

7.16 TRELLIS (JAFFRI) WORK

7.16.1 General:- Para 7.8.1 will apply.

7.16.2 Plain Trellis (Jaffri)

This shall consist of wooden strips or laths 35 x 10 mm section unless otherwise specified planed and nailed together at every alternate crossing. The strips shall cross each other at right angle and shall be spaced 35 mm apart, so as to form 35 x 35 mm square opening or as shown in the drawing. These shall be fixed with nails to the frame. To cover the ends of strips, 50 x 12 mm beading shall be fixed to the frame with screws. The finished work with a tolerance of ± 1 mm may be accepted).

7.16.3 Trellis (Jaffri) Doors and Windows Shutters

Shutter frame of specified timber shall consist of two stiles and top, lock and bottom rails, each of section 75 x 35 mm unless otherwise specified. The stiles and rails shall be properly mortised and tenoned. The tenons shall pass through the stiles for at least $\frac{3}{4}$ th of the width of the stile. Shutter frame shall be assembled and passed by the Engineer before jointing. The joints shall be pressed and secured by bamboo pins of about 6 mm diameter. To this frame, plain trellis (Jaffri) work as described in 7.12.2 shall be fixed as shown in the drawings or as

directed by the Engineer, Fixing, fittings, wooden cleats and blocks shall be provided as specified under 7.6.

7.16.4 Measurements

Width and height of plain trellis work and trellis shutters shall be measured overall correct to a cm. The area shall be calculated in square metres nearest to two places of decimal. In case of shutters, the measurement shall be as specified in 7.6.

7.16.5 Rate - It includes the cost of materials and labour required in all the operations described above.

7.17 PELMETS

7.17.1 General:- Para 7.8.1 will apply.

7.17.2 Components:- Sides, front and top of the pelmets shall be of 12 mm planks or boards of specified quality and width unless otherwise stated. These shall project from the wall face by 15 cm or as specified and shall be securely fixed to walls with wood screws by means of wooden plugs and 10 cm long 25 x 3 mm M.S. flat bent in the form of angle or by any other device approved by the Engineer. The pelmets shall be provided with curtain rods and brackets or curtain rails with rollers., stop ends and brackets wooden, brass or chromium plated brass as specified. Intermediate wooden brackets shall be provided, if the front length of pelmet exceeds 1.5 metres.

7.17.3 Measurements

The pelmets box shall be measured along the sides and front planking correct to a centimeter.

7.17.4 Rate - The rate includes the cost of sides, front and top planking, curtain rods with brackets or curtain rails with rollers, labour and materials required for all the operations described above.

7.18 HOLD FASTS

7.18.1 General:- These shall be made from mild steel flat 40 x 5 mm size conforming to IS : 7196 without any burns or dents. 5 cm length of M.S. flat at one end shall be bent at right angle and one hole 11 mm dia shall be made in it for fixing to wooden frame with 10 mm dia nut and bolt. The bolt head shall be sunk into the wooden frame, 10 mm deep and plugged with wooden plug. At the other end 10 cm length of the hold fast flat shall be forked and bent at a right angle in opposite direction and embedded in cement concrete block of size 30 x 10 x 15 cm of mix 1:2:4 (1 cement : 2 coarse sand : 4 graded stone aggregate, 20 mm nominal size) or as specified (Refer **Figure 7.6**).

7.18.2 Measurements - Measurements for the hold fasts shall be in number/Kgs.

7.18.3 Rate - It includes the cost of labour and material involved in all the operations described above including fixing bolt and cement concrete blocks.

7.19 EXPANDED METAL, HARD DRAWN STEEL WIRE FABRIC, WIRE GAUZE, MS BARS AND MS GRILLS IN WOODEN FRAMES

7.19.1 General:- (a) Expanded metal, hard drawn steel wire fabric or wire gauge or weld mesh as described in the item of work shall be fixed to the window frames on the outside or inside as per detailed drawings or as directed by the Engineer. These shall be free from rust and other defects.

I. Expanded Metal

This shall be in the form of rhombus with its opening diagonals 20 x 60 mm and strands 3.25 mm wide and 1.6 mm thick weighing 3.633 kg/m² unless otherwise specified.

II. Welded Steel Drawn Wire Fabric

This shall conform to IS : 4948 and shall have rectangular mesh of 75 x 25 mm size with wires of diameter not less than 5 mm longitudinally and 3.15 mm transversely. Its weight shall be not less than 7.5 kg/m² unless otherwise specified.

III. Wire Gauze

This shall conform to 7.2.10. MS Bars and Grills shall be fixed as per detailed drawings or as directed by the Engineer.

7.19.2 Fixing

(a) Expanded metal, hard drawn steel wire fabric and wire gauze shall be cut in one piece to the size of the frame (out to out). Expanded metal and hard drawn steel wire fabric shall be fixed on to the frame with staples, over which wooden beading 50 x 20 mm shall be fixed with wood screws.

(b) For MS Bars to be fixed in wooden frames of windows etc. through holes shall

be drilled in one frame and in the other frame, holes shall be drilled 5cm deep. The bars shall be passed into the frame from one side and these shall be of the correct length to fit in at one end and be flush with the outside of the frame at the other end. Where there are MS flats provided along with the bars, these shall be fixed to the wooden frame with screws. Holes for passing MS bars shall be drilled or punched in the flats at the proper positions. Grills shall be fabricated as per design and fixed to the frame by round headed bolts and nuts in the new work, and by screws for old work.

7.19.3 Measurements

(a) The length and breadth shall be measured correct to a cm, the area from outside to outside of beading shall be calculated in square metre nearest to two places of decimal.

(b) For MS bars and flats as well as for grills, the length of MS bars and flats shall be measured separately correct to a cm and their weight calculated from Standard Tables.

7.19.4 Rate

It includes the cost of labour and materials required for all the operations described above.

7.20 SAL BALLI WORK / CASURINA POSTS

7.20.1 General:- Ballies/posts shall be free from large and dead knots, cracks and wooden borer infection. The sal ballies/casurina posts shall be of the variety popularly known as gollas in Northern India. These shall be as far as possible straight and of uniform section. The diameter specified shall be the mean diameter being the average of two diameters at ends. The tolerance shall be permitted as per **Table 7.10**.

TABLE 7.10

Length	Mean diameter or diameter at the center	Tolerance in diameter at the thinner end
Ballies/posts not exceeding 3 metre length	Not less than the specified diameter	The diameter at the thinner end shall not be less than specified diameter by more than 10 mm.
Ballies / posts exceeding 3 metre length	Not less than the specified diameter	The diameter at the thinner end shall not be less than specified diameter by more than 20 mm.

7.20.2 Surface Treatment - It shall be as specified in 7.5.6.

7.20.3 Fixing - The fixing of the ballies for posts, purlins and rafters shall be done by

clamps, bolts and nuts and spikes (country nails) as specified or as directed by the Engineer. In case of the last alternative, the large nail with a cap shall be driven through about 40 mm beyond the ballies to be fixed together and the end of the nail turned back so as to ensure proper fastening. Where so required, holes of slightly smaller size may be drilled before hammering the spike.

7.20.4 Trusses

The ballies in truss work shall be as far as possible of full lengths. Where making up is considered necessary it may be done by half lap joints secured together with 50 x 6 mm M.S. clamps of suitable length and shape fixed with bolts and nuts.

7.20.5 Measurements

The sal ballies/casurina posts shall be measured in running metres correct to a cm. Each piece shall be measured overall so as to include half lap joints etc.,

7.20.6 Rate

The rate will include the cost of materials and labour required for all the operations described above. The cost of bolts, nuts, flat iron clamps and other iron work except nails and spikes shall be paid for separately under relevant item of steel work.

7.21 FITTINGS

Fittings shall be of mild steel, brass, aluminium or as specified. Some mild steel fittings may have components of cast iron. These shall be well made, reasonably smooth and free from sharp edges and corners, flaws and other defects. Screw holes shall be counter sunk to suit the head of specified wood screws. These shall be of the following types according to the material used.

(a) Mild Steel Fittings

These shall be bright satin finish black stone enameled or copper oxidised (black finish), nickel chromium plated or as specified.

(b) Brass Fittings

These shall be finished bright satin finish or nickel chromium plated or copper oxidized or as specified.

(c) Aluminium Fittings

These shall be anodized to natural matt finish or given dyed anodic coating not less than grade AC 10 of IS : 1868.

The fittings generally used for different type of doors and windows are indicated in **Annexure 7.6**. The fittings to be actually provided in a particular work shall, however, be decided by the Engineer.

Screws used for fittings shall be of the same metal, and finish as the fittings. However, chromium plated brass screws or stainless steel screws shall be used for fixing aluminium fittings. These shall be of the size as indicated in respective figures.

Fittings shall be fixed in proper position as shown in the drawings or as directed by the Engineer. These shall be truly vertical or horizontal as the case may be. Screws shall be driven home with screw driver and not hammered in. Recesses shall be cut to the exact size and depth for the counter sinking of hinges.

7.21.1 Butt Hinges (Figure 7.7A)

These shall be of the following types according to the material used.

- (a) Mild steel butt hinges (Medium)
- (b) Cast brass butt hinges light/ordinary or heavy.
- (c) Extruded aluminium alloy butt hinges.
- (d) Stainless steel butt hinges

7.21.1.1 Mild Steel (Medium) : These shall be medium type manufactured from M.S. sheet. These shall be well made and shall be free from flaws and defects of all kinds. All hinges shall be cut clean and square and all sharp edges and corners shall be removed. These shall generally conform to IS : 1341.

Hinge Pin: Hinge pin shall be made of mild steel wire. It shall fit inside the knuckles firmly and riveted head shall be well formed so as not to allow any play or shake, and shall allow easy movement of the hinge, but shall not cause looseness.

Knuckles: The number of knuckles in the hinges of different sizes shall be as per IS : 1341. The sides of knuckles shall be straight and at right angle to the flap. The movement of the hinges shall be free and easy and working shall not have any play or shake.

Screw Holes: The screw holes shall be clean and counter sunk. These shall be suitable for counter sunk head wood screws and of the specified size for different types, and sizes of hinges. The size of the holes shall be able to accommodate the full depth of counter sunk head of the wood screws.

7.21.1.2 Cast Brass: These shall be light/ordinary or heavy as specified. These shall be well made and shall be free from flaws and defects of all kinds. These shall be finished bright or chromium plated or oxidized or as specified. These shall generally conform to IS : 205.

Hinge Pin: Hinge pin shall be made of brass or of phosphor bronze. The hinge pins shall be firmly riveted and shall be properly finished. The movement of the hinge shall be free easy and square and shall not have any play or shake.

Knuckles: The number of knuckles in each hinge shall not ordinarily be less than five. The number of knuckles in case of sizes less than 40 mm shall be three. The sides of the knuckles shall be straight and at right angle to the flap. The movement of the hinge pin shall be free and easy and working shall not have any play or shake.

Screw Holes: The screw holes shall be clean and counter sunk and of the specified size for different types and sizes of hinges. The size of the holes shall be such that when it is counter sunk it shall be able to accommodate the full depth of counter sunk head of wood screw specified.

7.21.1.3 Extruded Aluminium alloy: These shall be manufactured from extruded sections. These shall be well made and free from flaws and defects of all kinds. These shall generally conform to IS : 205.

Hinge Pin: Hinge pin shall be made of mild steel (galvanized or aluminium alloy). The aluminium alloy hinge pin shall be anodized. The hinge pin shall be finally riveted and shall be properly finished. The movement of hinges shall be free easy and square and shall not have any play or shake.

Knuckles: Number of knuckles in each hinge pin shall ordinarily not be less than 5. The sides of knuckles shall be straight and at right angle to the flap. The movement of the hinge pin shall be free and easy and working shall not have any play or shake.

Screw Holes: The screw holes shall be suitable for counter sunk head wood screws, and of specified sizes for different type of hinges. The size of the holes shall be such that when it is counter sunk it shall be able to accommodate the full depth of counter sunk head of wood screw specified.

7.21.1.4 Stainless Steel Hinges

These shall generally conform to IS 12817 and fall under four Types Light weight, Medium weight, Heavy weight and Unequal flap with dimensions and tolerances as given in Tables 1 to 4 of IS 12817. Screw holes shall be suitable for taking counter sunk head of wood screws. Unless otherwise specified, hinges shall be naturally finished bright with smooth surface without chemical coating. Scale of sampling and Criteria for conformity shall be as given in Table 5 of IS 12817.

7.21.1.5. Sampling and Criteria for Conformity: The number of butt hinges to be selected from a lot shall depend on the size of lot and shall be in accordance with **Tables 7.11A & 7.11B**. Butt hinges for testing shall be taken at random from at least 10 per cent of the package subject to a minimum of three, equal number of hinges being selected from each package. All butt hinges selected from the lot shall be checked for dimensional and tolerance requirements. Defects in manufacture and finish shall also be checked. A lot shall be considered conforming to the requirements of this specification if the number of defective hinges among those tested does not exceed the corresponding number given in **Tables 7.11A & 7.11B**.

TABLE 7.11A

SCALE OF SAMPLING AND CRITERION FOR CONFORMITY (FOR MILD STEEL HINGES)

Lot Size	Sample Size	Permissible No. of defective hinges
Up to 150	5	0
151 to 300	20	1
301 to 500	32	2
501 to 1000	50	2
1001 and above	80	3

TABLE 7.11B

(FOR NONFERROUS HINGES)

Lot Size	Sample Size	Permissible No. of defective hinges
Up to 200	15	0
201 to 300	20	1
301 to 500	30	2
501 to 800	40	2

801 and above	55	3

Note : Any hinge which fails to satisfy the requirements of any one or more of the characteristics shall be considered as defective hinge.

7.21.2 Parliament Hinges (Figure 7.7B)

7.21.2.1. These shall be of mild steel, cast brass or as specified, and shall generally conform to IS: 362. The size of Parliament hinges shall be taken as the width between open flanges. Mild steel parliamentary hinges shall be copper oxidized (thick finish) or as specified. The brass parliament hinges shall be finished bright, chromium plated or oxidized or as specified.

7.21.2.2. The hinge pin shall be made of mild steel or Phosphor Bronze in the case of brass hinges. The hinge pin shall be mild steel (galvanized) or aluminium alloy in the case of aluminium alloy hinges. The hinge pin shall be firmly riveted and shall be properly finished. The movement of the hinges shall be free, easy and square, and shall not have any play or shake. All screw holes shall be clean and counter sunk to suit the counter sunk head of wood screws specified.

7.21.2.3. Sampling and Criteria for and Conformity:- It shall be as specified in Para 7.21.1.5 except that in Table 7.11A .Sample size upto 150 shall be 13 in place of 5.

7.21.3 Spring Hinges (Single or double acting)

7.21.3.1. These shall be single acting when the shutter is open on one side only or double acting when the shutter opens on both sides. These shall be made of M.S. or brass as specified, and shall generally conform to IS : 453 in case of Double acting spring hinges.

Hinges shall work smoothly and shall hold the door shutter truly vertical in closed

position. Each double-acting spring hinge shall withstand the following tests which shall be carried out after fixing it to a swing door in the normal manner.

(a) When the door is pushed through 90° and released 2000 times on each side in quick succession the hinge shall show no sign of damage or any appreciable deterioration of the components during or on completion of the test.

(b) The door shall require a force of 2.0 ± 0.5 kg for 100mm hinges and 3.0 ± 0.5 kg for 125 mm and 150 mm hinges, at a distance of 45 cm from the hinge pin to move the door through 90°.

The Size of spring hinge shall be taken as the length of the plate.

7.21.3.2 These shall be of the following type:

(a) Mild Steel: The cylindrical casing shall be made either from M.S. sheet of 1.60 mm thickness, lap jointed and brazed, welded or riveted, or from solid drawn tube of thickness, not less than 1.60mm or from mild steel sheet of 1.60mm thickness pressed to form the two casings and the distance piece.. It shall be stove enameled black or copper oxidized or as specified.

(b) Cast Brass: The cylindrical casing shall be made either from brass sheet of 1.60 mm thickness, lap jointed and brazed or from solid drawn brass tube of not less than 1.60 mm thickness. It shall be satin bright nickel plated or copper oxidized or as specified.

7.21.3.3 Sampling: The number of spring hinges shall be selected from the lot and this number shall depend on the size of the lot and shall be in accordance with **Table 7.12** based on IS 453.

TABLE 7.12
SCALE OF SAMPLING AND CRITERION FOR CONFORMITY

Lot size	Sample Size	Permissible No. of defective spring hinges
Upto 100	13	0
101 to 300	20	1
301 to 500	32	2
501 to 1000	50	3
1001 and above	80	5

7.21.4 Rising Hinges

These shall be made of brass, finished bright or chromium plated or oxidized or as specified. Its shape and pattern shall be

approved by the Engineer. The size of the rising hinge shall be taken as the length of its plate.

7.21.5 Continuous Piano Hinges (Figure 7.8A)

7.21.5.1 These shall be made from mild steel or aluminium alloy sheet, and shall generally conform to IS : 3818. All screw holes shall be clean and counter sunk. Piano hinges shall be fixed in the entire length of the cup board shutters. Its size will be the width of the two flaps when open.

7.21.5.2 M.S. Piano Hinges: These shall be made from 1 mm or 0.80 mm thick M.S. sheets and shall be protected with anti-corrosive treatment, such as bright polished, chromium plated or oxidized finish.

Hinge pin shall be of galvanized mild steel. It shall fit in the knuckle firmly so as not to allow any play or shake and shall allow easy movement of hinge, but shall not cause looseness.

The sides of the knuckles shall be straight and at right angle to the flap. The movement of the hinge shall be free and easy and working shall not have any play and shake.

7.21.5.3 Aluminium Piano Hinges: These shall be made from aluminium alloy sheet, and shall be anodized. The anodic coating shall not be less than the grade AC 15 of IS : 1868.

Hinge pin shall be made of aluminium alloy with anodic coating not less than the grade AC 15 of IS 1868. The Hinge pin shall fit in the knuckle firmly so as not to allow any play or shake and shall allow easy movement of hinge, but shall not cause looseness.

The sides of the knuckles shall be straight and at right angle to the flap. The movement of the hinge shall be free and easy and working shall not have any play and shake.

7.21.5.4.1 Sampling and Criteria for Conformity. It shall be same as specified in **Table 7.11A**.

7.21.6 Tee Hinges (Figure 7.8B)

These shall be made from M.S. sheets and shall be either bright finished or stove enameled black or as specified. These shall generally conform to IS : 206 Tee hinges shall be well made, free from burrs, flaws and defects of any kind. The movement shall be square, and the working shall be free and easy without any play or shake. The hole for the hinge shall be central to the bore and shall be square.

The hinge pin shall be firm and riveted over, so that the heads are well formed. All screw

holes shall be clear and counter sunk and shall be suitable for the counter sunk head of wood screws.

7.21.6.1 Sampling and Criteria for conformity:

It shall be same as specified in 7.21.1.5 **Table 7.11A**.

7.21.7 Sliding Door Bolts (Aldrops) (Figure 7.9)

7.21.7.1 These shall be mild steel, cast brass, aluminium or as specified, and shall be capable of smooth sliding action.

7.21.7.2 Mild Steel Sliding Door Bolts:- These shall be made of M.S. sheets and M.S. rods and shall generally conform to IS : 281. M.S. sliding door bolts shall be copper oxidized (black finish) or as specified.

7.21.7.3 Cast Brass Sliding Door Bolts

These shall be made from rolled brass and shall generally conform to IS : 2681. The hasp shall be of cast brass and secured to the bolt as shown in **Figure 7.9**. Alternatively, the hasp and the bolt may be cast in one piece. The fixing and staple bolts shall be cast with 6 mm studs. Bolts shall be finished to shape and have threaded ends and provided with round washers and nuts of square or hexagon type. All components shall be finished smooth and polished before assembly. Cast brass sliding bolts shall be finished bright or chromium plated or oxidized or as specified.

7.21.7.4 Aluminium Sliding Door Bolts

These shall be made of aluminium alloy and shall generally conform to IS : 2681. Aluminium sliding door bolts shall be anodized. All screw holes shall be counter sunk to suit the counter sunk head of screws of specified sizes. All edges and corners shall be finished smooth. In case of single leaf door, when iron socket plate or a brass or aluminium fixing bolt (or sliding door bolt) cannot be fixed, hole of suitable size shall be drilled in the door frame and an iron or brass plate cut to shape shall be fixed at the face of the hole.

7.21.7.5 Sampling and Criteria for Conformity

It shall be as specified in 7.21.1.5 **Table 7.11B**.

7.21.8 Tower Bolts (Figure 7.10)

7.21.8.1. These shall generally conform to IS : 204 (Part I) and IS 204 (Part II). Tower bolts shall be well made and shall be free from defects. The bolts shall be finished to the correct shape and shall have a smooth action. All tower bolts made with sheet of 1.2

mm thickness and above shall have counter sunk screw holes to suit counter sunk head wood screws. All sharp edges and corners shall be removed and finished smooth.

The height of knob of tower bolt when the door, window etc., is in closed position shall be not more than 1.9 meter from the floor level.

7.21.8.2 Tower bolts shall be of the following types:

(a) Aluminium barrel tower bolts with barrel and bolt of extruded sections of aluminium alloy.

(b) Brass tower bolts with cast brass barrel and rolled or cast brass bolt

or

Brass tower bolts with barrel and bolt of extruded sections of brass and rolled or drawn brass bolt.

Note: Tower bolts, where possible, shall have the knob integral with the bolt. If not possible, the knob may be fitted to the bolt with a pin or alternatively screwed and riveted to the bolt. Nonferrous metal tower bolts shall each be provided with a small spring and a ball on the inside of barrel to enable smooth working.

(c) Mild steel barrel tower bolts with mild steel barrel and mild steel bolt. Or Mild steel tower bolts with mild steel barrel and cast iron bolts.

The plates and straps after assembly shall be firmly riveted or spot welded. The rivet head shall be properly formed and the rivet back shall be flush with the plate. These shall be made in one piece.

7.21.8.3 Unless otherwise specified bolt shall have finish as given below:

(a) Mild steel tower bolts (Types 1A and 1B) Bolts bright finished or Nickel chromium plated as specified and barrel and socket stove enameled black.

(b) Brass tower bolts (Types 1 to 3 as per IS 204 Pt.2) Bolt and barrel polished or plated as specified.

(c) Aluminium alloy tower bolts (Type 4 as per OS 204 Pt.2) Bolt and barrel anodized. The anodic film may be either transparent or dyed as specified. The quality of anodized finish shall not be less than grade AC – 10 of IS : 1868.

7.21.8.4 Sampling and Criteria for Conformity

It shall be same as specified in 7.21.1.5 Table 7.11.B.

7.21.9 Door Latch

7.21.9.1 This shall be of mild steel, cast brass, or as specified and shall be capable of smooth sliding action. In case of mild steel latch, it shall be copper oxidized (black finish) or as specified and in case of brass, it shall be finished bright, chromium plated or oxidized or as specified. The size of door latch shall be taken as the length of the latch.

7.21.10 Mortice Lock and Latch (Figure 7.13)

7.21.10.1 This should generally conform to IS : 2209. The size of the mortice lock shall be denoted by the length of the body, measured from the outside face of fore end to the rear end. It shall be 65 mm, 75 mm and 100 mm as specified. The measured length shall not vary by more than 3 mm from the length specified.

7.21.10.2 Non-interchangeable Keys

Testing of non-interchangeable keys shall be as per IS : 2209.

7.21.10.3 The clear depth of the body shall not be more than 15 mm. The fore end shall be firmly fitted to the body suitably by counter sunk head screw. The latch bolt shall be of specified material and of section not less than 12 x 16 mm for all sizes of locks. If made of two piece construction both parts shall be riveted. Ordinary lever mechanism with not less than two levers shall be provided. False levers shall not be used. Lever shall be fitted with one spring of phosphor bronze or steel wire and shall withstand the tests as provided in IS : 2209.

7.21.10.4 Locking bolts, spring and strike plate shall conform to IS : 2209.

7.21.10.5 Handles : These shall conform to IS : 4992.

7.21.10.6 Keys : Each lock shall be provided with two keys.

7.21.10.7 Sampling, Criteria for conformity: It shall be the same as specified in 7.21.1.5 Table 7.11B.

7.21.10.8 Tests

The finally assembled locks shall be tested as prescribed in Clause 9 of IS 2209.

7.21.11 Mortice Latch (with locking bolt)

7.21.11.1 These are generally used in doors of bath rooms, WC's and private rooms.

7.21.11.2 Mortice latch shall, in respect of shape, design and mechanism of the latch and its components parts, generally conform to IS : 5930. The material used for the different component parts of the latch shall comply with Tables 1 and 2 of IS : 5930 , unless otherwise specified.

7.21.11.3 The size of the latch shall be denoted by the length of the body measured from the outside face of the fore end to the rear end and shall be 65 mm, 75 mm or 100 mm as specified. The depth of the body shall not be more than 15 mm.

7.21.11.4 The latch shall be of size (10 x 18 mm) of shape as shown in Fig. 1 of IS : 5930. The locking bolt shall be of section not less than 8 x 25 mm for all size of locks. The mechanism of the latch bolt, its spring, striking plate etc., shall be described in IS : 5930.

7.21.11.5 The handles provided shall conform to IS : 4992.

7.21.11.6 Sampling, criteria for conformity shall be as per 7.21.1.5 Table 7.11B.

7.21.12 Mortice Lock and Latch (Rebated)

7.21.12.1 These are slightly different from mortice lock described in 7.21.14 and are designed for use in double leaved doors. These should generally conform to IS : 6607.

7.21.12.2 Handles, Keys, Sampling, Criteria for Conformity and Test.

These shall be as specified in 7.21.1.5 Table 7.11B.

7.21.13 Mortice Night Latch (Fig. 7.14)

7.21.13.1 This is a mortice lock having a single spring bolt withdrawn from the outside by using the key and from inside by turning the knob and with an arrangement whereby the lock can be prevented from being opened by its key from outside while the night latch is used from inside the room.

7.21.13.2 This should generally conform to IS : 3847.

7.21.13.3 It shall be of cast or sheet brass, cast or sheet aluminium alloy or Mild steel as specified and of best quality of approved make. These shall be bright finished or copper oxidized (black) finish as specified. Nominal size of the latch shall be denoted by the length of the face over the body in millimeters. These shall have not less than two levers. False (Dummy) levers shall not be allowed.

7.21.13.4 Keys

Each latch shall be provided with two keys which should work smoothly and without any appreciable friction in the lock.

7.21.14 Cupboard or Wardrobe Lock

This should generally conform to IS:729. The size of the cupboard lock shall be 40,50,65 & 75 mm, This shall be made of cast brass and shall be of the best make of approved quality. These shall be finished

bright or chromium plated or oxidized or as specified. The size of the lock shall be denoted by the length of the face across the body in mm.

These locks shall be fitted with four, five or six levers as specified. False (dummy) levers shall not be used.

7.21.15 Ball Catches for Wooden Almirah

7.21.15.1 This should generally conform to IS : 8756. These may be of brass sheets or cast brass with steel balls of sizes, 6, 7.5, 9 or 12 mm dia as specified. The size shall be denoted by the external diameter of the cylinder holding the steel ball with spring. When the almirah is in the closed position it shall be retained in that position by the spring action of the ball catch and shall be so in continuous usage. The door shall open only when it is pulled open.

7.21.15.2 Sampling, criteria for conformity and test shall be as specified in 7.21.1.5.

7.21.16 Finger Plate

7.21.16.1 This shall be of brass (finished bright, chromium plated, oxidized), or anodized aluminium or transparent plastic or as specified. This shall be made from brass or aluminium plate of 1.6 mm thickness with beveled or square edge as specified.

7.21.16.2 The size of the plate shall be 300 x 65 mm unless otherwise specified. The shape and pattern shall be approved by the Engineer.

7.21.17 Kicking Plates

7.21.17.1 This shall be of brass (finished bright or chromium plated or oxidized), bronze, stainless steel, aluminium or as specified. Aluminium kicking plates shall be anodized and the anodic coating shall not be less than grade AC-10 of IS : 1868. It shall be made from a plate of minimum thickness 3.0 mm and 1.5 mm in case of stainless steel. This shall have beveled or straight edges and shall be fixed by means of counter sunk or rounded screws of the same material and finish as that of the plate. The shape and pattern shall be according to the drawings or as specified and as approved by the Engineer.

7.21.18 Handles (Doors and Windows) (Figure 7.15)

7.21.18.1 These should generally conform to IS:208. The door handles shall be well made and free from defects. These shall be finished correct to shape and dimensions. All sharp edges and corners shall be removed and finished smooth so as to facilitate easy handling. Cast handle shall be

free from casting defects. Where the grip portion of the handle is joined with the piece by mechanical means, the arrangement shall be such that the assembled handle shall have adequate strength comparable to that of integrally cast type handles.

7.21.18.2 Door handles shall be of the following types according to the material used.

(a) Cast or Sheet Aluminium Alloy Handles: These shall be of aluminium of specified size, and of shape and pattern as approved by the Engineer. The size of the handle shall be determined by the inside grip of the handle. Door handles shall be of 100 mm size and window handles of 75 mm size unless, otherwise specified. These shall be fixed with 25 mm long wood screws of designation No.6. Aluminium handles, shall be anodized and the anodic coating shall not be less than grade AC 10 of IS :1868 or as specified. The finish can be bright natural, matt or satin or dyed as specified.

(b) Cast Brass Handles. These shall be of cast brass of specified size, and of shape and pattern as approved by the Engineer. The size of the handle shall be determined by the inside grip of the handle. Door handles shall be of 100 mm size and window handles of 75 mm size unless, otherwise specified. These shall be fixed with 25 mm long wood screws of designation No.6. Brass handles shall be finished bright satin or nickel chromium plated or copper oxidized or as specified.

(c) Mild Steel Handles: These shall be of mild steel sheet, pressed into oval section. The size of the handles will be determined by the inside grip of the handle. Door handles shall be of 100 mm size and window handles of 75 mm size unless otherwise specified.

These shall be fixed with 25 mm long wood screws of designation No.6. Iron handles shall be copper oxidized (black finish) or stove enameled black or as specified.

7.21.18.3 Sampling and Criteria for Conformity: It shall be as specified in Annexure B of IS 208.

7.21.19 Hanging Rubber Door Stopper

7.21.19.1 These shall be of cast brass, finished bright, chromium plated or as specified. Aluminium stopper shall be anodized and the anodic coating shall not be less than grade AC – 10 of IS : 1868. The size and pattern of the door stopper shall be approved by the Engineer. The size shall be determined by its length.

7.21.20 Universal Hydraulic Door Closer (Exposed Type) (Figure 7.17)

7.21.20.1 These shall be made of cast iron/aluminium alloy/zinc alloy and of shape and pattern as approved by the Engineer.

7.21.20.2 These shall generally conform to IS : Specifications for door closers (Hydraulically regulated) IS 3564.

7.21.20.3 The door closers may be polished or painted and finished with lacquer to desired colour. Aluminium alloy door closer shall be anodized and the anodic coating shall not be less than grade AC 15 of IS : 1868. All dents, burrs and sharp edges shall be removed from various components and they shall be pickled, scrubbed and rinsed to remove grease, rust, scale or any other foreign elements. After pickling, all the M.S. parts shall be given phosphating treatment in accordance with IS : 3618.

7.21.20.4 The nominal size of door closers in relation to the weight and the width of the door size to which it is intended to be fitted shall be as given in **Table 7.14**.

TABLE 7.14 : Type and Designation of door Closers

Designation of closers	Weight of door (kg)	Size of door (mm)	Remarks
1.	Up to 35	700	For light doors such as double leaved and toilet doors.
2.	36 to 60	850	Interior doors, such as bed rooms, kitchen and store
3	61 to 80	1000	Main doors in a building, such as entrance doors

7.21.20.5 Sampling and Criteria for Conformity: All the door closers of the same nominal size and shape and from the same batch of manufacture in one consignment shall constitute a lot. The number of door

closers to be taken at random from a lot shall depend upon the size of the lot. (**Table 7.15**). The sample shall be tested for construction, finish, dimensions, interchangeability of parts and performance.

TABLE 7.15
SCALE OF SAMPLING AND CRITERION FOR CONFORMITY

No. of door closers in the lot	Sample	Sample size	Cumulative Sample Size	Acceptance Number	Rejection Number
Up to 100	First	8	8	0	2
	Second	8	16	1	2
101 to 300	First	13	13	0	2
	Second	13	26	1	2
301 to 500	First	20	20	0	2
	Second	20	40	1	2
501 to 1000	First	32	32	0	3
	Second	32	64	3	4
1001 and above	First	50	50	1	4
	Second	50	100	4	5

7.21.20.6 Performance Requirements:

After being fitted in position when the door is opened through 90° the same should swing back to angle of $20^{\circ} \pm 5^{\circ}$ with nominal speed but thereafter, the speed should get automatically retarded and in case of doors with latches, it should be so regulated that in its final position the door smoothly negotiates with the latch.

7.21.21 Hooks and Eyes (Figure 7.18)

7.21.21.1 These shall be of mild steel or hard drawn brass or as specified. Mild steel hooks and eyes shall be copper oxidized (black finish) or as specified. Cast brass hooks & eyes shall be finished bright or chromium plated. These shall be well made and free from defects. They shall be finished to the correct shape and dimensions so as to function properly when they are in use. Cast hooks, eyes and plate shall be free from casting and other defects. All these shall generally conform to IS : 207. All sizes of hooks and eyes shall be determined by the length of the hooks measured "out to out". Unless otherwise specified the articles shall be finished bright.

7.21.22 Casement Window Fastners

7.21.22.1 These shall be made of cast brass, finished bright, chromium plated or oxidized or of Nylon or as specified. Casement fastners for single window shutter shall be left or right handed as specified. These shall not weigh less than 0.20 kg. per fastener. Nylon window fastners shall conform to IS : 6318.

7.21.23 Casement Brass Stays (Straight Peg Type) (Figure 7.19)

7.21.23.1 These shall be made of mild steel, cast brass, aluminium (extruded section) or plastic (polypropylene) or as specified. Mild steel casement stays shall be copper oxidized (black finish) or as specified. Cast

brass slays shall be finished bright or chromium plated or as specified. Aluminium stays shall be anodized and the anodic coating shall not be less than grade AC-10 of IS : 1868. Aluminium and M.S. stays shall be made from channel section. The stays shall not weigh less than that indicated below:-

200 mm 0.24 kg. each

250 mm 0.28 kg. each

300 mm 0.33 kg. each

7.21.23.2 The shape and pattern of the stays shall be as approved by the Engineer. The size of stays shall be determined by its length as shown in **Figure 7.19**. The plastic (Polypropylene) stays shall conform to IS : 6318.

7.21.24 Quadrant Stays 300 mm

These shall be made of cast brass and finished bright or chromium plated or as specified. The shape and pattern shall be approved by the Engineer. It shall not weigh less than 0.20 kg. each.

7.21.25 Hasp and Staple Safety Type (Figure 7.21)

7.21.25.1 This shall be made of mild steel, cast brass or aluminium as specified. This shall generally conform to IS : 363. M.S. Hasp and staples shall be finished black enameled, or copper oxidized (black finish) or as specified. Brass hasp and staples shall be finished bright chromium plated or oxidized or as specified. Aluminium hasp and staples shall be anodized and the anodic coating shall not be less than grade AC-15 of IS : 1868.

7.21.25.2 M.S. hasp and staples shall be manufactured from M.S. sheet and brass hasp and staples by casting and Aluminium hasp and staples shall be made from dye section. The hinge pin which in all cases

shall be of mild steel, shall be firm and its riveted heads well formed. The movement of hasp shall be free, easy and square, and shall not have any play or shake

The hasp shall fit in the staple correctly. The size shall be determined by the length of the bigger half of the hasp.

7.21.25.3 The staple except in the case of cast one, shall be riveted properly to its plate. The ends of the hinge pin for the safety type hasp shall be riveted and properly finished. All screw holes shall be clean and counter-sunk to suit counter wood screws. All edges and corners shall be rounded,

7.22 Bamboo Products

7.22.1 PRODUCT: BAMBOO MAT BOARD (BMB) : ISI : 13958-1994 certified product with CM/L No.: 5280865

PRODUCT APPLICATIONS: Walling & Wall Paneling

PRODUCT SIZES AVAILABLE: 6' x 3' OR 1.83m X 0.92m, 6' x 4' OR 1.83m X 1.22m & 8' x 4' OR 2.44m X 1.22m

PRODUCT THICKNESS AVAILABLE: 9 MM

TECHNICAL DETAILS :

SL	Properties	9 MM
1.	Density	800 kg/m ³
2.	Moisture Content	8 %
3.	Internal Bond Strength	
	a) Dry State :	
	(i) Average	0.96 N/mm ²
	(ii) Minimum Individual	0.96 N/mm ²
	a) Wet State :	
	(i) Average	1.11 N/mm ²
	(ii) Minimum Individual	0.79N/mm ²
4.	Modulus of Rupture (Avg.)	79 N/mm ²
5.	Screw Withdrawal Strength	4300 N
6.	Tensile Strength	30 N/mm ²
7.	Thermal Conductivity	0.194 k.cal/m-°c

7.22.2 PRODUCT : BAMBOO MAT BOARD (BMB) : ISI : 13958-1994 certified product with CM/L No.: 5280865

PRODUCT APPLICATIONS: Walling & Wall Paneling

PRODUCT SIZES AVAILABLE: 6' x 3' OR 1.83m X 0.92m, 6' x 4' OR 1.83m X 1.22m & 8' x 4' OR 2.44m X 1.22m

PRODUCT THICKNESS AVAILABLE: 12 MM

TECHNICAL DETAILS :

SL	Properties	12 MM
1.	Density	850 kg/m ³
2.	Moisture Content	9 %
3.	Internal Bond Strength	
	a) Dry State :	
	(i) Average	0.98 N/mm ²
	(ii) Minimum Individual	0.99 N/mm ²
	a) Wet State :	
	(i) Average	1.15 N/mm ²
	(ii) Minimum Individual	0.82N/mm ²

4.	Modulus of Rupture (Avg.)	86 N/mm ²
5.	Screw Withdrawal Strength	4800 N
6.	Tensile Strength	34 N/mm ²
7.	Thermal Conductivity	0.198 k.cal/m-°c

7.22.3 PRODUCT : VENEERED BAMBOO PARTICLE BOARD – Both Side Commercial Veneer SOGP GRADE II (Interior) : ISI : 3097 – 1980 certified product

PRODUCT APPLICATIONS : Cupboards, Partitions, Paneling, Modular Furniture & Kitchen Cabinets, Conference tables, office

tables, computer tables, Heavy Duty Racks & Cabinets

PRODUCT SIZES : 8' x 4' OR 2.44m X 1.22m

PRODUCT THICKNESS : 9MM / 12 MM / 18 MM / 25 MM

TECHNICAL DETAILS :

SL	Properties	Interior Grade Type (Grade II)
1.	Moisture Content	9 %
2.	Water Absorption	
	a) 2 Hr. Soaking	4 %
	b) 24 Hr. Soaking	30 %
3.	Swelling due to Surface Absorption (2 Hrs. immersion)	5.0 %
4.	Modulus of Rupture	32 N/mm ²
5.	Modulus of Elasticity (Avg. Value)	3000 N/mm ²

7.23 FRP DOORS, SHUTTERS & FRAMES :

7.23.1 SCOPE

This specification lays down requirements regarding types, sizes, material, construction, workmanship, finish, performance evaluation, sampling and testing of Fibre Glass reinforced Plastic Door Shutters for use in domestic buildings, schools, hospitals etc.

7.23.2 CONSTRUCTION / FABRICATION

The FRP Shutter shall be paneled door shutter with hollow rails and stiles monolithically cast with panels.

The shutters shall be contact moulded i.e. by hand lay up process in two pieces as shown in Figure 1. The process shall consist of laying gelcoat at 1,000 gms/m² and laid over with three layers of FRP mat (one layer of 300 CSM mat and two layers of 450 CSM mat) for each of the web (panel) portion and four layers of FRP mat for the flange (rails and stiles) portion (one layer of 300 CSM mat and three layers of 450 CSM mat). While closing the two pieces, additional layer of 450 CSM mat shall be provided in the web portion. The CSM mat shall be bonded with Isophthalic resin in the ratio not less than 1:2

(one part of mat to two parts of isophthalic resin and fillers and additives) by weight. The edges shall be sealed with gelcoat and FRP mat to obtain smooth finish sufficient 4021 rovings shall be laid in the corners to have smooth curve while laying the CSM mat.

Blocks of exterior grade MDF or seasoned and treated rubber wood for eucalyptus wood of sufficient thickness and length shall be provided inside the shutter at suitable place to hold fittings and fixtures such as aldrop, tower bolt, handle, sliding door bolt, mortice locks etc. Blocks for hinges shall be provided at three locations, unless otherwise specified by the purchaser, one at the centre and other two at 200 mm from the top and the bottom of the shutter.

Suitable depression shall be made in the profile of shutter at edges where blocks are provided for hinges and concealed mortice locks.

The finished surface shall be buffed and polished with wax.

7.23.3 DIMENSIONS, SIZES AND TOLERANCES :

Dimensions of Components & Tolerances –

The finished dimensions and tolerances of the different components of door shutter

shall be given in Table -1.

Table – 1 : Dimensions and Tolerances of Components of Door Shutters			
SL	Description	Width (mm)	Thickness (mm)
1.	Vertical stile, top and freeze rail	90 $\pm$ 3	30 $\pm$ 1 or 35 $\pm$ 1
2.	Lock rail	120 $\pm$ 3	30 $\pm$ 1 or 35 $\pm$ 1
3.	Bottom rail	150 $\pm$ 3	30 $\pm$ 1 or 35 $\pm$ 1

Thickness of FRP laminate of hollow rails and stiles shall be 3 mm.

Thickness of FRP laminate used for panel in the shutter shall be 5 mm.

Sizes and Types.

7.23.4 LOCATIONS OF FITTINGS AND ACCESSORIES

The lock rail of door shutters shall be so placed that its centre line is at a height 950 mm from the bottom of the shutter.

Each door shutter shall be fixed to the frame with three hinges, unless otherwise specified by the purchaser, of the type specified. These location shall be, one at the centre and other two at 200 mm from the top and the bottom of the shutter, where blocks have already been provided and suitable indication, by depressing the profile has been made.

Other fixtures shall also be provided at locations where blocks have already been provided.

Hinges and other fixtures shall be fixed with full threaded steel screws after coating the screws with adhesive such as fevicol etc. For fixing of hinges, holes of 3.5 mm

diameter and 52 mm length shall be bored and No.10 full threaded parallel shank steel screws coated with adhesives shall be screwed. In on circumstances screws shall be hammered into board.

For re-screwing, a plastic sleeve of appropriate diameter shall be inserted into the hole and then fixing with full threaded steel screws shall be done.

7.23.5 TESTS

Tests on Material :

Tests as per Table-2 shall be conducted on FRP laminate (without removing gel coat cut from door shutter. The method of carrying out the test shall be as per the reference code mentioned against each test. Acceptable criteria shall be as mentioned against each test.

Tests on Shutter :

The tests as given in Table-3 shall be carried out by the manufacturer on paneled FRP door shutters with panels of FRP. The method of carrying out the test and acceptability criteria shall be as per IS:4020-1994.

Table -2 : Tests on FRP Laminate			
SL	Test	Test Method as per	Acceptable Value
1.	Fibre Glass Content	ISO:1172-1975	Not less than 25%
2.	Barcol Hardness	ASTM:D2583-1987	Not less than 26 BIU when tested on the face of laminate finished with gelcoat
3.	Ultimate Tensile Unit Strength	BS:4994-1973	Not less than 150 N/mm Per Kg/m ² of glass.
4.	Tensile Unit Modulus	ISO:3268-1978	Not less than 6500N/mm per Kg/m ² of glass
5.	Flexural Strength	ISO:178-1975	Not less than 110 N/mm ²
6.	Flexural Modulus	ISO:178-1975	Not less than 7000 N/mm ²
7.	Izod Impact	ISO:180-1982	Not less than 10 J/cm
8.	Water Absorption	ISO:62-1980	Not more than 0.5% by weight

Table – 3 : Tests on Door Shutter	
SL	Test
1.	Slamming Test
2.	Impact Indentation Test
3.	Shock Resistance Test

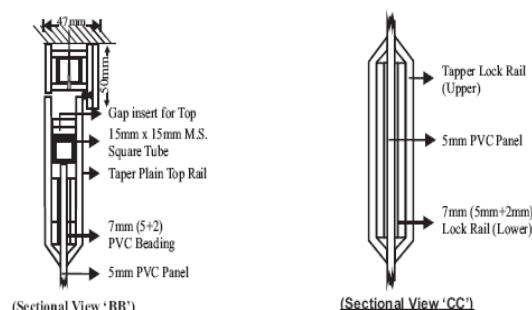
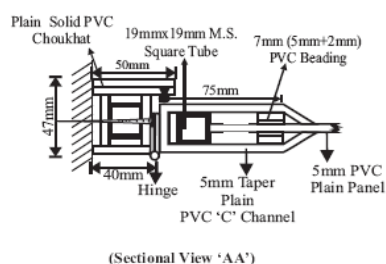
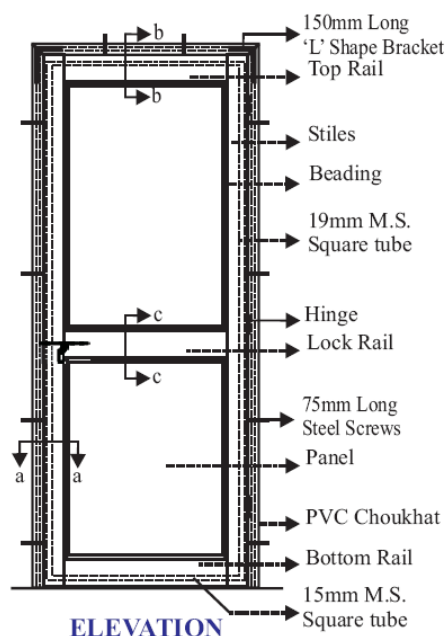
4.	Edge Loading Test
5.	Misuse Test
6.	Buckling Test
7.	Dimensions and Defects of Squareness Test
8.	General Flatness Test
9.	Local Plainness Test*

* Local Plainness test shall be carried out on rails, stiles and panels separately.

7.24 SOLID PANEL / WIRE MESH / GLASS PANEL PVC SHUTTER :

The Solid Panel PVC Door shall be fabricated from 5mm PVC Sheet. The sheets used may be in plain color, printed design or pre-laminated veneer shade as specified before hand of as approved by the Engineer-in-Charge.

The nominal thickness width and height of the shutter shall be as shown in the drawings or as indicated by the Engineer-in-Charge. All form edges of the shutters shall be square. The shutter shall be free from twist of warp in its plane. The 5mm Sheet used in the fabrication of the door shall be of minimum density of 600 kgs/cbm and the doors shall weigh a minimum of 8 kg/sqm.



7.24.1 TESTS

Samples of PVC Solid Panel Doors shall be subjected to the following tests:

- Edge loading test as per IS 1998 4042.
- Slamming test as per IS 1998 4042.
- Shock Resistant test for soft body and heavy body as per IS 1998 4042.

No permanent damage or delaminating / dismembering of the stiles and nails should be observed on the sample door.

These tests may be conducted at the door-testing laboratory at the factory of the principal company provided the principal company stands warranty for the doors supplied.

One door may be tested when the sample size is more than 100 doors and less than 300 doors. In sample size of higher than 300 doors two doors may be tested.

7.24.2 FIXING OF SHUTTERS

PVC Solid Panel Door Shutter shall be side hung on three bolt hinges of size 100mm, one at the centre and the other two at 200mm from the top and bottom of the shutter. The flap of the hinges shall be neatly counter sunk in to the recesses out to the exact dimensions of the hinge flap. The door shall be drilled on the thickness to fit hinges. Screws for fixing the hinges shall be screwed in with screwdrivers and not hammered. The length of the screws should be 8mm/30mm and it should be ensured that the screws pass through the two opposite surfaces of the M.S. reinforcement. The hinges used should be of stainless steel or aluminum.

Under no circumstance MS hinges should be used stainless steel screws should be used.

in the doorframe if required. A tolerance of ± 3 mm shall be permitted in the specified dimension of PVC section in the doorframes.

7.24.3 PVC DOOR FRAME

The Solid PVC Door Frames shall be fabricated from 5mm PVC Sheet having density of 600 kg/cum. The Sheet used may be in plain color, printed design or pre-laminated veneer shade as specified before hand or as approved by the Engineer-in-Charge.

A 19mm x 19mm square tube of 19 gauge thickness is to be inserted in the door frame section for reinforcement. Weight per running metre of door including reinforcement should be a minimum of 1.5kg/sqm.

Depth of rebate of door frame shall be 20mm frames shall have smooth surface, without any warping or bending in any member of the doorframe. All the parts of the doorframe are to be joined to each other using solvent cement adhesive conforming to IS 14182. Provision of rubber gasket is to be provided



ANNEXURE 7.1

TABLE FOR PERMISSIBLE DEFECTS FOR VARIOUS GRADES OF TIMBERS

SL	Defects	First Grade	Second Grade
(1)	(2)	(3)	(4)
(i)	Cross-grain	Not steeper than 1 in 15	Not steeper than 1 in 10
(ii)	Sound knots and live knots	(i) Stiles and rails (a) Short Exposed Face: Not more than 15 mm size and not more than 1 knot/metre. (b) Long Exposed Face: Not more than 15 mm size and not more than 1 knot/m. No knot shall occur within 20 mm of the edges. (ii) Panels – Not more than 20 mm size and not more than 2 knots/m ² . No knot shall occur on edge of any component of a panel.	(i) Stiles and rails (a) Short Exposed Face: Not more than 15 mm size and not more than 3 knots per stile and 1 knot per rail. (b) Long Exposed Face: Not more than 20 mm size and not more than 3 knots per stile and 1 knot per rail. (ii) Panels – Not more than 20 mm size and not more than 4 knots/m ² . No knot shall occur on edge of any component of a panel.
(iii)	Dead and loose knots (Plugged)	(i) Stiles and Rails – Not more than 10 mm size, centrally located and not more than 1 knot/m. (ii) Panels: Not more than 15 mm size and not more than 2 knots/m ² . No knot shall occur on edge of any component of a panel.	(i) Stiles and Rails – Not more than 10 mm size, centrally located and not more than 3 knots per stile and 1 knot per rail. (ii) Panels: Not more than 15 mm size and not more than 4 knots/m ² . No knot shall occur on edge of any component of a panel.
(iv)	Pitch pockets or streaks	None	Permissible except on exposed edges provided that they are clean and filled up with suitable putty or filler. When

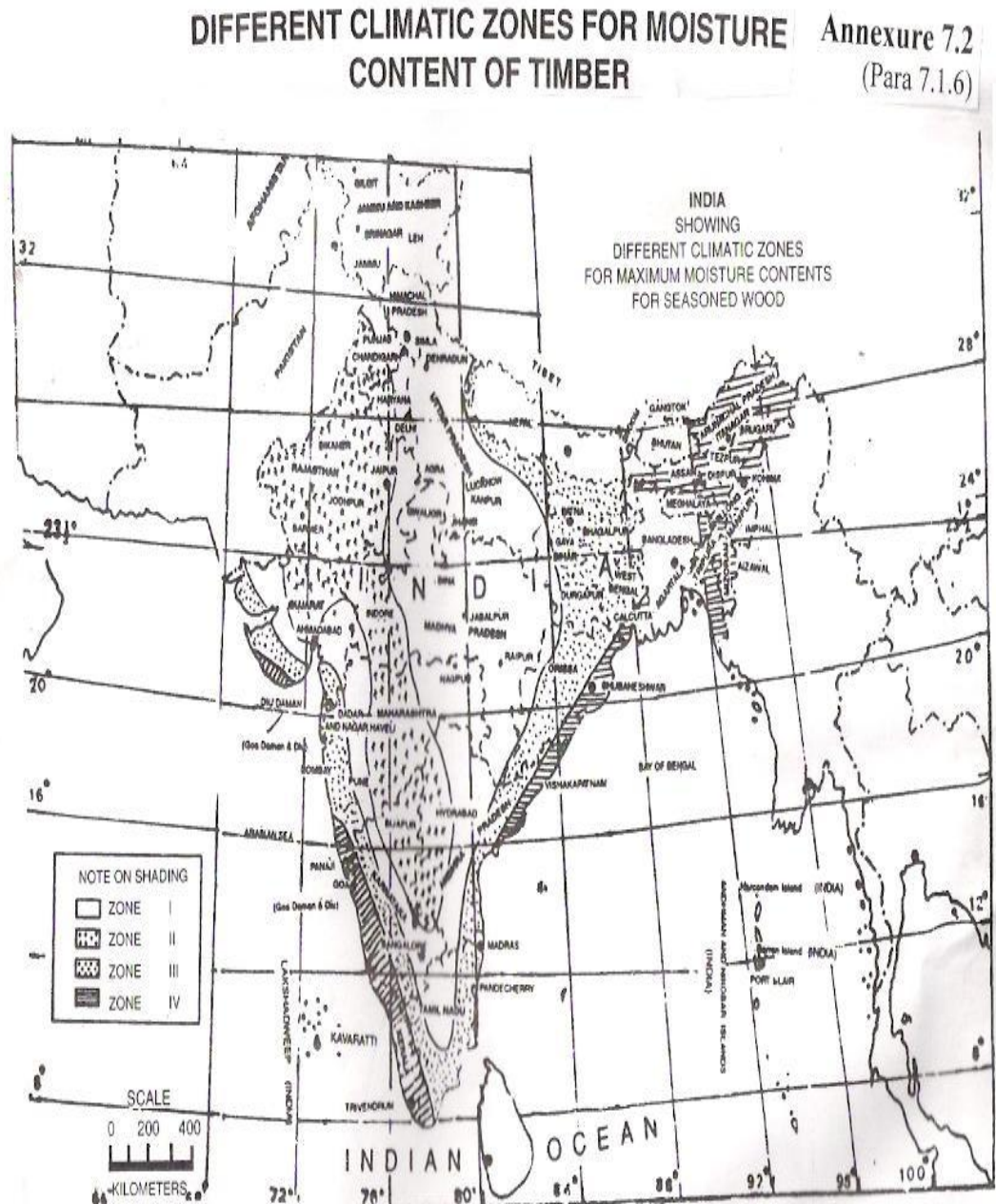
			pitch pockets or streaks are located on the exposed edges of the core, they shall be cut out and filled with piece of wood of similar species with grain running in the same direction. The piece shall be well glued.
(v)	Sapwood	Total not exceeding 5 mm wide and 150 mm long per metre.(This restriction applies only to super group species)	Total not exceeding 10 mm wide and 300 mm long per metre.(This restriction applies only to super group species)
(vi)	Pin holes	Permitted provided they are not in cluster	Permitted.
(vii)	Worm holes	None	Permitted provided they are not more than 10 mm in diameter and not more than one per metre and provided such worm holes are plugged with similar timber in such a manner that the plugging merges with the surrounding area both as to colour and grain.

Notes :

- (i) Dead and loose knots are permitted only if they are suitably plugged.
- (ii) Knot shall not occur where hinges or locks are to be fixed.

ANNEXURE 7.2

DIFFERENT CLIMATIC ZONES FOR MOISTURE CONTENT OF TIMBER



DRAWINGS NOT TO SCALE

- Note 1 : Based upon Survey of India map with the permission of the Surveyor General of India.
- Note 2 : The territorial waters of India extend into the sea to a distance of twelve nautical miles measured from the appropriate base line.
- Note 3 : The boundary of Meghalaya shown on this map is as interpreted from the North-Eastern Areas (Reorganisation) Act, 1971, but has yet to be verified.
- Note 4 : The administrative headquarters of Chandigarh, Haryana and Punjab are at Chandigarh.

ANNEXURE 7.3**MOISTURE CONTENT OF TIMBER**

1 Moisture content of timber shall be checked for every 1 cum or part thereof by electrical moisture meters as per IS : 287.

2 Electrical moisture meters are of resistance type and shall be used when the moisture content is within a range of 8 to 35 percent. When checking moisture content with electrical moisture meter, it shall be ensured that:-

(a) Timber is not hot or surface wet and the moisture gradient is not large due to wet cores.

(b) Electrode probes are of adequate depth (not less than one-fifth the thickness of the timber).

3 Sufficient number of readings at different positions are taken on each piece of timber to eliminate localized variations in surface moisture and species corrections are applied for the make of electrical resistances and type of moisture meter.

4 If for any reason, whatsoever, the results of electrical moisture meter are not to be relied upon, the moisture content shall be checked by the oven drying method.

5 For checking for moisture content by oven drying method, a complete test cross section, 12 to 19 mm long in the direction of timber grain, free from all defects shall be cut from each piece of timber selected for test as follows:-

(a) If weighing can be done immediately, the test section shall be cut from a point at least 45 cm from one end of the piece or from its center.

(b) If weighing cannot be made immediately, a sample of 30 cm long shall be cut from a point at least 45 cm from one end of the piece or from its centre. Subsequently (within 24 hours) the test section shall be cut from the centre of this sample.

(c) In case cutting of test section from the piece is not permissible, the moisture content in the whole section can also be determined by collecting a boring to a depth of half of the thickness of the piece by means of an auger, in a pre-weighed weighing bottle which should then be securely stoppered.

6 The test sections obtained above shall be weighed, immediately after cutting, on a balance the sensitivity of which is not less than 10 mg. They shall be dried in a ventilated and preferably thermostatically controlled oven at a temperature of 100°C to 105°C until the weight is constant. The weight of the test section shall be deemed to have become constant if successive weighings at intervals of 2 to 5 hours do not differ from one another by more than 50 mg. The test weight shall be taken to be the oven dry weight of the test section.

7 The percentage moisture content in the test section shall be calculated as follows:

$$\text{Moisture content (Per cent)} = \frac{W_1 - W_0}{W_0} \times 100$$

Where :

W_1 – initial weight of test section and

W_0 – oven dry weight of test section

8 When moisture content of timber is checked by oven drying method, results of electrical moisture meter shall be ignored.

ANNEXURE 7.4

EXTRACTS FROM IS - 4021-1995 ON TIMBER DOOR, WINDOW & VENTILATOR FRAMES- SPECIFICATIONS

5 Dimensions, Sizes and Tolerances

5.1 Dimensions of Frames and Tolerances

The finished dimensions of timber sections in frames for doors, windows and ventilators shall be as given in Table 2 (see fig.5,6,7 and 8) subject to a general tolerance of +3/-0 mm/for width and +2/-3 mm for thickness.

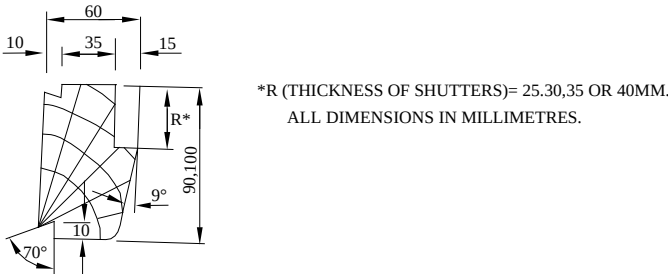


Fig. 5 Typical Cross Section of Frame for Doors and Large Windows carrying one set of shutters

6.2 Size and Types

Sizes and types of the door shutters shall generally conform to the modular size as shown in Fig. 9 Size other than modular sizes, as agreed to between the manufacturer and the purchaser, may also be permitted.

Note: - The size shown in Fig 9 is overall height and width on the outside of frames. This size is derived after allowing a margin of 5 mm all round for fitting and fixing to fit up to modular openings based on 10 cm module . The sizes marked with asterisk in Fig. 9 will be given preference.

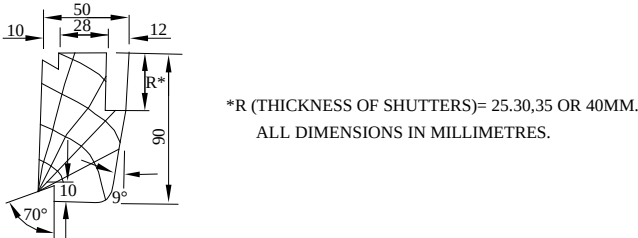


Fig. 6 Typical Cross Section of Frame for small Window and Ventilator carrying one set of shutters

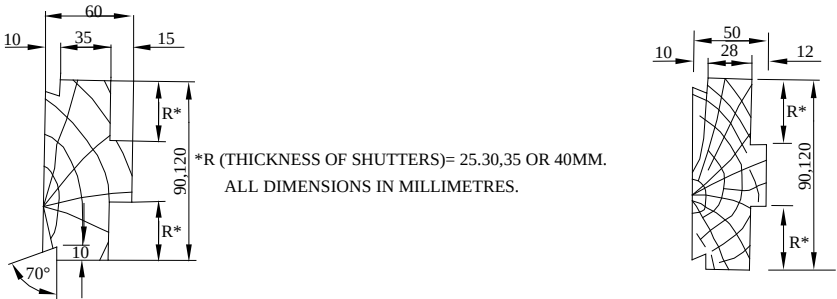


Fig. 7 Typical Cross Section of Frame for Doors and Large Windows carrying two set of shutters

Fig. 8 Typical Cross Section of Frame for small Windows and Ventilators carrying two set of shutters

6.3 Designation

Frames of doors, Windows and ventilators shall be designated by symbols denoting their width, type and height in succession in the following manner:

(a) Width - It shall be indicated by the number of modules in the width of opening.

(b) Type - It shall be indicated by the following letters of alphabet:

D for door

W for Window

V for Ventilator

S for single shutter

T for double shutter

Note :- Where a frame is intended to carry two setsof shutters. The frame shall be designated as DD. WW and VV.

(c) Height - It shall be indicated by the number of modules in height of opening.

Example: 12 DT 20' would mean a frame of double shutter door with a width of 12 modules (119 cm) and height of 20 modules(199 cm).

Table 2 Dimensions of Doors, Windows and Ventilators

Requirements	(Clause 6.1)			
	Door	Dimensions mm		Ventilator
		Window size > 120 cm	size < 120 cm	
(1)	(2)	(3)	(4)	(5)
(a) Width of frame carrying one swt of shutters:				
(1) for 35,40 mm shutter	100	100	90	90
(2) for 25,30 mm shutter	90	90	90	90
(b) Width of frame carrying two sets of shutters:				
(1) for 30,35 and 40 mm shutter	120	120	120	120
(2) for 25 mm shutter	90	90	90	90
(c) Thickness	60	60	50	50

6.3.1 Combination of Frames of Doors, Windows and ventilators

When frames of doors and windows are combined with those of windows and ventilators, they shall be designated as illustrated below. However size of frame for such combination shall be uniform for doors, windows and ventilators, by choosing the highest recommended dimension vide 6.1.

Example 1 : 6 WS 12/12 DT 20/6 WS. 12' means 12 modules wide and 20 modules high double shutter door frame combined in its two sides with two windows, 6 modules wide and 12 moduies high.

Example 2 : $\frac{6V6}{6WS12} \frac{6V6}{6WS12}$ means frames of two single. windows of 6 modules wide and 12 modules high combined side by side and with two ventilators at top 6 modules wide and 6 modules high.

7 Location of Holdfasts

A minimum of three holdfasts shall be fixed on each side of the door frame, one at the centre point and other two at 30 cm from the top and bottom of frame excepting in case of horned head when two equally spaced holdfasts shall be provided. in case of windows and ventilators one holdfast on each side centrally placed shall be fixed up to a height of 60 cm. in case of height more than 60 cm, with or without harms two holdfasts shall be suitably fixed at each side.

8 Finish

8.1 Defective knots, when permitted on surfaces exposed to view, shall be completely bored or cut out and tightly plugged with same timber species and properly glued in. The grain of the plug shall run in the direction of the piece.

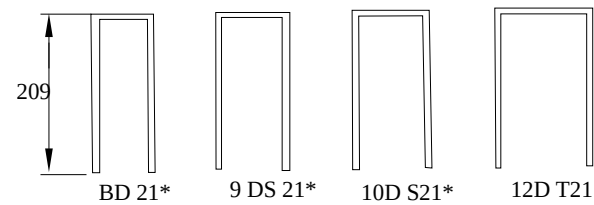
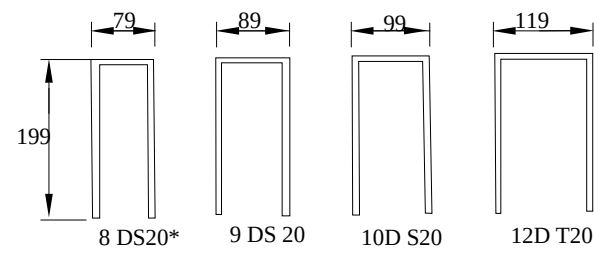
8.2 the unexposed surfaces in contact with either wall or lintel shall be properly painted with coal tar pitch (conforming to IS 216: (1961) before delivery.

8.3 All surfaces of door, window and ventilator frames which are required to be painted ultimately shall be covered evenly by brush painting with a priming coat of a wood primer as specified in IS 3536 : 1966.

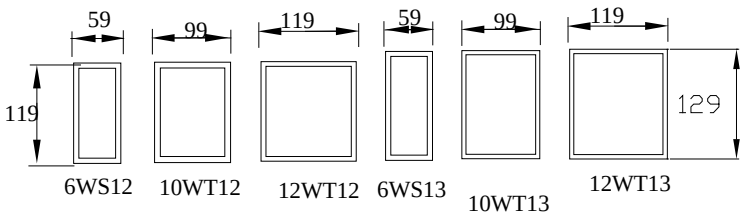
8.3.1 In the case of frames to be polished or varnished, a priming coat of suitable polish or varnish shall be given before

Notes : - (1) Priming alone does not provide full protection against weather and, therefore, all work should receive coats of paint, polish or varnish, as the case may be, within a reasonable period. Any cut surface, particularly that exposing end grain should be primed before the joinery is set in position.

(2) When aluminium primer is used, the user should assure himself it is of a type especially prepared for this purpose. Unless suitable aluminium primers are used, it is not possible to obtain satisfactory finish.

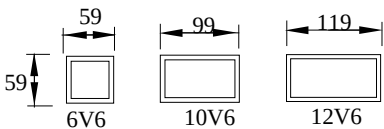


DOORS



WINDOWS

ALL DIMENSIONS IN CENTIMETRES.
PREFERRED SIZES



VENTILATORS

Fig. 9 Type and size of Frame of timber Doors, Windows and Ventilators

ANNEXURE 7.5 A

EXTRACTS FROM IS - 1003 pt. 1-1991 ON TIMBER PANELLED & GLAZED SHUTTERS (DOOR SHUTTERS)

7 Dimensions, size and Tolerances

7.1 Dimensions of components and Tolerances

The finished dimensions and tolerances of the different components of door shutters shall be as given in Table 2.

Table 2: Dimensions and Tolerances of Components of Door shutters

SI. NO.	Description	Width mm	Thickness mm
(1)	(2)	(3)	(4)
(1)	Vertical stile top and freeze rail	100±3	35±1 or 40±1
(2)	Lock rail	150±3	35±1 or 40±1
(3)	Bottom rail	200±3	35±1 or 40±1
(4)	Munting	100±3	35±1 or 40±1
(5)	Glazing bar	40±3	35±1 or 40±1

7.2 Sizes and Types

Sizes and types of the timber panelled and glazed shutters shall generally conform to the modular sizes specified in Table 3 (see also Fig. 6). Sizes other than modular sizes as agreed to between the manufacturer and the purchaser, may also be permitted.

Table 3 : Dimension of Door shutters

Designation of Doors	Width mm	Height mm
(1)	(2)	(3)
8 DS 20	700	1 905 (1 945)
8 DS 21	700	2 005 (2 045)
9 DS 20	800	1 905 (1 945)
9 DS 21	800	2 005 (2 045)
10 DS 20	900	1 905 (1 945)
10 DS 21	900	2 005 (2 045)
12 DT 20	1100 *	1 905 (1 945)
12 DT 21	1100 *	2 005 (2 045)

- Notes (1) The designation refers to modular sizes of door openings. First number stands for width and the last for height in module (M=100mm). Alphabet 'D' refer to doors, 'S' to single shutter and 'T' to double leaf shutter.
- (2) Standard size of door frames are covered in IS : 4021 - 1983 and IS : 4351 - 1976.
- (3) The standard widths and heights for panel doors are arrived at as shown in Fig. 6. In case the modular height is taken from the finished floor level, the height of the door shall be the one given in bracket. In the case of double leaf shutters, the rebate in the shutters shall be as given in 6.12.

Combined width of double leaf shutters.

Illustration of components of Door

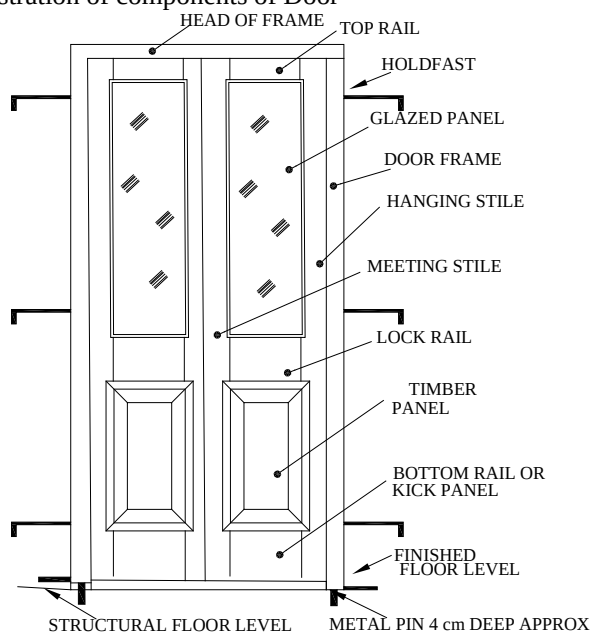


Fig. 1 : Typical Illustration of Double Panelled Door with Timber and Glazed panels

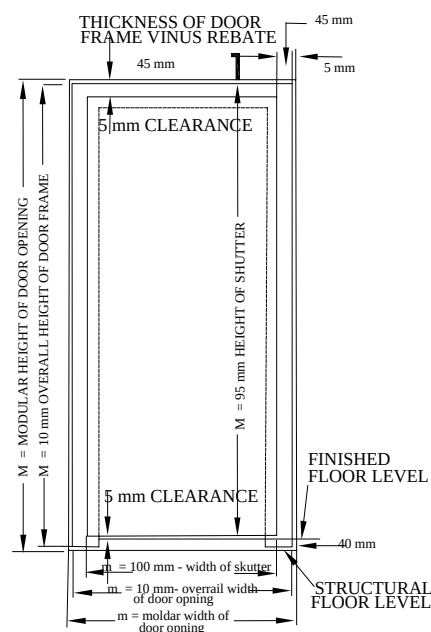


Fig.6 : Sketch Illustrating Dimensions of Shutter

7.3 Tolerances

Tolerances on the sizes of door shutters shall be ± 3 mm.

8. Location of fittings and Accessories

8.1 The lock rail of door shutters, where provided, shall be so placed that its centre line is at a height of 850 ± 5 mm from the bottom of the shutter.

8.2 Each door shutter shall be fixed to the frame with three hinges of the type specified by the purchaser one at the centre and the other two at 200 mm from the top and the bottom of the shutter.

8.3 Timber panelled shutter may be provided with louvers or vision panels as specified by the purchaser. Where such a provision is made, the position, size and shape of louver or vision panel opening shall be as specified by the purchaser.

9 . Finish

9.1 All door shutters shall be sanded and finished smooth.

9.2 Panels of shutters shall be flat and well sanded to a smooth and level surface.

9.3 Defective knots, when permitted on surfaces exposed to view shall be completely bored or cut out and tightly plugged with the same timber species and properly glued in. The grains of the plug shall run in direction of the grains of the piece.

9.4 All the surfaces of door shutters which are required to be painted or polished or varnished ultimately shall be covered initially before delivery by protective coat of primer polish or varnish as specified in IS : 2338 (part 1)-1967 and IS : (part 2)-2338

10. Glazing

10.1 The glass used for panels shall be of good and durable quality, weighing not less than 10 kg/m^2 and the thickness shall not be less than 4 mm. The particular type, quality and shade shall be as agreed between the purchaser and the supplier.

10.2 In specifying size of openings or panels of glass, the first dimension shall be the width.

10.3 The glass shall be embedded in putty and secured to the rebate by wooden beads of suitable size and shape.

10.4 Wash leather, ribbon velvet, rubber flannel, felt, asbestos or other similar material may be used in place of putty for internal Glazing. The material shall be fitted tighter as a beading on one side or in such a manner that it covers all parts of the glass which will be covered by the beading

ANNEXURE 7.5B
(Para 7.6)

EXTRACTS FROM IS 1003 PT.II – 1994 ON TIMBER PANELLED AND GLAZED SHUTTERS (WINDOW AND VENTILATOR SHUTTERS)

7. Dimensions, Sizes and Tolerances

7.1 Dimensions of Components and Tolerances

The finished dimensions and tolerances of different components of window / ventilator shutters shall be as given in Table 2.

Table 2: Dimensions and Tolerances of Components of Window and Ventilator Shutters (Clause 7.1)

Description of Component	Window Shutters		Ventilators Shutters	
	Width mm	Thickness mm	Width mm	Thickness mm
Stiles and rails	80 ± 3	25 ± 1	80 ± 3	20 ± 1
		30 ± 1		22.5 ± 1
				25 ± 1
				27.5 ± 1
Munting	60 ± 3	25 ± 1	60 ± 3	-do-
		30 ± 1		
Glazing Bars	40 ± 1	25 ± 1	40 ± 1	-do-
		30 ± 1		

7.2 Designation (Window and Ventilator Shutters)

Window and ventilator shutters shall be designated by symbols denoting the width type and height of window and ventilators in succession in the following manner:

a) Width: It shall be indicated by the number of modules in the width of opening.

b) Type: It shall be indicated by the following letters of alphabet:

W= Window

V= Ventilator

S= Single Shutter

T = Double Shutter

c) Height : It shall be indicated by the number of modules in the height of opening.

Example:

10 WT 12 would mean a window shutter suitable for a double shutter window of 10 modules width and 12 modules height.

12 V6 would mean ventilator shutter suitable for a ventilator of 12 modules width and 6 modules height.

7.3 Sizes

7.3.1 Sizes of the window and ventilator shutters shall generally conform to the modular sizes specified in Tables 3 and 4 respectively. These sizes are derived after allowing the thickness of the frame and a margin of 5mm all round for fitting and fixing into a modular opening based on 100mm module. Sizes other than modular sizes, as agreed to between the manufacturer and the purchaser, may also be permitted.

7.3.2 Tolerances on the overall dimensions of window and ventilator shutters shall be ± 3 mm.

Table 3: Dimensions of Timber Window Shutters

(Clause 7.3.1)

Designation	Width mm	Height mm
(1)	(2)	(3)
6WS 12	500	1 100
10 WT 12	460	1 100
12 WT 12	560	1 100
6 WS 13	500	1 200
10 WT 13	460	1 200
12 WT 13	560	1 200

Table 4: Dimensions of Timber Ventilator Shutters
(Clause 7.3.1)

Designation	Width mm	Height mm
(1)	(2)	(3)
6 V 6	500	500
10 V 6	900	500
12 V6	1100	500

8. Location of Fitting and Accessories

8.1 Each window shutter shall be fixed to the frame with two hinges of the suitable type generally at quarter points. Prefer locating hinges so that the bottom hinge is at a larger distance (say 15 cm) from the lower end of shutter than the distance for the upper hinge (say 10 cm) from the upper end of shutter. Each ventilator shutter shall be either fixed to its frame with two hinges of suitable type at quarter points of top rail or bottom rail or suspended on a suitable peg stay in the centre of the frame according as it is to be hung; top hung, bottom hung or centre hung ventilator.

8.2 Timber panelled shutters may be provided with louvers or vision panels as specified by the purchaser. Where such a provision is made, the position, size and shape of louver or vision-panel opening shall be specified by the purchaser.

9. Finish

9.1 Same as in IS 1003 (Part 1)

9.2 Same as in IS 1003 (Part 1)

9.3 Same as in IS 1003 (Part 1)

9.4 Same as in IS 1003 (Part 1)

10.0 Glazing

10.1 Same as in IS 1003 (Part 1)

10.2 Same as in IS 1003 (Part 1)

10.3 Same as in IS 1003 (Part 1)

10.4 Same as in IS 1003 (Part 1)

Notes

A: Door Shutters

1. Door of room adjoining the verandah, corridor, lobby or hall, shall be considered as external door.
2. Where the height of the door leaf exceeds 2.15 metres above the floor level, one extra hinge shall be provided for every additional height of 0.50 metre, or part thereof and the length of top bolts shall be increased by the height of the leaf above 2.15 metres from floor level.
3. Single leaf door shutters of more than 0.80 m in width shall be provided with one extra hinge.
4. Fan light shutters of more than 0.80 metre width shall be provided with one extra hinge and extra quadrant stay.
5. In double leaf shutters of doors, two door bolts shall be fixed to the first shutter and one on the closing shutter at the top.
6. In case of single leaf inter communicating, panelled, glazed or panelled door shutter for bath and w.c. one tower bolt will be replaced by a bathroom latch.
7. For shutter exceeding 40 mm thickness heavy type M.S. butt hinges of 125 x 90 x 4 mm shall be used.
8. In case of external door shutters, instead of sliding door ball mortice lock can be provided where specified.
9. Cupboard and wardrobe shutters will have ball catches where specified.
10. Finger plates shall be provided in case of bath and W.C. shutters in office buildings.

B. Window Shutters

11. In case of windows with double shutters, two lower bolts shall be fixed to the closing shutters and one tower bolt to the first shutter at the top.
12. In case of window shutters, hooks and eyes may be provided in lieu of casement stays where specified.
13. Where the height of window shutter exceeds 1.20 metres one extra hinge shall be provided and length of top bolts shall be increased by height of the leaf above 2.15 metres from the floor level.
14. Window shutter with steel frames shall be provided with six hinges in case of double leaf shutters and three hinges in case of single leaf shutters, irrespective of height and width of shutters.

C. Fanlight and Clerestory Window or Ventilator

15. Centrally hung and bottom hung CS windows and fan lights, will be provided with chain and hook bamboo pole with hook for opening ventilators shall be provided for each residence or for set of 4 rooms in case of office building.
16. Centrally hung clerestory windows or fanlights will have fan light pivots in lieu of hinges.

ANNEXURE 7.6

SCHEDULE OF FITTINGS FOR TEAK WOOD JOINERY AND FLUSH DOORS

S.No.	Name of fittings	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)
		Double leaf flush door shutters	Single leaf external flush door shutters width upto 80 cm	Single leaf inter communicating door shutters width upto 80 cm	Single leaf flush door shutters for lavatory opening in corridor width upto 80 cm.	Double leaf door shutters panelled, glazed, or panelled and glazed	Single leaf external door shutters, panelled, glazed, or panelled and glazed width upto 80 cm.	Single leaf inter communicating door shutter, panelled, glazed or panelled and glazed width upto 80 cm.	Double leaf cupboard or wardrobe shutters, panelled, glazed, panelled and glazed or flush	Single leaf cupboard or wardrobe shutters, panelled, glazed, panelled and glazed or flush	Double leaf window shutters of heights upto 1.20 metres, panelled, glazed or venetianed	Single leaf window shutters of heights upto 1.20 metres, panelled, glazed or venetianed	Fan light shutter, bottom hung upto 80 cm width	Clerestory window or fan light shutter, central hung	Clerestory window shutter bottom hung upto 80 cm width	Double leaf wire gauze door shutters	Single leaf wire gauze door shutters width upto 80 cm.	Double leaf wire gauze window shutter upto 1.20 metres	Single leaf wire gauze window shutter upto 1.20 metres	Remarks
1	Butt hinges 100mm	6	3	3	1	6	3	3	6	3	4	2	2	1	2	6	3	4	2	
2	Butt hinges 75 mm	1	1	1	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	
3	Single action spring hinges	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	
4	Mortice lock	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	
5	Sliding door bolt (Aldrop) 300mm	3	1	2	1	3	2	4	2	1	2	1	1	1	1	3	2	2	1	
6	Sliding door bolt (Aldrop) 250mm	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	
7	Flush bolts 250mm	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	
8	Flush bolts 100mm	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	
9	Barrel bolts 250mm	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	
10	Barrel bolts 150mm	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	
11	Barrel bolts 100mm	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	
12	Furniture handles	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	
13	Door handle with plate 100mm	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	
14	Door handle with plate 75mm	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	
15	Helical door springs (Superior quality)	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	
16	Ball catchers 10mm dia	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	
17	Cup-board or ward-robe lock 65mm. 6 lever (Godrej or equivalent)	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	
18	Fan light pivot set	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	
19	Fan light catch	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	
20	Chain and hooks 300mm	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	
21	Hooks and eyes 150mm	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	

Annexure 7.6 (II)

SCHEDULE OF FITTINGS FOR JOINERY WORK OF WOOD OTHER THAN TEAK WOOD

S.No.	Name of fittings	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
(1)		Double leaf door shutters, panelled, glazed, panelled and glazed, framed	Single leaf external door shutters panelled, glazed, panelled and glazed, framed and battened or jaffri	Single leaf inter communicating door shutter panelled width upto 80 cm	Single leaf battened and braced door shutter width upto 80 cm.	Single leaf, door shutter battened and braced with top and bottom clearance fro W/C's and bath rooms	Double leaf cup-board or wardrobe shutter panelled, glazed, or panelled and glazed	Single leaf cup-board or wardrobe shutters, panelled, glazed or panelled and glazed	Double leaf window shutters of heights upto 1.20 metres glazed, battened and braced, veneetianed or wire gauzed	Single leaf window shutters, of heights upto 1.20 metres glazed, battened and braced, veneetianed of wire gauzed.	Clerestory window and fan light shutters central hung	Clerestory window and fan light shutters bottom hung upto 80 cm width	Double leaf wire gauze door shutters	Single leaf wire gauzed door shutters width upto 80 cm.	Remarks
1	Butt hinges 100mm	6	3	3	-	-	6	3	4	2	1	2	6	3	
2	Butt hinges 75 mm	-	-	-	-	-	-	-	-	-	-	-	-	-	
3	Tee hinges 115mm (arm length 300mm)	1	-	-	1	2	-	-	-	-	-	-	-	-	
4	Sliding door bolt (Aldrop) 300mm	-	1	-	-	-	-	-	-	-	-	-	-	-	
5	Sliding door bolt (Aldrop) 250mm	-	-	-	-	-	-	-	-	-	-	-	-	-	
6	Door bolts 250mm	2	-	2	2	-	2	-	2	1	-	-	2	-	
7	Door bolts 150mm	1	1	2	2	2	-	-	1	1	-	-	1	1	
8	Door bolts 100mm	-	-	-	-	-	-	-	-	-	-	-	-	-	
9	Door handles 100mm	-	-	-	-	-	-	-	-	-	-	-	-	-	
10	Door handles 75mm	2	2	2	2	-	2	-	2	1	-	-	2	1	
11	Cupboard or wardrobe knob (Brass)	-	-	-	-	-	-	-	-	-	-	-	-	-	
12	Helical door spring 150mm	-	-	-	-	-	-	-	-	-	-	-	-	-	
13	Ball catchers 10mm dia	-	-	-	-	-	-	-	-	-	-	-	-	-	
14	Hooks and eyes 100mm	-	-	-	-	-	-	-	-	-	-	-	-	-	
15	Chain and hooks 300mm long	-	-	-	-	-	-	-	-	-	-	-	-	-	
16	Safety hasp and stable 115 mm	-	-	-	-	-	-	-	-	-	-	-	-	-	
17	Fan light pivot (set)	-	-	-	-	-	-	-	-	-	-	-	-	-	
18	Fan light catch	-	-	-	-	-	-	-	-	-	-	-	-	-	

ANNEXURE 7.7**(Para 7.7A.2)**

SIZES OF FLUSH DOOR SHUTTERS
(Extracted from Clause 4 of IS 2191 Pt.1)

4 SIZES

Sizes of the door shutters shall generally conform to the modular sizes specified in Table 1. Sizes other than modular sizes as agreed to between the manufacturer and the purchaser, may also be permitted; however, the thickness of shutters in such cases shall not be less than that specified against the nearest higher modular size given in 4.2.

TABLE 1 DIMENSIONS OF FLUSH DOOR SHUTTERS

DESIGNATION OF DOORS	WIDTH	HEIGHT MM
8 DS 20	700	1 905 (1 945)
8 DS 21	700	2 005 (2 045)
9 DS 20	800	1 905 (1 945)
9 DS 21	800	2 005 (2 045)
10 DS 20	900	1 905 (1 945)
10 DS 21	900	2 005 (2 045)
12 DT 20	1100*	1 905 (1 945)
12 DT 21	1100*	2 005 (2 045)

NOTE 1 D = Door, S = Single shutter and T = Double shutter.

NOTE 2 The designation indicates the size of door openings, the first number denoting width in modules of 100mm and the last number, the height in modules.

NOTE 3 Standard sizes of door frames are covered in IS:4021-1983+ and IS:4351-1976++.

NOTE 4 In arriving at the standard widths and heights for flush doors, an allowance of 60mm has been made for door frames, 40mm for floor finish and 5mm for clearance all round (see also Fig.7.4A) between door opening and door frame and 15mm for rebate all round for the shutter into the frame. In case the modular height is taken from the finished floor level, the height of the door shall be the one given in bracket. In the case of double shutters, the rebate and clearance between the shutters shall be as given in Para 6.7 of IS 2191 (Part 1)- 1983.

“6.7 Rebating: In the case of double leaved shutters, the meeting of the stiles shall be rebated by one-third the thickness of shutter. The rebating shall be either splayed or square type as shown in Fig. 4 of IS 2191 Pt.1. Where lipping is provided, the depth of lipping at the meeting of stiles shall not be less than 35mm”.

*Combined width of two shutters in closed position.

+ Specification for timber door, window and ventilator frames (second revision)

++ Specification for steel door frames (first revision)

1.2 Nominal thickness of shutters shall be 25, 30 or 35mm.

NOTE – It is recommended that as far as possible the thickness adopted for flush doors should be as given below :

Door Designation	Thickness of Shutter (mm)
8 DS 20 and 8 DS 21	25
9 DS 20 and 9 DS 21	30 or 35
10 DS 20 and 10 DS 21	35
12 DT 20 and 12 DT 21	35

4.3 Tolerances – Tolerance on nominal width and height shall be +3mm / -0mm; tolerance on nominal thickness shall be ± 1.2 mm. The thickness of the door shutter shall be uniform throughout with a permissible variation of not more than 0.8mm when measured at any two points.

ANNEXURE 7.8

SCHEDULE OF FITTINGS FOR TEAK WOOD JOINERY AND FLUSH DOORS

S.No.	Name of fittings	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	Remarks
1	Bull hinges 100mm	6	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	Single leaf wire gauze window shutter of height upto 1.20 metres
2	Butt hinges 75 mm	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	Double leaf wire gauze window shutter of height upto 1.20 metres
3	Single action spring hinges	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	Single leaf wire gauze door shutters upto 80 cm.
4	Mortice lock	3	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	Double leaf wire gauze door shutters upto 80 cm width
5	Sliding door bolt (Aldrop) 300mm	3	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	Cerestory window shutter bottom hung upto 80 cm width
6	Sliding door bolt (Aldrop) 250mm	3	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	Cerestory window or fan light shutter, central hung
7	Flush bolts 250mm	3	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	Fan light shutter, bottom hung upto 80 cm width
8	Flush bolts 100mm	3	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	Single leaf window shutters of heights upto 1.20 metres, panelled, glazed or venetianed
9	Barrel bolts 250mm	3	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	Double leaf window shutters of heights upto 1.20 metres, panelled, glazed or venetianed
10	Barrel bolts 150mm	3	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	Single leaf cupboard or wardrobe shutters, panelled, glazed, and glazed or flush
11	Barrel bolts 100mm	3	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	Double leaf cupboard or wardrobe shutters, panelled, glazed, and glazed or flush
12	Furniture handles	3	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	Single leaf cupboard or wardrobe shutters, panelled, glazed, and glazed or flush
13	Door handle with plate 100mm	3	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	Double leaf cupboard or wardrobe shutters, panelled, glazed, and glazed or flush
14	Door handle with plate 75mm	3	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	Single leaf inter communicating door shutter, glazed or panelled and glazed upto 80 cm.
15	Helical door springs (Superior quality)	3	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	Single leaf external door shutters, panelled, glazed, or panelled and glazed upto 80 cm.
16	Bail catchers 10mm dia	3	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	Double leaf door shutters panelled, glazed, or panelled and glazed upto 80 cm.
17	Cup-board or ward-robe lock 65mm. 6 lever (Godrej or equivalent)	3	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	Single leaf flush door shutters upto 80 cm.
18	Fan light pivot set	3	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	Single leaf flush door shutters upto 80 cm.
19	Fan light catch	3	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	Single leaf flush door shutters upto 80 cm.
20	Chain and hooks 300mm	3	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	Single leaf flush door shutters upto 80 cm.
21	Hooks and eyes 150mm	3	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	Single leaf flush door shutters upto 80 cm.

SCHEDULE OF FITTINGS FOR JOINERY WORK OF WOOD OTHER THAN TEAK WOOD

S.No.	Name of fittings	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	Remarks
1	Butt hinges 100mm	6	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	Single leaf wire gauzed door shutters width upto 80 cm.
2	Butt hinges 75 mm	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	Double leaf wire gauze door shutters
3	Tee hinges 115mm (arm length 300mm)	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	Clerestory window and fan light shutters central hung
4	Sliding door bolt (Aldrop) 300mm	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	Clerestory window and fan light shutters bottom hung upto 80 cm width
5	Sliding door bolt (Aldrop) 250mm	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	Single leaf window shutters, of heights upto 1.20 metres glazed, battened and braced, venetian of wire gauzed.
6	Door bolts 250mm	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	Double leaf window shutters of heights upto 1.20 metres glazed, battened and braced, venetian of wire gauzed
7	Door bolts 150mm	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	Single leaf window shutters, of heights upto 1.20 metres glazed, battened and braced, venetian of wire gauzed
8	Door bolts 100mm	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	Single leaf cup-board or wardrobe shutters, panelled, glazed or panelled and glazed
9	Door handles 100mm	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	Double leaf cup-board or ward-robe shutter panelled, glazed, or panelled and glazed
10	Door handles 75mm	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	Single leaf cup-board or wardrobe shutter panelled, glazed, or panelled and glazed
11	Cupboard or wardrobe knob (Brass)	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	Double leaf cup-board or ward-robe shutter panelled, glazed, or panelled and glazed
12	Helical door spring 150mm	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	Single leaf, door shutter battened and braced with top and bottom clearance fro WC's and bath rooms
13	Ball catchers 10mm dia	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	Double leaf cup-board or ward-robe shutter panelled, glazed, or panelled and glazed
14	Hooks and eyes 100mm	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	Single leaf cup-board or wardrobe shutter panelled, glazed, or panelled and glazed
15	Chain and hooks 300mm long	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	Double leaf cup-board or ward-robe shutter panelled, glazed, or panelled and glazed
16	Safety hasp and stable 115 mm	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	Single leaf, door shutter battened and braced door shutter width upto 80 cm.
17	Fan light pivot (set)	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	Single leaf inter communicating door shutter panelled width upto 80 cm
18	Fan light catch	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	Single leaf external door shutters glazed, panelled and glazed, framed

JOINTS IN TIMBER

FIGURE 7.1 A to D

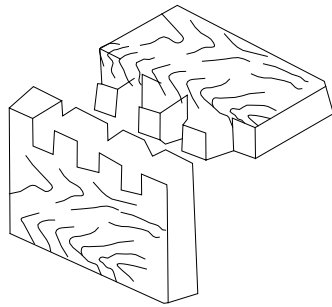


Fig. 7.1 A DOVETAIL JOINT

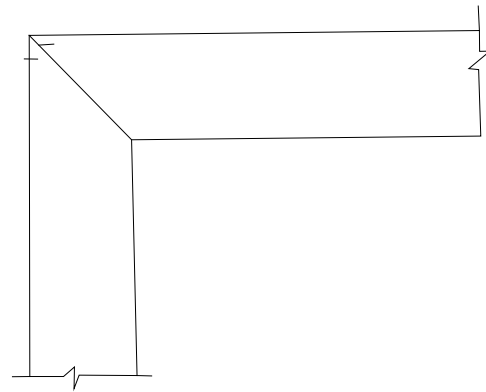


Fig. 7.1 B MITRED JOINT

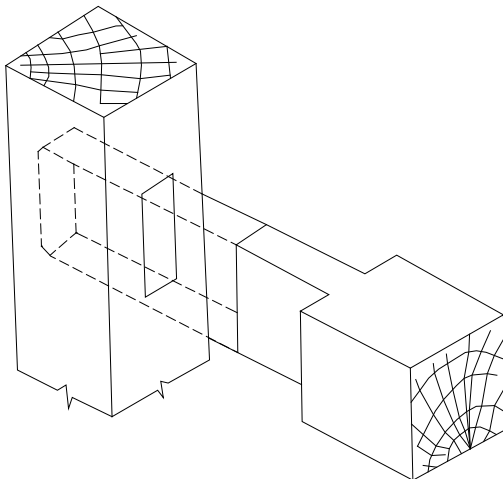


Fig. 7.1 C MORTISE & TENON JOINT

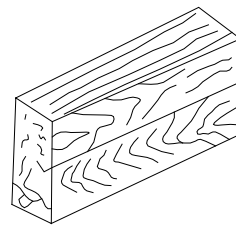
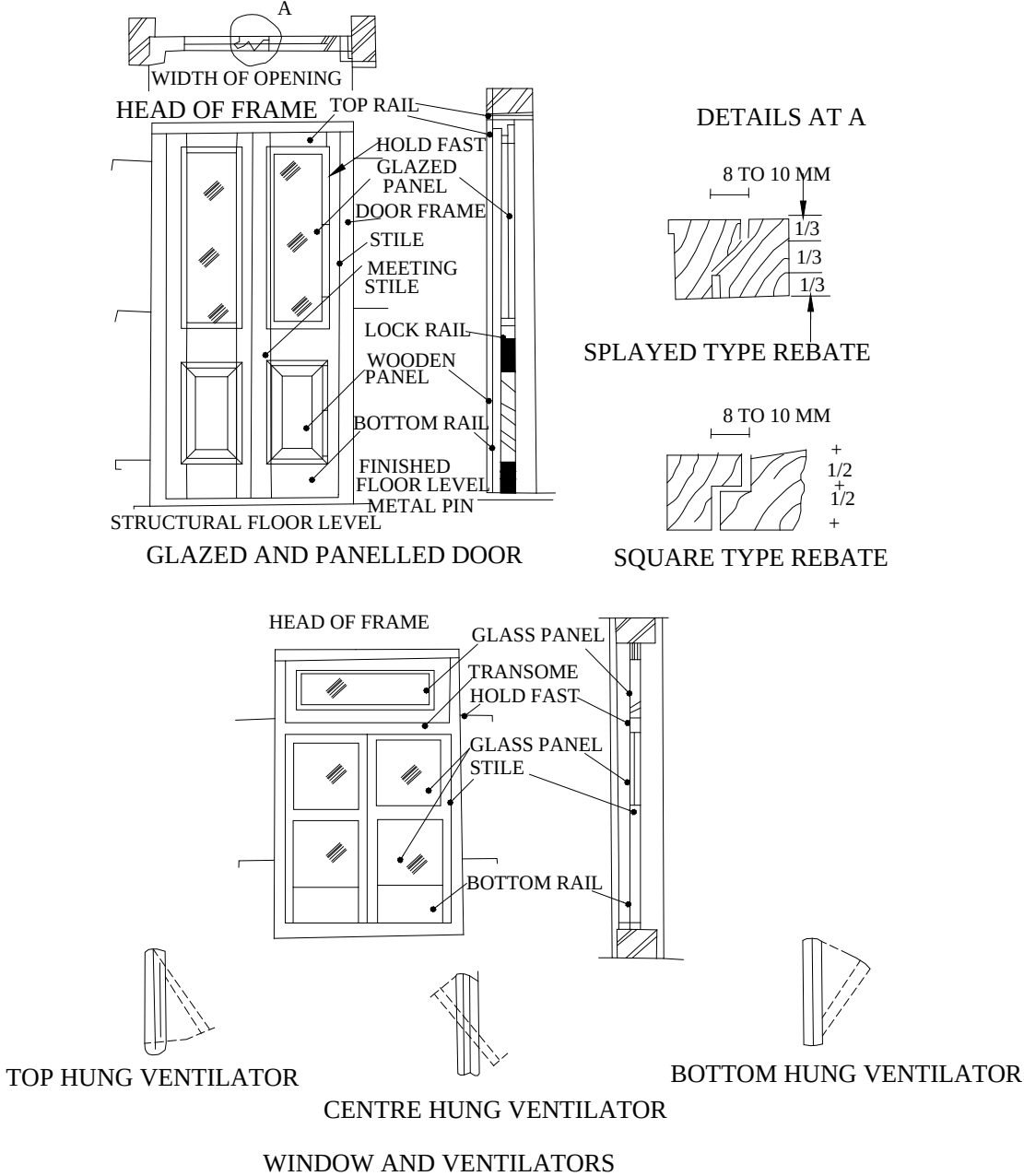


Fig. 7.1 D TONGUE & GROOVE JOINT

All dimensions are in mm
Drawings Not to Scale

TERMINOLOGY - TIMBER DOOR, WINDOW &
VENTILATOR COMPONENTS

FIGURE 7.2

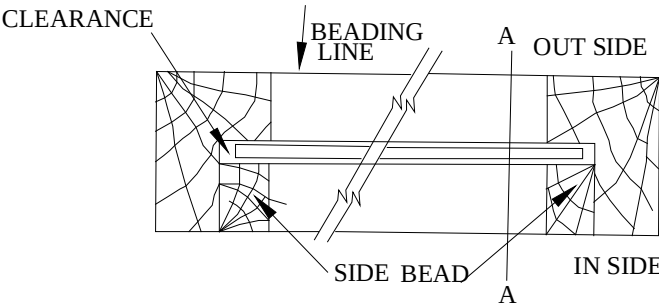
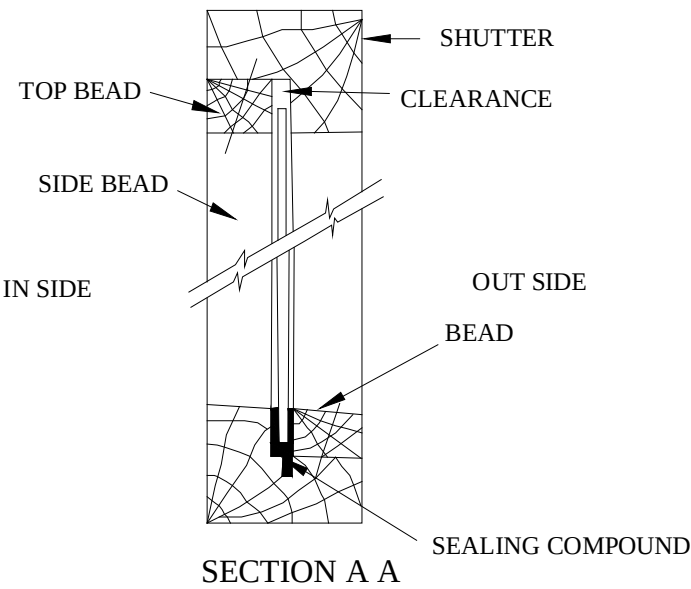


All dimensions are in mm

Drawings Not to Scale

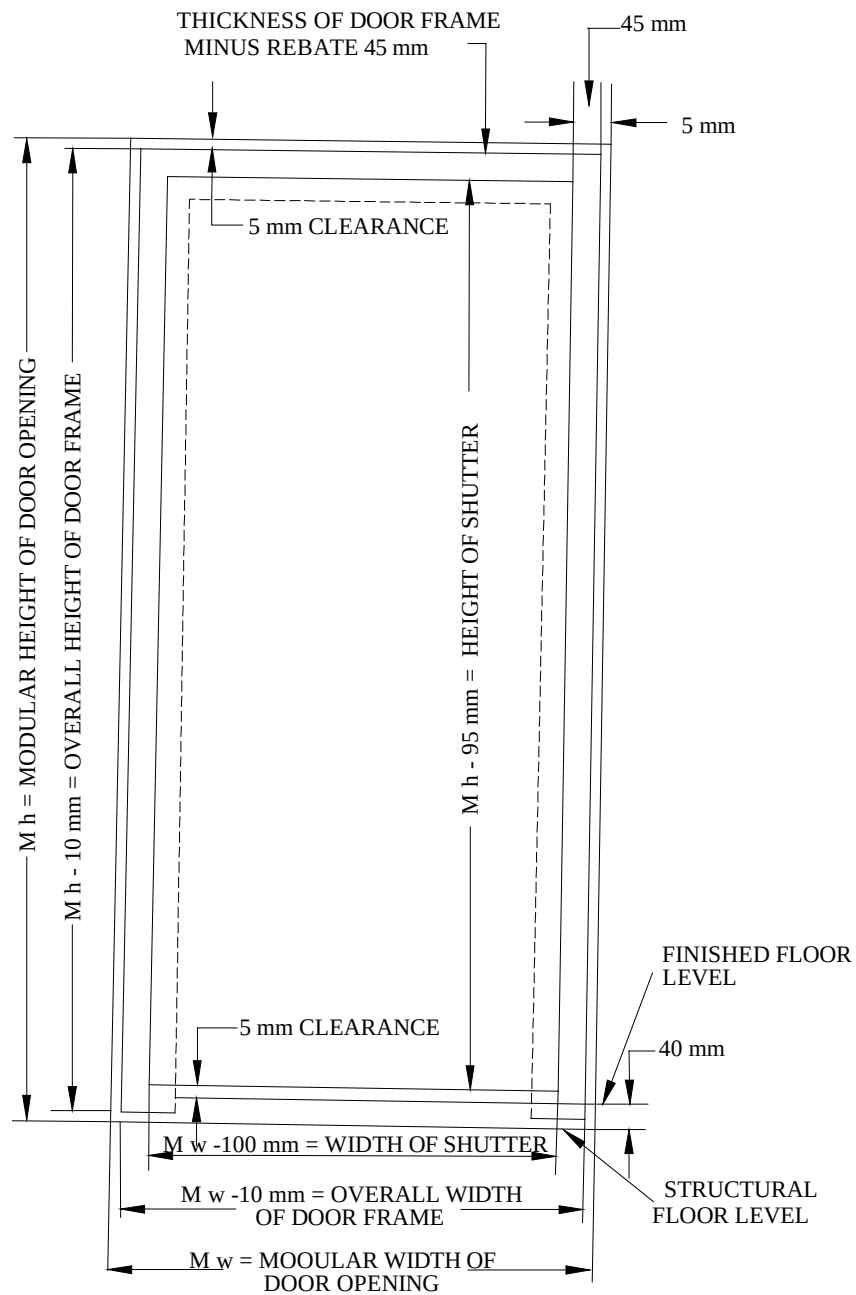
GLAZING

FIGURE 7.3



SKETCH ILLUSTRATING DIMENSIONS OF SHUTTER

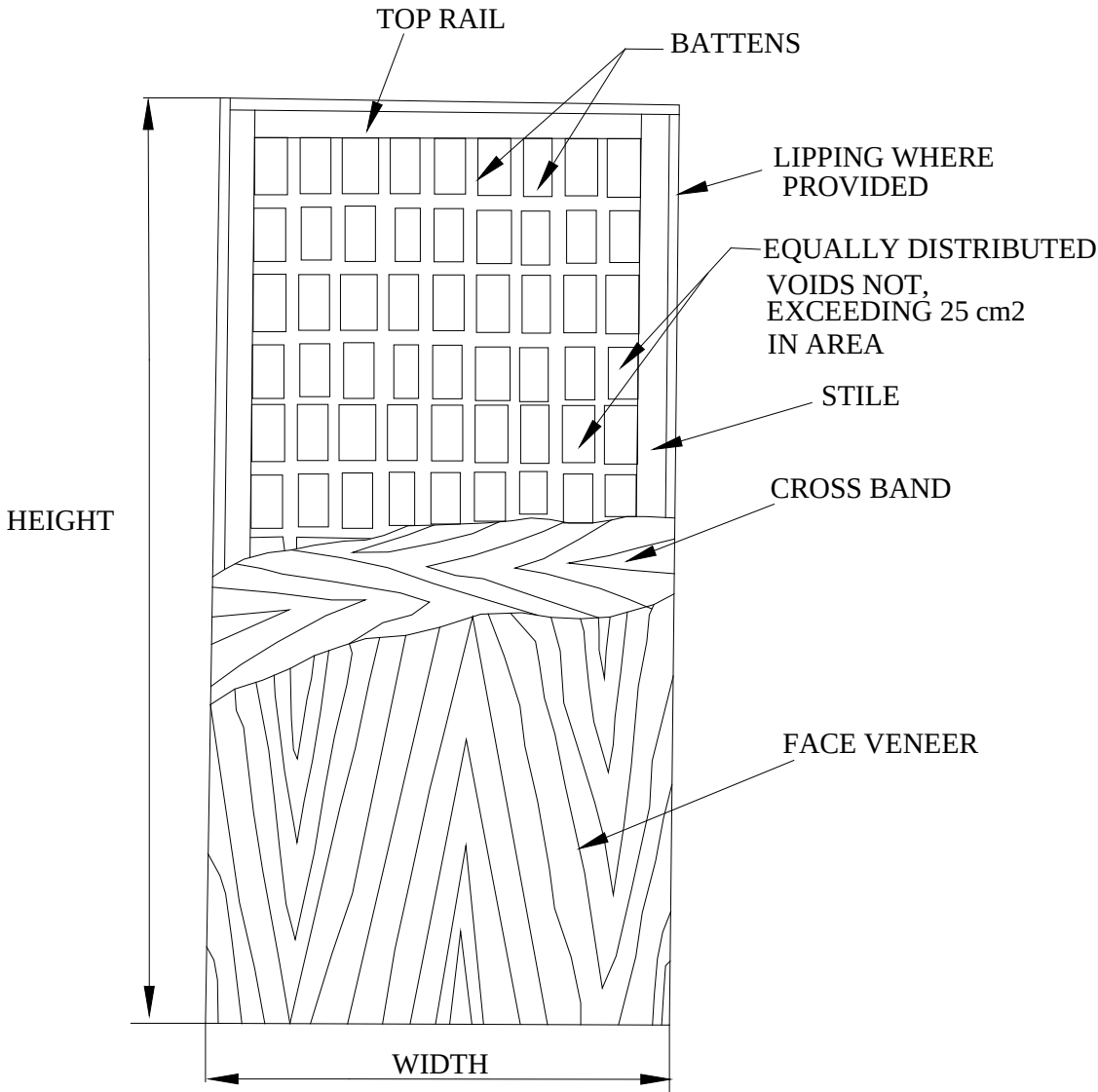
FIGURE 7.4 A



SKETCH ILLUSTRATING DIMENSIONS OF SHUTTER

CELLULAR CORE FLUSH DOOR SHUTTER

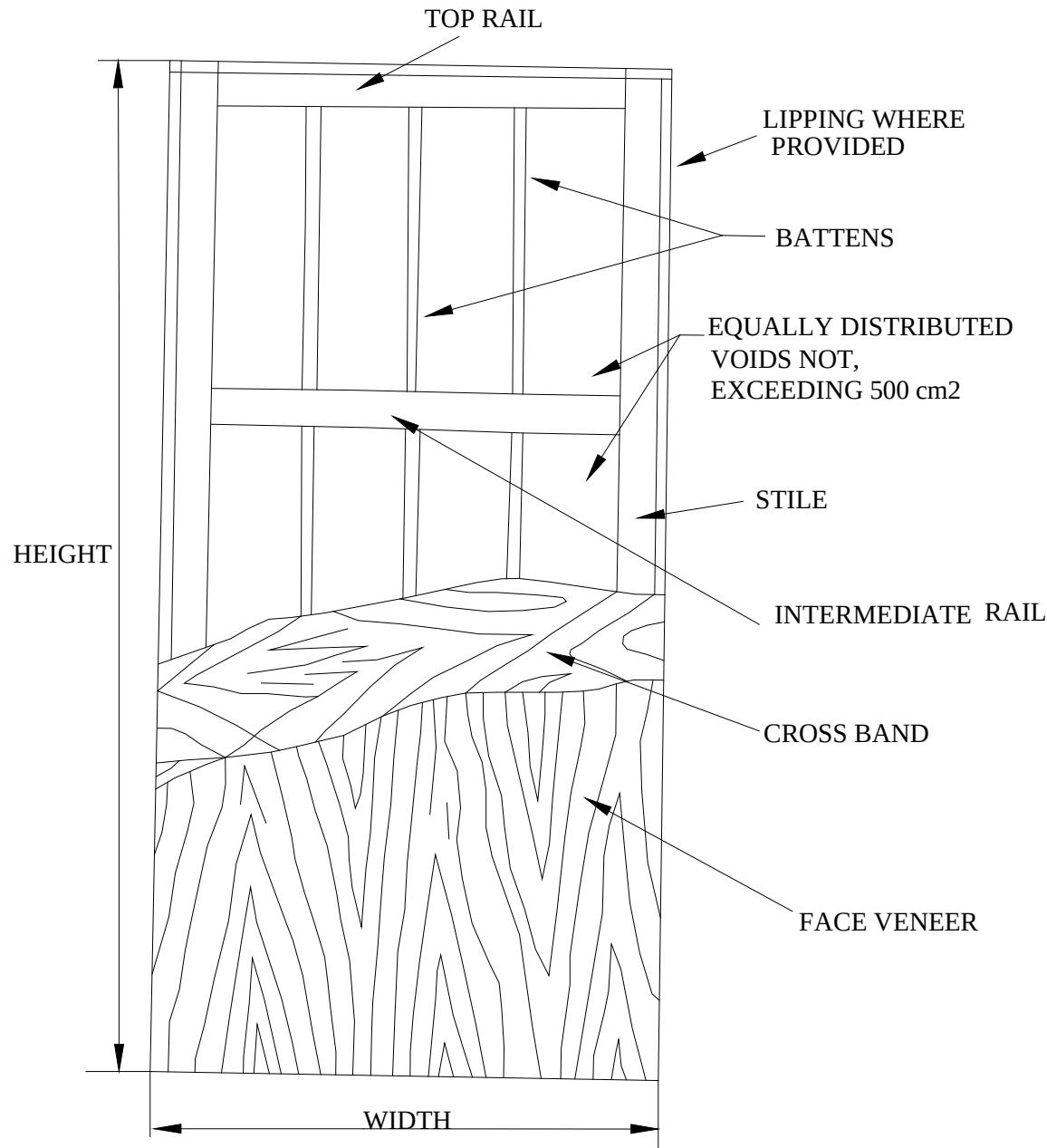
FIGURE 7.4 B



CELLULAR CORE FLUSH DOOR SHUTTER

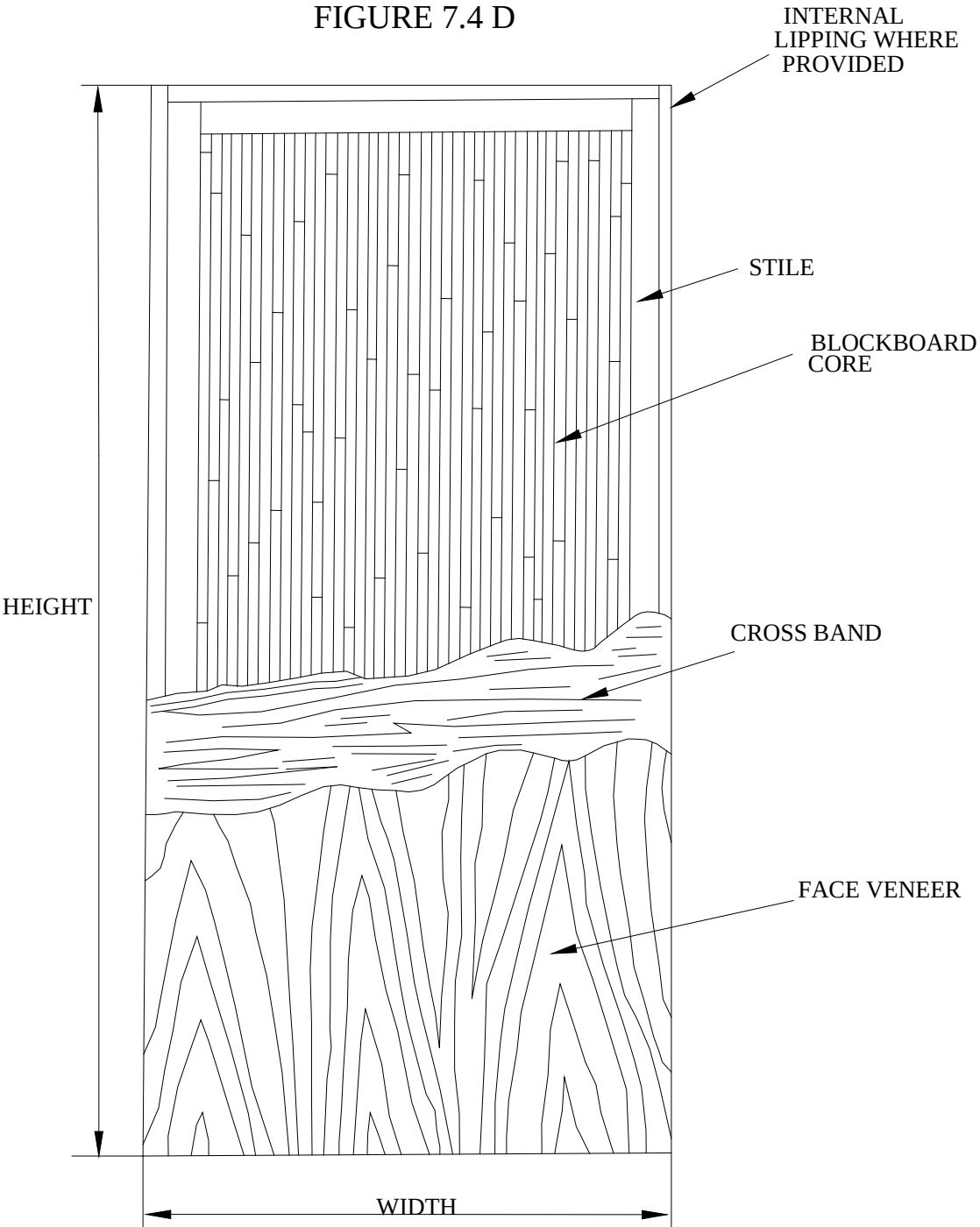
HOLLOW CORE FLUSH DOOR SHUTTER

FIGURE 7.4 C



HOLLOW CORE FLUSH DOOR SHUTTER

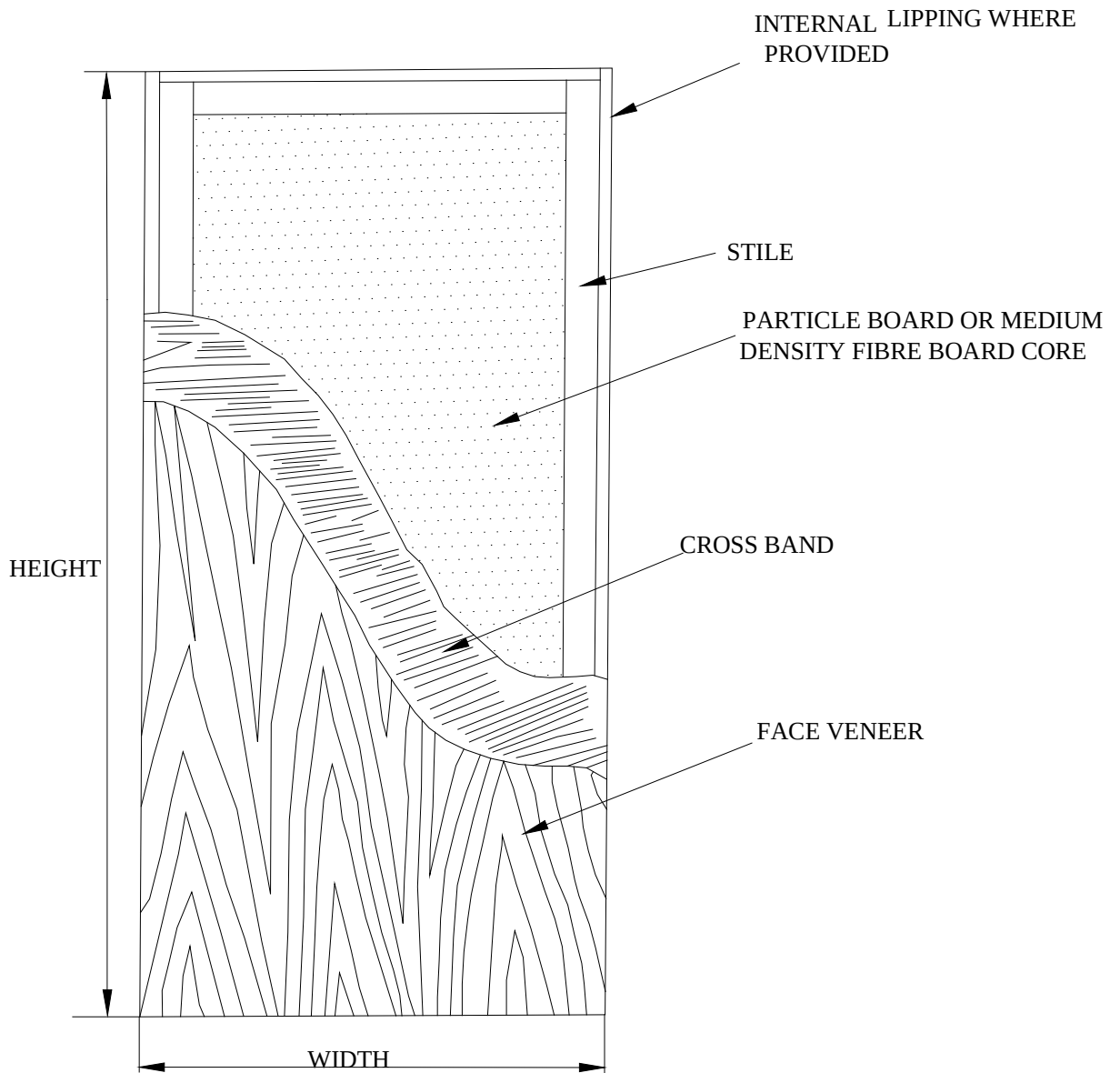
BLOCKBOARD CORE FLUSH DOOR SHUTTER



BLOCKBOARD CORE FLUSH DOOR SHUTTER

PARTICLE BOARD/MEDIUM DENSITY FIBRE BOARD CORE FLUSH DOOR SHUTTER

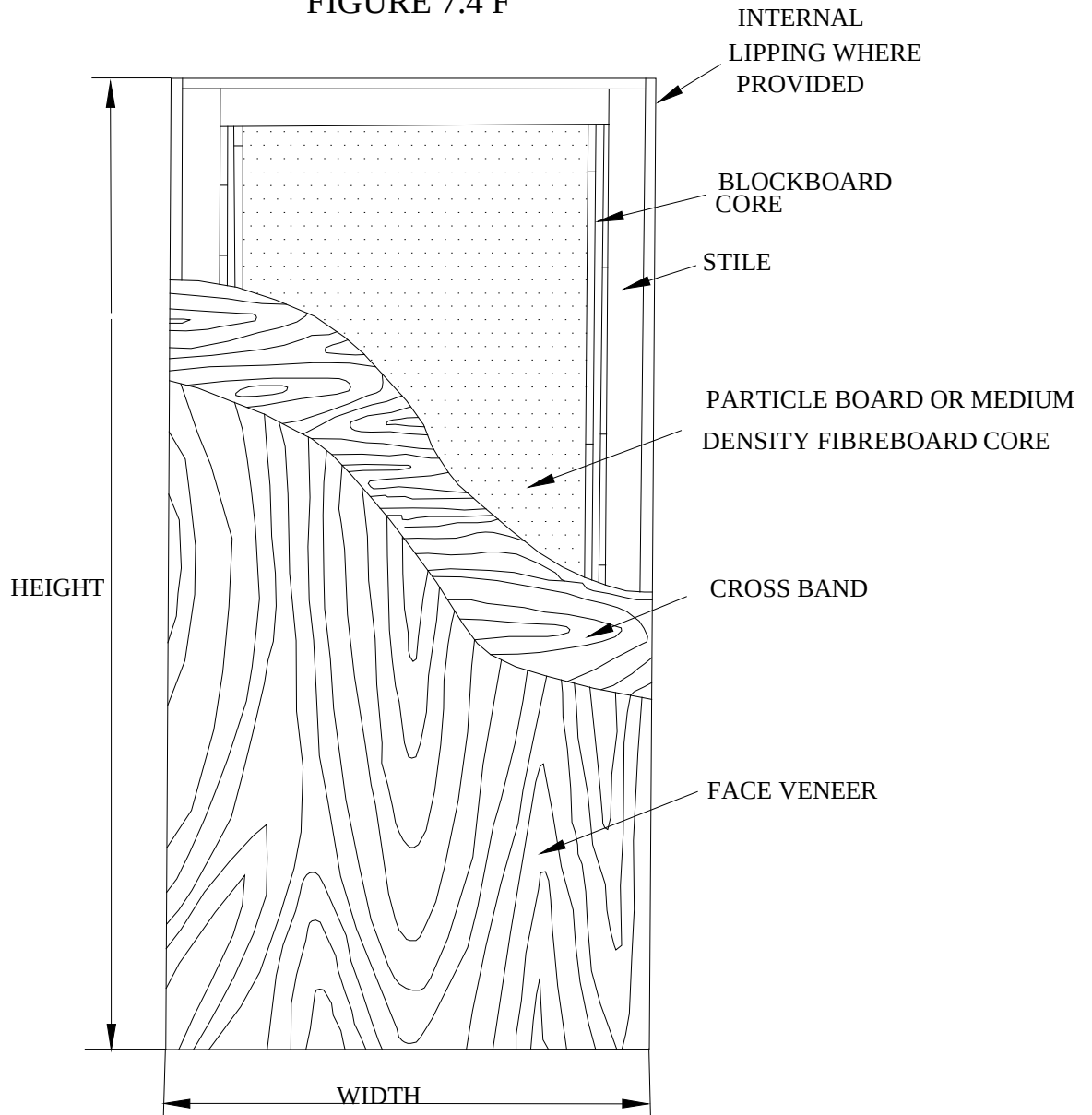
FIGURE 7.4 E



PARTICLE BOARD/MEDIUM DENSITY FIBRE BOARD CORE FLUSH DOOR SHUTTER

PARTICLE BOARD/MEDIUM DENSITY FIBRE BOARD AND BLOCKBOARD CORE FLUSH DOOR SHUTTER

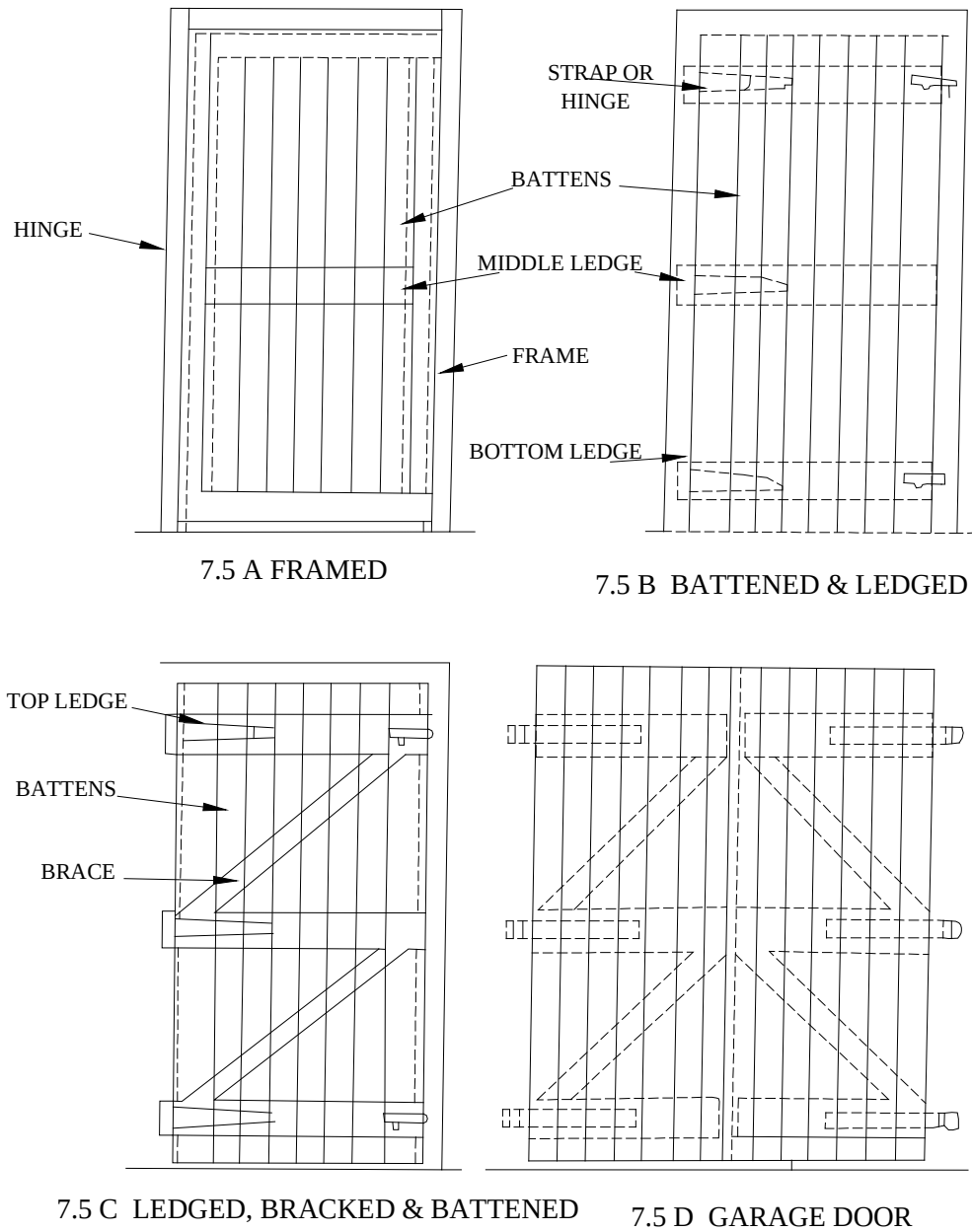
FIGURE 7.4 F



PARTICLE BOARD/MEDIUM DENSITY FIBRE BOARD AND BLOCKBOARD CORE FLUSH DOOR SHUTTER

FRAMED, LEDGED, BRACED, BATTENED DOORS

FIGURE 7.5A toD

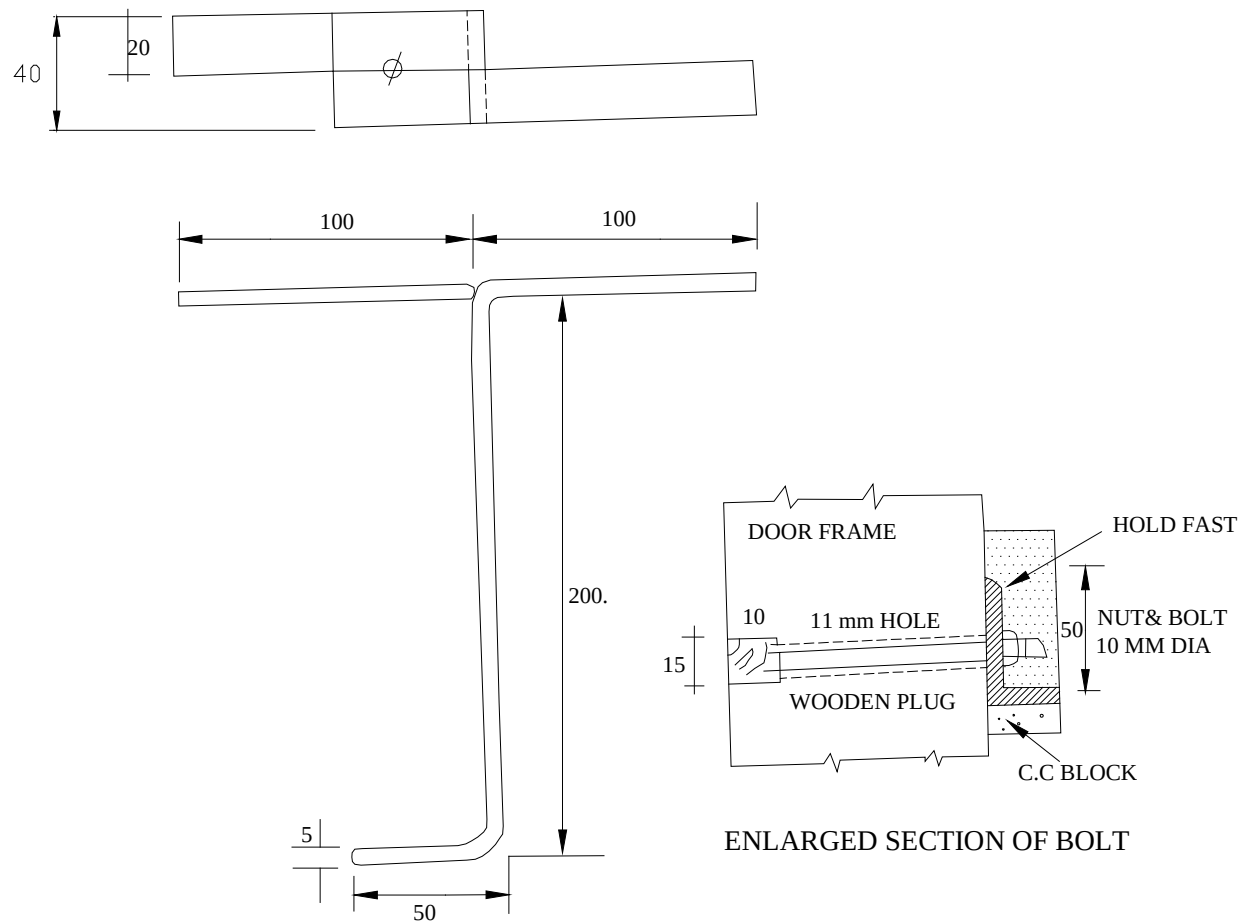


All dimensions are in mm

Drawings not to Scale

HOLD FAST

FIGURE 7.6

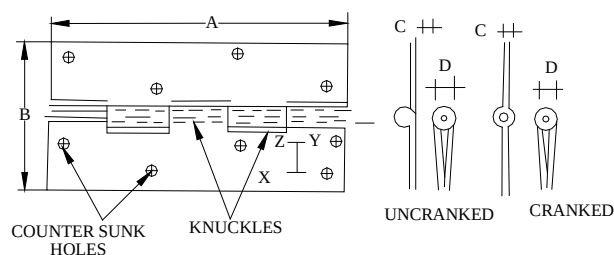


All dimensions are in mm

Drawings not to Scale

HINGES (BUTT & PARLIAMENT)

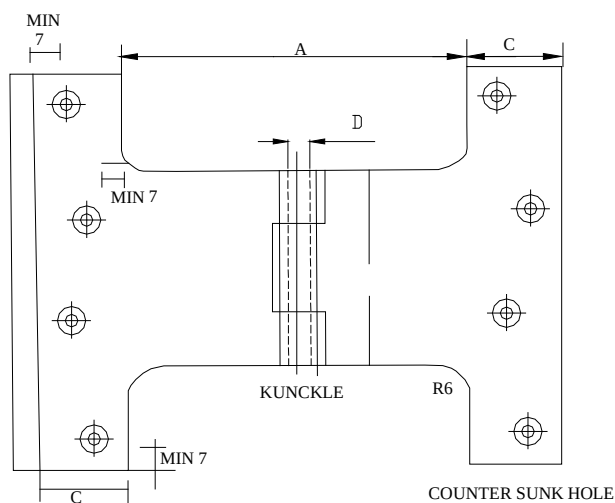
FIGURE 7.7 A - BUTT HINGES



7.7 A DIMENSION OF MEDIUM WT. MILD STEEL BUTT HINGES

Size of Hinge	Length (A)	Breadth (B)	Thickness of Flap (C)	Dia of Hinge Pin (D)	No. of Knuckles	No. of screw Holes	Holes for Screw No
1	2	3	4	5	6	7	8
50	50±0.5	37±1	1.50±0.06	3.15±0.08	3	4	6
75	75±0.5	47±1	1.70±0.06	4.00±0.08	5	6	8
100	100±0.5	58±1	1.90±0.06	5.60±0.08	5	8	10

7.7 B PARLIAMENT HINGES



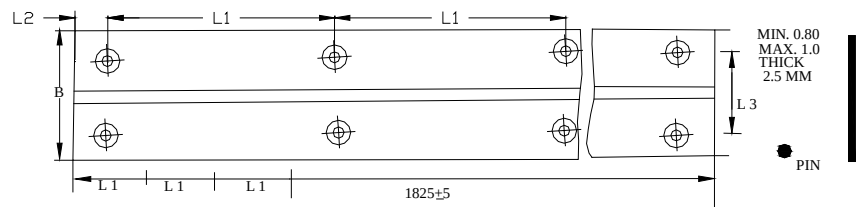
Size of Hinge	Flanges		Diameter of hinge pin D		Diameter of butt for cast brass hinges	Length of joint	Thickness of flanges		No. of screw holed	Screw Designation	Length of wood No. screw	
	Width between flanges		Mild steel cast brass				Mild steel	Cast Brass				
	A	B	C									
	E											
75	75±2	100±1	20±1	6.30±0.10	4.50±0.10	8.0±0.5	48±1	2.24±0.10	3.2±0.5	6	8	30
100	100±3	125±1	27±1	7.10±0.10	6.30±0.10	12.5±0.5	63±1	2.50±0.10	5.0±0.5	8	10	40
125	125±3	125±1	27±1	7.10±0.10	6.30±0.10	12.5±0.5	63±1	2.50±0.10	5.0±0.5	8	10	40
150	150±3	125±1	27±1	7.10±0.10	6.30±0.10	12.5±0.5	63±1	2.80±0.10	5.0±0.5	8	10	45

All dimensions are in mm

Drawings not to Scale

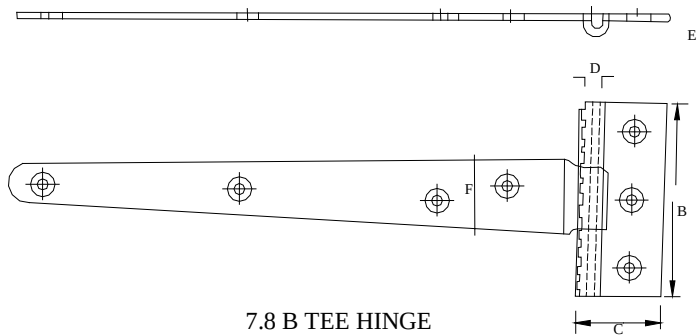
HINGES (TEE & PIANO)
TEE HINGE
PIANO HINGE

FIGURE 7.8



DIMENSIONS				
Nominal Size	B	L ₁	L ₂	L ₃
40	40±1	25±2	25±1	20±1
30	30±1	75±2	25±1	15±1

7.8 A PIANO HINGE



7.8 B TEE HINGE

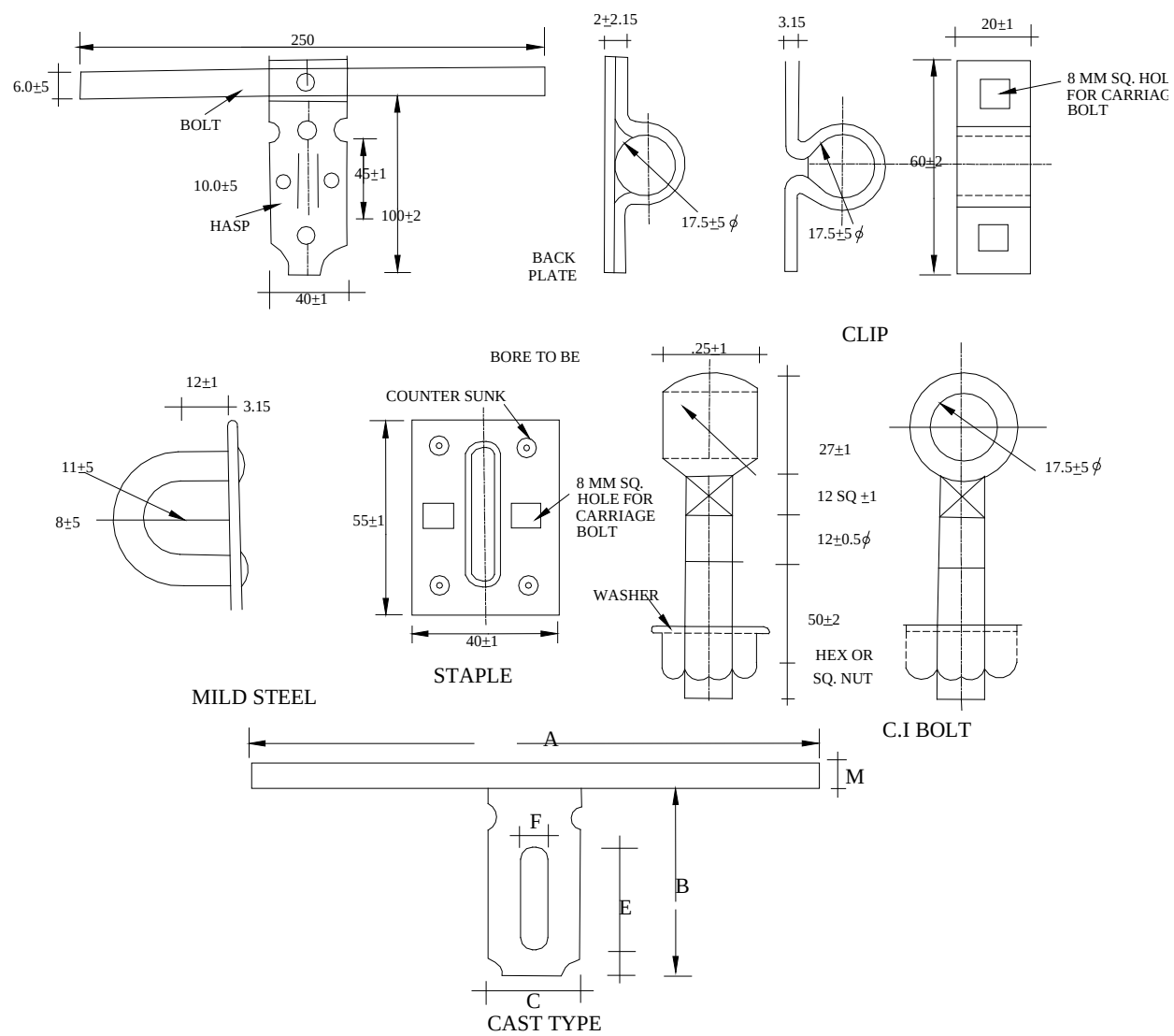
DIMENSIONS									Screw Designation No.	No. of Holes in Strap	No. of Holes in Tee
Size	A	B	C	D	E	F	G	R			
250	250±03	100±2	30±1.5	5.6±0.10	2.24±0.10	45±2	40±1	8±1	9	5	3
300	300±03	115±2	30±1.5	6.30±0.10	2.26±0.10	50±2	50±1	8±1	9	5	3

All dimensions are in mm

Drawings not to Scale

SLIDING DOOR BOLTS (ALDROPS)

FIGURE 7.9



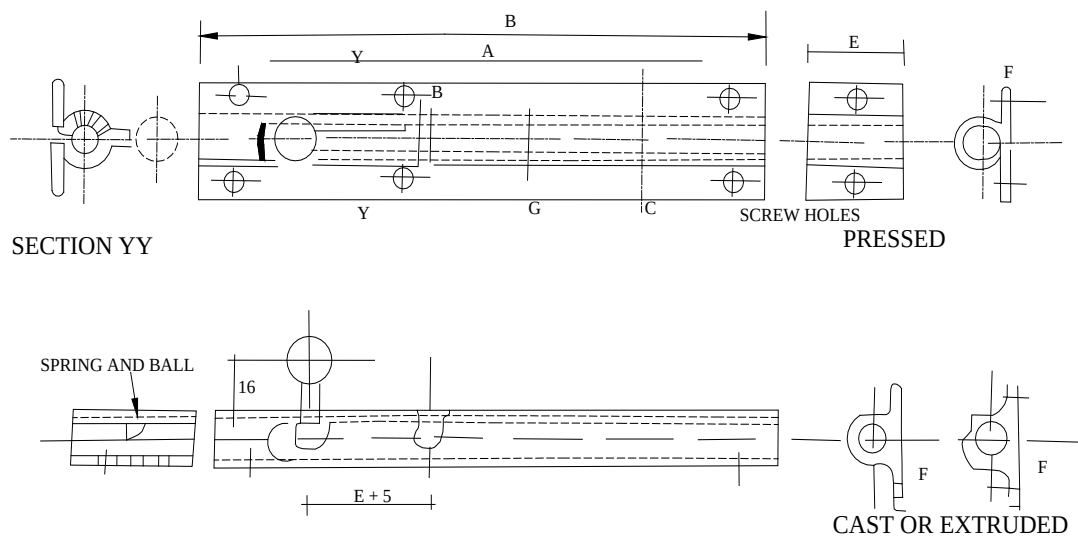
Size	DIMENSIONS						Screw Designation No.
	A	B	C	E	F	M	
250	250+2	100±2	45±1	55±1	15±1	16.0±0.5	9
300	300+2	100±2	45±1	55±1	15±1	16.0±0.5	9

All dimensions are in mm

Drawings not to Scale

BARREL TOWER BOLTS

FIGURE 7.10



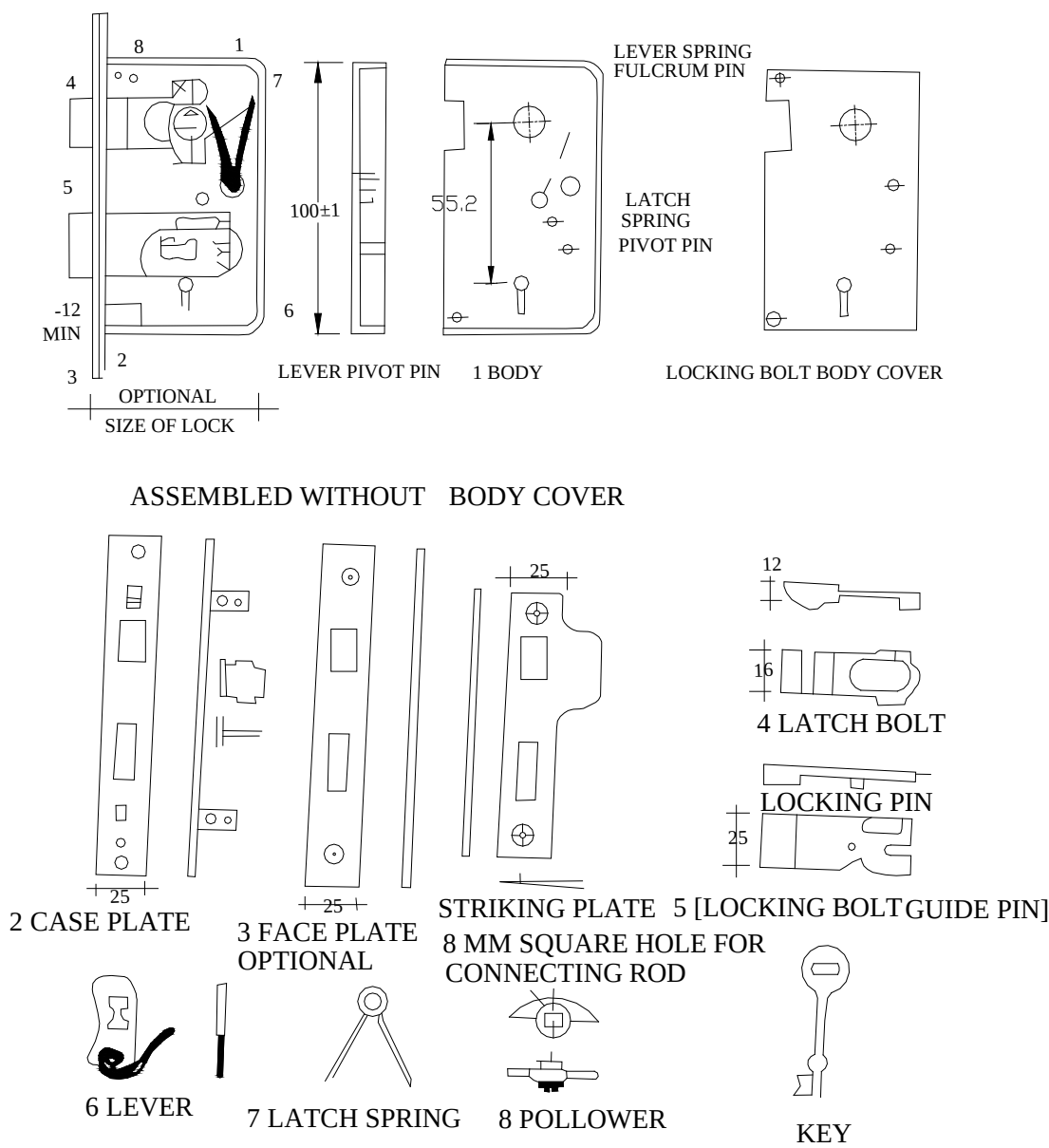
Size	DIMENSIONS										Screw Designation No.		
	A	B	Width of Barrel		D	E	Thickness of Metal of Barrel Sheet					G	
			C	When D = 10.0			When D = 12.0	Brass or Zinc Alloy	Aluminium Alloy	Mild Steel			Brass
150	150 + 3	170 + 3	32 + 3	38 + 310 or 12 ± 0.5	25 ± 1	2.0 + 0.5 - 0.2	1.60 ± 0.33	2.40 ± 0.36	{1.25 ± ± 0.15	1 to 1.25 ± 0.15]	1 to 1.5 more than Dia of Bolt	8	
200	200 + 3	220 + 3	32 + 3	38 + 310 or 12 ± 0.5	25 ± 1	2.0 + 0.5 - 0.2	1.60 ± 0.33	2.40 ± 0.36	{1.25 ± ± 0.15	1 to 1.25 ± 0.15]		8	
250	250 + 3	270 + 3	32 + 3	38 + 310 or 12 ± 0.5	25 ± 1	2.0 + 0.5 - 0.12	1.60 ± 0.33	2.40 ± 0.36	{1.25 ± ± 0.15	1 to 1.25 ± 0.15]		10	

All dimensions are in mm

Drawings not to Scale

MORTICE LOCK & LATCH

FIGURE 7.13

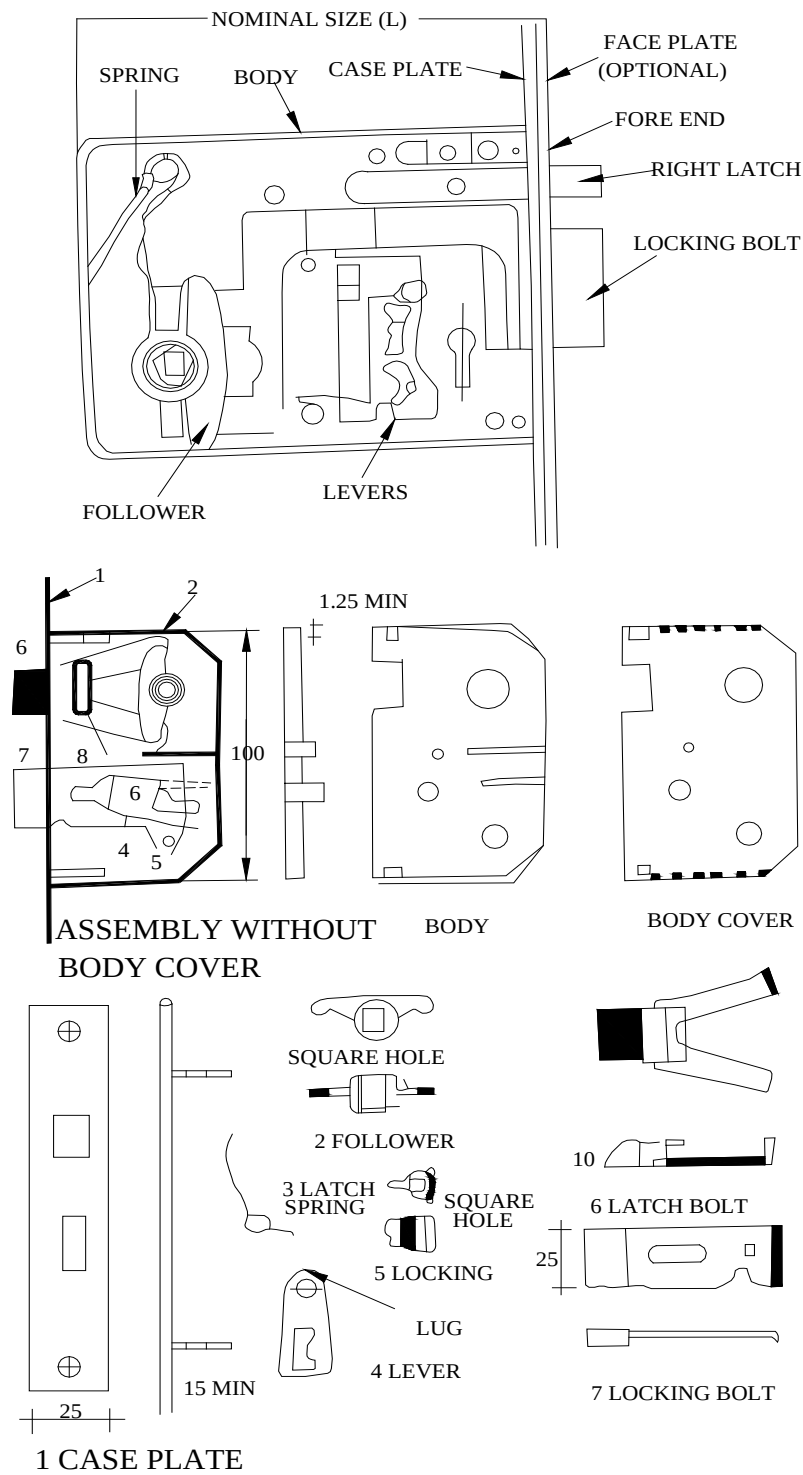


All dimensions are in mm

Drawings not to Scale

MORTICE NIGHT LATCH

FIGURE 7.14



All dimensions are in mm

Drawings not to Scale

DOOR HANDLES

FIGURE 7.15

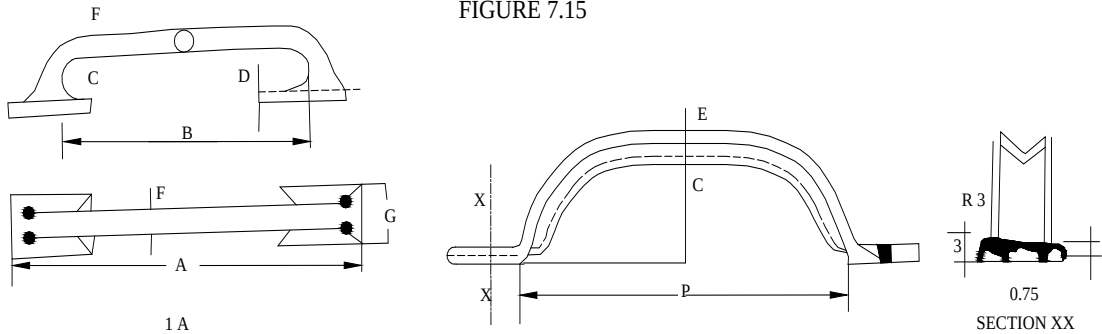


FIG.3: TYPICAL DOOR HANDLE (TYPE3)

FIG.1: TYPICAL DOOR HANDLE (TYPE1)

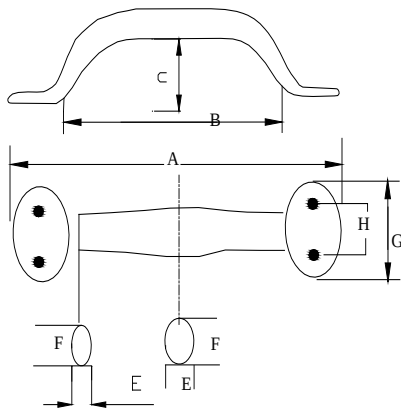
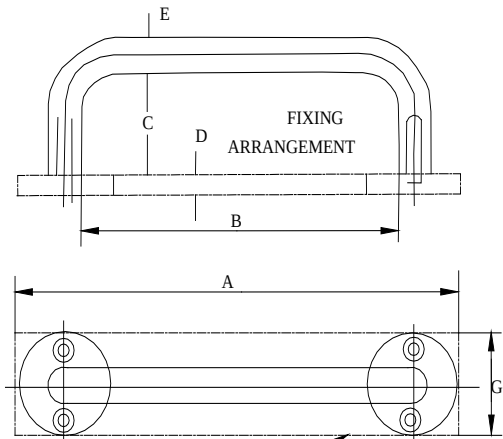


FIG.2: TYPICAL DOOR HANDLE (TYPE2)

All dimensions are in mm



CONTINUOUS PLATE MAY BE PROVIDED WHERE DESIRED

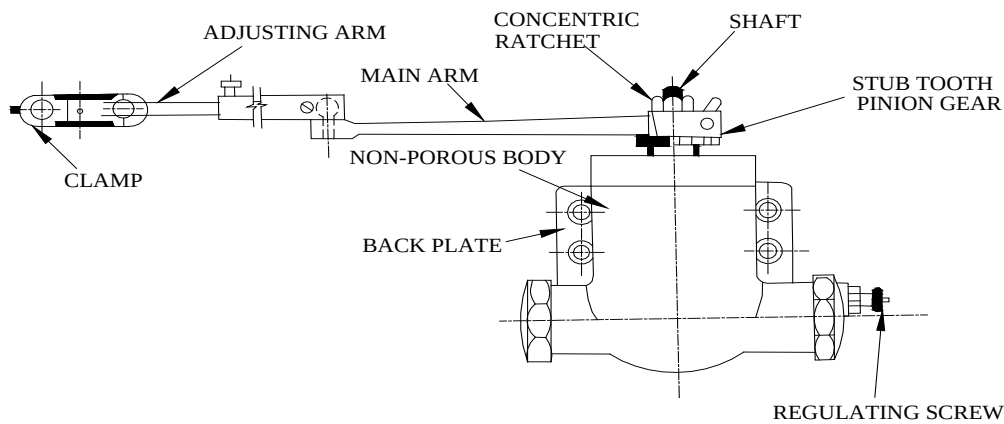
Note : M5 x 20 mm GI countersunk machine screw or any other suitable fixing arrangement may be used

FIG.4: TYPICAL DOOR HANDLE (TYPE4)

Drawings not to Scale

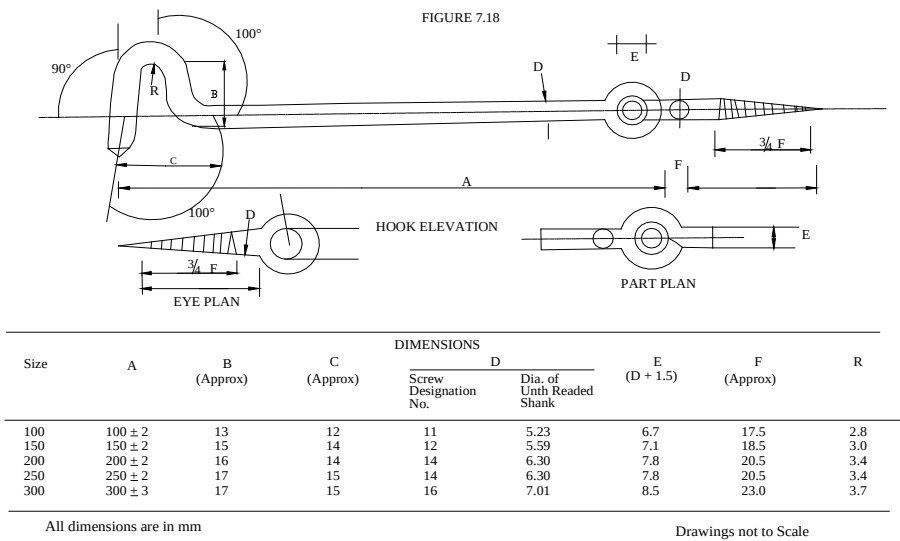
HYDRAULIC DOOR CLOSER

FIGURE 7.17



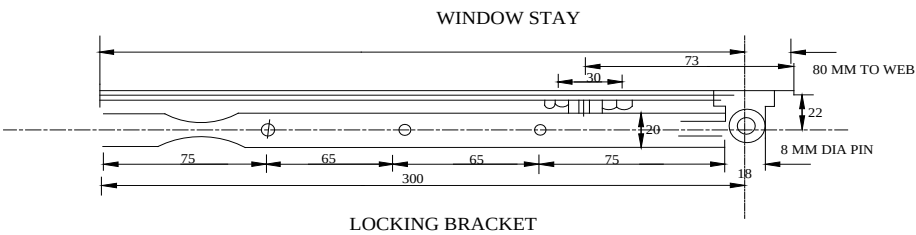
HOOKS & EYES - MILD STEEL & BRASS

FIGURE 7.18



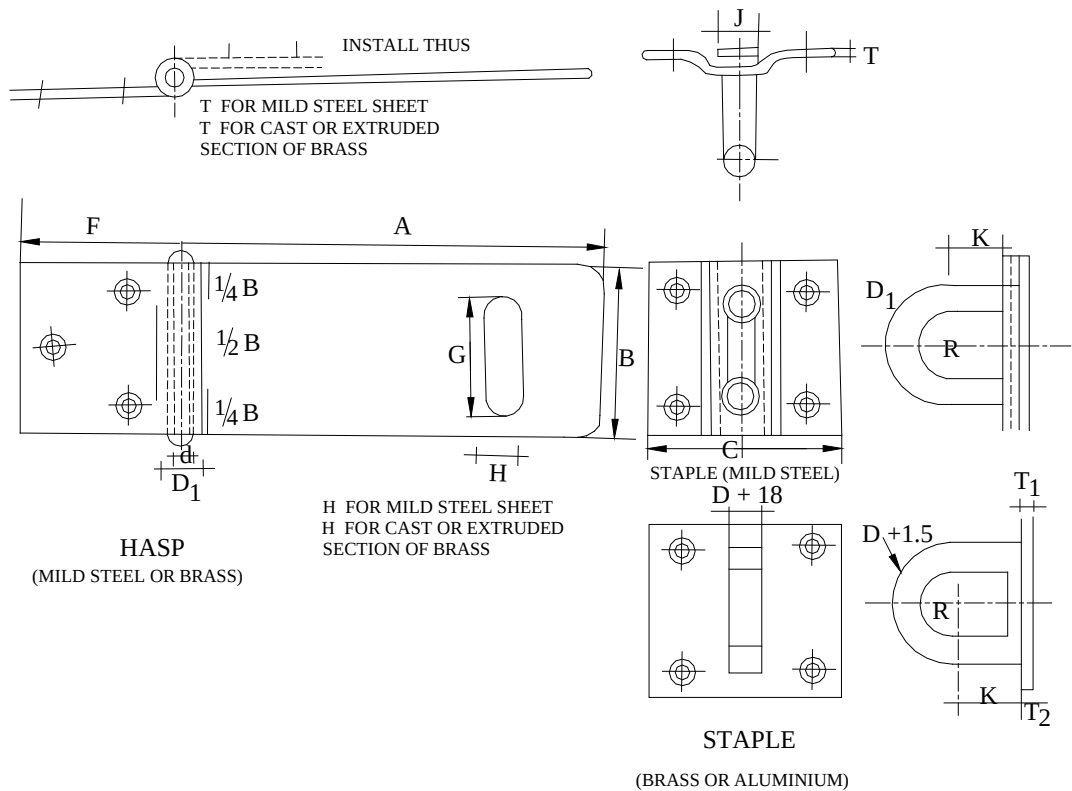
WINDOW STAY

FIGURE 7.19



HASP & STAPLE

FIGURE 7.21



MILD STEEL

MILD STEEL												Thickness of sheet	Dia of hinge Pin D	Screw Holes		
														No. on HASP	No. on Staple	Screw Designation No.
Size	A	B	C	D	E	F	G	H	J	K	R	T				
90	90±2	38±1.5	46±2	5.0±.10	5.0±.5	35±1.5	28±1.5	8±.5	12±1	8±1	8±.5	2±.10	4±.10	3	4	8
115	115±2	38±1.5	46±2	5.0±.10	5.0±.5	55±1.5	28±1.5	8±.5	12±1	8±1	8±.5	2±.10	4±.10	3	4	8
150	150±2	45±1.5	60±2	6.30±.10	6.0±.5	65±1.5	33±.5	10±.5	15±1	14±1	9±.5	2.24±.10	5±.10	4	4	10

BRASS CAST OR EXTRUDED

Size	A	B	C	D	E	F	G	H	K	R	T ₁	T ₂	Thickness	Dia of hinge Pin D	Dia of Butt D,	Screw Holes		
																No. on HASP	No. on Staple	Screw Designation No.
90	90±2	40±1.5	42±1.5	5±.25	6±.5	35±1	28±.5	10±.5	8±1	6.5±.5	2±.25	3±.25	3.15±.10	6±2	3	4	4	5
115	115±2	40±1.5	42±1.5	5±.25	6±.5	45±1	28±.5	10±.5	11±1	6.5±.5	2±.25	3±.25	3.15±.10	6±2	3	4	4	8
150	150±2	46±1.5	48±1.5	6±.25	7±.5	65±1	32±.5	11±.5	14±1	7.5±.5	3±.25	4±.25	4±.10	8±2	4	4	4	0

All dimensions are in mm

Drawings not to Scale

ANNEXURE 7.6**(Para 7.6.9 & 7.21)****SCHEDULE OF FITTINGS FOR TEAK WOOD JOINERY AND FLUSH DOORS**

SL	Name of fittings	Double leaf flush door shutters	Single leaf external flush door shutters width upto 80 cm	Single leaf inter communicating flush door shutters width upto 80 cm.	Single leaf flush door shutters for lavatory opening in corridor width upto 80 cm.	Double leaf door shutters panelled, glazed, or panelled and glazed	Single leaf external door shutters, panelled, glazed, or panelled and glazed width upto 80 cm.	Single leaf inter communicating door shutter, panelled, glazed or panelled and glazed width upto 80 cm.	Double leaf cupboard or wardrobe shutters, panelled, glazed, panelled and glazed or flush	Single leaf cupboard or wardrobe shutters, panelled, glazed, panelled and glazed or flush	Double leaf window shutters of heights upto 1.20 metres, panelled, glazed or venetian	Single leaf window shutters of heights upto 1.20 metres, panelled, glazed or venetian	Fan light shutter, bottom hung upto 80 cm width	Clerestory window or fan light shutter, central hung	Clerestory window shutter bottom hung upto 80 cm width	Double leaf wire gauze door shutters	Single leaf wire gauze door shutters width upto 80 cm.	Double leaf wire gauze window shutter of height upto 1.20 metres	Single leaf wire gauze window shutter of height upto 1.20 metres
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
1	Butt hinges 100mm	6	3	3	--	6	3	3	6	3	--	--	--	--	--	6	3	--	--
2	Butt hinges 75 mm	--	--	--	--	--	--	--	--	--	4	2	2	--	2	--	--	4	2
3	Single action spring hinges	--	--	--	2	--	--	--	--	--	--	--	--	--	--	--	--	--	y
4	Mortice lock	1	1	1	1	--	--	--	--	--	--	--	--	--	--	--	--	--	--
5	Sliding door bolt (Aldrop) 300mm	--	--	--	--	1	--	--	--	--	--	--	--	--	--	--	--	--	--
6	Sliding door bolt (Aldrop) 250mm	--	--	--	--	--	1	--	--	--	--	--	--	--	--	--	--	--	y
7	Flush bolts 250mm	3	1	2	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
8	Flush bolts 100mm	--	--	--	--	--	--	--	2	1	--	--	--	--	--	--	--	--	--

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
9	Barrel bolts 250mm	--	--	--	--	3	2	4	--	--	--	--	--	--	--	3	2	--	--
10	Barrel bolts 150mm	--	--	--	--	--	--	--	--	--	2	1	--	--	--	--	--	2	1
11	Barrel bolts 100mm	--	--	--	--	--	--	--	--	--	1	1	--	--	--	--	--	1	1
12	Furniture handles	--	--	--	--	--	--	--	2	1	--	--	--	--	--	--	--	--	--
13	Door handle with plate 100mm	--	--	--	--	2	2	2	--	--	--	--	--	--	--	2	1	--	--
14	Door handle with plate 75mm	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	2	1
15	Helical door springs (Superior quality)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	2	1	--	--
16	Ball catchers 10mm dia	--	--	--	--	--	--	--	2	1	--	--	--	--	--	--	--	--	--
17	Cup-board or ward-robe lock 65mm. 6 lever (Godrej or equivalent)	--	--	--	--	--	--	--	1	1	--	--	--	--	--	--	--	--	--
18	Fan light pivot set	--	--	--	--	--	--	--	--	--	--	--	--	1	--	--	--	--	--
19	Fan light catch	--	--	--	--	--	--	--	--	--	--	--	1	1	1	--	--	--	--
20	Chain and hooks 300mm	--	--	--	--	--	--	--	--	--	--	--	1	--	1	--	--	--	--
21	Hooks and eyes 150mm	--	--	--	--	--	--	--	--	--	2	1	--	--	--	--	--	2	1

TABLE A : DIMENSIONS OF DOOR HANDLES

Fig. 1 to 3
All dimensions are in mm

Type	Ref to. FIG.	Sizes	A Min.	B	C Min.	D Min.	E Min.	F Min.	G Min.	H Min.	I Min.	No. in Each Lug	Screw Holes * Size Designation of Counter - sunk Head Wood Screw (see IS : 6760-1972 \$)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
1.	1 A	75	125	75	20	2.5	5	8	15	-	-	2	6
		100	150	100	25	3.0	8	10	20	-	-	2	6
		125	190	125	25	4.0	10	12	22	-	-	2	6
		150	215	150	30	1.5	12	15	25	-	-	2	8
	1 B	75	85	75	20	2.5	5	8	15	-	-	2	6
		100	110	100	25	3.0	5	10	20	-	-	2	6
		125	140	125	25	3.0	7.5	12	22	-	-	2	6
		150	165	150	30	4.0	7.5	15	25	-	-	2	8
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
2.	2	75	125	75	20	-	10	16	32	20	1.0	2	6
		100	150	100	25	-	11	19	38	20	1.0	2	6
		115	175	115	28	-	13	22	45	25	1.0	3	8
		135	200	135	30	-	14	25	50	32	1.25	3	8
3.	3	75	100	75	20		5	14	16	8	1.25	1	6
		90	125	90	25		6	16	20	10	1.25	2	6
		100	150	100	28		7	18	25	12	1.60	2	6

* More evenly spaced screw holes may be provided, if so required, by the purchaser.

\$ Specification for slotted countersunk head wood screws.

TABLE B : DIMENSIONS OF DOOR HANDLES

Fig. 4
All dimensions are in mm

Type	Ref to. FIG.	Sizes	A Min.	B	C Min.	D	E#	G Dia	No. in Each Lug	Screw Holes *** No. in a plate when a continuous plate is used	Size Designation of Counter - sunk Head Wood Screw (see IS : 6760-1972\$)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
4.	4	75	115	75	25	5 ± 0.5	10 ± 0.5	30	+ 0 - 1	2	6
		100	140	100	30	5 ± 0.5	10 ± 0.5	30	+ 0 - 1	2	6
		125	175	125	35	5 ± 0.5	12 ± 0.5	38	+ 0 - 1	3	6
		150	200	150	35	5 ± 0.5	12 ± 0.5	38	+ 0 - 1	3	6

In case a continuous base plate is used, the thickness may be reduced to 3 mm.

** Hexagonal or round.

*** More evenly placed screw holes may be provided, if so required by the purchaser.

\$ Specification for slotted countersunk head wood screws.

CHAPTER 8

STEEL WORK AND ALUMINIUM WORK

8.0. DEFINITIONS (Refer Figure 8.1 for Details)

1. Bead: A single run of weld metal deposited on surface.
2. Butt Weld: A weld in which the weld metal lies substantially within the extension of the planes and the surfaces of the parts joined.
3. Crater: A depression left in weld metal where the arc was broken or the flame was removed.
4. End Crater: A crater at the end of a weld or at the end of a joint.
5. Fillet Weld: A weld of approximately triangular cross-section joining two surfaces approximately at right angles to each other in a lap joint, tee joint or corner joint. It is of two types :
 - (a) Continuous
 - (b) Intermittent
6. Fusion Welding: Any welding process in which the weld is made between metals in a state of fusion without hammering or pressure.
7. Non-fusion Welding: A term applied to the deposition, by the Oxy-Acetylene process of filler metal on parent metal without fusion of the latter.
8. Oxy-Acetylene Pressure Welding: Pressure welding in which any Oxy-Acetylene flame is used to make the surface to be united plastic. No filler metal is used.
9. Run: The metal deposited during one passage of the electrode or blow pipe in the making of a joint.
10. Throat thickness : See **Figure 8.1**
11. Weld: A union between two pieces of metal at faces rendered plastic or liquid by heat or pressure, or both. Filler metal maybe used to effect the union.

8.1. MATERIALS

8.1.1. Steel

All finished steel shall be well and cleanly rolled to the dimensions and weight specified by BIS subject to permissible tolerances as per IS:1852. The finished materials shall be reasonably free from cracks, surface flaws, laminations, rough and imperfect edges and all other harmful defects.

Steel sections, shall be free from excessive rust, scaling and pitting and shall be well protected. The decision of the Engineer regarding rejecting any steel section on account of any of the above defects shall be final and binding.

Structural steel work shall conform to the following requirements. The mechanical and chemical properties of the structural steel shall be as per **Annexure 8.1**. The following varieties of steel should be used for structural purposes -

8.1.1.1. S.T. 42 – S: The standard quality of steel designated as S.T. 42-S conforming to IS : 226 shall be used for all types of structures (riveted or bolted) including those subject to dynamic loading and where fatigue, wide fluctuation of stresses and reversal of stresses are involved, as for example crane gantry girders, road and rail bridges etc., It is also suitable for welded structures provided that the thickness of materials does not exceed 20 mm.

8.1.1.2. S.T. 42-W: The fusion welding quality steel designated as S.T. 42-W conforming to IS:2062 shall be used for all types of structures subject to dynamic loading (Wind load is not to be considered as dynamic load for this purpose) where welding is employed for fabrication and where fatigue, wide fluctuation of stresses, reversal of stress and great restraint are involved as for example, crane gantry girders and road and rail bridges.

8.1.1.3. S.T. 42 – 0. The ordinary quality steel designated as S.T. 42 – 0 conforming to IS:1977 shall be used for structures not subjected to dynamic loading other than wind loads where welding is not employed or/and structures not situated in earth quake zones or design has not been based on plastic theory.

8.1.1.4. S.T. 32 – 0: The ordinary quality steel designated as S.T. 32 – 0 conforming to IS : 1977 shall be used for doors, window frames, window bars, grills, steel gates, hand railing, builders hardware, fencing posts, tie bars etc.,

8.1.2. Rivets

Rivets shall be made from rivet bars of mild steel as per IS : 1148 and should conform to the Indian Railways Standard Specifications.

8.1.3. Bolts

These are of two types namely turned & fitted bolts and black bolts. Turned & fitted bolts are turned to exact diameter in automatic lathe. For these bolts, whether in reamed or drilled holes, the same unit stresses are allowed as for rivets. In case of black bolts which are not finished to exact sizes, a lower working stress other than for turned bolts is adopted. They shall conform to IS : 1367 (Technical supply conditions for threaded steel fasteners) and relevant Indian Railway Standard Specifications.

8.1.4 Using Rivets & Bolts:- Rivets or Turned and fitted bolts shall be used where the connection such that slip under load has to be avoided. Black bolts may be used very sparingly where the force is carried through the connection without impact vibration or reversal of stresses (unless such reversal is due solely to wind forces)

8.1.5 Electrodes

The electrodes required for metal arc welding shall be covered electrodes and shall conform to IS : 814.

8.2. STEEL WORK IN SINGLE SECTION FIXED INDEPENDENTLY

The steel work in single sections of R.S. Joints, flats, Tees Angles fixed independently with or without connecting plate, is described in the sub paras below.

8.2.1 Fabrication

The steel sections as specified shall be straightened and cut square to correct lengths and measured with a steel tape. The cut ends exposed to view shall be finished smooth. No two pieces shall be welded or otherwise jointed to make up the required length of a member.

All straightening and shaping to form, shall be done by pressure. Bending or cutting shall be carried out in such a manner as not to impair the strength of the metal.

8.2.2. Painting

All surfaces which are to be painted, oiled or otherwise treated shall be dry and thoroughly cleaned to remove all loose scale and loose rust. Surfaces not in contact but inaccessible after shop assembly, shall receive the full specified protective treatment before assembly which will involve two or more coats of paint. This does not apply to the interior or sealed hollow sections. Part to be encased in concrete shall not be painted or oiled. A priming coat of approved steel primer i.e. Red Oxide Zinc chrome primer conforming to IS : 2074 or as specified shall be applied before any member of steel structure is placed in position or taken out of workshop.

8.2.3. Erection

Steel work shall be hoisted and placed in position carefully without any damage to itself and other building work and injury to workmen. Where necessary, mechanical appliances such as lifting tackle, winch etc., shall be used. The suitability and capacity of all plant and equipment used for erection shall be to the satisfaction of the Engineer.

8.2.4. Measurements

The work as fixed in place shall be measured in running metres correct to a millimeter and weights calculated on the basis of standard tables correct to the nearest kilogram.

Unless otherwise specified, weight of cleats, brackets, packing pieces, bolts, nuts, washers, distance pieces, separators, diaphragm gussets (taking overall square dimensions), fish plates, etc., shall be added to the weight of respective items. Payment for holding down bolts and anchor channels shall be made separately. No deduction shall be made for skew cuts. In riveted work, allowance is to be made for weight of rivet heads. Unless otherwise specified, an addition of 3 per cent of the weight of structure shall be made for shop and site rivet heads in riveted steel structures. No deduction shall be made

for rivet/or bolt holes (excluding holes for anchor or holding down bolts). Deduction in case of rivet or bolt hole shall however be made if its area exceeds 0.02 sqm.

The weight of steel sheets, plates and strips shall be taken from relevant Indian Standards based on 7.85 kg/m² for every millimetre sheet thickness. For rolled sections, steel rods and steel strips, weight given in relevant Indian Standards shall be used.

8.2.5. Rate

The rate includes the cost of all labour and materials including the cost of steel, rivets, bolts and service bolts, required for all the operations described above except painting. This will include only the steel work where single sections are used except steel work with rails. It will exclude the steel work in built up sections, trusses and framed work, where riveting, bolting or welding is involved. Cost of painting primary coat is included in the rate. Unless otherwise specified, the rates include the supply, erection and removal of scaffolding, machinery, hoisting, gear, derricks, ropes, pulleys, tools, plants and all consumable materials such as coal, oil etc.

8.3. STEEL WORK IN BUILT UP SECTIONS (RIVETTED AND BOLTED)

The steel work in built up sections (Riveted and bolted) such as in trusses, framed work etc., is specified in the subparas below.

8.3.1. Laying Out

A figure of the steel structure to be fabricated shall be drawn on a level platform to full scale. This may be done in full or in parts, as shown on drawings or as directed by the Engineer. Steel tape shall be used for measurements.

8.3.2. Fabrication

Fabrication shall generally be done as specified in IS : 800. In major works or where so specified, shop drawings giving complete information for the fabrication of the component parts of the structure including the location, type, size, length and details of rivets, bolts or welds, shall be prepared in advance of the actual fabrication and approved by the Engineer. The drawings shall indicate the shop and field rivets, bolts and welds. The steel members shall be distinctly marked or stenciled with paint with the identification marks as given in the shop drawings.

Great accuracy shall be observed in the fabrication of various members, so that these can be assembled without being unduly packed, strained or forced into position and when built up, shall be true and free from twist, kinks, buckles or open joints.

Wooden or metal sheet templates shall be made to correspond to each member and position of rivet holes shall be marked accurately on them and holes drilled. The templates shall then be laid on the steel members, and holes for riveting or bolting marked on them. The ends of the steel members shall also be marked for cutting as per required dimensions. The base of steel columns and the positions of anchor bolts shall be carefully set out at the required locations.

8.3.2.1. The steel section shall be straight or be straightened or flattened by pressure unless required to be of curvilinear form and shall be free from twists. These shall be cut square either by shearing or sawing to correct length and measured by steel tape. No two pieces shall be welded or joined to make up for the required length of member.

8.3.2.2. Making Holes: Holes through more than one thickness of material for members, such as compound stanchion and girder flanges shall, where possible, be drilled after the members are assembled and tightly clamped or bolted together. Punching may be permitted before assembly, provided the holes are punched 3 mm less in diameter than the required size and reamed after assembly to the full diameter. The thickness of material punched shall be not greater than 16 mm.

Rivet Holes: The diameter for rivets and black bolts shall be taken as the nominal diameter of a rivet plus 1.5 mm for rivets of nominal diameter less than or equal to 25 mm and 2.0 mm for rivets of nominal diameter exceeding 25 mm, unless specified otherwise. Holes for turned and fitted bolts shall be drilled or reamed large by 0.2 to 8 mm depending upon the dia. of bolts as shown in **Table 8.1**.

TABLE 8.1
HOLES FOR TURNED AND FITTED BOLTS

Bolt diameter	Hole diameter	Bolt diameter	Hole diameter
1.6	1.8	(39)	42
2	2.4	42	45
(2.2)	2.6	(45)	48
2.5	2.9	48	52
3	3.4	(52)	56
(3.5)	4.0	(56)	62
4	4.5	(60)	66
(4.5)	5.0	64	70
5	5.5	(68)	74
6	6.6	72	78
(7)	7.6	(76)	82
8	9.0	80	86
10	11.0	(85)	91
12	14.0	90	96
(14)	16.0	(95)	101
16	18.0	100	107
(18)	20.0	105	112
20	22.0	110	117
(22)	24.0	(115)	122
24	26.0	120	127
(27)	30.0	125	132
30	33.0	(130)	137
(33)	36.0	140	147
36	39.0	(150)	158

Note: 1) All dimensions are in millimetres

2) Diameters in parenthesis are to be treated as second preference.

Holes shall have their axis perpendicular to the surface bored through. The drilling or reaming shall be free from burrs, and the holes shall be clean and accurate. Holes for rivets and bolts shall not be formed by gas cutting process. Holes for counter sunk bolts shall be made in such a manner that their heads sit flush with the surface after fixing.

8.3.2.3.Assembly: Before making holes in individual members for fabrication, steel work intended to be riveted or bolted together shall be assembled and clamped properly and tightly so as to ensure close abutting or lapping of the surfaces of the different members. All stiffeners shall bear tightly both at top and bottom without being drawn or caulked. The abutting joints shall be cut or dressed true and straight, and fitted close together. Before riveting or bolting up finally, the members shall be taken apart and all burrs removed.

Web plates of girders which have no cover plates, shall have their ends flush with the tops of angles unless otherwise required. The web plates when spliced, shall have clearance of not more than 5 mm. The erection clearance for cleated ends of members connecting steel shall preferably be not greater than 1.5 mm. The erection clearance at the ends of beams without web cleats shall not be more than 3 mm at each end but where for practical reasons, greater clearance is necessary suitably designed seating shall be provided.

Column splices and butt joints of struts and compression members depending on contact for stress transmission shall be accurately, machined and close butted over the whole section. In column caps and bases, the ends of shafts together with the attached gussets, angles, channels etc., after riveting together shall be accurately machined so that the parts connected butt against each other over the entire surfaces of contact. Connecting angles or channels shall be fabricated and placed in position with great

accuracy so that they are not unduly reduced in thickness by machining. The ends of all bearing stiffeners shall be machined or grounded to fit tightly both at top and bottom.

8.3.2.4. Rivetting: (a) Rivets shall be used, where the connection is such that slip under load has to be avoided.

(b) Preliminaries before riveting : Members to be riveted shall have all parts firmly drawn and held together before and during riveting. Special care shall be taken in this respect for all single riveted connections. For multiple riveted connections, a service bolt shall be provided in every third or fourth hole.

(c) Drifting of holes shall not be permitted except to draw the parts together and the drifting tool so used shall have its maximum diameter not exceeding the nominal diameter of rivet or bolt. Drifting done during assembling shall not distort the metal or enlarge the holes.

(d) The work shall be got approved from the Engineer before rivetting is commenced. It shall be ensured that the alignment is correct, the vertical plumb, the camber correct with all camber jacks screwed tight where applicable, all joint and cover plates in correct position, service bolts tight and drifts driven and field rivet holes coinciding.

(e) Process of riveting : The riveting shall be carried out by using machines of the steady pressure type. However, where such facilities are not available, hand riveting may be permitted by the Engineer. The rivets shall be heated red hot, care being taken to control the temperature of heating so as not to burn the steel.. Rivets of diameter less than 10 mm may be driven cold. Rivets shall be finished neat, with heads full and of equal size. The heads shall be central on shanks and shall grip the assembled members firmly. All loose, burnt or badly formed rivets with eccentric or deficient heads shall be cut out and replaced. In cutting out rivets, care shall be taken so as not to injure the assembled members. Caulking and recapping shall not be permitted. All surplus materials round the rivet heads shall be removed by chipping after the rivets have cooled.

(f) For testing rivets, a hammer weighing approx. 0.25 kg. shall be used and both heads of the rivet (specially the machine head) shall be tapped. When so tested, the rivets shall not give a hollow sound and a jar. Where so specified, other tests shall be carried out to check the soundness of rivet. All rivets heads shall be painted with approved steel primer paint within a week of their fixing.

(g) All tightened up, recapped or recaulked rivets or rivets with split heads shall be replaced.

(h) Loose rivets and rivets not passed shall be painted white on head and shall be replaced at once, care being taken not to disturb the adjacent rivets.

(i) Counter sunk rivets shall be inspected after chipping heads and no unnecessary chipping shall be permitted.

(j) With the prior approval of Engineer, for rivet holes made in places where it is impossible to rivet effectively, the hole may be fitted with a machine or turned bolt and the end of the bolt hammered down over the tightened nut to prevent the latter working loose.

(k) Tools and plants will not be supplied by the Railway, unless definitely specified. The contractor shall also arrange free of cost the coal required for heating the rivets and will erect and maintain all staging as necessary. He will also do all petty repairs to snaps and other tools which may be supplied to him by the Railway.

8.3.2.5. Bolting: (a) The nominal length of the bolt shall be the distance from the underside of the head to the farther end of the shank. The nominal diameter of the bolt shall be the diameter at the shank above the screwed threads. Bolts, nuts and washers shall be thoroughly cleaned and dipped in double boiled linseed oil, before use. The linseed oil should be supplied by the Contractor and nothing extra shall be paid for this. All bolt heads and nuts shall be hexagonal unless specified otherwise. The screwed threads shall conform to IS : 1363 and the threaded surface shall not be tapered. The bolts shall be of such length as to project at least two clear threads beyond the nuts when fixed in position, and these shall fit in the holes without any shake. The nuts shall fit in the threaded ends of bolts properly.

(b) Where necessary, washers shall be tapered or otherwise suitably shaped to give the heads and nuts of bolts a satisfactory bearing. The threaded portion of each bolt shall project through the nut at least two threads. In all cases where the full bearing area of the bolt is to be developed, the bolt shall be provided with a washer of sufficient thickness under the nuts to avoid any threaded portion of the bolt being within the thickness of the parts bolted together.

(c) Where there is a risk of the nuts being removed or becoming loose due to vibrations or reversal of stresses, these shall be secured from slackening by the use of lock nuts, spring washers or as directed by the Engineer.

(d) Where turned and fitted bolts are required to be used in place of rivets, these shall be provided with washers not less than 6mm thick, so that the nut, when tightened, shall not bear on the unthreaded body of the bolt. Tapered washers shall be provided for all heads and nuts bearing on levelled surfaces. The threaded portion of the bolt shall not be within the thickness of the parts bolted together. The faces of bolt heads and nuts abutting against steel members shall be machine finished.

8.3.3. Erection

8.3.3.1 Steel work shall be hoisted and erected in position carefully, without any damage to itself or other structures and equipment and injury to workmen. The method of hoisting and erection proposed to be adopted by the contractor shall be got approved from the Engineer in advance. The contractor, however, shall be fully responsible for the work being carried out in a safe and proper manner without unduly stressing the various members. Proper equipment such as derricks, lifting tackles, winches, ropes etc., shall be used.

8.3.3.2 The work may be erected in suitable units as may be directed by the Engineer. Fabricated members shall be lifted at such points as to avoid deformation or excessive stress in members. The structure or part of it placed in position shall be secured against over-turning or collapse by suitable means.

During execution, the steel work shall be securely bolted or otherwise fastened and when necessary temporarily braced to provide for all loads to be carried safely by the structure during erection including those due to erection equipments and their operations. The steel work shall be placed in proper position as per approved drawing. Final riveting or permanent bolting shall be done only after proper alignment has been checked and confirmed.

8.3.3.3 Trusses shall be lifted only at nodes. The trusses above 10 m in span shall not be lifted by slinging at two mid points of rafters, unless temporarily braced by a wooden member of a suitable section. After the trusses are placed in position, purlins and wind bracings shall be fixed as soon as possible.

The end of the truss which faces the prevailing winds shall be fixed with holding down bolts, and the other end kept free to move. In case of trusses of spans up to 10 m the free end of the truss shall be laid on lead sheet or steel plate as per design and the holes for holding down bolts shall be made in the form of oblong slots so as to permit the free movements of the truss end. For large spans the truss shall be provided with proper bearings as per design.

8.3.3.4 Columns and stanchions shall be erected truly vertical with the necessary cross bracing etc., and the base shall be properly fixed with the foundation concrete by means of anchor bolts etc., as per drawing.

8.3.3.5 Anchor bolts to be placed in the concrete foundation should be held in position with a wooden template. At the time of concreting, anchor bolt locations shall be provided with suitable timber mould or pipe sleeve to allow for adjustment which shall be removed after initial setting of concrete. The spaces left around anchor bolts shall be linked to a stopping channel in the concrete leading to the side of the pedestal and on the underside of the base plate to allow the spaces being grouted up after the base plate is fixed in position along with the column footing. Grouting shall be of cement mortar 1:3 (1 cement : 3 coarse sand) or as specified.

8.3.3.6 Bedding of Column, Stanchions Etc., : Bedding shall not be carried out until the steel work has been finally levelled, plumbed and connected together. The stanchion shall be supported on steel wedges and adjusted to make the column plumb. For multi-storeyed buildings, the bedding shall not be done until sufficient number of bottom lengths of stanchions have been properly lined, levelled and plumbed and sufficient floor beams are fixed in position. The base plates shall be wedged clear of the plumbed and sufficient floor beams are fixed in position. The base plates shall be wedged clear of the bases by M.S. wedges and adjusted where necessary to plumb the columns. The gaps under the base plate which may be up to 25 mm shall then be pressure grouted with cement grout. With small columns, if permitted by the Engineer, the column base shall be floated on a thick cement grout on the concrete pedestal. The anchor bolt holes in the base plate may be made about 10 to 15 mm larger than the bolts. In such cases suitable washers shall be provided.

8.3.4. Painting

Before the members of the steel structure are placed in position or taken out of the workshop these shall be painted as specified in para 8.2.2. Subsequent coat or coats of paint shall be applied after all the members are finally fixed in position.

8.3.5 Measurements:- Provisions in Para 8.2.4 will apply.

8.3.6 Rate

The rate for the item shall include the cost of all labour and materials including the cost of steel, rivets, bolts and service bolts required for all the operations of the work as described above except painting of final coats. Cost of painting primary coat is included with rate. Purlins and wind bracings shall be paid for separately as steel work in single sections. Cleats, when forming part of the trusses, shall be paid for under this item. When the cleats are required to be manufactured and erected for an existing truss, payment for the same shall be made as steel work in single sections. The rates include the supply erection and removal of scaffolding, machinery, hoisting gear, derricks, ropes, pulleys, tools, plants and all consumable materials such as coal, oil etc. Painting of the final coat / coats of the steel work shall be paid for separately.

8.4 STEEL WORK IN BUILT UP SECTION (WELDED)

The steel work in built up sections (welded) such as trusses, framed work etc., has been described in the subparas below.

8.4.1 Laying out - It shall be as specified in para 8.3.1.

8.4.2 Fabrication, Erection & Painting

8.4.2.1. Straightening, shaping to form, cutting and assembling, shall be as per para 8.3.2. as far as applicable, except that the words "riveted or bolted" shall be read as "welded" and holes shall only be used for the bolts used for temporary fastening as shown in drawings.

8.4.2.2. Welding: Welding shall generally be done by electric arc process as per IS : 816 as it is economical. Where electric supply is not available, generators shall be arranged by the contractor at his own cost unless otherwise specified. Gas welding shall only be resorted to using oxyacetylene flame with the specific approval of the Engineer. Gas welding shall not however be permitted for structural steel work. Gas welding requires heating of the members to be welded along with the welding rod and is likely to create temperature stresses in the welded members. Precautions shall therefore be taken to avoid distortion of the members due to these temperatures stresses.

The work shall be done as shown in the shop drawings which should clearly indicate various details of the joint to be welded, type of welds, shop and site welds as well as the types of electrodes to be used. Symbol for welding on plane and shops drawings shall be according to IS : 813.

As far as possible every effort shall be made to limit the welding that must be done after the structure is erected so as to avoid the improper welding that is likely to be done due to heights and difficult positions on scaffolding etc., apart from the aspect of economy. The maximum dia of electrodes for welding any work shall be as per IS : 814. Joint surfaces

which are to be welded together shall be free from loose mill scale, rust, paint, grease or other foreign matter, which adversely affects the quality of weld and workmanship.

8.4.2.3. Precautions: All operations connected with welding and cutting equipment shall conform to the safety requirements given in IS : 818 for Safety requirements and Health Provision in Electric and gas welding and cutting operations.

8.4.2.4. Operation, Workmanship and Process of "Welding are described in **Annexure 8.2.**

8.4.2.5. Inspection and testing of welds shall be as per IS : 822.

8.4.2.6. Assembly: Before welding is commenced, the members to be welded shall first be brought together and firmly clamped or tack welded to be held in position. This temporary connection has to be strong enough to hold the parts accurately in place without any disturbance. Tack welds located in places where final welds will be made later shall conform to the final weld in quality and shall be cleaned off slag before final weld is made.

8.4.2.7. Erection: The specifications shall be as described in para 8.3.3. except that while erecting a welded structure adequate means shall be employed for temporary fastening of the members together and bracing the frame work until the joints are welded. Such means shall consist of erection bolts, tack welding or other positive devices imparting sufficient strength and stiffness to resist all temporary loads and lateral forces including wind. Owing to the small number of bolts ordinarily employed for joints which are to be welded, the temporary support of heavy girders carrying columns shall be specially checked. Different members which shall be fillet welded, shall be brought into as close contact as possible. The gap due to faulty workmanship or incorrect fit if any shall not exceed 1.5 mm. If gap exceeds 1.5mm or more gap occurs locally the size of fillet weld shall be increased at such position by an amount equal to the width of the gap.

8.4.2.8. Painting: Before the members of the steel structures are placed in position or taken out of the workshop these shall be painted as specified in para 8.2.2.

8.4.3. Measurements

The mode of measurements shall be the same as specified in para 8.2.4. except that weight of welding material shall not be added in the weight of members for payment and nothing extra shall be paid for making and filling holes for temporary fastening of members during erection before welding.

8.4.4. Rate

The rate shall include the cost of all labour and materials involved in all the operations described above and as described in para 8.3.6.

8.5. COLLAPSIBLE GATES (For details refer Figure 8.2)

8.5.1. Types & Components:- These shall be of approved manufacture and shall be fabricated from the mild steel sections. The gates shall consist of double or single collapsible gates depending on the size of the opening. These shall consist of vertical double channels each 20 x 10 x 2 mm at 10 cm centres braced with flat iron diagonals 20 x 5 mm and top and bottom rails of T-iron 40 x 40 x 6 mm @ 3.5 kg/m with 40 mm dia. ball bearings in every fourth double channel, unless otherwise specified. Wherever collapsible gate is not provided within the opening and fixed along the outer surface. T-iron at the top may be replaced by flat iron 40 x 10 mm.

The collapsible gate shall be provided with necessary bolts and nuts, locking arrangement, stoppers and handles. Any special fittings like spring, catches and locks, shall be so specified in the description of item where so required. The gate shall open and close smoothly and easily.

8.5.2. Fixing

T-iron rails shall be fixed to the floor and to the lintel at top by means of anchor bolts embedded in cement concrete of floor and lintel. The anchor bolts shall be placed approximately at 45 cm centres alternatively in the two flanges of the T-iron. The bottom runner (T-iron) shall be embedded in the floor and proper groove shall be formed along the runner for the purpose. The collapsible shutter shall be fixed at sides by fixing the

end double channels with T-iron rails and also by hold-fasts bolted to the end double channel and fixed in masonry of the side walls on the other side. In case the collapsible shutter is not required to reach the lintel, beam or slab level, a Tee-section suitably designed may be fixed at the top, embedded in masonry and provided with necessary clamps and roller arrangement at the top. All the adjoining work damaged in fixing of gate shall be made good to match the existing work, without any extra cost.

8.5.3. Painting

All the members of the collapsible gate including T-iron shall be thoroughly cleaned off rust, scales, dust etc., and given a priming coat of approved steel primer i.e. red oxide zinc chrome primer conforming to IS : 2074 or as specified before fixing them in position.

8.5.4. Measurements

The height and breadth shall be measured correct to a cm. The height of the gate shall be measured as the length of the double channels and breadth from outside to outside of the end fixed double channels in open position, of the gate. The area shall be calculated in square metres, correct to two places of decimal.

8.5.5. Rate

The rate shall include the cost of all labour and materials involved in all the operations described above.

8.6. M.S. SHEET SLIDING SHUTTERS (Refer Figure 8.3A)

8.6.1.Types & Components:- These shall be manufactured as per drawings and specifications. These shall be fabricated from mild steel sheets. The shutters shall be double or single leaf shutter as specified. The shutters shall be fabricated of specified size of M.S. angle iron frame diagonally braced with the same size of M.S. angle and riveted together with 3 mm gusset plate at junction to form a rigid frame M.S. sheet of 1 mm thickness or as specified shall be fixed to the frame with rivets, as approved by the Engineer. These shall also be provided with top and bottom guide rails of specified size angles or T-irons and 25 mm diameter pulley or with 25 mm diameter ball bearing at the bottom and guide back with steel pulleys at the top. The shutters shall also be provided with locking arrangement, handles, stoppers, holdfasts and other fittings as specified in the description of the item.

The guide rails shall be sufficiently long and continued along the wall on both ends so that the sliding shutters can rest against the walls, giving full opening when so required.

8.6.2. Fixing

The guide rails shall be fixed to the floor by means of anchor bolts embedded in the floor. The steel section at the top shall be suitably supported from the walls. Two channel sections shall be suitably fixed vertically below the extreme clamps in the wall and floor to avoid the shutter from going out of the supports at top and bottom. A suitable clamping arrangement will be provided at either end of the opening to avoid the shutters from rolling back into the opening. All the adjoining work damaged in fixing shall be made good to match the existing work.

8.6.3. Painting

All members of the sliding shutters including fittings shall be thoroughly cleaned of rust, scales, dust etc., and given a priming coat of approved steel primer i.e. Red oxide chrome primer conforming to IS : 2074 or as specified before fixing them in position.

8.6.4. Measurements

The height and breadth shall be measured correct to a cm. and its area for payment shall be calculated in square metres correct to two places of decimal. The height of the shutter shall be measured from outside to outside of the guide rail and width outside to outside of the shutter including the vertical position channels in sides, when closed.

8.6.5. Rate

The rate shall include the cost of all labour and materials involved in all the operations described above.

8.7. M.S. SHEET SIDE HUNG SHUTTERS (REFER FIGURE 8.3B)

8.7.1.Types & Components:- These shall be manufactured as per drawing and specifications. These shall be fabricated from mild steel sheets and angle iron. The doors shall be provided as double leaf shutters unless otherwise specified. The shutters shall be fabricated with frame of M.S. angle 40 x 10 x 6 mm @ 3.5 kg/metre and two diagonal braces of the same section as shown in **Figure 8.3B** unless otherwise specified. The frame shall be riveted and/or welded at the junctions. Wherever riveting shall be done 3 mm gusset plate shall be provided at the junctions. M.S. sheet of 1 mm thickness or as specified, shall be fixed to the frame with rivets as approved by the Engineer.

Alternatively the diagonal bracing may be replaced by one horizontal and two cross flats 30 x 6 mm unless otherwise specified.

The outer frame shall be provided with cleats made of section 40 x 40 mm and bent in the shape of angle cleats with one arm 150 mm long and the other arm 50 mm long and fixed to the angle iron frame of the door with two 12 mm dia bolts and nuts, For doors up to 2.40 m height, two angle cleats per door shall be provided.

The cleat shall have a vertical leg of 150 mm which shall be fixed with frame and horizontal leg of about 50 mm which shall be provided with a hole of 24 mm dia and fixed in the projected pin of the pin clamp.

8.7.2. Fittings and Fixtures

The shutter shall be fixed to the wall masonry with four pin clamps (pintles) where the height of the shutter is up to 2.4 m. Each pin clamp shall consist of 50 x 6 mm flat iron 45 cm long bent and forked at one end and provided with 20 mm diameter. M.S. pin on the other. The pin shall be firmly riveted or welded to the pin clamp, the other end of which shall be embedded in masonry by means of cement concrete block 40 x 20 x 20 cm of 1:2:4 mix (1 cement : 2 coarse sand : 4 graded stone aggregate 20 mm normal size). It shall be so placed that bottom pin shall face towards and Top pin downward in order that the gate may not be removed by lifting over pins.

One hook with eye 45 cm long of 10 mm diameter shall be provided for each shutter to keep it fixed in open position. The hook shall be fixed in wall masonry with wooden block and the eye shall be fixed on 6 mm thick M.S. plate as staple and fixed in the shutter frame with rivet or weld.

A cement concrete block 15 x 10 x 20 cm in 1:2:4 (1 cement : 2 coarse Sand : 4 Graded Stone aggregate of 20 mm nominal size) mix shall be embedded in the floor or at junction of two shutters so that door shutters, open only on the outside and not on the inside. The shutters shall also be provided with locking arrangement and two handles of the shape and pattern as approved by the Engineer.

8.7.3. Painting

All the members of the door including angle iron shall be thoroughly cleaned off rust, scales, dust etc., and given a priming coat of approved steel primer i.e. Red Oxide Zinc primer conforming to IS : 2074 or as specified before fixing them in position.

8.7.4. Measurements

The width and height of shutters shall be measured to the nearest cm. The area shall be calculated in square metre correct to two places of decimal.

8.7.5. Rate

The rate shall include the cost of all labour and materials involved in all the operations described above. Nothing extra shall be paid for cement concrete blocks or wooden blocks nor anything deducted for these from the measurement of the masonry wall.

8.8. ROLLING SHUTTERS

8.8.1. General:

8.8.1.1 Rolling shutters shall conform to IS : 6248. These shall include necessary locking arrangement and handles etc., These shall be suitable for fixing in the position, which may be one of the following as specified

1. Fixture on the inside, above bottom of lintel, with guides on the inside face of wall.

2. Fixture on the outside, above bottom of lintel, with guides on the outside face of wall.
3. Fixture on the outside, below bottom of lintel, with guides on the outside face of wall.
4. Fixture under the lintel, with guides on the jambs.
5. Fixture on the inside, below bottom of lintel, with guides on the inside face of wall.

The door shall be either of push and pull type or operated with mechanical device supplied by the manufacturer. Shutters up to 10 sq. metre shall be of push and pull type and shutters with an area of over 10 sq. metre shall generally be provided with reduction gear operated by mechanical device with chain or handle. If bearings are specified for ease of operation, these shall be paid for separately.

8.8.1.2. Shutter : The shutter shall be built up of inter-locking lath section formed from cold rolled steel strips. The thickness of the sheets from which the lath sections have been rolled shall be not less than 0.90 mm for the shutters up to 3.5 metre width and not less than 1.20 mm for shutters above 3.5 m width. Shutters above 9 metres in width should be divided in 2 parts with provision of one middle fixed or movable guide channel or supported from the back side to resist wind pressure. The lath section shall be rolled so as to have interlocking curls at both edges and a deep corrugation at the centre with a bridge depth of not less than 12 mm to provide sufficient curtain of stiffness for resisting manual pressures and normal wind pressure. Each lath section shall be a continuous single piece without any welded joint. When interlocked, the lath sections shall have a distance of 75 mm rolling centres. Each alternate lath section is fitted with malleable cast iron or mild steel clips securely riveted at either ends, thus locking the lath section at both ends and preventing lateral movement of the individual lath sections. The clips shall be so designed as to fit the contour of the lath sections.

8.8.1.3. Spring:- The spring shall be of coiled type. The spring shall be manufactured from high tensile spring steel wire or strips of adequate strength conforming to IS : 4454 Part I.

8.8.1.4. Roller and Brackets: The suspension shaft of the roller shall be made of steel pipe conforming to heavy duty as per IS : 1161. For shutter up to 6 metre width and height not exceeding 5 metre, steel pipes of 50 mm nominal bore shall be used. The shaft shall be supported on mild steel brackets of size 375 x 375 x 3.15 mm, for shutters up to a clear height of 3.5 metre. The size of mild steel brackets shall be 500 x 500 x 10 mm for shutters of clear height above 3.5 m and up to 6.5 m. The suspension shaft clamped to the brackets shall be fitted with rotatable cast iron pulleys to which the shutter is attached. The pulleys and pipe shaft shall be connected by means of pre-tensioned helical springs to counter-balance the weight of the shutter and to keep the shutter in equilibrium in any partly open position

8.8.1.5. When the width of the opening is greater than 3.5 mtr, the cast iron pulleys shall be inter-connected with a cage formed out of mild steel flats of at least 32 x 6 mm and mild steel dummy rings made of similar flats to distribute the torque uniformly. Self aligning two row ball bearings with special cast iron casings shall be provided at the extreme pulley and caging rings shall have a minimum spacing of 15 mm and at least 4 number flats running throughout length of roller shall be provided.

8.8.1.6. In case of shutters of large opening with mechanical device for opening the shutter the roller shall be fitted with a purion wheel at one end in contact with a worm fitted to the bracket plate, caging and pulley with two ball bearings shall be provided.

8.8.1.7. Guide Channel : The width of guide channel shall be 25 mm and the minimum depth of guide channels shall be as follows:-

Clear width of shutters	Depth of guide channel
Up to 3.5 m	65 mm
3.5 m up to 8 m	75 mm
8 m and above	100 mm

8.8.1.8. The gap between the two legs of the guide channels shall be sufficient to allow the free movement of the shutter and at the same time close enough to prevent rattling of the shutter due to wind.

8.8.1.9. Each guide channel shall be provided with a minimum of three fixing cleats or supports for attachment to the walls or column by means of bolts or screws. The spacing of cleats shall not exceed 0.75 m. Alternatively, the guide channels may also be provided with suitable dowels, hooks or pins for embedding in the walls.

8.8.1.10. The guide channels shall be attached to the jambs, plumb and true either in the over-lapping fashion or embedded in grooves, depending on the method of fixing.

8.8.1.11. Cover: Top cover shall be of mild steel sheets not less than 0.90 mm thick and stiffened with angle or flat stiffeners at top and bottom edges to retain shape.

8.8.1.12. Lock plates with sliding bolts, handles and anchoring rods shall be as per IS : 6248.

8.8.2. Fixing

8.8.2.1 The arrangement for fixing in different situations in the opening shall be as per IS : 6248.

8.8.2.2. Brackets shall be fixed on the lintel or under the lintel as specified with rawl plugs and screws, bolts etc., The shaft along with the spring shall then be fixed on the brackets.

8.8.2.3 The lath portion (shutter) shall be laid on ground and the side guide channels shall be bound with ropes etc., The shutter shall then be placed in position and top fixed with pipe shaft with bolts and nuts. The side guide channels and cover frames shall then be fixed to the walls through the plate welded to the guides. These plates and bracket shall be fixed by means of steel screws bolts, and rawl plugs concealed in plaster to make their location invisible. Fixing shall be done accurately in a workman- like manner so that the operation of the shutter is easy and smooth.

8.8.3. Measurements

The actual area of rolling shutters shall be measured in square metres correct to two places of decimals. The width shall be measured as the width of the shutter including portions hidden in the guide channels and height shall be measured as the length of the shutter from the bottom of the locking plate to the top of the laths including portion above the opening. The area shall be calculated in square metres correct to two places of decimal.

8.8.4. Rate

The rate shall include the cost of materials and labour involved in all the operations described above including cost of top cover and spring except ball bearing and mechanical device of chain and crank operation, which shall be paid for separately.

8.9. ROLLING GRILLS

8.9.1 General: (a) Rolling grill is meant to provide visibility or ventilation or both though the degree of protection and safety is less as compared to a rolling shutter. In the situations where a certain amount of ventilation combined with safety is required, rolling shutter-cum-grill may be provided in which the rolling shutter may have rolling grill portion either at the top or at the bottom or at both places. The rolling grill portion may also be provided in the middle of the shutter. The total height of the grill portion in all the segments of rolling shutter-cum-grill shall not exceed 1.0 m and the height of the grill portion in any individual segment shall not be more than 0.5 m.

(b) Rolling grills are similar in design, construction and operation to rolling shutters and all the provisions of para 8.8 shall be applicable to rolling grills which shall also conform to IS : 6248.

8.9.2. Shutters

Rolling grill shutter and the rolling grill portion of the rolling shutter-cum-grill shall be fabricated with 8 mm diameter mild steel round bars. Straight bars and bars bent to the required profile are placed alternatively and held in position with 20 mm wide and 5 mm thick mild steel flat links. Straight bars shall be spaced not exceeding 150 mm centre to

centre and the bars bent to required profile shall be placed symmetrically between two consecutive straight bars. Unless otherwise specified or directed by the Engineer, bars placed alternately with straight bars shall be bent to form a corrugated profile such that the pitch of the corrugation is 100 to 120 mm and the depth of corrugation is 80 to 100 mm. All the bent bars shall have uniform profile. Straight bar along with the adjoining bent bars on both sides shall be held in position by passing the bars through holes in the links. Each link shall have three holes and the length of the links shall be such that the distance from the centre of the hole to the nearest edge of the flat is not less than the diameter of the hole. The corner of the links shall be rounded. All links shall be of uniform size and shape. The spacing of the links measured along the straight bar shall be of uniform size and shape and shall be the same as centre to centre distance between two consecutive crests/troughs of the bars bent to the required profile. Each bar and link shall be a continuous single piece without any joint.

8.9.3. Measurements and Rate

The measurements and rate shall be as specified in paras 8.8.3. and 8.8.4 respectively. In case of Rolling Shutter-cum-Grill, where the area of the grill portion is half or less than half the area of opening, it shall be measured and paid as rolling shutter and where the area of grill portion is more than half the area of opening, it shall be measured and paid as rolling grill.

8.10. STEEL DOORS, WINDOWS, VENTILATORS AND COMPOSITE UNITS (Refer Figure 8.4)

8.10.1 General(a) Hot rolled steel /sections for fabrication of steel doors, windows, ventilators and fixed lights including shapes, weights and designations of the sections shall be as per IS : 7452. **Annexure 8.3** indicates the purpose or the situation where the sections are normally used. Tolerance in thickness of the sections shall be + 0.2 mm. The steel doors, windows, ventilators and composite units shall be got fabricated in a workshop approved by the Engineer.

(b) Steel doors, windows, ventilators and sashes shall conform to Indian Standard Specification No. IS 1038. The type, over all sizes, side opening position of steel doors, windows and ventilators shall be specified as per details given in IS 1038. The provision of a thresh hold or tie bar etc at the bottom of the door frame shall also be specified. Unless otherwise specified, the weight of the different rolled steel sections used for the manufacture of doors, windows, and ventilators shall not be less than those specified in IS 1038.

(c) Standard sizes and their designation

The overall sizes of standard doors, windows and ventilators as per IS:1038 are derived after allowing a clearance of 1.25 cm on all the four sides for purpose of fitting them into "modular" openings (i.e. openings with the principal dimensions in multiples of the 10 cm module) In the case of doors, if threshold at bottom of door opening is not to be provided as is the present general practice, there will be no need for a gap of 1.25 cm at the bottom and the height of steel door may be 1.25 cm instead of 2.5cm less than the height of modular opening. The standard sizes of openings prescribed for doors, windows and ventilators are the following:-

For	Standard Sizes of openings	
	Heights (cm)	Widths (cm)
Doors	210	60, 80 and 120
Windows	90,120 and 150*	60,100, 120, 150 and 180
Ventilators	60	60, 80, 100, 120, 150 and 180

(Note:- * Windows 150 cm in height are with fixed light above).

Doors, windows and ventilators are designated by a sequence of symbols denoting their width, type and height respectively. The width and height are indicated in terms of the

number of modules and the type through a combination of two of the following letters of the alphabet.

	Letter	Denoting
i)	H-----	With horizontal glazing bars.
	N-----	Without horizontal glazing bars.
ii)	C-----	Centre-hung shutters
	S-----	Side-hung shutters
	T-----	Top-hung shutters
	F-----	Fixed glass panes.

A few examples of standard designations are (a) Door 12 HS 21, (b) Window 12 HS/12 and (c) Ventilators 12 HF 6, as illustrated in **Figure 8.4** in the form of a combination of the three which is jointly designated as –

12 HF 6 / 12 HF 6
12 HS 21 / 12 HS 12

(d) Fittings:- The following are the minimum items to be supplied with steel doors, windows, and ventilators:-

- i) Frames and Shutters (including coupling sections, weather bars etc as required)
- ii) Projecting hinges for shutters
- iii) Lugs or other fixing device as necessary
- iv) One peg stay for each window shutter and top-hung ventilator shutter
- v) One spring catch, cord eye and pulley and 2 sets of pivots for each centre-hung ventilator shutter
- vi) One handle for each window shutter
- vii) One door handle for each door shutter
- viii) Lock plate, with locking arrangements for each door
- ix) Glazing clips (where necessary)
- x) Two drop-bolts for each door (for the first closing shutter in double leaf doors)

The handle for window shutters shall have a “two point” nose, with a striking plate on the fixed frame to engage it either in the fast position or in a slightly open position, when the handle is turned. The fittings under items (iv) to (vii) and (x) shall be of brass, bronze or other non-ferrous metal mentioned in IS:1038, notwithstanding steel being mentioned in some cases as a permitted alternative.

e) Tolerance in Size:- The steel doors and windows shall be according to the specified sizes and design as indicated in (c) above. The actual sizes of doors, windows and ventilators shall not vary by more than + 1.5 mm from those given in the drawing.

8.10.2. Fabrication

8.10.2.1. Frames: Both the fixed and opening frames of Hot rolled steel shall be made of sections which have been cut to length and mitred. The corner of fixed and opening frames shall be welded to form a solid fused welded joint conforming to the requirements given below. All frames shall be square and flat. The process of welding adopted shall be flash butt welding or metal arc welding or any other suitable method. The section for glazing shall be tennoned and riveted into the frames and where they intersect the vertical tie shall be broached and horizontal tie threads through it, and the intersection closed by hydraulic pressure. equirements of welded joints for steel products:-

(i) Visual Inspection Test - When two opposite corners of the frame are cut, paint removed and inspected, the joint shall conform to the following:

- (a) Welds should have been made all along the place of meeting the members and tack welding shall not be permitted.
- (b) Welds should have been properly grounded and
- (c) Complete cross section of the corner shall be checked up to see that the joint is completely solid and there are no cavities visible.

(ii) Micro and Macro Examinations

From the two opposite corners obtained for visual test, the flanges of the sections shall be cut with the help of a saw. The cut surface of the remaining portions shall be polished,

etched and examined. The polished and etched faces of the weld and the base metal shall be free from cracks and reasonably free from under cutting, overlaps, gross porosity and entrapped slag.

(iii) Fillet Weld Test

The fillet weld in the remaining portion of the joint shall be fractured by hammering. The fractured surfaces shall be free from slag intrusion, porosity, crack penetration defects and fusion defects.

8.10.2.2.Door: The hinges shall normally be of 50 mm projecting type. Non-projecting type hinges may also be used if approved by the Engineer. The hinge pin shall be of electro-galvanized steel or aluminium alloy of suitable thickness and size. Door handles shall be approved by the Engineer. A suitable latch lock for door open-able both from inside and outside shall be provided.

In the case of double doors, the first closing leaf shall be that the left hand leaf with locking of the door from the push side. The first closing shutter shall have a concealed steel bolt at top and bottom. The bolts shall be so constructed as not to work loose or drop by its own weight.

Single and double shutter door may be provided with a three way bolting device. Where such device is provided in the case of double shutters, concealed brass or steel bolts shall not be provided.

8.10.2.3. Windows

(a) For fixed windows, the frames shall be fabricated as per para 8.10.2.1.

(b) Side hung windows

For fixing steel hinges, slots shall be cut in the fixed frame and hinges inserted inside and welded to the frame at the back. The hinges shall normally be of projecting type with thickness not less than 3.15 mm and length not less than 65 mm and width not more than 25 mm. Non projecting type hinges may also be allowed if approved by the Engineer. The diameter of hinge pins shall not be less than 6 mm. The hinge pin and washer shall be of galvanized steel or aluminium alloy of suitable thickness.

For fixing hinges to inside frame, the method described above may be adopted but the weld shall be cleaned, or the holes made in the inside frame and hinge riveted.

The handle of side hung shutters shall be pressed brass, cast brass, aluminium or steel protected against rusting and shall be mounted on a steel plate. Thickness of handle shall not be less than 3 mm in case of steel or brass and 3.5 mm in case of aluminium. The handle plate shall be welded, screwed and/or riveted to the opening frame in such a manner that it should be fixed before the shutter is glazed and should not be easily removable after glazing.

The handle shall have a two point nose which shall engage with a brass or aluminium alloy striking plate on the fixed frame in a slightly opened position as well as closed position. The boss of handle shall incorporate a friction device to prevent the handle from dropping under its own weight and the assembly shall be so designed that the rotation of the handle may not cause it to unscrew from the pin.

The height of the handle plate in each type of standard windows will be as specified. Otherwise it shall be at a height of 3/8 of the height of shutter, from its bottom. The strike plate shall be designed and fixed in such a position in relation to the handle that with the later bearing against its stop, there shall be adequately tight fit between the casement and outer frames.

In case where no friction type hinges are provided, the window shall be fitted with peg stays which shall be either of black oxidized steel, pressed or cast brass or as specified, 300 mm long with steel peg and lacking brackets. The pegs stay shall have three holes to open the side hung casement in three different angles. The peg stay shall be of minimum thickness 2 mm in case of brass or aluminium and 1.25 mm in case of steel. Where specified, Side hung shutters fitted with friction hinges shall also be provided with a peg stay.

If specified, side hung shutters may be provided with an internal removable fly proof screen in a 1.25 mm thick sheet steel frame fitted to the outer frame of the shutter by

brass turn buckles at the jamb, and brass studs at the sill to allow the screen being readily removed. The windows with removable fly proof screen shall be fitted with a through-the-screen level operator at the sill level to permit the operation of the shutter through an angle of 90° without having to remove the fly proof screen. The lever shall permit keeping the shutter open in minimum three different positions.

8.10.2.4. Ventilators

(a) Top Hung Ventilators - The steel butt hinges for top hung ventilators shall be riveted to the fixed frame or welded to it at the back after cutting a slot in it. Hinges to the opening frame shall be riveted or welded.

Top hung ventilators shall be provided with a peg stay with three holes which when closed shall be held tightly by the locking bracket. The locking bracket shall either be fitted to the fixed frames or to the window.

(b) Centre Hung Ventilators - Central hung ventilators shall be hung on two pairs of brass or aluminium cup pivots as specified, riveted to the inner and outer frames of ventilators to permit the ventilator shutter to swing to an angle of approx 80° . The opening portion of the ventilators shall be so balanced that it remains open at any desired angle under normal weather conditions.

8.10.2.4.1. A black oxidized steel spring catch approved by the Engineer shall be fitted in the centre of the top of the centre hung ventilator, for the operation of ventilators. The spring catch shall be secured to the frame with M.S. screws and shall close into a mild steel or malleable iron catch plate riveted, screwed or welded to the outside of the outer window frame bar.

8.10.2.4.2. A black oxidized cord pulley wheel in galvanized mild steel brackets shall be fitted at sill of the centre hung window with mild steel screws or alternatively welded together with a mild steel or malleable iron cord-eye riveted or welded to the bottom inter frame bar of the window in a position corresponding to that of pulley.

Removable fly-proof screen may be provided as specified in para 8.10.2.3.(b). This shall be fitted with a through-the-screen operator to enable operating and keeping the shutter open in minimum three different positions.

8.10.2.5. Composite Units: Composite units consist of a combination of two or more units of doors, windows and ventilators etc., as the case may be. The different units shall be coupled by using coupling sections K-11B or K-12B (Ref. **Annexure 8.3**) as the case maybe.

Wherever the ventilators, windows and doors shall be coupled with a coupling section, mastic cement shall be applied between the junction to make the joint water tight.

8.10.3. Glazing

8.10.3.1. Specifications described in para 7.2.9. shall apply. The glass panes shall have square corners and straight edges. The glass pane shall be so cut that it fits slightly loose in the frames. In doors, windows and clerestory windows of bath, WC and lavatories frosted glass panes shall be used which shall weigh not less than 10.00 kg/m^2 for 4 mm thick glass.

8.10.3.2. Glazing shall be provided on the outside of the frame unless otherwise specified. Putty of approved make conforming to IS : 419 shall be used for fixing glass panes. Putty shall first be applied between glass panes and glazing bars. Putty shall then be applied over the glass pane, which shall stop 2 to 3 mm from the sight line of the back rebate to enable the painting to be done up to the sight line to seal the edge of the putty to the glass. The oozed out putty shall be cleaned and putty cut to straight line. Quantity of putty shall not be less than 185 gm/metre of glass perimeter. Putty shall be painted within 2 to 3 weeks, after glazing is fixed to avoid its cracking.

Note: Putty may be prepared by mixing one part of white lead with three parts of finely powdered chalk and then adding boiled linseed oil to the mixture to form a stiff paste and adding varnish to the paste at the rate of 1 litre of varnish to 18 kg of paste.

8.10.3.3. Four glazing clips may be provided per glass pane for a size larger than $30 \text{ cm} \times 60 \text{ cm}$ for all types. Where the glass panes size exceed $80 \text{ cm} \times 200 \text{ cm}$, 6 glazing clips shall be used. In case of doors, windows and ventilators without horizontal glazing bars,

the glazing clips may be spaced according to the slots, in the vertical members, provided the spacing does not exceed 30 cm, otherwise the spacing shall be 30 cm.

Note: Where large size glass panes are required to be used or where the door or window is located in heavily exposed situation, holes for glazing clips have to be drilled prior to fabrication as it cannot be done at any later stage. Use of glazing clips shall be specified while placing the order.

8.10.3.4. Where specifically stipulated, fixing of glass panes may be done with metal or wooden beading instead of with putty. Where beadings are proposed to be used, the manufacturers shall be intimated in advance to drill holes for hard screws. Usually beads shall be fixed with screws spaced not more than 10 cm from each corner and the intermediate not more than 20 cm apart. When glass panes are fixed with wooden or metal beading having mitred joints, a thin layer of putty shall be applied between glass panes and sash bars and also between glass panes and the beading. Where metal beading is specified extra payment shall be made on this account unless specified otherwise.

8.10.4. Finishing

(a) All steel surfaces shall be thoroughly cleaned of rust, scale and dirt. Where so specified, the steel surfaces shall be treated for rust proofing by the hot dip, zinc spray or electro galvanizing process. A priming coat of approved steel primer i.e. red oxide zinc chrome primer conforming to IS: 2074 or as specified shall be given. The fabricated steel door, windows, ventilators and composite units shall be inspected in the factory and approved by the Engineer before priming coat is applied.

(b) Final finishing cost shall be given to the doors, windows and ventilators after they are erected and fixed in final position. The rate shall be exclusive of final finishing coats but shall include the priming coat.

(c) In case of galvanized doors, windows and sashes, their surface shall be treated with copper acetate solution or other approved mordant solution to ensure proper adherence of the paint, unless the galvanised surface has weathered adequately at the time of final painting. Non-ferrous parts and working parts such as handles, stays, catches, handle pins, hinges / pins, etc shall not be painted. Treatment with the mordant solution is not included in the rate and shall be paid for separately.

8.10.5. Fixing (Refer Figure 8.5)

8.10.5.1. Steel, doors and windows shall be so stacked as to keep them in true shape without damage. Doors, windows and ventilators shall be fixed as described below:

8.10.5.2. Metal doors, windows and ventilators may be required to be fixed to either masonry openings (including brick, concrete, stone and marble) or timber openings or steel work openings.

- a) Masonry openings – Masonry openings may either be rebated or flush and in either case, they may have either external rendering applied or be ‘fair-faced’ (that is, without external rendering). It is usual for stone or marble masonry to be fair-faced.
- b) Timber openings – Timber openings are invariably rebated.
- c) Steelwork openings – Steelwork openings vary in detailed design but shall be so designed that the outer frame of the door, window or ventilator frame sections overlap a steel surface either externally or internally.

Opening may be flush or rebated as shown in the drawings. Where openings are flush and with a rendered finish a clearance of 1.25 cm shall be provided between the steel frame and opening (**Figure 8.5**). In case of external masonry finish “fair faced” and with rebated jambs, a minimum 1.25 cm clearance between frame and opening shall be provided (**Figure 8.5**). Opening in steelwork shall be so designed that the outer flange of the door, windows, or ventilator frame section over-laps the steel surface by 10 mm (**Figure 8.5**).

Note: As mentioned in Para 8.10.1 (c) the sizes of Indian Standard doors, windows and ventilators, are designed for modular opening 1.25 cm larger all round than the doors, windows etc., This gap of 1.25 cm is for the purpose of fixing of doors, windows etc., In masonry openings, the gap is filled up with mastic cement and plaster after the door or

windows is fixed in position. In the case of steel or timber modular openings, extra steel or timber fillets will be necessary to cover this gap of 1.25 cm.

8.10.5.3. Fixing in Masonry Openings

(a) Fixing with Lugs

(i) Doors, windows and ventilators unit, shall not be “built in” as the work proceeds but opening shall be left out and frames fitted afterwards so that the minimum specified clearance between opening and unit frame is left around. The size of the opening shall first be checked and cleared of obstruction, if any. The position of the unit and fixing holes shall be marked on the jamb. Necessary holes shall be made in the masonry and lugs not less than 10 cm long 15 x 3 mm size fixed in cement concrete blocks 15 x 10 x 10 cm size of 1:2:4 mix (1 cement : 2 coarse sand : 4 graded stone aggregate 20 mm nominal size). The frames of units shall be set in the opening by using wooden wedges at the jamb, head and sill. Wedges shall preferably be placed near the points where a glazing bar meets the frames and be plumbed in position.

(ii) After it, the frame shall be fixed with the lugs with 20 mm long and 6.3 mm dia G.I. counter sunk machine screws and nuts. In case of flush opening which are rendered smooth, wedges shall be removed and gap between unit and the jambs shall be filled with cement mortar (see **Figure 8.5**)

(iii) In case of flush jamb with external “fair faced” finish the gap between the opening and frame shall be filled with mastic from inside till it oozes out on external face. The oozing mastic shall be cleaned and flush pointed. The internal gap shall be filled with mastic to about 1/3rd depth and the rest with cement mortar (**Figure 8.5**).

(iv) In case of rebated jambs and jambs finished ‘fair faced’ externally, the mastic shall be freely applied to the inside channel of frame, jamb and sill, so as to ensure a watertight joint. After the unit is firmly tied in position surplus mastic shall be cleaned and flush pointed, as shown in **Figure 8.5**.

(b) Fixing with screws and plugs

In R.C.C. work where lugs cannot be embedded due to reinforcement bars etc., and in dressed stone and Marble surrounds, rawl plugs or other approved metallic fasteners may be fixed in proper position and frame fixed to them with 60 mm galvanized wood screws of designation 10.

8.10.5.4. Fixing in Wood Works Opening: Openings in wood work are normally rebated and approved mastic or rubber linings shall be applied to jambs, sill and channel before fixing in position. The frame shall be set in opening using wooden wedges as specified in para 8.10.5.3. and fixed to the opening with 60 mm galvanized wood screws of designation 10. Extra timber fillets of hard wood to match the adjoining work shall also be provided around the frame to close the extra gap between opening and frame (Refer **Figure 8.5**)

8.10.5.5. Fixing in Steel Work Opening: Before placing the unit frame in position approved mastic shall be applied as specified in para 8.10.5.3. (a.iv) and a mild steel or hard wood fillet shall be provided around the frame to close the extra gap between opening and frame. The unit shall be fixed to the opening with fixing clips or with nuts and bolts as shown in the drawings or as directed by the Engineer. (Refer **Figure 8.5**)

8.10.5.6. Fixing of Composite Units: The fixing procedure for composite units shall generally be as described under paras 8.10.5.1. to 8.10.5.5 except that :

Where large units shall be formed by coupling individual units together (with coupling sections) the mullions and transoms shall be bedded in mastic to ensure water tightness. Mastic shall be applied liberally to the channels of the outside frame sections before assembly and after coupling. All oozing out mastic shall be cut out neatly. If there is a cross joint of mullion and transome, the shorter coupling unit shall run through unbroken. Mullions normally project 2.5cm at head and sill into the surround; transomes also project 2.5cm into surround and where appropriate they shall be cut.

8.10.5.7 Fixing of Aluminium frames

In case of Aluminium frames, the surfaces shall be anchored in direct contact with the surrounds and shall be protected with two coats of alkali resistant paints, to avoid chemical attack from the materials of surround.

8.10.6. Precautions

Care shall be taken that steel doors and windows etc., are not deformed/damaged during subsequent constructions. Particular care shall be taken that scaffolding does not rest on the steel door /window frames or glazing bars.

All fittings and hinges (projecting hinges) shall be protected, preferably with alkathene sheets so that these may not be damaged during execution of work.

8.10.7. Measurements

The height and width shall be measured correct to 1 mm. The area shall be calculated in square metre correct to two places of decimal. The fixed, side hung and top hung categories shall be measured separately.

All composite units shall first be measured as fixed. Extra shall then be added for side hung, top hung and centre hung portions. The measurements for extra for side hung, centre hung and top hung windows shall be taken from outside to outside of the casement frames.

8.10.8. Rate for Supply and Fixing by the Contractor

Rates shall include the cost of materials and labour involved in all the operations described above excluding two coats of painting but including cost of glazing and priming coat and the cost of projecting hinges in case of side hung doors/windows, plain hinges in case of top/bottom hung windows/ventilators and pivots for centre hung windows/ventilators.

Metal beading and other fittings such as peg stays and casement window fasteners etc. shall be enumerated and paid for separately. Rate shall not include the cost of cement concrete blocks if required for fixing of hold fasts which will be paid for separately.

8.11. T-IRON DOORS, WINDOWS AND VENTILATOR FRAMES (Refer Figure 8.6)

8.11.1 General:-(a) T-iron doors, windows and ventilators frames shall be manufactured from uniform mild steel Tee section. The steel shall be of the grade as provided in para 8.1.1. The frames shall be got fabricated in a workshop as approved by the Engineer.

(b) The sizes of doors, windows and ventilator frames shall be as per drawing or as decided by the Engineer MS tie bar of 10 mm dia shall be welded at bottom of the frame. The size of doors, windows and ventilators shall be calculated so as to allow 12.5 mm clearance on all sides to allow an easy fitting in opening. The actual size of doors, windows and ventilators shall not vary by more than ± 2 mm than those shown in the drawings.

The size of T section used for manufacture of doors, windows and ventilators shall not be less than those specified in IS:1038 (See **Figure 8.6**), unless otherwise directed by the Engineer.

8.11.2. Fabrication

The frame shall be constructed using section which has been cut to length and mitred. The corners of the frames shall be butt welded to form a true and right angle. All frames shall be square and flat meeting the requirements stated under para 8.10.2.1. The T section shall be mitre joined and continuously butt welded all along. The requirement of welded joints shall be as specified under para 8.10.2.1.

8.11.3. Fittings

Requisite number of holes shall be made in the frame for fixing of fittings. Detailed arrangements of fixing fittings shall be as shown in **Figure 8.6**. All fittings shall be fillet welded to T-iron frame all along the periphery of contact.

i) Butt hinges shall be fixed to the frame as below:

M.S. flat of size 100 mm x 25 mm x 6 mm will be welded with fillet weld all along the periphery of contact on the rear side of the web of T-iron to receive the hinges. Requisite

number of holes shall be made in T-iron frame and MS flat for fixing of hinges with counter sunk steel screws as shown in **Figure 8.6**.

(ii) An alternate method of fixing butt hinges can be adopted by fillet welding the hinge to the T-iron frame on three sides. No welding shall be done along the hinge pin to allow free movement of butt hinges as shown in **Figure 8.6**.

8.11.4. Fixing

Fixing procedure for T-iron doors, windows and ventilator frames in masonry opening shall be as described in para 8.10.5. Fixing arrangements of shutters to such frames is shown in **Figure 8.6**.

8.11.5. Measurements

T-iron doors, windows and ventilator frames shall be measured in running metre, along the centre line of the frame correct to a 1 mm and weight calculated on the basis of standard tables. No deduction or extra payment shall be made for making holes and making arrangements for fixing fittings including packing wherever necessary. No deduction will be made for not providing tie bars in case of windows and ventilators.

8.11.6. Rate

The rate includes cost of materials and labour involved in all the operations described above. It shall include the necessary butt hinges and screws for fixing the same with frame or as specified. But it does not include the cost of other door and ventilator fittings.

8.12. PRESSED STEEL DOOR FRAMES (Refer Figure 8.7)

8.12.1. Material

Steel door frames shall be manufactured from commercial mild steel sheet of 1.25 mm thickness conforming to IS : 226 and fittings conforming to IS : 4351.

Steel door frames with or without fan light shall be made in the profiles indicated in **Figure 8.7** and may be manufactured to suit doors of either type, opening inwards or outwards as directed by the Engineer.

8.12.2. Construction

Each door frame shall consist of hinge jamb, lock jamb, head and if required angle threshold (Refer **Figure 8.7**). These shall be welded or rigidly fixed together by mechanical means. Where no angle threshold is required, temporary base tie shall be screwed to the feet of frames in order to form a rigid unit. Where so specified, base ties shall be of pressed mild steel 1.25 mm thick adjustable to suit floor thickness of 35 or 40 mm and removable, or alternatively, threshold of mild steel angle of section 50 x 25 mm minimum shall be provided for external doors frames.

8.12.3. Fabrication

The pressed steel door frames shall be got fabricated in a workshop approved by the Engineer.

8.12.3.1. Fixing lugs (Figure 8.7). There shall be three adjustable lugs with split end tail to each jamb without fan light, and four for jamb with fan light. The head of the fixing lug shall be one of the following lengths:

- (a) 95 mm long for use with profile A
- (b) 120 mm long for use with profile B
- (c) 160 mm long for use with profile C

The head shall be made from flat steel strip 25 mm wide and not less than 1.60 mm thick. The tail of the lugs shall be 200 mm long and shall be made of steel strip no less than 40 mm wide and not less than 1 mm thick.

8.12.3.2. Hinges (Figure 8.7) 100 mm mild steel butt hinges shall be used. For door frames 89 cm wide and under, three hinges shall be rigidly fixed to one jamb and for frames for door above 89 cm wide, four hinges shall be rigidly fixed to one jamb, if it is a single shutter. Where the height of the door shutter exceeds 2.15 metres, one additional hinge shall be provided for every 0.5 m or part thereof of the additional height.

In all cases the hinges shall be so fixed that the distance from the inside of the head rebate to the top of the upper hinge is 20 cm and distance from top of upper hinge to lower hinge is about 175 cm.

Hinges shall be made of steel 2.5 mm thick with zinc coated removable pin of 6 mm diameter. The space between the two leaves of the hinge when closed shall be 3 mm and the leaf that is not welded to the frame shall have four counter sunk holes to take No. 10 wood screws.

8.12.3.3. Mortar Guards: Mortar guards as instructed by Engineer shall be provided. These shall be welded to the frame at the head of the frame for double shutter doors to make provision for bolts.

8.12.3.4. Lock-Strike Plate: There shall be an adjustable lock-strike plate of steel complete with mortar guard to make provision for locks or latches complying with the relevant Indian Standards. Lock-strike plates shall be galvanized mild steel and fixed at 95 cm from the head of the frame.

8.12.3.5. Shock Absorbers: For side hung door there shall not be less than three buffer of rubber or other suitable material inserted in holes in the rebate and one shall be located on the centre line of the lock strike plate and the other two at least 45 cm above and below the centre line of the lock strike plate. For double shutter doors, there shall be two buffers of rubber or similar suitable material inserted in holes in the rebate in the lock jamb only at the head and spaced 15 cm at either side of the centre line of the door.

8.12.4. Finish

The surface of door frame shall be thoroughly cleaned, free of rust, mill-scale dirt, oil etc., either by mechanical means, for example, sand or shot blasting or by chemical means such as pickling. After pre-treatment of the surface one coat of approved primer i.e. red oxide zinc chrome primer conforming to IS : 2074 or as specified and two coats of paints as directed by the Engineer shall be applied to the exposed surface.

8.12.5. Fixing

Frames shall be fixed up right in plumb. To avoid sag or bow in width during fixing or during construction phase, temporary struts across the width preventing sides bulging inwards may be provided. Wall shall be built solid on each side and grouted at each course to ensure solid contact with frame leaving no voids behind the frame.

Three lugs shall be provided on each jamb with spacing not more than 75 cm. The temporary struts should not be removed till the masonry behind the frame is set. In case screwed base tie is provided, this should be left in position till the flooring is laid when it can be removed.

After pre-treatment of the surface, one coat of steel primer and two coats of paint as directed by the Engineer shall be applied to the exposed surface.

8.12.6. Measurements

The length shall be measured in running metre correct to a cm along the centre line of the frames.

8.12.7. Rate

The rate shall include the cost of labour and material involved in all the operations described above including one coat of approved steel primer but excluding two coats of final paint.

8.13. TUBULAR TRUSSES

8.13.1. Structural Steel Tube - These shall be of :

1. Hot finished welded (HFW) type or
2. Hot finished seamless (HFS) type, or
3. Electric resistance or induction butt welded (ERS), having carbon content less than 0.03 percent, yield stress of 21.5 kg/mm² (YST 22) type.

Conforming to the requirement of IS : 1161. The steel tubes when analyzed in accordance with the method specified in IS : 226 shall show not more than 0.06 per cent sulphur, and not more than 0.06 per cent phosphorous.

Tubes shall be designated by their nominal bore. These shall be light, medium or heavy as specified depending upon the wall thickness. The standard sizes and weights of tubes are listed in **Annexure 8.4**.

Tubes shall be clean finished and reasonably free from scale. They shall be free from cracks, surface flaws, laminations and other defects. The ends shall be cut clean and square with axis of tube, unless otherwise specified. IS 806 deals with Code of Practice for use of Steel Tubes for General Building Construction and may be referred to for details.

8.13.2. Minimum thickness of Metals

Wall thickness of tubes used for construction exposed to weather shall be not less than 4 mm and for construction not exposed to weather it shall be not less than 3.2 mm. Where structures are not readily accessible for maintenance, the minimum thickness shall be 5 mm.

8.13.3. Fabrication

8.13.3.1. The component parts of the structure shall be assembled in such a manner that they are neither twisted nor otherwise damaged and be so prepared that the specified cambers, if any, are maintained. The tubular steel work shall be painted with one coat of approved steel primer after fabrication. All fabrication and welding is to be done in an approved workshop.

8.13.3.2. Straightening: All material before being assembled shall be straightened, if necessary, unless required to be of curvilinear form and shall be free from twist.

8.13.3.3. Bolting: Washers shall be specially shaped where necessary, or other means, used, to give the nuts and the heads of bolts a satisfactory bearing. In all cases, where the full area of the bolt is to be developed, the threaded portion of the bolt shall not be within the thickness of the parts bolted together and washers of appropriate thickness shall be provided to allow the nuts to be completely tightened.

8.13.3.4. Welding : Where welding is adopted, it shall be as per IS : 816.

8.13.3.5. Caps and Bases for columns: The ends of all the tubes, for columns transmitting loads through the ends, should be true and square to the axis of the tubes and should be provided with a cap or base accurately fitted to the end of the tube and screwed, welded or shrunk on. The cap or base plate should be true and square to the axis of the column.

8.13.3.6. Sealing of Tubes: When the end of a tube is not automatically sealed by virtue of its connection by welding to another member, the end shall be properly and completely sealed. Before sealing, the inside of the tubes should be made dry and free from loose scale.

8.13.3.7. Flattened Ends: In tubular construction the ends of tubes may be flattened or otherwise formed to provide for welded, riveted or bolted connections provided that the methods adopted for such flattening do not injure the material. The change of sections shall be gradual.

8.13.4. Hoisting and Erection

Tubular trusses shall be hoisted and erected in position carefully, without damage to themselves, other structures, equipment and injury to workmen.

The method of hoisting and erection proposed to be adopted shall be got approved from the Engineer. The contractor shall however be fully responsible for the work being carried out in a safe and proper manner without unduly stressing the various members. Proper equipment such as derricks, lifting tackles, winches, ropes etc., shall be used.

8.13.5. Measurements

The work as fixed in place shall be measured in running metres correct to a centimeter and their weights calculated on the basis of standard tables correct to the nearest kilogram unless otherwise specified.

Weight of cleats, brackets, packing pieces bolts, nuts, washers, distance pieces, separators diaphragm gussets (taking over all square dimensions), fish plates etc., shall be added to the weight of respective items unless otherwise specified. No deduction shall be made for skew cuts.

8.13.6. Rate

The rate shall include the cost of labour and materials involved in all the operations described above including application of one coat of approved steel primer i.e. red oxide zinc chrome primer conforming to IS : 2074 or as specified.

8.14. FAN CLAMPS (Figure 8.8)

8.14.1. Types

The fan clamp shall be of the following types:

(a) Fan clamp to be fixed during the laying of R.C.C. slab, shall be of type I, as shown in **Figure 8.8**. This shall be made of 16 mm M.S. bar bent to shape with its ends hooked. The overall height of the clamps shall be made to suit the depth of the slab.

(b) Fan clamp for beams shall be of type II as shown in **Figure 8.8**. It shall be similar to fan clamp, type I, except that its height shall be greater depending on the depth of the beam rib.

(c) In case of low ceiling heights, circular cast iron box for ceiling fan clamp, Type III shall be fixed during the laying of R.C.C. slab and shall be as shown in **Figure 8.8**. The size of cast iron box shall be 140 mm internal dia with 73 mm height. The thickness of cast iron rim shall be 4.5 mm Bottom and top lids shall be of 1.5 mm thick M.S. sheet with the top surface hacked so as to ensure proper bonding with the concrete. The lids shall be screwed into the cast iron box by means of 3.3 mm dia round head screws one each at the corners. The box can be of M.S. sheet and the thickness of side walls can be reduced to 3 mm without affecting inner dia of the box. The fan clamp shall be made of 12 mm dia M.S. bar bent to shape with its ends bent as per drawing.

8.14.2. Fixing

Holes for inserting the fan clamps in the positions shown in the drawing or as instructed by the Engineer shall be made in the shuttering after the latter has been fixed in position. After steel reinforcement is tied, fan clamps shall be fixed with their loops truly vertical and at the correct depth from the underside of the slab or beam. The hooked arms and the loop shall be tied to the reinforcement, either directly or through cut pieces of M.S. bars with annealed steel wire 1.6 mm or 1.00 mm thick. The clamp shall neither be disturbed out of position during concreting nor shall it be bent out of shape when shuttering of slabs or beams is removed.

The exposed portion of loops of the clamp shall be given two or more coats of paint, including priming coat of approved steel primer as ordered by the Engineer.

8.14.3. Measurements

Clamps of type I and III shall be counted in numbers. Fan clamps type II, shall be counted and paid for under fan clamps type I, but they shall in addition be paid for their extra height as determined by the depth of the beam.

8.14.4. Rate

The rate per fan clamp shall include the cost of labour and materials involved in all the operations described above. In the case of type I and III clamps, the rate shall apply irrespective of the thickness of the slabs.

8.15. MILD STEEL CLAMPS AND RINGS FOR CHICKS

8.15.1. M.S. Clamps

These shall be fabricated from M.S. flat iron 20 mm x 6 mm. One end shall be bent at right angles for 25 cm length and other end shall be tapered to a point. Total length of clamp shall not be less than 15 cm.

These shall be built into the wall masonry, while the work is in progress, so as to project 2.5 cm from the finished surface. These shall be fixed in cement mortar. All clamps shall be fixed in straight horizontal line as shown in drawings or as specified by the Engineer.

8.15.2. M.S. Rings

These shall be made of 6 mm dia bars with 40 mm internal diameter. Their joint shall be well formed or welded together. These shall be provided with a 50 mm forked clamp of 10 x 3 mm M.S. flat iron. It shall be wide at the fork end and pointed on the other end. These shall be fixed in the masonry as specified in para 8.15.1.

8.15.3. Measurements

The M.S. clamps and rings shall be counted in numbers.

8.15.4 Rate

The rate shall include the cost of materials and labour involved in all the operations described above.

8.16. M.S. BARS AND M.S. GRILLS IN WOODEN OR STEEL FRAMES**8.16.1. Fabrication**

8.16.1.1 When M.S. round or square bars are to be fixed in wooden or steel frames these are cut into required length to form the required pattern and then fixed as per drawing. In the case of wooden frames the length will be for fixing in the hole 5 cm deep in one frame and right through and flush with outer side of the frame.

8.16.1.2 When M.S. round or square bars are to be fixed to steel frames or in combination with M.S. flats these are to be cut to proper size welded to steel frames or MS flats to form the required pattern. In case of MS flats they should have counter sunk holes to facilitate fixing them to wooden frames with wood screws. Welding is to be done in an approved workshop and not at site.

8.16.1.3. When the grill is to be fabricated mainly with M.S. flats with or without M.S. round or square bars, the flats of required size are cut and bent to form the required pattern and design as per drawing or as directed by the Engineer. The cut and bent flats and bars are then welded by fillet welding all around the width of the flats or circumference of bars which are joined. At corners of flats proper mitred joint forming a right angle shall be provided with welding for full width. Welding is to be done in approved workshop and not at site.

8.16.2. Fixing

8.16.2.1. When M.S. round or square bars are to be fixed to wooden frames the bars shall be passed in to the wooden frame, from the end having a through hole and fixed flush with that end while at the other end it will be 5 cm deep in the hole drilled in the frame. In case of steel frames, the bars will be welded to the steel frame by fillet weld all along the circumference of the bars in an approved workshop and not at site.

8.16.2.2. In case of grill of bars welded to M.S. flat forming the required pattern, the outer frame of M.S. flats shall be fixed to the wooden frame with wood screws in the counter sunk holes drilled in M.S. flats ensuring that screws are driven with a screw driver (not hammered) till the screws are embedded fully inside flush with the M.S. flats.

In case of fixing to steel frames, M.S. flats of required pattern with or without M.S. round or square bars, the method of fixing will be similar to what is described above.

8.16.3. Welding:- Any kind of welding at site shall be permitted only under written orders of the Engineer.

8.16.4. Measurements

The different types of M.S. grills as described in para 8.16.1 will be measured separately and paid for. The length of bars and flats used in grills will be measured correct to a cm and then weights calculated in kg by using standard tables. The weight of complete grill should be weighed at site and minimum of the two will be taken for payment.

8.16.5. Rate

The rate shall include the cost of materials and labour required for all the operations described above. Grills of different types mentioned in para 8.16.1 shall be paid for separately.

8.17 ALUMINIUM WORK – GENERAL**8.17.1 Materials**

Aluminium alloy standard extruded sections in a wide range of solid and hollow profiles are used in the manufacture of frames, shutters of doors / windows / ventilators, supports for hand railings, curtain wall facings, partitions, structural glazings and similar other applications. Tee / angle sections are used for frame work of false ceiling. The chemical composition and mechanical properties of the extruded sections should comply with the

requirements of IS 733, IS 1285 and IS 737. Extruded sections should be procured only from recognised ISO 9002 or equivalent companies.

8.17.2 Anodising

The extrusions are anodised upto 30 Micron in different colours like silver, champagne, bronze and black and are to be tested to see if the anodising conforms to the quality standards laid down in Indian /British Standard Specifications.

8.17.3 Aluminium Work for Doors, Windows, Ventilators and Composite Units

IS 1948 on Aluminium doors, windows and ventilators and IS 1949 on Industrial Aluminium Windows were issued in 1961 and not revised since then. Major manufacturers of Aluminium products are however manufacturing extruded sections etc to suit the latest construction practice based on British and International Standards. Hence it may be difficult to procure Aluminium sections to the sizes stipulated in IS codes but the quality of extruded sections as regards the materials and the anodising etc is maintained by the manufacturers to satisfy the requirements of IS Codes. Thus, for procurement of Aluminium doors, windows, ventilators etc a practical approach will be to go in for sections manufactured by reputed ISO 9002 or similar companies whether they are strictly to sizes specified in IS Codes or as specified in British or International Codes. For joining procedure, providing fittings, lugs, method of fixing etc. IS codes may be followed in general with some modification to suit the present day practice.

8.17.4 General Specifications and Tolerances for Aluminium extrusions

Dimensions of the sections manufactured should conform to the relevant IS, British or other International Standards. Standard cut length of sections is 3.66m. The tolerance in cut length is + 5.00 mm upto 6 Metres length of sections and + 7.00 mm for over 6 Metre length sections. Actual weight per metre may vary by $\pm 10\%$ of weight as specified depending on functions like tolerance and alloy.

8.18 ALUMINIUM DOORS

8.18.1 Extruded Sections

Dimensions and weight per Metre run of extruded sections to be used for manufacture of doors as laid down in IS 1948 are shown in **FIGURE 8.9**. Reputed manufacturers produce various other types of Extruded sections for use in doors.

8.18.2 Components of Doors and Terminology

IS 1948 has specified the Terminology for different components of the doors and the same have been shown in **FIGURE 8.4**.

8.18.3 Sizes of fabricated doors

As per IS 1948, the sizes of doors specified in the drawings (modular openings) should be reduced by 1.25 cm on all four sides during the manufacture of doors to enable their fixing easily in the openings in the Masonry. The module of opening in the masonry is of 100mm. In practice while the reduction in width of manufactured door by 2.50 cms as compared to the size of door opening will result in availability of gap of 1.25 cm in each side, reduction in height by 2.50 cms will result in a gap of 2.5cms between the bottom surface of RCC Lintel and the gap of door to be filled by cement plaster which is not desirable. This situation arises due to discontinuation of the old practice of providing a threshold at the bottom of doors. With this proposal, the following will be the desirable position for some sizes of door openings.

Size of Door opening	Size of manufactured door
1200 mm x 2100mm	1175mm x 2087.5mm
800mm x 2100mm	775mm x 2087.5mm
600mm x 2100mm	575mm x 2087.5mm

The door verticals are to be embedded to a length of 50mm in the floor and are not to be counted while framing the door sizes or for payment to the Contractor.

8.18.4 Use of symbols for Designating Doors, Windows and Ventilators

Designated symbols and units as specified in IS 1948 are as under:

- a) Width:- To be indicated by the number of modules of 100mm each. Only the width of opening is to be specified and not the width of joinery of door.
- b) Height:- Similar to width
- c) Type:- To be indicated by alphabets as below.

C= Centre Hung Shuttles

F = Fixed Glass Panes

H = With Horizontal Glazing Bars

N = Without Horizontal Glazing Bars

S= Side Hung Shutters

T= Top Hung Shutters

Thus Door Designated as 12 HS 21 means Door to be fixed in opening 1200mm wide and 2100mm high with Horizontal Glazing bars and Side Hung Shutters. The size of door will be 1175 mm wide and 2087.5mm high as explained earlier. Doors and Side lights are coupled with only 12 module high window (opening 1200mm; Height of window 1175mm). In windows, since the question of provision of threshold does not arise the height of window will be 25mm, smaller than height of opening with a gap of 12.5mm on both top and bottom.

8.18.5 Glazing

Specifications described in Para 8.10.3.1 will apply. Glass panes shall weigh atleast 7.5 kgs / sqm and shall be free from flaws, specks or bubbles. All panes shall have properly squared corners and straight edges. The glass panes shall be so cut that they are slightly loose in the frames.

Glazing shall be provided on the outside of the frames unless otherwise specified. Fixing of glass panes shall be done with Aluminium beading. Fabricator shall drill appropriate holes for screws. Normally the screws are spaced not more than 10 cms from each corner and intermediate screws are not more than 20 cms apart. When the glass panes are fixed with Aluminium beading having mitred joints, epoxy resin or silicon sealant shall be applied between glass panes and sash bars and also between glass panes and the beading. The size of glass panes will depend on the size of doors / windows / ventilators and the number of horizontal glazing bars. All glass panes shall be fixed within the Aluminium framing by use of CP brass or stainless steel screws and the joints sealed with epoxy resin or silicon sealant to make the unit completely water proof. Glazing or caulking compound around the perimeter of glass shall not be permitted. Fixed glass panes shall be supported by setting blocks. For normal size glass panes, glazing clips are not provided. For larger size glass panes provisions in Para 8.10.3.3 will apply. The Aluminum anodised extruded glazing beads or snap beading to be used should be procured only from the manufacturer of Aluminium extruded sections used for fabricating the doors / windows/ ventilators.

8.18.6 Panelling

8.18.6.1 Different Types of Panels

The different types of panels that can be used for aluminium doors shall be as follows:

i) Ply Wood Panels:

Plywood boards used for panelling shall be BWR type or grade as specified under Paras 7.2.2A & 7.2.2B. Each panel shall be a single piece of 9mm thickness for two or more panel construction and 12mm for single panel construction unless otherwise specified.

ii) Block Board Panels

(a) Block boards used for panelling of shutters shall be Grade I (Exterior Grade) bonded with BWP type synthetic resin adhesive as specified under Para 7.2.6.

(b) Each panel shall be a single piece of thickness 12mm unless otherwise specified.

iii) Veneered Particle Board Panels / Prelaminated Particle Board Panels

(a) Veneered particle board / Prelaminated particle board panels used for panelling of shutters shall be exterior grade bonded with BWR type synthetic resin as specified in Para 7.2.3B & 7.2.3C.

(b) Each panel shall be a single piece of thickness 12mm unless otherwise specified.

iv) Fibre Board Panels / Prelaminated Fibre Board Panels

Fibre boards / Prelaminated Fibre Board used for panelling of shutters shall be exterior grade bonded with BWP type synthetic resin adhesive as specified under Para 7.2.8A & 7.2.8B. Each panel shall be a single panel of thickness 12mm unless otherwise specified.

8.18.6.2 Thickness and Tolerance

i) Plywood Panels: Plywood boards are available in thickness ranging from 3 to 25mm. Tolerance in thickness shall be $\pm 10\%$ for boards upto and including 6mm and $\pm 5\%$ for boards above 6mm thickness.

ii) Block Board Panels: Block board panels are available in thickness ranging from 12 to 50mm. Tolerance in thickness shall be $\pm 5\%$ for board upto and including 25mm thick and $\pm 2.5\%$ for boards above, 25mm thickness.

iii) Veneered Particle Board / Prelaminated Particle Board: Veneered particle boards are available in thickness ranging from 6 to 50mm and Prelaminated 6mm to 45mm. Tolerance in thickness shall be $\pm 5\%$

iv) Fibre Board Panels/ Prelaminated Fibre Board Panels: Fibre boards are available in thickness ranging from 6 to 40mm. Tolerance in thickness shall be $\pm 0.3\text{mm}$

8.18.6.3 Testing

The following stipulations will apply.

i) Plywood	:	IS 304, IS 328, IS1328
ii) Block Board	:	IS 3087
iii) Veneered Particle Board/ Prelaminated Particle Board	:	IS3097, IS 12823
iv) Fibre Board / Prelaminated Fibre Board	:	IS 12406, IS 14587

8.18.6.4 Fixing

The specified panels, cut to correct size with minimum 12mm portion to be inserted in the frame, shall be fixed firmly with CP brass or stainless steel screws. The joints between the panels and the members shall be sealed with epoxy resin or silicon sealant to make the unit water tight.

8.18.7 Aluminium Panels

Aluminium alloy sheet conforming to IS 737 and of thickness 1.25mm for use as kick panels and of thickness as specified for other general panels shall be procured from reputed manufacturers. Fixing shall be done as for other types of panels as indicated above.

8.18.8 Fabrication

- i) Frames shall be square and flat. Both the fixed and openable frames shall be constructed of sections, which have been cut to length, mitred and mechanically jointed at the corners. Sub-dividing bars of units shall be tenoned and rivetted into frames.
- ii) All frames shall have corners welded to true right angles. For jointing hollow sections flash butt welding, argon arc welding or mechanical jointing by inserts shall be used. Gas welding or brazing shall not be done. Concealed screws shall be used for joining the sub-units.
- iii) Doors shall be constructed with sections as detailed in the drawing. Unless stipulated otherwise, Hinges shall be non-projecting and of heavy type. If specified or directed by the Engineer floor springs, closers, long grip handles and locks shall be provided. In normal course standard lock with lever handle shall be provided.
- iv) For double door, the first closing door shall have a concealed aluminium alloy bolt at top and bottom so constructed as not to work loose or drop by its own weight.
- v) Standard projecting or butt hinges as specified or as directed by the Engineer shall be provided which shall be inserted into the frames and riveted. For anodized work suitable aluminium alloy pins shall be used. The Engineer may permit the use of mechanical jointing instead of welding.

- vi) Openable shutters shall be provided with continuous neoprene weather strips. Details of construction of aluminium doors are shown in **Figure 8.10A**.

8.18.9 Tolerance

The sizes for doors shall not vary by more than $\pm 1.5\text{mm}$.

8.18.10 Fittings

All fittings and fixtures shall be of high quality and as shown in the drawings. The samples of all fittings shall be got approved by the Engineer before fixing. The general details of fittings for doors as prescribed in IS:1948 are given below.

8.18.10.1 Hinges: Cast or extruded aluminium alloy hinges for doors shall be of same type as in the windows but of larger size. Normally the hinges shall be of 50mm projecting type as shown in **Fig. 8.10B** or non projecting type as shown in **Fig. 8.10C**.

8.18.10.2 Handles: Handles for the doors may be of the design as specified.

8.18.10.3 Locks : A suitable lock for doors which can be operated from inside or outside shall be provided. From point of view of security, the lock which can be operated from only one side is better and in case of such locks, a bolt shall be provided to make it impossible to operate from the other side.

8.18.10.4 Bolts

- i) In double shutter doors, the first closing shutter shall have a concealed aluminium alloy bolt at top and bottom as shown in **Fig. 8.10D**. It shall be so constructed as not to work loose or drop by its own weight.
- ii) Single and double shutter doors may be provided with a three way bolting device as shown in **Fig.8.10E**. Where this is provided in the case of double shutter door, concealed aluminium bolts may not be provided.

8.18.11 Positions of Holes and Number of Lugs per Units

Outer frames shall be provided with fixing holes centrally in the web of the section in the positions indicated in the Figure depicted in IS Code but with lugs in the threshold of the doors omitted. Instead the verticals of doors are embedded to a length of 50mm in the floor.

8.18.12 Fixing Aluminium Doors in position

8.18.12.1 Fixing in opening of brick or stone masonry (a) Aluminium doors shall be stacked as to keep them in true shape without damage. Doors shall be fixed as described below:

b) The sizes of Indian Standard doors are designed for modular opening of larger width by 1.25cm on both sides and larger height of 1.25cm only on top face. In masonry openings the gap is filled up with mastic cement and plaster after the door is fixed in position. In case of steel or timber modular openings, extra steel or timber fillets will be necessary to fill the gaps. Unlike in case of wooden joinery where the wooden frame is erected first and the masonry around is constructed later, in this case the size of the opening is exactly same as in case of wooden Joinery but the only difference is that size of the door is reduced to enable fixing of units easily.

(c) Arrangement for fixing door frame with steel lugs is shown in **Figure 8.10F**.

i) Slotted steel adjustable lugs (natural finish) of size 100 x 16 x 3mm shall be as shown in **Figure 8.10G**.

ii) Any steel lug coming in contact with aluminium should be either galvanised or given a coat of bitumen paint.

iii) Before the aluminium doors are fixed in position, a thick shop coat of clear transparent lacquer based on methyrate or cellulose shall be applied on aluminium doors, windows etc to protect the surface from wet cement during installation. The lacquer coating shall be removed carefully after plastering etc. complete to the satisfaction of the Engineer without any extra cost.

iv) The size of the opening shall first be checked and cleared of obstruction if any. The position of the fixing holes shall be marked on the jamb. Necessary holes shall be made in the masonry and lugs of size not less than 100mm long and 15 x 3 mm size fixed in cement concrete blocks of size 150 x 100 x 100 mm in 1:3:6 mix (1 cement: 3 coarse sand: 6 graded stone aggregate 20mm nominal size). The frame of units after treating

with lacquer coating shall be set in opening by using wooden wedges at jambs head. Wedges shall be preferably placed near the points where glazing bar or other members meet.

v) The wedges should be fixed firmly only when the doors / windows are kept in perfect position and plumb. Later the frames should be fixed with lugs with 20mm long and 6.3mm dia. GI counter sunk machine screws and nuts. Only after ascertaining that the doors are firmly fixed with lugs in the opening, the wedges should be removed very carefully and the gap should be filled with mastic cement and plaster, taking particular care to see that the plaster done over jambs does not in any way about the front surface of aluminium door.

vi) After the gaps are filled with mastic cement and plaster and the filling is finally set, still if any crack / gap is noticed / pointed out by the Engineer, the same should be immediately filled with either epoxy resin or silicon sealant.

8.18.12.2 Fixing on Concrete Surfaces:-

- i) In this case instead of using lugs to fix the doors the same is fixed with wood screws to the wooden plugs fixed in the concrete surface.
- ii) As in earlier case the opening is checked for size etc. The specified treatment is given to the surfaces of aluminium doors and the correct positions for fixing wooden plugs marked on the jamb with respect to the holes provided in the door for fixing screws.
- iii) On duly marked points on the jambs, required size of hole shall be made in the concrete and the wooden plug of teak wood of specified size shall be fixed in the hole with rich cement mortar. Units shall be erected after plugs are duly set.
- iv) The door should be fixed to the wooden plugs, with the help of galvanised wood screws of size 45 x 10mm.
- v) Later the 12.5mm wide gap between the concrete surface and the aluminium unit shall be filled neatly with mastic cement and mortar. Alternatively if approved by the Engineer instead of fixing the units on wooden plugs, the same can be conveniently and firmly fixed with rawl plugs using little longer size screws of designation 10.

8.18.12.3 Fixing in Wood Work openings

Openings in wood-work are normally rebated. Approved mastic or rubber lining shall be applied to jambs, sill and channel before fixing in position. The door shall be set in frame using wooden wedges. The unit shall be fixed using wooden screws designation 10 of suitable length. Extra timber fillets of specified type and size of wood to match the adjoining work shall also be provided around the frame to close the 1.25cm gap between the opening and the aluminium unit.

8.18.12.4 Fixing in Steel-Work Opening

- i) Steel surfaces where the aluminium units are to be fixed are cleaned and the exact position of fixing the units is marked on the surfaces with reference to the holes already provided in the units.
- ii) Suitable holes are drilled in the steel surfaces so that the clips / bolts used for fixing units can be inserted.
- iii) The aluminium unit is then erected in position and fixed temporarily with wooden wedges. The frames are then fixed to the steel surface using clips as shown in **Fig.8.10H** or with suitable nuts and bolts as directed by the Engineer.
- iv) Before the clips or the bolts are fully tightened a suitable size mild steel or hard wood fillet is introduced in the 1.25cm wide gap after treating the surface of fillet and jambs with approved mastic.
- v) The clips / bolts are then tightened and simultaneously the wooden wedges provided are removed. The gaps if any between the units and steel surfaces shall be filled by suitable / specified mastic or treated as directed by the Engineer.

8.18.13 Measurements

8.18.13.1 Frame work

i) Only after ascertaining that the aluminium doors fixed on site are manufactured by reducing the width by 2.5cm and height by 1.25cm compared to the specified size of openings in the drawings issued for construction, the length of each extruded section used for fabrication of the door shall be measured correct to 1mm. In case the sizes of doors that are manufactured, happen to be the same as sizes specified in the drawings, the theoretical dimensions arrived by reducing the overall sizes may be considered.

ii) The weight of material used shall be calculated on the basis of actual weight of extruded sections used for fabrication and shall be compared with the weights given in the manufacturer's catalogue, subject to the condition that the variation in actual weight should not exceed $\pm 10\%$ compared to the weights specified in manufacturer's catalogue. Payment shall be made for the actual weight of the extruded section. The final weights shall be calculated in kgs upto two places of decimal.

8.18.13.2 Glazing: Length and width of opening for glazing inserts shall be measured correct to a cm and area for payment shall be calculated in sqm. nearest to 0.01 sqm.

8.18.13.3 Panelling with Different Types of Materials: Same as in Para 8.18.13.2 above.

8.18.13.4 Panelling with Aluminium Sheet: The length and breadth of the panel inserts shall be measured correct to a cm and the area calculated to the nearest 0.01 sqm. The weights of panel used shall be calculated as under:-

i) As per manufacturer's catalogue

ii) The actual weight of sample of sheet used should be found out and weight of panel actually used. (Actually calculated weight shall be recorded subject to condition that variation in actual weight shall not exceed $\pm 10\%$ compared to the weight specified in the manufacturers catalogue)
Least of above shall be considered for payment.

The actual weight shall be calculated in kgs to two places of decimal.

8.18.13.5 Fittings: All fittings for doors except hinges and handles shall be enumerated.

8.18.14 Rate

i) The rate shall include the cost of material and labour for all operations described above except the cost of glazing and panelling. It shall include screws, expansion hold fasteners, snap beading including filling with necessary PVC / neoprone felt, cleats etc. The rate does not include the cost of fittings except the hinges and handles.

ii) The rate will include the cost for providing aluminium alloy doors for the openings of all shapes and sizes.

iii) The cost of glazing, panelling and additional fittings shall be paid under separate item, as described herein.

8.19 ALUMINIUM WINDOWS – OPENABLE TYPE

8.19.1 Aluminium Alloy Extruded Sections Dimensions and weight per metre run of extruded sections to be used for manufacturing aluminium openable windows as recommended in IS: 1948 are shown in **Fig. 8.11A**. Reputed Manufacturers produce various other types of Extruded Sections for use in Windows.

8.19.2 Components of Windows and Terminology

IS 1948 has specified the Terminology for different components of Windows and the same have been shown in **Figure 8.4**.

8.19.3 General Specifications on tolerance for extruded sections. Refer Para 8.17.4.

8.19.4 Sizes of Fabricated Windows

As per IS 1948 the sizes of windows specified in the drawings should be reduced in size by 1.25cm for all four sides of openings while manufacturing the windows so that fixing the windows in the openings will be easy. Thus if the opening is of width 1000mm and height 900mm, the outer dimensions of the fabricated windows shall be of width 975mm and height 875 mm.

8.19.5 Use of symbols for Designating Windows - Please refer to earlier Para 8.18.4.

8.19.6 Glazing - Please refer to earlier Para 8.18.5.

8.19.7 Fabrication - Specifications under earlier Para 8.18.8 (i) to (vi) will apply in the case of windows also. Details of Construction of Aluminium alloy windows in accordance with IS 1948 are shown in **Figures 8.11B to 8.11E.**

8.19.8 Tolerance: Same as prescribed under Para 8.18.9.

8.19.9 Fittings

8.19.9.1 Side Hung Shutters

- i) For fixing aluminium alloy hinges, slots shall be cut in the fixed frame and the hinges inserted inside and may be rivetted to the frame. The hinges shall normally be 67mm wide projecting type as shown in **Fig. 8.11F.**
- ii) The hinges should be of specified quality preferably with ISI mark manufactured by reputed manufacturers.
- iii) The pins for hinges shall be stainless steel of non-magnetic type or of aluminium alloy HR 30. Irrespective of hinges being anodised or not, the aluminium alloy pins shall be anodised to a minimum film thickness of 0.025mm and shall be sealed with oil, wax or lanolin.
- iv) Non projecting type hinges as shown in **Fig. 8.11.G** may also be used if specified or permitted by the Engineer.
- v) Friction hinges: Working principle of this is shown in **Fig. 8.11.H.** This may be provided for side hung shutter aluminium windows, in which case the windows need not be provided with peg stays which are normally used.

8.19.9.2 Handles – For Side Hung Shutters

- i) The handles shall be of cast aluminium of specified quality, manufactured by reputed manufacturers.
- ii) The handles shall be mounted on a handle plate welded or rivetted to the opening frame in such a way that it could be fixed before the shutter is glazed.
- iii) The handle should have anodised finish with minimum anodic film thickness of 0.015mm. The handle shall have a two point nose which shall engage with an aluminium striking plate on the fixed frame in a slightly open position as well as in a fast position shown in **Fig. 8.11I.**
- iv) The height of the handles in each type of side hung shutters shall be fixed in approximate position as shown in **Fig. 8.11J.**

8.19.9.3 Peg Stay

- i) The peg stay shall be either of cast aluminium or folded from aluminium alloy sheet. It shall be 300 mm long complete with peg and levelling bracket as shown in **Fig. 8.11K.**
- ii) The stay shall have holes for keeping the shutter open for three different positions. The peg and locking bracket shall be rivetted or welded to the fixed frame.
- iii) The peg stays shall be provided only when no friction hinges are provided for the shutters.

8.19.10 Weather Bar: When a coupling member is fitted over an external opening shutter the coupling member should incorporate an integrally extruded weather bar as indicated in **Figure 8.11A.**

8.19.11 Position of Holes and Number of Lugs per unit: The position of holes and number of lugs to be provided for windows of different sizes shall be in accordance with IS: 1948.

8.19.12 Fixing Aluminium Windows in Position: Same as explained for doors under Para 8.18.12.

8.19.13 Measurements: As far as applicable same, as prescribed under Para 8.18.13.

8.19.14 Rate

- i) Same as prescribed under Para 8.18.14.
- ii) Rate shall also include for windows in openings of all shapes including circular, segmental or other shapes and sizes.

8.20 ALUMINIUM WINDOWS – SLIDING TYPE

8.20.1 Aluminium Alloy Extruded Sections

IS 1948 has not laid down any guidelines for manufacture of Extruded Sections. Reputed manufacturers produce various types of Extruded Sections for use in Sliding Windows.

8.20.2 General Specification and Tolerances for Aluminium Extrusions Sections:

Same as in Para 8.17.4.

8.20.3 Sizes of Windows for Fabrication: Same as under Para 8.19.4.

8.20.4 Glazing: Same as under Para 8.18.5.

8.20.5 Fabrication

- i) Same as under Para 8.18.8 (i)
- ii) Same as under Para 8.18.8 (ii)
- iii) The different types of sliding windows that are in use are:
 - 1) 2/3 Track Sliding window
 - 2) 3/4 Track Sliding window
 - 3) 20mm Sliding window
 - 4) 100mm Sliding window
 - 5) 123.45mm Sliding window
- iv) Use of these windows has increased in the recent past as they do not occupy either interior or exterior space while opening. Windows are easy to operate.
- v) The sliding window of types described under para (iii) above can be manufactured in complete shape using aluminium alloy extruded sections available in the market.
- vi) These windows do not require any fittings except the self closing latch normally fixed to the shutter while manufacturing and the knob fixed on the sliding glass panes.
- vii) The broad details of the construction of a 3 track sliding window normally used are shown under **Fig.8.12**. However, it should be noted that the length and height of the sliding window shall be reduced by 1.25cm on all four sides from the prescribed length and height of the opening for sliding window shown in the drawing / item of work while manufacturing the window.

8.20.6 Tolerance: Same as under Para 8.18.9.

8.20.7 Position of Holes and number of Lugs per Unit:-

In absence of any guidelines issued by IS Code for sliding windows, details prescribed for openable windows can be followed with suitable modifications, wherever necessary.

8.20.8 Fixing Sliding Windows: Same as explained under Para 8.18.12.

8.20.9 Measurements: Same as prescribed under Para 8.18.13. Glazing shall be same as prescribed under Para 8.18.13.2. However the cost of knob fixed in the glass of sliding window glass need not be paid separately.

8.20.10 Rate: Same as prescribed under Para 8.18.14. Also the rate shall include the cost of automatic closing latch provided in the sliding window while manufacturing.

8.21 ALUMINIUM VENTILATORS

8.21.1 Aluminium Alloy Extruded Sections

IS 1948 has laid down the dimensions and weight per metre of Extruded Sections for Ventilators. Details have been given in **Figure 8.13A**. No extruded sections of other sizes and shapes are being made by Reputed Manufacturers. However such Extrusions as are being manufactured for openable window can be used for making ventilators.

8.21.2 Components of Ventilators and Terminology – IS 1948 has laid this down as shown in **Figure 8.4**.

8.21.3 General Specifications and tolerances for Aluminium Extruded Sections: Same as in Para 8.17.4.

8.21.4 Sizes of Ventilators for Fabrication: Same as under Para 8.19.4.

8.21.5 Symbols for Designating Windows: Same as under Para 8.18.4.

8.21.6 Glazing: Same as under Para 8.18.5.

8.21.7 Fabrication:

- i) As prescribed under Para 8.18.8 (i) to (vi)

- ii) Details of construction of aluminium alloy ventilators as prescribed in IS : 1948 is shown in **Fig.8.13B**

8.21.8 Tolerance: Same as under Para 8.18.9.

8.21.9 Fittings

8.21.9.1 Hinges – Top Hung Ventilators

- i) Top hung ventilators shall be provided with aluminium hinges of recognised brand or as specified. The hinges shall be either cast or fabricated out of extruded sections and shall be riveted to the fixed rail after cutting a slot in it.
- ii) The ventilators shall also be provided with a 300mm long peg stay
- iii) The peg stay shall have three holes in different positions for opening the ventilator and when closed shall hold the shutter tightly by the locking bracket, which would be fixed to the frame.

8.21.9.2 Cup Pivots – Centre Hung Ventilators

- i) The centre hung ventilators shall be hung on two pairs of cup pivots as shown in **Fig. 8.13C** or on brass or bronze cup pivots which should be either chromium or cadmium plated and riveted to the inner and outer frames of the ventilator to permit the ventilator to swing through an angle approximately 85°
- ii) The opening portion of the ventilator shall be so balanced that it remains open at any desired angle under normal weather conditions.

8.21.9.3 Spring Catch – Centre Hung Ventilator

- i) The spring catch shall be of specified make and type conforming to relevant IS Specifications and shall be made of either chromium plated or cadmium plated.
- ii) The spring catch shall be fitted in the centre of the top bar of the ventilator, for its operation. This spring catch shall be secured (preferably screwed or rivetted) to the frame and shall close into the aluminium catch plate rivetted or welded to the outside of the outer ventilator frame bar.

8.21.9.4 Cord Eye and pulley arrangement – Centre Hung Ventilator

- i) Cord pulley wheel shall be of aluminium or cadmium plated brass in an aluminium bracket.
- ii) This shall be fitted to the sill of the ventilator, with aluminium or galvanised or cadmium plated steel screws or alternatively, welded together with an aluminium cord eye rivetted or welded to the bottom inner frame bar of the ventilator in a position corresponding to that of pulley.

8.21.10 Position of Holes and Number of Lugs per Unit: The position of holes and the number of lugs should be provided for the ventilators of different sizes in conformation to relevant IS Code.

8.21.11 Fixing Aluminium Ventilators in position: Same as prescribed for doors under Para 8.8.12.

8.21.12 Measurements: Same as explained under Para 8.18.3. Glazing shall be same as explained under Para 8.18.13.2

8.21.13 Rate: Same as prescribed under Para 8.18.14.

8.22 ALUMINIUM COMPOSITE UNITS

8.22.1 Aluminium Alloy Extruded Sections

IS 1948 has laid down the dimensions and weight per metre of Extruded Sections for doors, operable windows and ventilators. In addition, reputed manufacturers fabricate other sizes and shapes of extensions which can be used. The extruded section specially indicated for composite units and IS 1948 are shown in **Figure 8.14A**.

8.22.2 Components and Terminology: IS 1948 has laid down the same as shown in **Figure 8.4**.

8.22.3 General Specification and Tolerances for Aluminium Extrusions sections: Same as under Para 8.17.4.

8.22.4 Sizes of Doors, Windows and Ventilators of Composite Unit for Fabrication

- i) Fixing sizes of composite unit for fabrication is a most complex issue as not only the three items like door, window and ventilator are involved but also the width of

extruded sections like mullion and transome have also to be accounted for, while deciding the actual fabrication width and height of members and ultimately the composite unit after accounting for the necessary deduction of 1.25 cms from specified size of composite unit before proceeding with the fabrication of the different components of the composite unit.

- ii) Consider a 12 module (1200mm) wide and 21 module (2100mm) high door is coupled on its top with a 12 module (1200mm) wide and 6 module (600mm) high ventilator.
- iii) This unit i.e. the door coupled with ventilator on top is again coupled by its side with a window 15 module (1500mm) wide and 12 module (1200mm) high which is also coupled on top with a ventilator of 15 module (1500mm) width and 6 module (600mm) height and the shape will be as shown in **Figure 8.14B**.

8.22.5 Symbols for Designating Composite Units: Same as under Para 8.18.4.

IS 1948 has recommended the method of designating the composite unit consisting of door, window and ventilator as described below:

- (1) A 12 module wide and 21 module high horizontally glazed side hung door coupled on its two sides with two side hung horizontally glazed windows 6 module wide and 12 module high is designated by the symbol 6HS 12/12HS21/6HS12.
- (2) Two 10 module wide and 12 module high horizontally glazed side hung windows coupled side by side with two fixed glass pane ventilators at top each 10 module wide and 6 module high is designated by the symbol.

10 HF6/10HF6

10HS12/10HS12

8.22.6 Glazing: Same as under Para 8.18.5.

8.22.7 Panelling: Same as under Para 8.18.6.

8.22.8 Aluminium Panel: Same as under Para 8.18.7.

8.22.9 Fabrication:

- i) Same as prescribed under Para 8.18.8 for doors, Para 8.19.7 for windows and Para 8.21.7 for ventilators. In addition the following requirements for composite units shall be noted.
- ii) The doors shall be coupled with windows or side lights with extruded aluminium mullion coupling bars and transome as shown in the drawings or as directed by the Engineer.
- iii) The coupling member should conform to the dimensions shown in **Figure 8.14C or 8.14D**.
- iv) Where a coupling member/ transome is fitted over an external opening shutter, the coupling should incorporate an integrally extruded weather bar as shown in **Figure 8.11A**.

8.22.10 Tolerance: Same as under Para 8.18.9.

8.22.11 Fittings: Same as prescribed for doors, windows and ventilators.

8.22.12 Position of Holes and Number of Lugs per unit

- i) The position and number of lugs to be provided for a composite unit have been shown in IS 1948 and the same can be followed with certain modifications wherever needed.
- ii) In case the lugs are not to be used and only holes are to be drilled the same shall be drilled in the position of lugs as shown in the Drawing in IS 1948.

8.22.13 Fixing Aluminium Composite Unit in Position: Same as prescribed under Para 8.18.12

8.22.14 Measurements: Same as under Para 8.18.13

8.22.15 Rate

- i) Same as in Para 8.18.14 and in (ii) of Para 8.19.14.
- ii) The rate does not include the cost of mullion bar or transome / weather bar and the same shall be paid separately under a separate item in running metres.

8.23 FLOOR SPRING (HYDRAULICALLY REGULATED)

8.23.1 Type and Size – Typical details are given in **Figure 8.15**. It shall be as per **IS 6315**.

8.23.2 Construction and Operational Details

- i) The floor springs shall be suitable for fixing to the doors weighing upto 125 kg without use of additional door units.
- ii) The floor spring shall operate smoothly and easily without undue delay during the opening and closing operations.
- iii) The oil check shall work satisfactorily at all temperatures between 49° and (-) 10° without requiring any other change except by adjustment of the capstan nut.
- iv) The speed of the closing door shall be adjustable by means of a suitable controlling device. Tension of the spring shall be increased or decreased by turning the capstan nuts clock-wise or anti-clockwise. For exceptionally low temperature the adjustment in the speed could be made by change in the grade of oil.
- v) The shoe shall be fitted to the governing pivot of the floor spring by a square profile so that it stands horizontally parallel with the top cover plate of the floor spring. Provisions shall be made in the shoe for adjusting the door leaf to the final closing position by turning a screw.
- vi) When the door is opened at right angle, the door shall stand open till it is pushed to close.

8.23.3 Performance of Floor Spring

- i) The closing time of the floor spring shall be easily adjustable between 3 and 20 seconds for which a suitable device to adjust the speed shall be provided.
- ii) After being fitted in position the door leaf shall be opened through 90° plus 5° and released. When opened to an angle less than a right angle the door shall swing back automatically.

8.23.4 Workmanship -The floor spring shall be free from all mechanical defects, sharp edges and other surface defects.

8.23.5 Quality Assurance - The floor spring should be with ISI mark for quality assurance.

8.23.6 Fixing

Suitable recess of the required size shall be cut in floor and the floor spring with all its components viz. cover plate, outer box with slide plate etc. shall be embedded in floor.

8.23.7 Measurements - The floor spring shall be measured in numbers.

8.23.8 Rate

The Rate shall include the cost of labour and material involved in all the operations described above and making good the floor.

8.24 ANODIZED ALUMINIUM ALLOY GRID FOR FALSE CEILING

8.24.1 Material and Anodizing - Same as under Para 8.17.1 and 8.17.2

8.24.2 Aluminium Alloy equal / unequal angles and tees prescribed as per IS Standards.

IS 3908 and IS 3909 may be referred to for details. Reputed manufacturers manufacture other sizes of angles as required.

8.24.3 Fabrication and Fixing in Position

- i) The interlocking aluminium alloy grid shall consist of aluminium main "Tee" runners of size 25 x 40 mm and 2.10mm thick or as specified / directed, spaced 1200mm c/c and cross "Tee" of size 24 x 24 mm and 2.10 mm thick or as specified/directed, 1200mm long spaced between the main "Tee" at 600 mm c/c to form a grid of 1200 x 600 mm. Again a secondary cross "Tee" of length 600 mm and size 24 x 24 mm and 2.10 mm thickness or as specified / directed to be interlocked of the centre of 1200 x 600 mm panel to form a grid of 600 x 600 mm.
- ii) Main "Tee" runners are to be suspended from ceiling with M.S. level adjusting hangers.

- iii) The perimeter support on wall shall consist of aluminium angle of size 25 x 25 mm and 1.60 mm thickness or as specified/directed fixed firmly to the walls with the help of rawl plugs spaced at 230 mm c/c and tightened with 25 mm long cadmium plated screws or as directed.

8.24.4 Measurements

The aluminium Tee or Angle iron sections when fixed in position shall be measured correct to 1mm.

The weight per metre length of used 'T' angle sections shall be ascertained by weighing the sample length and the weight thus worked out shall be compared with the weight per metre prescribed by the manufacturer. However payment shall be made for only the actual weight worked out after ascertaining the weight of sample piece, subject to the condition that the weight per metre ascertained is within the tolerance limit of $\pm 10\%$ of the weight of section prescribed in the manufacturer's catalogue.

8.24.5 Rate

The rate includes the cost of materials and labour involved in all operations described above except the M.S. Level adjusting hangers and its fixing arrangement which shall be measured and paid separately as described under Para 8.25.

8.25 PROVIDING AND FIXING LEVEL ADJUSTING HANGERS 6 MM DIA M.S. ROD (UPTO 1200 MM LENGTH)

8.25.1 Materials: Mild steel bars shall conform to the relevant IS specifications. These shall be fabricated from MS bar of 6 mm diameter .

8.25.2 Fixing

Necessary holes for expansion hold fasteners as per the architectural drawing shall be made in slab with drilling machine. MS angle 40 x 40 x 5 mm and 40 mm long shall be fixed with hold fasteners 12.5 mm dia and 40 mm long. MS angle and steel rod should be given a priming coat of zinc chromate yellow primer or any other primer as stipulated, complete as per direction of the Engineer.

8.25.3 Measurements - The level adjusting hanger rods shall be measured in Kg.

8.25.4 Rate

The rate shall include the cost of labour and material involved in all the operation described above.

8.26 PROVIDING AND FIXING MACHINE MOULDED ANODISED ALUMINIUM COVERING OVER EXPANSION JOINTS

8.26.1 General:- Specifications and material shall conform to requirements as laid in paras 8.17.1 & 8.17.2. The aluminium sheet shall be of approved make and conforming to specification laid in IS: 737. Aluminium sheet of required width and thickness shall be made out of wider sheet duly machine cut. Machine moulded covering may be:

- (i) 170 mm wide anodised aluminium sheet 2.5 mm thick.
- (ii) 210 mm wide anodised aluminium sheet 2.5 mm thick.
- (iii) or of any other width/thickness specified in the description of item.

8.26.2 Fixing

Aluminium sheet shall be machine-holed at required spacing. Staggered holes in the receiving surface will be done with drilling machine and expandable plastic sleeve be provided in the holes. Aluminium sheet shall be fixed with cadmium plated 4 mm dia 30 mm long full threaded screws with 2 mm thick anodised aluminium washer complete as per the direction of as Engineer. Anodising on the aluminium sheet and washer to be 15 micron thick.

8.26.3 Measurements

The length of aluminium sheet covering shall be measured in running metre correct to 1 cm. Payment shall be made for least of weight calculated on the basis of unit weight:

- (i) Unit weight specified in manufacturer catalogue.
- (ii) Actual weight per sqm.

8.26.4 Rate

Rate includes the cost of material and labour involved in all the operations described above. It shall include screws, plastic sleeves etc. complete.

8.27 ALUMINIUM CURTAIN WALL SYSTEM /CLADDING

8.27.1 General

- (1) The type of work is not an ordinary job which can be executed by the Contractors doing the general building works but this is a specialised job.
- (2) These structures are designed for the following effects:
 - (a) Permanent Deformation, thermal expansion
 - (b) Wind and seismic load
 - (c) Air and water infiltration or leakage
 - (d) Lateral deflection per floor height
- (3) Normally for executing such works, the design of the system is prepared by the specialized firm and then the same is submitted to the department/architect for approval and only after detailed scrutiny and checking design calculations and drawings, the design is accepted and the firm is asked to take up the job.

8.27.2 Specification for Materials used for Curtain Wall

(1)	Glazing	As specified in the description of the item or as described under Para 8.18.5.
(2)	Framing system	Aluminium anodized extruded sections manufactured by reputed manufacturers for all types of members like brackets, mullions, transoms etc.
(3)	Sealant	As specified in the item or silicon sealant.
(4)	Insulation	50 mm thick glass wool of minimum density 48 kg/cum sandwiched with black polythene sheet 100 micron on one side and aluminium foil of 100 micron on the other side or as specified by manufacturer at spandrel area. The surface after fixing insulation shall be plain without any distortion.
(5)	Heat Reflective Toughened Glass	As specified. Brown or Grey Colour of any shade approved by the Engineer.

8.27.3 Aluminium Alloy Extruded Sections – Manufactured and supplied by reputed companies.

In absence of specific extruded sections available conforming to BIS Specifications, extruded sections manufactured by reputed companies are used on works.

8.27.4 Main Components

Main Components of the Curtain Wall System are shown in **Figure 8.16 A**

8.27.5 General Specification and Tolerances for Aluminium Extrusions Produced by manufacturers - Same as under Para 8.17.4

Product Composition of composite aluminium panel should be as below

- The Aluminium Composite Panel shall be of total thickness comprising of Aluminium skin of 0.5 mm + with Kynar 500 PvdF Paint + 3.0mm LDPE based core material + 0.5mm aluminium skin with service coat bonded together by calendaring process. The total thickness of the Panel shall be 4mm (Tolerance = +/- 0.2 mm).

- The Aluminium outer skin and inner skin should confirm to 3003 grade having a Temper of H-18 Sourced from Hindalco/Nalco. Tensile Strength of Skin – 165 N/mm² Minimum. The Coil sourced from Hindalco is manufactured by adopting Direct Casting Method resulting in better bonding of aluminium molecules. Thickness of Aluminium Skin – 0.5mm (+/- 0.03mm).
- The LDPE Core is Low Density Polyethylene having a Density Range of 920 Kg/m³ to 960 kg/m³ Raw material sourced from IPCL 040 Grade.
- Thickness of self adhesive peel off / Protective foil – 80 microns tested to withstand atleast 45 Days exposure to local weather conditions without losing the original peel off characteristics or causing stain / damages on the coated surface of the Aluminium Composite Panel.

Coating Properties _

- Coating Method – 3 Steel Roller Based Simultaneous Two Coat – Two Bake / Three Coat Three Bake depending on color / shade or RAL / Pantone No.
- Top Coat – 25 microns – 30 microns as per AAMA 2605/620 (PVDF Paint – 18 – 20 Microns) + (Primer – 6 – 8 Microns)
- Back Coat – 4 – 7 Microns as per AAMA 2605/620.
- Technical Specification of Aluminum Composite Panels
- Product Grade – AL 45.
- Total thickness of the panel – 4 mm (+/-0.2mm)
- Thickness of the aluminum skin – 0.5mm (+/- 0.03mm) (Top & Bottom skin)
- Thickness of PE Core – 3.0 mm
- Grade of aluminum skin – a) 3003 series H-14 to H-18
b) 5005 series H -16 to H-18.
- Tensile strength of aluminum skin
(a) 3003 Series – 165 N/mm² Minimum
(b) 5005 Series – 185 N/mm² Minimum
- Density of PE – Core – 920 Kg/m³ – 980 Kg/m³. (Non – Toxic Grade Polyethylene).
- Coating – a) PVDF (for exterior applications)
b) Modified polyester/polyester (for interior applications).
- Adhesive film – Made from ethylene co polymer supplied from Dupont, USA
- Coating thickness (front foil) a) 25 u – 30 u in PVDF including primer.
b) 15u – 18 u in polyester coating.
- Coating thickness (back foil) a) 4u – 7u Polyester coating
- Color choice – Color choice shall be as per the selection of the Client / Architect from our shade card. Special color may be available on request
- Product warranty and tests PVDF coated panels carry A 10 years warranty on chalking, etc. panels shall be manufactured and tested extensively as per the AAMA / ASTM / ECCA Standards.
- Coil is sourced from Hindalco/and is manufactured as per IS-737:1986 Where, AA3003 is IS:31000, AA 3105 is 51300.

8.27.6 Glazing - Same as under Para 8.18.5

8.27.7 Panelling - Same as under Paras 8.18.6 and 8.18.7

8.27.8 Scope of Work

8.27.8.1 Preliminary Requirements

- (i) The Contractor shall design, test, fabricate, deliver, install and guarantee all construction necessary to provide a complete curtain wall system for the proposed building, all in conformity with the drawings as shown.

- (ii) Specification and all relevant construction regulations including providing any measures that may be required to that end, notwithstanding any omissions or inadequacies of the drawings.
- (iii) The curtain wall system shall also include the following activities/elements.
 - (a) Metal frames, glass glazing, spandrels, ventilators, finish hardware, copings, metal closure, windows etc.
 - (b) All anchors attachments, reinforcement and steel reinforcing for the systems required for the complete installations.
 - (c) All thermal insulation associated with the system.
 - (d) All fire protection associated with the system.
 - (e) All copings and closure and metal cladding to complete the system.
 - (f) All sealing and flushing including sealing at junctions with other trades to achieve complete water tightness in the system.
 - (g) Isolation of dissimilar metals and moving parts.
 - (h) Anticorrosive treatment on all metals used in the system
 - (i) Polyester powder coating of aluminium sections.
- (iv) The Contractor shall also be responsible for providing the following:
 - (a) Engineering proposal, shop drawings, engineering data and structural calculations in connection with the design of the curtain wall system.
 - (b) Mock-ups, samples and test units.
 - (c) Performance testing of the curtain wall framing and glazing assembly.
 - (d) Co-ordination with the work of other trades.
 - (e) Insulation with glass wool 48 kg/cum at spandrels area.
 - (f) Protection.
 - (g) All final exterior and interior cleaning and finishing of the curtain wall system.
 - (h) As built record drawings and photographs.
 - (i) Guarantes and warranties.
 - (j) All hoisting, scaffolding, staging and temporary services.
 - (k) Conceptualising and design of a suitable maintenance system for curtain glazing.
- (v) The water tightness and structural stability of the whole curtain wall system are prime responsibility of the contractor. Any defect or leakage found within the guarantee period shall be sealed and made good all at the risk and cost of the contractor.
- (vi) The curtain wall system shall be designed to provide for expansion and contraction of components which will be caused by an ambient temperature range without causing buckling, stress on glass, failure of joint sealents, undue stress on structural elements or other detrimental effects, specific details should be designed to accommodate thermal and building movements.

8.27.8.2

Design Requirements

- (i) Curtain wall shall comply with all government codes and regulations, building bye-laws, if any.
- (ii) All curtain walling, individual aluminium and glass components and all completed work shall be designed and erected to comply with the requirements given in (iii) below:
- (iii) **(a) Basic Requirement:** The basic design and architectural requirements shall consist of the size of window, net glass area, ventilator, configuration of widows and spandrels to be retained. However the

contractor may propose alternatives on the construction details provided that all basic functional and architectural requirements are fulfilled.

(b) Quality Consideration and other Activities

The contractor while submitting the detailed design calculations should submit the following information on the quality of materials to be used and other aspects as detailed below:-

- (1) Metal quality, finishes and thickness
- (2) Glass quality, coating and thickness and manufacturer's brand names.
- (3) Aluminium extruded sections including mullions and transoms together with structural calculations and manufacturer's brand name and also the name of agency proposed for fabrication work.
- (4) Arrangement and jointing of components.
- (5) Field connections especially mullion to mullion and transome to mullion.
- (6) Fixing and anchorage system of typical wall unit together with structural calculations.
- (7) Drainage system and provision in respect of water leakage in the curtain wall system.
- (8) Provisions for thermal movements
- (9) Sealant and sealing methods.
- (10) Glazing Method.
- (11) Wind load and seismic load and any other specific load considered in the design.

Design concept over lightning protection link-up system of the curtain wall for connection and incorporation into the lightning conductor system of the building (Lightning conductor system of the building to be done by any other agency).

The maximum permissible structural tolerances of the building that the system has been designed to accommodate in case these tolerances exceed those specified in the specification.

(c) Tolerances: Any parts of the curtain wall, when completed, shall be within the following tolerances:

- (1) Deviation from plumb, level or dimensioned angle must not exceed 3 mm per 3.5 m length of any member, or 6 mm in any total run in any line.
- (2) Deviation from theoretical position on plan or elevation, including deviation from plumb, level or dimensioned angle must not exceed 9 mm total at any location.
- (3) Change in deviation must not exceed 3 mm for any 3.5 m run in any direction.

- (d) Samples:** The contractor shall also submit samples of aluminium extruded sections, mullion and transome sections in lengths of 300 mm with the same finish and workmanship as per the tender proposals and 300 mm x 300 mm samples of glass (samples to include exposed screws and other exposed securing devices if any).
- (e) Ancillary Requirements** to be fulfilled by the Contractor
The contractor/sub-contractor shall submit a maintenance manual for the curtain wall system covering of all metal parts, glass and finish etc.

During detailed design scrutiny and also during the actual execution of the work, any additions and extra provisions that will have to be made as per theoretical requirements or site conditions shall be implemented and executed by the contractor at his own cost, without claiming any thing extra under any circumstances.

8.27.9 Execution of Work

8.27.9.1 Performance Testing

To be done at the cost of the Contractor with copies of Test Reports to be submitted to the Engineer.

- (i) Mock-up units shall be constructed by the Contractor and tested to determine the structural stability as well as air and water infiltration or leakage at glazing beads and all other joints designed into the face of the building.
- (ii) Tests of wind pressure, lateral deflection per floor height and water tightness shall be conducted on the mock-up unit in a recognized Testing Laboratory to prove the satisfactory functioning of the curtain wall system. Record of Tests and of Drawings of the System should be made available to the Railway by the Testing Laboratory.

8.27.9.2 Fabrication and Erection

The Grid for the Curtain Walls System shall be fabricated as per approved drawing. Care should be taken to see that any gap between its frame and support and the frame itself is sealed with Silicon Sealants. Finish of grid frame shall be either anodised, organic coating, baked enamel finish or as specified in the item of work. Care should be taken to see during erections that the curtain walls system is not deformed or damaged.

A typical curtain wall system with the position of main members like mullions, transome glazing etc is shown to **Figure 8.16 B**.

8.27.10 Performance Guarantee

Normally, performance guaranty for a period of 5 years should be insisted upon to cover the cost of rectification of defects noticed during the guarantee period.

8.27.11 Measurements

- (i) The breadth and height of the finished work including the openable window shall be measured in metres and net quantity for payment calculated in Sqm up to two places of decimal.
- (ii) The area to be considered for the payment shall be the net area of the exterior face of the curtain wall as fixed including the operable windows if any as part of the curtain wall system.

8.27.12 Rate

The rate shall include the cost of all operations described above including the cost of materials labour, design, shop drawings, erection and testing of mock-up test unit, fabrication, erection, finishing scaffolding and undertaking of performance guarantee.

8.28 STRUCTURAL GLAZING

8.28.1 Specification for materials to be used - Para 8.27.2 will apply

8.28.2 Aluminium Alloy Extruded Sections

BIS Codes have not laid down the standards. Reputed companies manufacture extruded sections of different types and unit weights.

8.28.3 General Specification and Tolerances for Aluminium Extrusions - Same as under Para 8.17.4

8.28.4 Glazing - Same as under Para 8.18.5

8.28.5 Scope of Work - Same as under Para 8.27.8

8.28.6 Execution of Work

- (i) Same as under Para 8.27.9
- (ii) Though both the systems i.e. curtain wall system and structural glazing are very much similar, still the type and shape of aluminium extruded sections that are used in this case are totally different.
- (iii) Another noted difference between the two systems is that in elevation the structural glazing looks as total glass surface without any beading visible externally, whereas in case of curtain wall system the cover plate used on the surface is clearly visible in elevation.
- (iv) A large quantity of sealant has to be used for the execution of the work of structural glazing with the result the cost per sqm. of structural glazing works out to be much on higher side.
- (v) There is also a slight difference in the actual fabrication of the two systems though quantity of materials required for execution in both the cases is same except the quantity of sealant.
- (vi) A typical structural glazing system with the position of main members like mullion, transome, glazing etc., are shown in **Fig. 8.17.**

8.28.7 Performance Guarantee - Same as under Para 8.27.10

8.28.8 Measurements - Same as under Para 8.27.11

8.28.9 Rate - Same as under Para 8.27.12

8.29 ALUMINIUM STAIRCASE RAILINGS AND BALUSTER

8.29.1 Materials

Aluminium extruded railing section and baluster section shall comply with the chemical composition and mechanical proposals as laid down in Para 8.17.1

8.29.2 Hand Rails

There are supported on Balusters. Type of Hand Rail shall be as specified in the item. A few typical Hand Rail sections are given **Fig. 8.18.A.**

8.29.3 Baluster

Balusters are out of specified Aluminium section. Usually it is circular/square aluminium rod or of designer pattern as shown in **Fig. 8.18.B.**

8.29.4 Fabrication and Fixing

8.29.4.1 Baluster for specified railing height are cut from the stipulated aluminium section. These are properly embedded in slab/step while its casting. Before concreting work is started it shall be checked that balusters is truly in position and are vertical and top of all the balusters are in proper line. Aluminium channels, square fillet or round fillet as specified in the item shall be run connecting top of all the balusters, either by soldering, argon arc welding, wooden screwing as may be applicable **Fig. 8.18.C.**

8.29.4.2 Specified extruded railing section is cut for the required length. The railing section is fixed on the top of square/round fillet as specified in the item by soldering, brazing etc. Precaution shall be taken to avoid distortion of member. Gap of any sort shall be filled with silicon sealant.

8.29.5 Measurements

Length of each member (i) Baluster (ii) Hand rail, (iii) Channel square fillet/circular fillets shall be measured correct to a cm and payment shall be worked out in running metres correct to two places of decimals.

8.29.6 Rate

Rate includes the cost of material and labour involved in all the operations described above. It shall include cleats, silicon sealant etc.,

ANNEXURE 8.1

MECHANICAL PROPERTIES OF STEEL

Annexure 8.1
(Para No.8.1.1)

MECHANICAL PROPERTIES OF STEEL

Steel Designation	Class of Steel Product	Nominal thickness/dia mm	Tensile strength kg/l/mm ²	Yield stress min. kg/l/mm ²	Percentage elongation gauge minimum length 5.65 $\sqrt{so}$ *
ST-42-W and ST-42-S	Plate sections (For example, angles, tees, beams, channels etc.) and flats	Below 6 mm only bend test shall be required. 6 mm and upto 20 mm Over 20 mm upto 40 mm Over 40	42 to 54 42 to 54 42 to 54	26 24 23	23 23 23
	Bars (round square and Hexagonal)	Below 10 only bend test shall be required 10 mm and upto 20 mm Over 20 mm	42 to 54 42 to 54	26 24	23 23
ST-42-0	Plate sections (For example, angles, tees, beams, channels etc.) and flats	Below 6 only bend test shall be required 6 mm and above	42 to 54	26	23
	Bars (round square and Hexagonal)	Below 10 mm only bend test shall be required 10 mm and above	42 to 54	26	23
ST-32-0	Plates sections (for example beams, channels etc.) & flats	Below 6 m only bend test shall be required 10 mm and above	32 to 44	—	26
	Bars (round square and Hexagonal)	Below 10 only bend test shall be required 10 mm and above	32 to 44	—	26

*SO—Where so is cross sectional Area of test piece.

CHEMICAL COMPOSITION OF STEEL

Steel Designation	Max percentage		
	Carbon	Sulphur	Phosphorous
ST-42-W	0.23	0.06	0.06
ST-42-S	* 0.25/0.28	0.06	0.06
ST-42-0	—	0.07	0.07
ST-32-0	—	0.07	0.07

* Note : 0.25 for thickness or dia 20 mm and below, 0.28 for thickness or dia over 20 mm.

ANNEXURE 8.2**WELDING PROCESS**

- (a) The work shall be positioned for downward welding wherever possible.
- (b) Arc length voltage and amperage shall be suited to the thickness of material, type of groove and other circumstances of the work. The welding current and electrode sizes for different types of joints shall be as per IS : 9595.
- (c) The sequence of welding shall be such as will avoid undue distortion and minimize residual shrinkage stresses. Recommendation of IS : 9595 shall be followed.

Process of Welding - The electrode manipulation during welding shall be such as to ensure that :

- (1) The parent metal is in a fused stage when the filler metal makes contact with it.
- (2) The weld metal does not overflow upon any un-fused parent metal forming overlapping.
- (3) The parent metal is not under-cut along the weld toes.
- (4) The following metal floats, the slag, the oxides, and the gas bubbles to the surface behind the advancing pool. In case any of these requirements is unattainable by manipulation, the current shall be adjusted or the electrode size changed.

Each time the arc is started the electrode shall be moved in such a way that the fusion of base metal at the starting point is assured. At the completion of a run the movement of electrode shall be slowed down to fill the arc crater.

After every interruption of the arc except at completion of a run, the arc shall be restarted ahead of the previous deposit and then moved back to fill the crater or such alternative technique shall be used as will ensure complete filling of the crater, or complete fusion between the new and old deposit and the base metal at the point of junction, and result in continuity of weld. Before welding operation is completed, all traces of slag shall be removed from the deposit, by chipping if necessary, and the deposit and the adjoining base metal shall be wire brushed and cleaned at all points. The requirements shall apply not only to successive layers, but also to successive beads, and to the over lapping area where a junction is made on starting a new electrode.

- (5) The welds shall be free from cracks, discontinuity in welding and other defects such as (i) under-size (ii) over-size, (iii) under-cutting and (iv) over-cutting in the case of fillet welds and defects (ii), (iii) & (iv) in the case of butt welds.

All defective welds which shall be considered harmful to the structural strength shall be cut out and re-welded. In case of welded butt joints in steel of thickness up to 50- mm the weld joint shall be subjected to radiographic examination as described in IS : 1182.

All welds shall be cleaned of slag and other deposits after completion. Till the work is inspected and approved painting shall not be done. The surface to be painted shall be cleaned of spatter, rust, loose scale, oil and dirt.

ANNEXURE 8.3**SHAPES, WEIGHTS AND DESIGNATIONS OF ROLLED STEEL SECTIONS**

Designation	Wt. in kg/m	Situation of Use of Section
T2	1.036	Horizontal-glazing bars for doors and sashes, horizontal glazing bars for door side lights, sub-dividing bars for fixed light, vertical glazing bar for ventilators, sash bars for window, ventilators and door where metal aluminium or wooden beading is used for fixing glasses.
T3	1.14	Vertical glazing bar for EZ 7 frame
T6	0.839	Horizontal glazing bar for standard windows and ventilators
F2	1.46	Inner frames for open-in-windows
F3	2.28	Outer frames for open-in-windows
F5	1.55	(a) Inner and middle frames in centre-hung ventilators (b) F5 is some times used as inner frames for open-out windows. Also used as inner frame for bottom hung ventilators. (c) F8 is also used as outer frame for bottom hung ventilators.
F4B	2.28	Central mullion (meeting bar for shutters) for windows using F7D as inner frames, outer frames for open-in-windows in rainy areas, subdividing bars for open-in-windows and top-hung ventilators.
F7D	1.419	Inner and outer frames for windows and top hung ventilators, for outer frames for centre-hung ventilators and outer frames for door sidelights.
FX6	2.52	Inner frame for doors,
FZ7	1.90	Used as outer frame for industrial sashes. Also used for outer frame for wooden doors.
FX8	1.92	Outer frames for doors.
FZ5	2.52	Inner frames for doors
K11B	1.80	(a) Vertical coupling mullion for standard windows. (b) Can be used as horizontal coupling bar when open-able windows are to be coupled above fixed ones or between two fixed windows. (c) Can also be used as horizontal coupling mullion where windows are not exposed to weather.
K12B	2.30	Horizontal coupling mullion, also known as weather bar, (Especially used when the coupled unit is exposed to rain).

ANNEXURE 8.4
STEEL TUBES FOR STRUCTURAL PURPOSES

Nominal Bore (mm)	Outside Diameter (mm)	Class	Wall thickness (mm)	Weight (kg/m)
15	21.3	H	3.25	1.43
20	26.9	H	3.25	1.90
25	33.7	M	3.25	2.46
		H	4.05	2.99
32	42.4	M	3.25	3.15
		H	4.05	3.86
40	48.3	M	3.25	3.61
		H	4.05	4.43
50	60.3	L-2	3.25	4.57
		M	3.65	5.10
		H	4.50	6.17
65	76.1	L	3.25	5.84
		M	3.65	6.53
		H	4.50	7.92
80	88.9	L	3.25	6.86
		M	4.05	8.48
		H	4.85	10.10
90	101.6	L	3.65	8.82
		M	4.05	9.75
		H	4.85	11.60
100	114.3	L	3.65	9.97
		M	4.50	12.40
		H	5.40	14.50
110	127.0	L	4.50	12.20
		M	4.85	14.60
		H	5.40	16.20
125	139.7	L	4.50	14.90
		M	4.85	16.20
		H	5.40	17.90
135	152.4	L	4.50	16.40
		M	4.85	17.70
		H	5.40	19.50
150	165.1	L	4.50	17.80
		M	4.85	19.20
		H	5.40	21.20
150	168.3	L	4.50	18.10
		M	4.85	19.60
		H-1	5.40	21.70
		H-2	6.30	25.30
175	193.7	L	4.85	22.60
		M	5.40	25.00
		H	5.90	27.30
200	219.1	L	4.85	25.70
		M	5.60	29.40
		H	5.90	31.00
225	244.5	H	5.90	34.20

L means Light M means Medium H means Heavy

RECOMMENDED LIST OF TESTS ON MATERIALS AND WORKS

Material	Test	Field/ Labora- tory Test	Text Procedu re	Minimum Quantity of material for carrying out the test	Frequency of testing
Steel	(a) Tensile Strength (b) Bend test	Labora- tory	IS:1599	20 Tonne	Every 20 Tonne or part thereof

Chapter 9

Flooring, Paving And Dado

9.1 BRICK FLOORING

9.1.1. Bricks

Bricks of specified dimensions and designations shall be used. These shall conform to the Specifications given in Brickwork Chapter. Broken bricks shall not be used in flooring except for closing the line. The bricks shall be laid on edge unless otherwise specified.

9.1.2. Mortar

The mortar used shall be as specified.

9.1.3. Base Concrete

9.1.3.1 Flooring shall be laid on base concrete where so specified. The base concrete shall be provided with the slope required for the flooring. Floors in verandahs, courtyards, kitchens and baths shall have slope ranging from 1:3:6 to 1:4:8 depending upon the locations, as decided by the Engineer.. Floors of water closet portion shall have slope of 1:30 or as decided by the Engineer to drain off washing water. Plinth masonry off-set shall be depressed so as to allow the base concrete to rest on it.

9.1.3.2. If the base consists of lime concrete, it shall be allowed to set for seven days and the Brick on edge flooring shall be laid in the next three days.

9.1.3.3. If the base is of lean cement concrete, the flooring shall commence within 48 hours of the laying of base, failing which, the surface of base shall be roughened with steel wire brushes without disturbing the concrete. Before laying the flooring, the base shall be wetted and smeared with a coat of cement slurry at 2 kg. of cement spread over an area of one sqm. so as to get a good bond between the base and flooring.

9.1.3.4 Where base concrete is not provided, the earth below shall be properly sloped, watered, rammed and consolidated. Before laying the flooring, it shall be moistened.

9.1.4 Soaking of Bricks

Bricks required for flooring shall be adequately soaked in stacks before use, by profusely spraying with clean water at regular intervals for a period of not less than six hours as to keep them wet to the satisfaction of the Engineer.

9.1.5 Laying

9.1.5.1 The bricks shall be laid on the edge in plain, diagonal, herring bone bond, or other pattern as specified or directed by the Engineer.

9.1.5.2 Bricks shall be laid on edge on 12 mm thick mortar bed and each brick shall be properly bedded and set home by gentle tapping with trowel handle or wooden mallet. Its inside face shall be buttered with mortar, before the next is laid and pressed against it. In Flat Brick flooring, the bricks shall be laid with Frog down.

9.1.5.3 On completion of a portion of flooring, the vertical joints shall be fully filled from the top with mortar. The surface of the flooring during laying, shall be frequently checked with a straight edge at least 2m long, so as to obtain a true plane surface with the required slope.

9.1.6 Joints

Bricks shall be so laid that all joints are full of mortar. The thickness of joints shall not exceed 1.0 cm for brick work with bricks of any class designation. All face joints shall be raked to a minimum depth of 15 mm by raking tool during the progress of work when the mortar is still green so as to provide proper key for the plaster or pointing to be done. Where plastering or pointing is not required to be done, the joints shall be struck flush and finished at the time of laying. The face of brick work shall be cleaned on the same day on which brick work is laid and all mortar droppings removed promptly.

9.1.7 Curing

Brick work shall be protected from rain by suitable covering when the mortar is green. Masonry work in cement mortar, composite lime mortar, lime mortar (lime of category other than C & D) (Refer Mortar chapter) shall be kept constantly moist on all faces for a minimum period of seven days. Brick work carried out during each day shall be suitably marked indicating the date on which the work is done so as to keep a watch on the curing period. In case of masonry with fat lime mortar, curing shall commence two days after laying of masonry and shall continue for at least seven days thereafter.

9.1.8 Measurements

Length and breadth shall be measured correct to a cm and area as laid shall be calculated in square metres correct to two

places of decimal. Length and breadth shall be measured before laying skirting, dado or wall plaster. No deduction shall be made nor extra paid for voids not exceeding 0.20 sqm. Deduction for ends of dissimilar materials or other articles embedded shall not be made for areas not exceeding 0.10 sqm.

Brick flooring when laid in diagonal herring bone bond or other pattern as specified or directed by the Engineer shall be measured separately.

9.1.9 Rate

The rate shall include the cost of all materials and labour involved in all the operations described above, including application of cement slurry on base concrete or RCC slab and cleaning of base. Base concrete shall be paid for separately.

9.1.10 Dry Brick Flooring

All provisions in paras 9.1.1. to 9.1.8. will be applicable subject to following modifications. Bricks need not be soaked. Bricks will be laid on a bed of 12 mm thick mud mortar with plasticity index of 9% to 12% laid to required slope. The joints shall be as fine as possible and not exceeding 5 mm which will be filled with fine sand. No curing is required to be done. Where so specified, Dry Brick flooring can be laid on a bed of dry sand of 25mm average thickness.

9.1.10.1 Rate

The rate shall include the cost of all materials and labour involved in all the operations described above.

9.2. CEMENT CONCRETE FLOORING

(Note:- For recommended Specifications for different types of Concrete Floors Table 9.1 of Chapter 9 of BIS Handbook of Building Construction Practices may be referred to).

9.2.1. Cement Concrete

Cement concrete of specified mix shall be used and it shall generally conform to the specifications described under Para 3.2. Generally Cement Concrete 1:2:4 (1 Cement; 2 Fine aggregates; 4 coarse aggregate of Graded size 20mm) by volume is used. It can be of richer grade, if required).

9.2.1.1 Cement Concrete flooring, if to be laid directly on ground should be laid on a sub-base comprising of earth filling watered and rammed in 15 cm layers. This shall then be covered with clean coarse sand / ordinary sand well consolidated to a thickness of not less than 10 cm. Sand layer shall be well wetted before laying Concrete for the Sub grade.

9.2.2. Base Concrete or Sub Grade Concrete

9.2.2.1. All provisions in para 9.1.3.1 will apply.

9.2.2.2. If the base consists of lime concrete, it shall be allowed to set for seven days and the flooring shall be laid within the next three days.

9.2.2.3. All provisions in Para 9.1.3.3 will apply.

9.2.2.4. (a) If the cement concrete flooring is to be laid directly on the RCC slab after the slab concrete has set for at least 3 hours the top surface of RCC slab shall be cleaned and the laitance shall be removed and a coat of cement slurry at 2 kg. of cement per sqm. area applied so as to get a good bond between the base and concrete floor

(b) When however it is possible to lay floor finish immediately within three hours of casting of structural / RCC slab, after ensuring proper bond, a floor finish 15mm thick, in cement concrete 1:2 to 1:3 (cement: stone aggregate of size 4.75mm and below by volume) shall be provided. Cement concrete topping shall be laid and finished monolithic with the structural slab. For this purpose the topping shall be laid immediately after the structural concrete has stiffened enough (but is still green) to allow for the workmen to tread over it by placing planks.

(c) Where required such as for providing proper levels over the RCC Slab, a cushioning layer can be provided of 40mm thickness of Lime / Lean Cement Concrete with brick aggregate of 20mm nominal size. Lime concrete is not to be used where it may come in contact with iron pipes or fittings.

Before laying the cushioning layer, the surface of sub floor shall be thoroughly cleaned of dirt, loose particles and laitance by scrubbing with steel wire brush. The surface shall then be thoroughly cleaned and soaked with water overnight and surplus water removed by mopping immediately before cushioning layer is laid in position. On the clean damp surface of the sub floor, cushioning layer shall be evenly spread between forms, and if necessary thoroughly tamped and levelled.

9.2.3. Protection against dampness

a) The sand layer as required under para 9.2.1.1 above will generally serve the purpose of damp-proofing required for ordinary floors under normal conditions. In more severe conditions where it is expected that the dampness may find its way to the floor in the course of usage, a more effective

damp proof treatment may be given by any of the methods given below which shall be paid for extra.

i) Laying of base concrete in two layers of thickness not less than 75mm each and painting the top of the lower layer with two coats of hot bitumen applied at the rate of 1.5 kg. per sqm. The surface of the lower layer shall be finished smooth while laying the concrete so as to apply the bitumen uniformly. The bitumen shall be applied after the concrete has set and is sufficiently hard.

ii) Sandwitching of water proofing membrane, such as bituminous felt or polyethylene sheet, in the base concrete laid in two layers of thickness 75mm each. The surface of the lower layer shall be finished smooth while laying the concrete so as to provide an even surface thus preventing any damage to the water proofing membrane.

iii) Adding some integral water proofing compound in the concrete mix for the topping.

b) Where it is expected that the dampness may find its way from the surrounding walls, the same shall also be effectively damp-proofed upto atleast 150mm above the level of the base concrete and the damp proof treatment below the floor shall be extended over the walls.

9.2.4. Laying

9.2.4.1 Thickness

The thickness of floor shall be as specified in the description of the item in the Schedule.

9.2.4.2 Panels

Flooring of specified thickness shall be laid in the pattern including the border/or as given in the drawings or as directed by the Engineer. The border panels shall not exceed 450 mm in width and the joints in the border should be in line with panel joints. The panels shall be of uniform size and no dimension of a panel shall exceed 2 m and the area of a panel shall not be more than 2 sqm. Normally Length of a panel should not exceed 1 ½ times its breadth.

9.2.4.3 Laying of flooring with strips

Normally cement concrete flooring shall be laid in one operation using glass/aluminium/PVC/brass strips or any other strips as required as per drawing or instructions of the Engineer, at the junction of two panels. This method ensures uniformity in colour of all the panels and straightness at the junction of the panels. 4 mm thick glass strips or 2 mm aluminium or brass strips shall be fixed with their tops at proper level, giving

required slopes. Cost of providing and fixing strips shall be paid for separately.

Concreting:- Cement concrete shall be placed in the panels and levelled with the help of straight edge and trowel and beaten with a wooden "Thapy" or mason's trowel. The blows shall be fairly heavy in the beginning but as consolidation takes place, light rapid strokes shall be given. Beating shall cease as soon as the surface is found covered with a thin layer of cream of mortar. The evenness of the surface shall be tested with straight edge and made true to required slopes. While laying concrete, care shall be taken to see that the strips are not damaged / disturbed by the labourers. The tops of strips shall be visible clearly after finishing with cement slurry.

9.2.4.4 Laying of flooring without strips:-

Laying of cement concrete flooring in alternate panels may be allowed by the Engineer in case strips are not to be provided.

i) Shuttering: The panels shall be bounded by angle iron or flats. The angle iron / flat shall have the same depth as the concrete flooring. These shall be fixed in position with their top at proper level giving required slope. The surface of the angle iron or flats, to come in contact with concrete shall be smeared with soap solution or non-sticking oil (Form oil or raw linseed oil) before concreting. The flooring shall butt against the un plastered masonry wall.

ii) Concreting:- The concreting shall be done in the manner described under para 9.2.4.3. The angle iron / flats used for shuttering, shall be removed on the next day of the laying of cement concrete. The ends thus exposed shall be repaired, if damaged, with cement mortar 1:2 (1 cement: 2 coarse sand) and allowed to set for minimum period of 24 hours. The alternate panels shall then be cleaned of dust, mortar, droppings etc and concrete laid. While laying concrete, care shall be taken to see that the edges of the previously laid panels are not damaged and fresh mortar is not splashed over them. The joints between the panels should come out as fine straight lines.

9.2.5 Finishing

9.2.5.1 The finishing of the surface shall follow immediately after the cessation of beating. The surface shall be left for some time, till moisture disappears from it or surplus water can be mopped up. Use of dry cement or cement and sand mixture sprinkled on the surface to stiffen the concrete or absorb excessive moisture shall

not be permitted. Excessive trowelling shall be avoided.

9.2.5.2 Fresh cement shall be mixed with water to form a thick slurry and spread at the rate of 2 kg of cement per sqm area of flooring while the flooring concrete is still green. The cement slurry shall be finished smooth.

9.2.5.3 The edges of sunk floors shall be finished and rounded with cement mortar 1:2 (1 cement: 2 coarse sand) and finished with a floating coat of neat cement.

9.2.5.4 The junctions of floor with wall plaster, dado or skirting shall be rounded off where so specified.

9.2.5.5 The men engaged on finishing operations shall be provided with raised wooden platform to sit on so as to prevent damage to new work.

9.2.6 Curing

The curing shall be done for a minimum period of ten days. Curing shall not be commenced until the top layer has hardened. Covering with empty gunnies shall be avoided as the colour of the flooring is likely to be affected due to the remnants of cement dust from the bags.

9.2.7 Precautions

Flooring in lavatories and bath room shall be laid only after fixing of water closets and squatting pans and floor traps. Traps shall be plugged while laying the floors and opened after the floors are cured and cleaned. Any damage done to WCs, squatting pans and floor traps during the execution of work shall be made good.

During cold weather, concreting shall not be done when the temperature falls below 4 deg. C. The concrete placed shall be protected against frost by suitable covering. Concrete damaged by frost shall be removed and work redone. During hot weather, precautions shall be taken to see that the temperature of the wet concrete does not exceed 38° C. No concreting shall be laid within half an hour of the closing time of the day, unless permitted by the Engineer. To facilitate rounding of junction of skirting, dado and floor, the skirting / dado shall be laid along with the border or adjacent panels of floor.

Plastering of all inside walls and ceilings, fixing of door frames and other heavy work shall be completed before laying the floors. The limits with regard to dimensions of panels as specified in para 9.2.4.2 above shall also apply to borders and skirting laid around the floor. The joints in the floor finish

shall extend through the border and the skirting. If the skirting is laid monolithic with the flooring, a border of about 30 cm width shall be provided around the floor. In case the skirting is not monolithic with the floor finish, the width of border shall not exceed 45 cm.

9.2.8. Measurements

Length and breadth shall be measured before laying skirting dado or wall plaster. No deduction shall be made nor extra paid for voids not exceeding 0.20 sqm. Deductions for ends of dissimilar materials or other articles embedded shall not be made for areas not exceeding 0.10 sqm.

The flooring done either with strips (in one operation) or without strips (in alternate panels) shall be treated as same and measured together.

9.2.9 Rate

The rate shall include the cost of all materials and labour involved in the operations described above including application of cement slurry on RCC slab or on base concrete and including roughening and cleaning the surface but excluding the cost of strips which shall be paid separately under relevant item. Nosing of steps where provided shall be paid for separately in running metre. Nothing extra shall be paid for laying the floor at different levels in the same room or courtyard and for rounding off edges of sunk floors. In case the flooring is laid in alternate panels, nothing extra shall be paid towards the cost of shuttering used for this purpose.

9.2.10 Inspection and Testing:- Adhesion between flooring and the base concrete may be examined by tapping the surface with the end of a rod or a hammer. Hollow sound indicates poor adhesion. Loss of adhesion does not necessarily mean that the floor finish is unsuitable unless it is accompanied by visible lipping of the edges of panels or cracks. Occasionally there may be no lipping but the panel edges may be noticeably higher than the centres of panels. Where the flooring is considered to be unsatisfactory, the topping concrete and any loose concrete in the base concrete shall be cut out and the base concrete keyed sufficiently to allow a sound renewal to be made. The unsatisfactory panels shall be renewed as a whole.

9.2.11 Cement Concrete Flooring, laid in two layers

9.2.11.1 General:- Where a very dense and smooth finish is desired, e.g. in quarters,

hospitals, waiting halls etc the topping may be laid in two layers, i.e. an under-layer and a wearing layer. The specifications for the sub-base, sub-grade, panels, shuttering, curing, precautions, and inspection and testing shall be the same as for "Cement Concrete Flooring, laid in one layer" described under para 9.2 and subsequent sub paras above.

9.2.11.2 Under Layer:- The under-layer shall be cement concrete 1:2:4 by volume. It shall be laid as per specifications for laying the topping under C.C. Flooring (para 9.2.4 above) with the difference that the surface of concrete of this layer shall not be finished smooth but left rough after tamping with the wooden 'thappy' and levelling with a screed board.

9.2.11.3 Wearing layer:- The top 15 mm wearing layer shall be of cement concrete mix 1:2 by volume (1 part cement: 2 parts very fine shingle or grit of size upto 6mm). The mix shall be of consistency stiffer than that of the under layer. It shall be laid over the rough but green surface of the under layer, thoroughly tamped, struck off level and the surface floated with wooden float. The surface shall then be finished smooth as described for "Finishing" under CC Flooring (para 9.2.5) above.

9.2.11.4 Polishing: The wearing layer may be polished, if ordered. The polishing shall be carried out after the floor has completely dried. For polishing, the surface shall be rubbed with medium grain carborundum block till all marks from trowels, scratches, etc are removed. This shall be followed by a similar rubbing with a finer grade of carborundum and finally with a fine hard grain stone so that the surface feels quite smooth to the touch. The final polish shall consist of a mixture of one part bees-wax and 3 parts turpentine, which shall be well rubbed with clean cotton waste into the surface, and all surplus removed. The best result is obtained with a minimum of bees wax and maximum of rubbing. The rubbing must be continued until the floor ceases to be sticky.

9.3 CEMENT CONCRETE FLOORING WITH METALLIC HARDENER TOPPING

9.3.1 General:- (a) Wherever floors are required to withstand heavy wear and tear, it is better to use richer mix of Concrete. Use of a metallic hardener should be resorted to only when justified on the basis of cost. Where metallic hardener topping is used, it shall be 12 mm thick.

(b) The Metallic Hardner compound shall be of approved quality consisting of uniformly graded iron particles, free from non-ferrous metal particles, oil, grease, sand and soluble alkaline compounds. Where so directed by the Engineer it shall be tested as described in **Annexure 9.1.**

9.3.2 Base Concrete

It shall be as specified in para 9.2.2.

9.3.3 Under Layer

Cement concrete flooring of specified thickness and mix shall be laid as under layer (paras 9.2.1. and 9.2.3.). The top surface shall be roughened with brushes while the concrete is still green and the forms shall be kept projecting up 12 mm over the concrete surface, to receive the metallic hardening compound topping.

9.3.4 Topping

This shall consist of 12 mm thick layer of mix 1:2 (1 cement : 2 stone aggregate 6 mm nominal size) by volume or as otherwise specified with which metallic hardening compound is mixed in the ratio of 1:4 (1 metallic concrete hardener : 4 cement) by weight. Metallic hardener shall be dry mixed thoroughly with cement on a clean dry pucca platform. This dry mixture shall be mixed with stone aggregate 6 mm nominal size or as otherwise specified in the ratio of 1:2 (1 cement : 2 stone aggregate) by volume and well turned over. Just enough water shall then be added to this dry mix as required for floor concrete.

The mixture so obtained shall be laid in 12 mm thickness, on cement concrete floor within 2 to 4 hours of its laying. The topping shall be laid true to provide a uniform and even surface. It shall be firmly pressed into the bottom concrete so as to have good bond with it. After the initial set has started, the surface shall be finished smooth and true to slope with steel floats.

The junction of floor with wall plaster, dado or skirting and finishing operations shall be dealt with as described in para 9.2.5.

The men engaged on finishing operations shall be provided with raised wooden platform to sit on, so as to prevent damage to new work.

9.3.5 Curing etc:- The specifications for curing, precautions to be taken, 'Measurements' and 'Rates' shall be as specified in para 9.2.

9.4 CEMENT PLASTER IN RISERS OF STEPS, SKIRTING, DADO

9.4.1 General:- (a) A band of plaster at the bottom of wall not exceeding 30 cm in height above the floor shall be classified as skirting. It shall be flush with wall plaster or projecting out uniformly by 6 mm from the wall plaster as specified. The work shall be preferably carried out simultaneously with the laying of floor. The corners and junctions with floor shall be finished neatly as specified and shall be rounded off neatly, wherever required upto 25mm radius.

(b) The thickness of the plaster specified for Risers of steps, Skirting or Dado shall be measured exclusive of the thickness of key i.e. grooves or open joints in brick work. The average thickness shall not be less than the specified thickness. The average thickness should be regulated at the time of plastering by keeping suitable gauges of different thicknesses. Extra thickness required in rounding of corners at junctions of wall shall be ignored.

9.4.2 Preparation of Wall Surface

The joints shall be raked out a depth of at least 15 mm in masonry walls. In case of concrete walls, the surfaces shall be roughened by hacking. The surface shall be cleaned thoroughly, washed with water and kept wet before skirting is commenced.

9.4.3 Application

Skirting with specified mortar and to specified thickness shall be laid immediately after the surface is prepared. It shall be laid along with the border of adjacent panels of floor. The joints in skirting shall be kept true and straight in continuation of the line of joints in borders or adjacent panels. The skirting shall be finished smooth and true, with top truly horizontal and joints truly vertical except where otherwise indicated.

9.4.4 Finishing

The finishing of surface shall be done simultaneously with the borders of the adjacent panels of floor. The cement to be applied in the form for slurry for smooth finishing shall be at the rate of 2 kg of cement per litre of water applied per sqm area.

Where skirting is flush with plaster, a groove 10 mm wide and up to 5 mm deep shall be provided in plaster at the junction of skirting with plaster.

9.4.5 Curing

Curing shall be commenced on the next day of plastering when the plaster has hardened sufficiently and shall be continued for a minimum period of 7 days.

9.4.6 Measurements

Length and height shall be measured correct to a cm and its area shall be calculated in sqm. correct to two places of decimals stating the thickness. Length shall be measured as the finished length of skirting. Height shall be measured from the finished level of floor correct to 5 mm.

9.4.7 Rate

Rate shall include the cost of all materials and labour involved in all the operations described above.

9.5 CEMENT PLASTER SKIRTING FINISHED WITH RED OXIDE OF IRON

9.5.1 Under Coat

The under coat of skirting shall be of cement plaster of the thickness and mix described in the item. 'Specifications given under paras 9.5.1 and 9.5.2 shall apply. As regards application, the work shall be carried out in the manner described in para 9.5.3. except that the under coat shall be finished rough with a scratching tool to form a key for the top coat.

9.5.2 Top Coat

Mortar : This shall consist of uniform and smooth layer of plaster of specified thickness and of mix 1 : 3 (1 cement : 3 coarse sand) unless otherwise specified, finished with a floating coat of neat cement. In both plaster and floating coat the ratio specified in the description of item shall be adopted. Normally 3.5 kg. of red oxide of approved quality shall be mixed with 50 kgs of cement. This ratio may, however, be adjusted to the tinge ordered by the Engineer. The red oxide shall be mixed with the cement and then sand added and mixed. The full quantity of dry mortar required for a room shall be prepared in one lot in order to ensure uniform colour. Wet mortar shall be prepared in the usual manner as and when required.

9.5.3 Application : The top coat shall be done the next day after the under coat has been applied. The plaster shall be done to the thickness specified and finished smooth, by application of cement-red oxide mix, at the rate of 1.0 kg. per square metre of surface, the ratio adopted for the mix being the same as that for the plaster. When the surface has hardened sufficiently it shall be brought to a fine polish by use of polishing stones.

9.5.4 Thickness

The thickness of the bottom and top coats shall be as specified. The total thickness of skirting specified is of total thickness of plaster as measured from the un-plastered face of the masonry. Average thickness of the under coat shall not be less than 6 mm and minimum thickness over any portion of the surface shall not be less than 4 mm. The thickness of top coat shall not be less than the thickness specified.

9.5.5 Curing

Curing shall be commenced on the next day of plastering when the plaster has hardened sufficiently and shall be continued for a minimum period of 7 days.

9.5.6 Measurements

Length and height shall be measured correct to a cm and its area shall be calculated in sqm. correct to two places of decimal stating the thickness. Length shall be measured as the finished length of skirting. Height shall be measured from the finished level of floor correct to 5 mm.

9.5.7 Rate

The rate shall include the cost of all materials and labour involved in all the operations described above.

Where the quantity of red oxide used is different from what is described in the item to get the tinge required by the Engineer, the difference in quantity used will be subject to corresponding adjustment in the rate of the item.

9.6 CEMENT CONCRETE PAVEMENT IN COURTYARD AND TERRACE

9.6.1 General : Specifications described in paras 9.2.1, 9.2.2.1, 9.2.3, 9.2.4, 9.2.6 and 9.2.7 shall hold good as far as applicable except that:

(i) The panels shall be of uniform size and no dimension of a panel shall exceed 1.25 m and the area of panel should not exceed 1.25 sqm. for the thickness of panels up to 50 mm.

(ii) Concreting shall be done in alternate panels only and glass strip shall normally not be provided.

9.6.2 Finishing

The finishing of the surface shall follow immediately after the cessation of beating. The surface shall be left for some time, till moisture disappears from it or surplus water can be mopped up.

Use of dry cement or cement and sand mix sprinkled on the surface to stiffen the

concrete or to absorb excessive moisture shall not be permitted. Excessive troweling shall be avoided. When the surface becomes fairly stiff, it shall be finished rough with wooden floats or where so specified chequered uniformly by pressing a piece of expanded metal of approved size.

9.6.3 Measurements

Same as in para 9.2.8 except that the volume will be calculated in cum nearest to two decimal places or as laid down in the item.

9.6.4 Rate

The rate shall include the cost of all materials and labour involved in all the operations described above except the base concrete below flooring which shall be paid for separately. Chequering to pattern shall be paid for separately unless otherwise specified.

9.7 TERRAZZO (MARBLE CHIPS) FLOORING LAID IN SITU

9.7.1 Under Layer

Cement concrete is specified mix shall be used and the specifications given under para 9.3.3 shall apply. The panels shall be of uniform size, not exceeding 2 sqm. in area or 2 m in length for inside situations. In exposed situations, the length of any side of the panel shall not be more than 1.25 metres. Cement slurry @ 2.00 kg. per sqm. area shall be applied before laying of under layer over the cement concrete/RCC base. The under layer shall be laid as per specifications for ordinary "Cement Concrete Flooring in one layer" under para 9.2 and subsequent sub-paras above except that the under-layer shall not be left smooth but shall be roughened with 1.5mm deep diagonal lines 7.5cm apart both ways with a scratching tool to form a key for the topping.

9.7.2 Fixing of Strips

4 mm thick glass strips or 2 mm thick PVC strips/aluminium strips/brass strips unless otherwise specified shall be fixed with their top at proper level to required slope. Strips of stone or marble or of any other material of specified thickness can also be used if specifically required. The fixing and laying shall be as specified in para 9.2.4.3. Portions of the bottom edges of the dividing strips may be cut to a height not exceeding 12mm and twisted so as to provide anchorage into the terrazzo finish. The spacing of such cut portions shall not be closer than 30 cm. Alternatively, anchorage

may be provided by fixing 4cm long cross nails through the strips.

9.7.3 Top Layer

9.7.3.1. (a) Terrazzo Mix: The mix for terrazzo topping shall consist of cement with or without pigment, marble powder (Grading Zone IV), marble aggregate (marble chips)

and water., The cement and marble powder shall be mixed in the proportion of three parts of cement to one part marble powder by weight. For every part of cement marble powder mix, the proportion of aggregate by volume shall be as shown in **Table 9.1** below.

TABLE 9.1

Grade No.	Size of aggregates (mm)	Proportion of aggregates to binder mix	Minimum thickness of top layer (mm)
00	1-2	1.75:1	6
0	2-4	1.75:1	9
1	4-7	1.75:1	9
2	7-10	1.5:1	12

The marble chips shall be white or pink Makrana, black Bhainslana, Chittoor black, Jaisalmer Yellow, Baroda green, Dehradun white, Chittoor pink, yellow Patam cherala (Andhra Pradesh), grey Gadu (Surat), Chittoor green and yellow and Alwar black or as specified. It shall be hard, sound, dense and homogenous in texture with crystalline and coarse grains. It shall be uniform in colour and free from stains, cracks, decay and weathering. The minimum thickness of the top layer for various sizes of marble aggregates (marble chips) shall be as shown in **Table 9.1**.

Where aggregate of size larger than 10 mm are used, the minimum thickness of topping shall not be less than 1½ times the maximum size of the chips. Where large size chips each as 20 mm or 25 mm are used, they shall be used only with a flat shape and bedded on the flat face so as to keep the minimum thickness of wearing layer.

Before starting the work, the contractor shall get the sample of marble chips approved by the Engineer. The cement to be used shall be ordinary grey cement/ white cement/ cement with admixture of colouring matter of approved quality in the ratio specified in the description of the item to get the required shade as ordered by the Engineer. Colouring materials where specified shall be mixed dry thoroughly with the cement and marble powder and then marble chips added and mixed as specified above. The full quantity of dry mixture of mortar required for a room shall be prepared in a lot in order to ensure a uniform colour. While mixing the aggregates, care shall be taken not to get the

materials into a heap, as this would result in the coarsest chips falling to the edge of the heap and the cement working to the centre at the bottom. The materials shall be kept, as far as possible, in an even layer during mixing. This mixture shall be stored in a dry place and well covered and protected from moisture. The dry mixture shall be mixed with water in the usual way as and when required. The mixed mortar shall be homogenous and stiff and contain just sufficient water to make it workable.

b) Laying:- The terrazzo topping shall be laid while the under layer is still plastic, but has hardened sufficiently to prevent cement from rising to the surface. This is normally achieved between 18 to 24 hours after the under layer has been laid. A cement slurry preferably of the same colour as the topping shall be brushed on the surface immediately before laying is commenced. It shall be laid to a uniform thickness slightly more than that specified in order to get the specified finished thickness after rubbing. The surface shall be rammed in order to consolidate the terrazzo. It is not sufficient just to 'float' lightly as this would cause depressions which have to be filled with mortar. A piece of smooth marble stone of size 15 cm x 15 cm x 2.5cm may be advantageously used for ramming. Following the rammer, a trowel may be used. When using the trowel, the object should be to make the surface level and smooth with as little use of the float as possible, relying upon pressure rather than upon trowelling action to achieve this end. Rolling will be easier than tamping and patting, but a rolled terrazzo is more likely to crack since the rolled surface

would draw the cement to the surface unless the mixture is very dry. The best results will be obtained by tamping combined with a minimum of trowelling. The compaction shall ensure that air bubbles are driven out from the mix. The surface shall be brought true to required level by a straight edge and steel float in such a manner that the maximum amount of marble chips come up and are spread uniformly over the surface and no part of the surface is left without chips.

c) Border and decorative designs:-

Borders and decorative designs shall be laid before the main body of the flooring. They shall be laid and finished in the same manner as flooring, preferably using dividing strips. Where, however, stencils or form work of wood or metal are used instead of dividing strips, they shall be removed before the topping mix commences to harden. The removal shall be effected with as little disturbance to the materials as possible, and any ragged edges left after removal of the stencils or form work shall be rectified with a trowel, care being taken to consolidate the terrazzo to avoid damage to the edges of the design.

The wooden strips or float iron used for shuttering of panels shall normally be removed the next day of the laying of the top layer. The edges shall be checked and made true and straight by chiselling and rubbing down with carborundum stone. The edges of the under-layer shall also be repaired, if necessary, with cement mortar 1:2 (1 cement: 2 coarse sand) and allowed to set for a day. On the next day, the alternate panels shall be cleaned of all dust, mortar, droppings etc. and concrete for the under-layer laid. The process of laying the top terrazzo layer in alternate panels shall then be repeated. Junctions of floor with wall plaster, dado or skirting shall be rounded off neatly, where so required.

9.7.3.2 Polishing, Curing and Finishing

: - Polishing shall normally be done by machine. About 36 hours after laying the top layer, the surface shall be watered and ground evenly with the machine fitted with special rapid cutting grit blocks (carborandum stone) of coarse grade (No. 60) till the marble chips are evenly exposed and the floor is smooth. After the first grinding, the surface shall be thoroughly washed to remove all grinding mud and covered with a grout of cement and colouring matter in same mix and proportion as the topping in order to fill any pin holes that appear. The surface shall be allowed to cure

for 5 to 7 days and rubbed with the machine fitted with fine grit blocks (No. 120). The surface is cleaned and repaired as before and allowed to cure again for 3 to 5 days. Finally the third grinding shall be done with the machine fitted with fine grade grit blocks (No.320) to get even and smooth surface without pin holes. The finished surface should show the marble chips evenly exposed.

Where use of machine for polishing is not feasible or possible, rubbing and polishing shall be done by hand, in the same manner as specified for machine polishing except that carborundum stone of coarse grade (No.60) shall be used for the first rubbing, stone of medium grade (No.80) for second rubbing and stone of fine grade (No.120) for final rubbing and polishing.

After the final polish either by machine or by hand, oxalic acid powder shall be dusted over the surface @ 33 gms per square metre sprinkled with water and rubbed hard with a namdah block (Pad of Woolen rags). The following day, the floor shall be wiped with a moist rag and dried with a soft cloth and finished clean. Curing shall be done by suitable means such as laying moist sawdust or ponding water.

9.7.3.3 Final finishing before occupation:-

Just before the area is occupied, the floor shall be washed clean with dilute oxalic acid solution, dried and rubbed with clean cotton waste. Rubbing shall be continued until the floor ceases to be sticky. In case wax-polished surface is desired, the wax polish shall be sparingly applied with soft linen on the clean and dry surface. This shall then be rubbed thoroughly with clean cotton waste or a polishing machine fitted with felt or hessian bobs. Any surplus wax shall be mopped up and the rubbing shall be continued until the floor ceases to be sticky. Wax polishing shall be done only where specifically ordered by the Engineer. Nothing extra will, however, be paid for the same.

9.7.4 Precautions

Flooring in lavatories and bathrooms shall be laid after fixing of water closets and squatting pans and floor traps. Traps shall be plugged, while laying the floors and opened after the floors are cured and cleaned. Any damage done to WCs, squatting pans and floor traps during the execution of work shall be made good.

During cold weather, concreting shall not be done when the temperature falls below 4°C . The concrete placed shall be protected against frost by suitable coverings. Concrete

damaged by frost shall be removed and work re-done. During hot weather, precautions shall be taken to see that the temperature of wet concrete does not exceed 38°C. No concreting shall be laid within half an hour of the closing time of the day, unless permitted by the Engineer.

While laying the floor, the joints in flooring shall always coincide with the expansion joints, if any, in the structural slab so that any movement of the base will open joints in the flooring instead of forming uncontrolled cracks. Floor panels should not generally exceed 2 sqm for the under-layer and the topping so as to reduce the risk of cracking. The longer dimension of any panel shall not exceed 2 m.

9.7.5 Measurements

9.7.5.1 Length and breadth shall be measured correct to a cm before laying skirting, dado or wall plaster. The area as laid shall be calculated in sqm. correct to two decimal places.

The thickness of the under layer shall be measured correct to a cm. The thickness of top layer shall not be less than that specified.

No deduction shall be made, nor extra paid for voids not exceeding 0.20 square metre. Deduction for ends of dissimilar materials or other articles embedded shall not be made for areas not exceeding 0.10 square metre. Nothing extra shall be paid for laying the floor at different levels in the same room or courtyard.

9.7.5.2 Terrazzo (Marble Chips) flooring laid as floor borders, margins and similar bands up to 30 cm width and on staircase treads shall be measured under the item of terrazzo flooring but extra shall be paid for such work. This extra in the case of staircase treads shall include the cost of forming the nosing also. However, moulded nosing shall be paid extra in running metres except where otherwise stated. Returned moulded ends and angles to mouldings shall be included in the description. Extra shall also be paid for laying flooring in narrow bands not exceeding 7.5 cm in width and such bands shall be measured in running metres for this purpose.

9.7.5.3 Dividing strips inserted in terrazzo to form bays/ patterns shall be described stating the materials, its width and thickness and measured in running metres.

9.7.5.4 Special surface finishes to treads, risers and the ends of concrete steps and the like shall be measured separately and recorded in square metres and shall include form work, if required.

9.7.6 Rate

The rate shall include the cost of all materials and labour involved in all the operations described above including cleaning of surface of RCC slab or base concrete and application of cement slurry but shall not include the cost of base concrete and cost of providing and fixing strips of glass or aluminium or of any other materials used for making panels, which shall be paid for separately.

9.7.7 Maintenance

Under normal conditions, the flooring may be kept clean by washing periodically with water and occasionally with a dilute solution of oxalic acid after which it shall be mopped down with cold water and dried. Soap in any form shall not be used, as it tends to make the terrazzo dangerously slippery; excessive polishing will have a similar effect. The surface may also be kept free from oil and grease to avoid slipperiness.

9.8 TERRAZZO (MARBLE CHIPS) SKIRTING IN SITU

9.8.1 Under Coat

The under coat of skirting shall be of cement plaster of the thickness and mix described in the item. Specifications given under paras 9.5.1 and 9.5.2. shall apply. As regards application, the work shall be carried out in the manner described in para 9.5.3. except that the under coat shall be finished rough with a scratching tool to form a key for the top coat.

9.8.2 Top Coat or Layer

The specifications as in para 9.7.3. shall hold good as far as applicable and shall include cutting to line and fair finish to top edges of terrazzo and polishing.

9.8.3 Thickness

The thickness of the bottom and top coats shall be as specified. The total thickness of skirting specified is of the total thickness of plaster including top coat as measured from the un-plastered face of the masonry. Average thickness of the under coat shall not be less than 6 mm and minimum thickness over any portion of the surface shall not be less than 4 mm. The thickness of top coat shall not be less than the thickness specified.

9.8.4 Measurements

Length and height shall be measured correct to a cm and its area shall be calculated in sqm. correct to two places of decimal. Length shall be measured as finished length of skirting. Height shall be measured from

the finished level of floor correct to 5 mm where the height of skirting does not exceed 30 cm and when the height exceeds 30 cm, it shall be measured correct to a cm.

9.8.5 Rate

The rates shall include the cost of all materials and labour involved in all the operations described above.

9.9 CRAZY MARBLE FLOORING (FIG.9.1)

9.9.1 Base concrete

Crazy marble stone flooring shall be laid on cement or lime concrete base. The base concrete shall be provided with slope required for the flooring in verandahs and courtyards to drain off washing and rain water. The surface of base shall be roughened with steel wire brushes, without disturbing the concrete, wetted and smeared with a floating coat of cement slurry at 2 kg. of cement per one sqm. area of spread so as to get a good bond between base and flooring.

Before laying the flooring on RCC slabs, the laitance shall be removed, the surface of slab hacked and a coat of cement slurry at 2 kg of cement per sqm. of area shall be applied so as to get a good bond between RCC slab and floor.

9.9.2 Under Layer

The under layer of crazy marble flooring shall be of cement concrete of thickness 25 mm or as specified. The mix shall normally be 1:2:4 (1 cement : 2 coarse sand : 4 graded stone aggregate 12.5 mm nominal size) by volume unless otherwise specified. It shall conform to the specifications given under para 3.2 of Chapter 3 on 'Cement Concrete'.

9.9.3 Top Layer

The mix of crazy marble stone flooring shall consist of white cement with or without pigment, marble powder, marble chips of 00 Nos. and marble stone pieces and water. The marble stone pieces shall be hard, sound, dense and homogenous in texture with crystalline and coarse grains. It shall be uniform in colour and free from stains, cracks, decay and weathering. Before starting the work the contractor shall get the sample of marble stone approved by the Engineer. The marble stone pieces shall be of sizes as approved by the Engineer but the thickness shall be according to the over all thickness specified which could be achieved when laid over the under layer as specified. Thus for 50 mm thick floor, the thickness of

marble pieces will be 25 mm while for 40 mm thick floor, the thickness will be 15 mm.

The white cement and marble powder shall be mixed in proportion of three parts of cement and one part of marble powder by weight, and the proportion of marble chips to binder mix by volume shall be 7 parts of marble chips to 4 parts of binder mix. The marble chips shall be as specified. It shall be hard, sound, dense and homogeneous in texture. It shall be uniform in colour and free from stains, cracks, decay and weathering.

9.9.4 Laying

A coat of cement slurry at the rate of 2 kg of cement per sqm of area shall be spread and then the marble stone pieces shall be set by hand in such a manner that the top surface of all the set marble stones shall be true to the required level and slopes. After fixing the stones, the cement marble chips mixture shall be filled in between the gaps of laid marble stone pieces. The filled surface then shall be trowelled over, pressed and brought to the level of the laid marble stone pieces.

9.9.5 Polishing, Curing and Finishing

Polishing, Curing and Finishing shall be as described in para 9.7.3.2.

9.9.6 Precautions

Flooring in lavatories and bathrooms shall be laid after fixing of water closets, squatting pans and floor traps. Traps shall be plugged while laying the floors and opened after the floors are cured and cleaned.

9.9.7 Measurements

Length and breadth shall be measured correct to a cm before skirting, dado or wall plaster and it shall be calculated in sqm correct to two decimal places. No deduction shall be made nor extra paid for voids not exceeding 0-20 square metre. Deductions for ends of dissimilar materials or other articles embedded shall not be made for areas not exceeding 0.10 square metre. Nothing extra shall be paid for laying floor at different levels in the same room or courtyards.

9.9.8 Rate

The rates shall include the cost of all materials and labour involved in all the operations described above including the cost of cleaning of RCC slab surface and applying the cement slurry, but it shall not include the cost of base concrete.

9.10 TERRAZO TILE FLOORING

Note : The specifications below shall be followed as far as they are applicable to Plain Cement Tiles.

9.10.1 Terrazzo Tiles

Terrazzo tiles shall generally conform to IS: 1237. Requirements and methods of testing of tiles are described in **Annexure 9.2**. Unless otherwise specified, the tiles shall be

supplied with initial grinding and grouting of wearing layer.

9.10.1.1 Size

The size of tiles shall be as given in **Table 9.3** or as shown in the drawings or as required by the Engineer. Half tiles for use with the full tiles shall be such as to make two half tiles when joined together, match the dimensions of one full tile.

TABLE 9.3

Length Nominal	Breadth Nominal	Thickness not less than
200mm	200 mm	20 mm
250 mm	250 mm	22 mm
300 mm	300 mm	25 mm

9.10.1.2 Tolerance

Tolerance on length and breadth shall be plus or minus one millimeter, and tolerance on thickness shall be plus 5 mm. The range in variation of dimensions in any one delivery of tiles shall not exceed 1 mm on length and breadth and 3 mm on thickness.

9.10.1.3. The tiles shall be manufactured in a factory under pressure process and subjected to hydraulic pressure of not less than 140 kg per square centimeter and shall be given the initial grinding with machine and grouting of the wearing layer before delivery to site. The wearing layer shall be free from projections, depressions, cracks, holes, cavities and other blemishes. The edges of wearing layer may be rounded.

9.10.1.4. The proportion of cement to aggregate in the backing of tiles shall be not leaner than 1: 3 by weight. Where colouring material is used in the wearing layer, it shall not exceed 10 per cent by weight of cement used in the mix.

9.10.1.5. The finished thickness of the upper layer shall not be less than 5 mm for size of marble chips ranging from the smallest up to 12 mm, and not less than 6 mm for size of marble chips varying from the smallest up to 20 mm.

9.10.2 Laying

9.10.2.1 Base concrete or RCC slab on which the tiles are to be laid shall be cleaned, wetted and mopped. The bedding for the tiles shall be with cement mortar of specifications as per SOR item prepared in conformity with provisions in relevant para of Chapter 26 on 'Mortar'.

The average thickness of the bedding mortar shall be 20 mm in floors and 12 mm in risers and dado and the thickness at any place shall not be less than 10 mm.

9.10.2.2. cement mortar bedding shall be spread, tamped and corrected to proper levels and allowed to harden for a day before the tiles are set. If cement mortar is laid in bedding the terrazzo tiles, these shall be set immediately after laying the mortar. Over this bedding neat grey cement slurry of honey like consistency shall be spread at the rate of 4.4 kg. of cement per square metre over such an area as would accommodate about twenty tiles. Tiles shall be washed clean and shall be fixed in this grout one after another, each tile being gently tapped with a wooden mallet till it is properly bedded, and in level with the adjoining tiles. The joints shall be kept as thin as possible not exceeding 1.5 mm and in straight lines or to suit the required pattern.

9.10.2.3 The surface of the flooring during laying shall be frequently checked with a straight edge at least 2 metre long, so as to obtain a true surface with the required slope.

9.10.2.4 Where full tiles or half tiles can not be fixed, tiles shall be cut (sawn) from full tiles to the required size and their edges rubbed smooth to ensure a straight and true joint.

9.10.2.5 Tiles which are fixed in the floor adjoining the wall shall enter not less than 12 mm under the plaster, skirting or dado. The junction between wall plaster and tile work shall be finished neatly and without waviness.

9.10.2.6. After the tiles have been laid, surplus cement grout that may have come out of the joints shall be cleared off.

9.10.3 Curing, Polishing and Finishing

9.10.3.1 The day after the tiles are laid, all joints shall be cleaned of the grey cement grout with a wire brush or trowel to a depth of 5 mm and all dust and loose mortar removed and cleaned. Joints shall then be grouted with grey or white cement mixed with or without pigment to match the shape of the topping of the wearing layer of the tiles. The same cement slurry shall be applied to the entire surface of the tiles as a thin coat with a view to protect the surface from abrasive damage and fill the pin holes that may exist on the surface.

9.10.3.2. The floor shall then be kept wet for a minimum period of 7 days. The surface shall thereafter be ground evenly with machine fitted with coarse grade grit block (No.60). Water shall be used profusely during grinding. After grinding, the surface shall be thoroughly washed to remove all grinding mud, cleaned and mopped. It shall then be covered with a thin coat of grey or white cement, mixed with or without pigment to match the colour of the topping of the wearing surface in order to fill any pin hole that may appear. The surface shall be again cured. The second grinding shall then be carried out with machine fitted with fine grade grit block (No.120)

9.10.3.3. The final grinding with machine fitted with the finest grade grit blocks (No.320) shall be carried out the day after the second grinding described in the preceding para or before handing over the floor, as ordered by the Engineer. Any joint which may open out after the grinding shall be repaired with Cement grout of matching colour.

9.10.3.4. For small areas or where circumstances so require, hand polishing may be permitted in lieu of machine polishing after laying. For hand polishing the following carborundum stones, shall be used :

First grinding Coarse grade stone (No. 60)

Second grinding Medium grade (No.80)

Final grinding Fine grade (No.120)

In all other respects, the process shall be similar to that for machine polishing.

9.10.3.5. After the final polish, oxalic acid powder shall be dusted over the surface at the rate of 33 gm per square metre of area sprinkled with water and rubbed hard with a 'namdah' block (pad of woolen rags). The following day the floor shall be wiped with a

moist rag and dried with a soft cloth and finished clean.

9.10.3.6. If any tile is disturbed or damaged, it shall be refitted or replaced, properly jointed and polished. The finished floor shall not sound hollow when tapped with a wooden mallet.

9.10.4 Measurements

9.10.4.1. Terrazzo tiles flooring with tiles manufactured from ordinary grey cement without pigment and coloured terrazzo tile flooring shall be measured separately and classified as in para 9.8.5. Terrazzo tile flooring shall be measured as laid in square metre correct to two places of decimal. For length and breadth dimensions correct to a cm before laying skirting, dado or wall plaster shall be taken. No deduction shall be made nor extra paid for voids not exceeding 0.20 sqm. Deductions for ends of dissimilar materials or other articles embedded shall not be made for areas not exceeding 0.10 square metre. Nothing extra shall be paid for use of cut tiles nor for laying the floor at different levels in the same room or courtyard.

9.10.4.2 Terrazzo tile flooring laid in floor borders and similar band shall be measured under the item of terrazzo tile flooring. Nothing extra shall be paid in respect of these and similar bands formed of half size or multiples of half size standard tiles or other uncut tiles.

9.10.4.3. Treads of stairs and steps paved with tiles without nosing, shall also be measured under flooring. Moulded nosing shall be paid in running metre except where otherwise stated. Returned moulded ends and angles to mouldings shall be included in the description. Extra shall, however, be paid for such areas where the width of treads does not exceed 30 cm.

9.10.5 Rate

The rate shall include the cost of all materials and labour involved in all the operations described above. Where cement mortar bedding is used in place of lime mortar the rate will be adjusted accordingly.

9.10.6 Maintenance : Same as in Para 9.7.7 for Terrazzo flooring laid-in-situ.

9.11 TERRAZZO TILES IN RISERS OF STEPS, SKIRTING AND DADO

9.11.1. General : The terrazzo tiles shall be as specified in para 9.10.1 as far as applicable. The minimum finished thickness of tiles shall, however, be 12 mm. The

finished thickness of the upper layer shall be not less than 5 mm for size of marble chips from the smallest up to 12 mm and not less than 6 mm for size of chips varying from the smallest up to 20 mm. Where the bigger sized chips are used, the tiles shall be not less than 20 mm thick. The requirements of transverse strength tests specified in **Annexure 9.2**, shall not apply when the tiles used are less than 20 mm thick.

9.11.2 Preparation of Surface

The specification for this shall be same as specified in para 9.5.2.

9.11.3 Laying

12 mm thick plaster of cement mortar 1:3 (1 cement : 3 coarse sand) or mix as specified, shall then be applied and allowed to harden. The plaster shall then be roughened with wire brushes or by scratching diagonal lines 2 mm deep at approximately 7.5 cm centers both ways. The back of tiles shall be buttered with a coat of grey cement slurry and edges with grey or white cement slurry with or without pigments to match the shade of tiles and set in the bedding mortar. These shall be tamped and corrected to proper planes and lines. The tiles shall be set in the required pattern and butt jointed. The joints shall be as fine as possible. Top of skirting or dado shall be truly horizontal and joints truly vertical except where otherwise indicated.

The risers of steps, skirting or dado shall rest on the top of the tread or flooring. Where full size tiles cannot be fixed, the tiles shall be cut (sawn) to the required size and their edges rubbed smooth.

9.11.4 Curing, Polishing and Finishing

The specifications as in para 9.10.3. shall hold good as far as applicable. Polishing shall be done only with hand.

9.11.5. Measurements

The thickness of the skirting shall be as stated. Length shall be measured along the finished face of riser, skirting or dado correct to a cm. Height shall be measured from the finished level of tread or floor to the top (the underside of tread in the case of steps). This shall be measured correct to 5 mm in case of risers and skirting not exceeding 30 cm in height. In case of heights more than 30 cms, as in the case of dado and on walls, the height shall be measured correct to a cm and such work shall be paid for separately. The area shall be calculated in square metre, correct to two places of decimal.

Where the height of risers, skirting or dado does not admit of full size or other finished

size tiles and the tiles are to be cut (sawn), nothing extra shall be paid for the same.

9.11.6 Rate

The rate shall include the cost of all materials and labour involved in all the operations described above. Nothing extra shall be payable for use of cut (sawn) tiles to suit the size of risers, skirting, portions of dado etc.

9.12 CHEQUERED TILE FLOORING

9.12.1 Chequered Tiles

The tiles shall be of nominal size such as 20 x 20 cm, 25 x 25 cm, and 30 x 30 cm or of standard sizes with equal sides. The size of tiles to be used shall be as shown in drawings or as required by the Engineer. The center to center distance of chequers shall not be less than 2.5 cm and not more than 5 cm.

The overall thickness of the tiles shall not be less than 22 mm. The grooves in the chequers shall be uniform and straight. The depth of the grooves shall not be less than 3 mm. The chequered tiles shall be cement tiles, or terrazzo tiles as specified in the description of the item. The thickness of the upper layer, measured from the top of the chequers shall not be less than 6 mm.

The terrazzo tiles shall be given the first grinding with machine before delivery to site. The tiles shall conform to the specifications for plain cement concrete or terrazzo tiles in respect of method of manufacture and the mix of the backing and wearing layers.

The relevant paras of IS 13801:1993 for CHEQUERD CEMENT CONCRETE TILES are reproduced below for guidance :

1.1 This standard covers chequered cement concrete flooring tiles.

2. REFERENCES

The Indian Standards listed in Annex A are necessary adjuncts to this standard.

3.1 Chequered Tiles

Chequered tiles, cement tiles or terrazzo tiles having grooves on the surface of the tile making it anti-slippery. The area of chequered gooves should not be less than 2 percent of the total surface area of the tile. The chequered groove can be in any shape and length, but the depth of grooves should not be less than 3 mm.

4 MATERIALS

4.1 Cement

Cement used in the manufacture of tiles shall be 33 grade ordinary Portland cement conforming to IS 269:1989 or rapid

hardening Portland cement conforming to IS 8041 : 1990 or white Portland Cement conforming to IS 8042:1989 or Portland pozzolana cement (Fly ash based) conforming to IS 1489 (Part I) : 1991 and Portland pozzolana cement (calcined clay based) conforming to IS 1489 (Part 2) : 1991 or 43 grade ordinary Portland cement conforming to IS 8112 : 1989 or 53 grade ordinary Portland cement conforming to IS 12269 : 1989.

4.2 Aggregates

Aggregates used in the backing layer of tiles shall conform to the requirements of IS 383 :

4.3.2

Pigments	Relevant Indian Standard
a) Black or red or brown pigments	IS 44 : 1991
b) Green pigments	IS 54 : 1988
c) Blue pigments	IS 55 : 1970
	or IS 56 : 1993
	or IS 3574
	(Part 2) : 1996

4.3.3 Colours other than mentioned above may also be used.

4.3.4 The pigments shall not contain zinc compounds organic dyes.

4.3.5 Lead pigments shall not be used unless otherwise specified by the purchaser.

5. MANUFACTURE

5.1 Chequered cement concrete flooring tiles shall be manufactured from a mixture of cement, natural aggregates, and colouring materials where required by pressure process. During manufacture, the tile shall be

1970. For the wearing layer, unless otherwise specified aggregates shall consist of marble chips or any other natural stone chips of similar characteristics and hardness, marble powder or dolomite powder or mixture of the two. Hardners, if required may also be added.

4.3 Pigments

4.3.1 Pigments, synthetic or otherwise, used for colouring tiles shall have durable colour. It shall not contain matters detrimental to concrete and shall according to the colour required be one of the following or their combination:

subjected to a pressure of not less than 14 N/mm².

5.2 The proportion of cement to aggregate in the backing of the tiles shall be not leaner than 1 : 3 by mass.

5.3 Where colouring material is used in the wearing layer, it shall not exceed 10 percent by mass of cement used in the mix.

5.4 On removal from the mould, the tiles shall be kept in moist conditions continuously for such a period that would ensure their conformity to the requirements of this standard. Tiles shall be stored under cover.

6. DIMENSIONS

6.1 The size of chequered cement flooring tiles shall be as follows:

Length	Breadth	Thickness
Mm	mm	mm
200	200	22
250	250	22
300	300	25

Note: The thickness shall be measured as two point situated approximately 50 mm from the ends on the fracture line of the tile that is tested for wet transverse strength. The total thickness is the arithmetic mean of these two measurements.

6.1.1 Half tiles rectangular in shape shall also be available. Half tiles for use with full tiles in the floor shall have dimensions which shall be such as to make two half tiles when joined together, to match with the dimensions of the one full tile.

7. TOLERANCES

7.1 Tolerances on length or breadth of tiles shall be ± 1 mm. In addition, the difference in length of side between the longest side and the shorter side in the sample shall not exceed 1 mm.

7.2 Tolerance on thickness shall ± 5 mm. In addition the difference in thickness between the thickest and the thinnest tile in the sample shall not exceed 3 mm.

7.3 Thickness of Wearing Layer

7.3.1 The thickness of wearing layer measured from the top of the chequers shall not be less than 6 mm.

7.3.2 The thickness of the wearing layer shall be measured at several points along the fracture line of the tile that was tested for wet transverse strength. The arithmetic mean of the two measurements which yielded the lowest value shall be the minimum thickness of the wearing layer.

8. SPECIAL SHAPE AND SIZE

8.1 Shapes and sizes of tiles other than those specified in 6.1 may be manufactured when agreed upon between the supplier and the purchaser but the depth of the grooves shall not be less than 3 mm. The tiles shall also meet all the requirements of the standard.

Note: In rectangular tiles, the requirements for the difference in the length of sides as specified in 7.1 shall be applicable both to the length and width of the tiles.

9. GENERAL QUALITY

9.1 Unless otherwise specified, the tiles shall be supplied with initial grinding and grouting of the upper layer. The upper layer of the tiles shall be free from projections, depressions, cracks (hair cracks not included), holes, cavities and other blemishes. The edges of the tile may be rounded.

10. FINISH

10.1 The colour and texture of the wearing layer shall be uniform throughout its thickness. No appreciable difference in the appearance of the tiles, from the point of view of colour of aggregate, its type and its distribution on the surface of the wearing layer shall be present.

11. PHYSICAL REQUIREMENT

11.0 The tests on tile shall not be carried out earlier than 28 days from the date of manufacture.

11.1 Flatness of the Tile Surface

The tiles when tested according to the procedure laid down in Annex B, the amount of concavity and convexity shall not exceed 1 mm.

11.2 Perpendicularity

When tested in accordance with the procedure laid down in Annex C, the longest gap between the arm of the square and the edge of the tiles shall not exceed 2 percent of the length of the edge.

11.3 Straightness

When tested according to the procedure given in Annex D, the gap between the thread and the plane of the tile shall not exceed 1 percent of the length of the edge.

11.4 Water Absorption

When tested according to the procedure laid down in Annex E, the average percent of water absorption shall not exceed 10.

11.5 Wet Transverse Strength

When tested according to the procedure laid down in Annex F, the average wet transverse strength shall not be less than 2 N/mm².

11.6 Resistance to Wear

When tested in the manner specified in Annex G, the wear shall not exceed the following value:

- a) Average wear 2mm
- b) Wear on individual specimen 2.5 mm

12. MARKING

12.1 Tiles shall be legibly and indelibly marked on the back with the identification of the source of manufacturer.

12.1.1 Each tile may also be marked with the Standard Mark.

13. PACKING

13.1 The tiles shall be packed according to the usual trade practice and adequately protected.

14. SAMPLING AND CRITERION FOR CONFORMITY

14.1 The consignment of chequered cement concrete flooring tiles shall be divided into a number of lots in accordance with 14.1.1. Each lot shall be inspected separately for ascertaining its conformity to the requirements of this specification.

14.1.1 Lot

All the chequered cement concrete flooring tiles in a consignment which are of same type, shape and size and manufactured by a single manufacturer from identical raw materials, under identical conditions of

manufacture shall be grouped together to constitute a single lot.

14.2 The sample of tiles for inspection and testing shall be chosen from a lot at random. For guidance in procedure of random selection IS 4905:1968 may be referred.

14.3 Number of Samples and Criterion for Conformity

For each characteristic the number of sample tiles to be selected from a lot and the criterion for determining the conformity of the lot on the basis of the test results on those samples, shall be in accordance with inspection level 1 in Table 1 and AQL 6.5 percent in Table 3 of IS 2500 (Part I) : 1992.

14.4 If the samples drawn for testing one characteristic can be utilized for testing any other characteristic, without introducing any prejudice in the test results of the latter, it would not be necessary to take fresh samples for the latter characteristics.

9.12.2. Laying etc. : Laying, curing, polishing and finishing shall be as specified in paras 9.10.2 and 9.10.3 except that the polishing of the tiles and the chequer grooves, after laying, may be done by hand. Special care shall be taken to polish the grooves in such a manner as to get a uniform section and to ensure that their finish shall match the finish of flat portion of the tiles. Cement concrete tiles normally do not require polishing but where polishing is required, the same shall be done as described above.

9.12.3 Measurements and Rate

Shall be as specified in paras 9.10.4 and 9.10.5.

9.13. CHEQUERED TILES IN STAIR TREADS (FIG.9.2)

9.13.1. Chequered Tiles

The specifications for tiles shall be specified in para 9.12.1 except in the following respects:

- (1) The length of the tiles including nosing shall be as specified.
- (2) The nosing edge of the tile shall be rounded.
- (3) The minimum thickness of the tile shall be 30 mm or as specified.
- (4) The front portion of the tile for a minimum length of 75 mm from and including the nosing shall have grooves running parallel to the nosing and at centers not

exceeding 25 mm. Beyond that, the tiles shall have the normal chequer pattern.

(5) The nosing shall also have the same wearing layer as the top.

9.13.2. Preparation of Surface and Laying

9.13.2.1. RCC or brick work in treads on which tiles are to be laid shall be cleaned, wetted and mopped. The bedding for tiles shall be with lime mortar of 1:1:1 (1 lime putty: 1 surkhi: 1 coarse sand) or Cement Mortar 1:4 (1 cement:4 coarse sand) or of specified mix. The minimum thickness of bedding mortar at any place shall be 10 mm. Bedding mortar shall be spread, tamped and corrected to proper levels. After laying bedding mortar, neat grey cement slurry of honey like consistency shall be spread over the mortar at the rate of 4.4 kg of cement per square metre of area over each tread. Tiles shall be washed, cleaned and shall be fixed in this grout one after another, each tile being gently tapped with a wooden mallet till it is properly bedded and is in level and line with the adjoining tiles. The joints shall be kept as thin as possible and in straight lines. The surface shall be checked with a straight edge during laying to obtain a true surface.

9.13.2.2. The square end of the tile shall, as far as possible butt against the riser face of the concrete or brick tread and in any case shall be embedded under the side wall plaster, skirting or dado and under the riser tile or other finish to a depth of not less than 10 mm.

9.13.2.3. Where full size tiles cannot be fixed, these shall be cut (sawn) to the required size (along the groove of the chequers where the cut edge is exposed) and used. The cut in the case of embedded edges will be neat and true while the cut in the case of exposed edges shall in addition be rubbed smooth to ensure a straight and true joints.

9.13.2.4 After the tiles have been laid surplus cement grout shall be cleaned off.

9.13.3 Curing, Polishing and Finishing

The specifications shall be as described in para 9.10.3. except that polishing of the treads nosing and chequered grooves, after laying, may be done by hand in the same manner as specified under terrazzo tile flooring. Special care shall be taken to polish the nosing and the grooves in such a manner as to get a uniform section for the grooves and the nosing and their finish shall match with the finish of the flat portion of the tiles.

9.13.4 Measurements

Chequered tiles on stair treads shall be measured in square metre correct to two places of decimal. Length shall be measured correct to a cm before laying skirting, dado or wall plaster. Width shall be measured correct to a cm from the outer edge of the nosing, as laid, before providing the riser. In the case of the edge tiles of the landing and wide steps, width shall be measured up to the near edge of the chequered stair tread tiles. Deductions for ends of dissimilar materials or other articles embedded shall not be made for areas not exceeding 0.10 square metre.

9.13.5 Rate

The rate shall include the cost of all materials and labour involved in all the operations described above. Nothing extra shall be payable for cutting the tiles to suit the size of treads and also for nosing.

9.14 GLAZED TILE FLOORING

9.14.1 White Glazed Tiles

The tiles shall be of approved make and shall generally conform to IS: 777. They shall be flat, and true to shape and free from blisters, crazing, chips, wells, crawling or other imperfections detracting from their appearance. The tiles shall be tested as indicated in Appendix of IS: 777.

The tiles shall be square or rectangular of nominal size such as 150 x 150 mm, 100 x 100 mm, 100 x 200 mm or as directed by Engineer. The thickness of the tiles shall be 5 mm, or 6 mm as specified. The length of all four sides shall be measured correct to 0.1 mm and average length or breadth shall not vary more than ± 0.8 mm from specified dimension. The variation of individual dimension from average value of length/breadth shall not exceed ± 0.5 mm. Tolerance in thickness shall be ± 0.4 mm.

Note 1 Where tiles of nominal sizes of 150 x 150 mm or 100 x 100 mm are not available tiles of nominal sizes 152 mm x 152 mm or 108 mm x 108 mm may be allowed to be used with the prior approval of the Engineer.

Note 2 The actual size of the tiles supplied shall be 1 mm less so that with 1 mm joint, the tile when laid shall conform to the nominal size.

The top surface of the tiles shall be glazed and glaze shall be either glossy or matt as specified. The underside of the tiles shall not have glaze on more than 5 per cent of the area in order that the tile may adhere

properly to the base. The edges of the tiles shall be preferably free from glaze. However, any glaze if unavoidable, shall be permissible on only up to 50 per cent of the surface area of the edges.

9.14.2 Coloured Tiles

Only the glaze shall be coloured as specified. The sizes and specifications shall be the same as for the white glazed tiles.

9.14.3 Decorative Tiles

The type and size of the decorative tiles shall be as follows:-

(i) Decorated white back ground tiles.

The size of these tiles shall be 152 x 152 x 6 mm and/or 108 x 108 x 6 mm or of any other approved size.

(ii) Decorated and having coloured background

The sizes of the tiles shall be 152 x 152 x 6 mm and/ or 108 x 108 x 6 mm or of any other approved size.

9.14.4 Preparation of Surface and Laying

9.14.4.1. Base concrete or the RCC slab on which the tiles are to be laid shall be cleaned, wetted and mopped. The bedding for the tile shall be with cement mortar 1:3 (1 cement : 3 coarse sand) or as specified. The average thickness of the bedding shall be 10 mm while the thickness under any portion of the tiles shall not be less than 5 mm.

9.14.4.2. Mortar shall be spread, tamped and corrected to proper levels and allowed to harden sufficiently to offer a fairly rigid cushion for the tiles to be set and to enable the mason to place a wooden plank across and squat on it.

9.14.4.3. Over this mortar bedding, grey cement slurry of honey like consistency shall be spread at the rate of 3.3 kg of cement per square metre over such an area as would accommodate about twenty tiles. Tiles shall be soaked in water, washed clean and shall be fixed in this grout one after another, each tile being gently tapped with a wooden mallet till it is properly bedded and in level with the adjoining tiles. The joints shall be kept as thin as possible and in straight lines or to suit the required pattern.

9.14.4.4. The surface of the flooring during laying shall be frequently checked with a straight edge about 2 m long, so as to obtain a true surface with the required slope.

9.14.4.5. Where full size tiles cannot be fixed, these shall be cut (sawn) to the required size, and their edge rubbed smooth to ensure straight and true joints.

Tiles which are fixed in the floor adjoining the wall shall enter not less than 10 mm under the plaster, skirting or dado.

9.14.4.6 After tiles have been laid surplus cement slurry shall be cleaned off.

9.14.5 Pointing and Finishing

The joints shall be cleaned off the grey cement slurry with wire/coir brush or trowel to a depth of 2 mm to 3 mm and all dust and loose mortar removed. Joints shall then be flush pointed with white cement added with pigment if required to match the colour of tiles. The floor shall then be kept wet for 7 days. After curing, the surface shall be washed and finished clean. The finished floor shall not sound hollow when tapped with a wooden mallet.

9.14.6 Measurements

Length and breadth shall be measured correct to a cm before laying skirting, dado or wall plaster and the area calculated in square metre correct to two places of decimal. Where coves are used at the junctions, the length and breadth shall be measured between the lower edges of the coves.

No deduction shall be made nor extra paid for voids not exceeding 0.20 square metre. Deductions for ends of dissimilar materials or other articles embedded shall not be made for areas not exceeding 0.10 square metre.

Areas, where glazed tiles or different types of decorative tiles are used will be measured separately.

9.14.7 Rate

The rate for flooring shall include the cost of all materials and labour involved in all the operations described above. Nothing extra shall be paid for the use of cut (sawn) tiles in the work. Extra over and above the normal rate for white tiles, shall be paid where coloured or any other type of decorative tiles have been used.

9.15 GLAZED TILES IN SKIRTING AND DADO

9.15.1 General

(a) Basic requirements:- The tiles shall be of approved make and shall generally conform to IS: 777. The tiles shall be of earthenware covered by a glaze thoroughly matured and fitted to the body. The tiles shall be sound, true to shape, flat and free from flaws and other manufacturing defects affecting their utility.

The top surface of the tiles shall be glazed. The underside of the tiles shall not have glaze on more than 5 percent of the area in

order that the tile may adhere properly to the base. The edges of the tiles shall be free from glaze. However, any glaze if unavoidable shall be permissible on only up to 50 percent of the surface area of edges.

The glaze shall be free from welts, chips, craze, specks, crawlings or other imperfections detracting from the appearance when viewed from a distance of one metre. The glaze shall be either glossy or matt as specified. The glaze shall be white in colour except in the case of coloured tiles when colours shall be as specified by the Engineer. There may be more than one colour on a tile.

(b) Dimensions

Glazed earthenware tiles shall be made square or rectangular in sizes such as 149 x 149 mm and 99 x 99 mm or 99 x 199 mm or as specified and shall be straight or cushion edge type.

Half tiles for use as full tiles shall have dimensions which shall be such as to make the half tiles when jointed together (with 1 mm joint) match with dimensions of full tiles. Tiles may be manufactured in sizes other than those specified above.

Note Commonly manufactured sizes include 108 x 108 mm, 152 x 152 mm, 200 x 200 mm, 200 x 150 mm and 200 x 100 mm. The thickness of the tiles shall be 5 mm or 6 mm as specified.

The dimensions of fittings associated with the glazed tiles namely cove base, round edge tile, angles corner cups, ridge and legs, cornices and capping beads shall be of the shape and dimensions as required and the thickness of fittings shall be the same as the thickness of tiles given above.

(c) Tolerances

Facial Dimensions – The lengths of all the four sides of the tile shall be measured to the nearest 0.1 mm. The average value of lengths/breadth shall not vary more than ± 0.8 mm from the above specified dimension.

The variation of individual dimensions from average value of length/breadth shall not exceed ± 0.5 mm. Tolerances on thickness shall be ± 0.4 mm.

(d) Trueness of Shape (Squareness)

Any variation from a right angle in the angle contained by any two adjoining sides shall be limited so that if a builder's steel square is placed against the angle, the distance between the inner edge of the square and the adjacent side of the tile or fitting shall not be more than 0.5 mm per 100 mm run.

(e) Warpage

The tiles when tested for warpage on the edges and on the diagonal as per Appendix – A of IS : 777 shall not have warpage exceeding the value as specified below :

Size of tile (mm)	Warpage (mm)
149 x 149	- 0.4
	+ 0.7
99 x 99	- 0.3
	+ 0.5

(f) Performance Requirements-Water absorption etc.

The average water absorption of the tiles when tested and evaluated in accordance with IS : 777 shall not exceed 20 per cent.

Crazing – Tiles subjected to two cycles of crazing test as per IS : 777 shall not show any sign of crazing.

Impact Resistance: Tiles when tested for impact resistance as per IS : 777 shall remain intact, apart from surface marking.

Chemical Resistance: When tested as per IS : 777, the glazed surface of tiles and/or the fittings having a white or cream coloured glossy glaze shall show no modification.

9.15.2 Preparation of Surfaces

The joints shall be raked out to a depth of at least 15 mm in masonry walls. In case of concrete walls, the surface shall be hacked and roughened with wire brushes. The surface shall be cleaned thoroughly, washed with water and kept wet before skirting is commenced.

9.15.3 Laying

12 mm thick plaster of cement mortar 1 : 3 (1 cement : 3 coarse sand) mix or as specified shall be applied and allowed to harden. The plaster shall be roughened with wire brushes or by scratching diagonal at close intervals.

The tiles should be soaked in water, washed clean, and a coat of cement slurry applied liberally at the back of tiles and set in the bedding mortar. The tiles shall be tamped and corrected to proper plane and lines. The tiles shall be set in the required pattern and jointed. The joints shall be as fine as possible. Top of skirting or dado shall be truly horizontal and joints truly vertical except where otherwise indicated. Skirting and dado shall rest on the top of the flooring. Where full size tiles cannot be fixed, these shall be cut by sawing to the required size and their edges rubbed smooth.

9.15.4 Curing and Finishing

The joints shall be cleaned off the grey cement grout with wire/coir brush or trowel to a depth of 2 mm to 3 mm and all dust and loose mortar removed. Joints shall then be flush pointed with white cement added with pigments if required to match the colour of tiles. The work shall then be kept wet for 7 days.

After curing, the surface shall be washed and finished clean. The finished work shall not sound hollow when tapped with a wooden mallet.

9.15.5 Measurements

Length shall be measured correct to a cm. Height shall be measured correct to a cm in the case of dado and 5 mm in the case of riser and skirting. The area shall be calculated in square metre, correct to two places of decimal. Length and height shall be measured along the finished face of the skirting or dado including curves where specials such as coves, internal and external angles and beads are used. Where cornices are used the area of dado shall be measured excluding the cornices. Nothing extra will be paid for cutting (sawing) the tiles to sizes.

In addition to payment for areas of skirting and dado, specials such as coves, internal and external angles and beads shall be measured separately and paid for in running metres. Cornices shall also be similarly measured for payment in running metres. Areas where coloured tiles or different types of decorative tiles are used will be measured separately to be paid extra over and above the normal rate for white tiles.

9.15.6 Rates

The rate shall include the cost of all materials and labour involved in all the operations described above. The specials such as coves, internal and external angles and beading shall be measured and paid for separately. The rate shall not include cost of cornices which shall be measured and paid for in running meters separately.

9.16 GLAZED TILE SPECIALS (FIG.9.3)**9.16.1 Specials**

The specials consist of coves, internal and external angles, beads, cornices and the corner pieces.

Coves beads and angles shall be of thickness not less than the thickness of the tiles with which they are used. The size of coves, beads and angles refers to the greatest width of the special measured in a

straight line. The stipulated size of cornices is their height. The lengths of specials shall be 15 cm, 10 cm or other standard size available conforming to the size of tiles available. In other respects the general specifications described in para 9.14.1. shall be applicable.

9.16.2 Preparation:- Preparation of Surface, Laying, Curing and finishing shall be as specified in paras 9.15.2, 9.15.3 and 9.15.4 as far as applicable.

9.16.3 Measurements: Special tiles to form coved internal angles of any radius, rounded external angles, architraves moulding, ceiling ribs, cornices and the like shall each be measured in running metres correct to a cm. Railing members and vertical members shall each be so described. Ends, angles and internal sections shall be enumerated separately.

9.16.4 Rate: It shall include the cost of all materials and labour involved in all the operations described above. Nothing extra shall be paid for corner pieces at junctions of coves, beads, cornices etc., nor for using cut lengths of specials.

9.17 CERAMIC TILE FLOORING

9.17.1 Ceramic Tiles :

9.17.1.1 Definitions, Classifications and characteristics:-

These are covered under IS 13712. Brief particulars gathered from this IS are given below.

i) Definition:- (a) These are made from clays, silica, fluxes, colouring and other mineral raw materials and are used as covering for floors, walls or facades. These are prepared by grinding, sieving, mixing, moistening etc and are shaped by pressing, extruding, casting or other process, usually at room temperature. They are then dried and subsequently fired at a high temperature. Tiles may be glazed, unglazed or engobed and are incombustible and unaffected by light. Depending on degree of vitrification water absorption may vary. A low water absorption tile is called Porcelain tile. An extremely low water absorption tile is called a fully vitrified tile and this may be in a polished or unpolished form.

(b) Extruded Tiles, Pressed Tiles and Cast Tiles are indicated as of Shaping A, B & C respectively.

(c) Sizes : Modular Sizes are based on M= 100mm and can be M, 2M, 3M and 5M and also their multiples. Non modular sizes are those excluding those based on M.

ii) Classification : Ceramic Tiles are divided into groups according to their method of manufacture and their water-absorption.

iii) Water Absorption groups

Pressed Tiles (Shaping B) : For details see 9.18.1.2 (c) below.

a) Tiles of very low and low water absorption (Group I)

Group B 1a – Ceramic Fully Vitrified Tiles

Group B 1b – Ceramic Porcelain tiles

b) Tiles of medium water absorption (Group II)

Group B II – Ceramic Floor tiles

c) Tiles of high water absorption (Group III)

Group B III – Ceramic Wall tiles

9.17.1.2 Pressed Ceramic Tiles :

a) Pressed Ceramic Tiles are covered by Specifications under IS 15622-2006. They cover Pressed Ceramic glazed / unglazed tiles of first quality for use as both floor and wall coverings. This specification is to be read with the following Specifications.

IS : 13630 Pts. 1 to 15:- Ceramic Tiles – Methods of Test

IS : 13712 (under revision):- Ceramic Tiles – Definitions, Classifications, Characteristics and marking.

b) Ceramic Tiles can be of plain type or with Space Lugs as defined in Clause 4.3 of IS Specification. The surface of tiles and associated components can be smooth, profiled wavy, decorated or finished in some other way. They can be unglazed, glossy, matt or semi-matt.

c) Depending on the maximum permitted water absorption the Tiles are grouped as under with their shapes and sizes as per following Tables of IS 15622. Tables 1 to 8 indicate the work or actual size of tiles, joint width, coordinating size (work size + joint width) and thickness of Tile.

GROUP	WATER ABSORPTION (%)	TABLE No. of IS 15622
B III	> 10	1 & 2
B II	> 3 but ≤ 6	3 & 4

B I b	$> 0.08 \text{ but } \leq 3$	5 & 6
B I a	≤ 0.08	7 & 8

d) Tables 9 to 12 of IS 15622 give Dimensional and Surface quality requirements of physical and chemical properties of the four groups.

e) As indicated in Clause 4.4 of IS 15622-2006, Dimensions and tolerances of accessories, for example soap-holder, have not been standardised and left to the manufacturers.

f) The tiles shall be selected of group, size and thickness as required by end user.

9.17.2 Preparation of Surface and Laying

9.17.2.1 Base Concrete or the RCC Slab on which the tiles are to be laid shall be cleaned, wetted and mopped. The bedding for the tiles shall be with Cement Mortar 1:4 (1 Cement: 4 Coarse Sand) or as specified. The average thickness of the bedding shall be 20mm while the thickness under any portion of the tiles should not be less than 10mm.

9.17.2.2 Mortar shall be spread, tamped and corrected to proper levels and allowed to harden sufficiently to offer a fairly rigid cushion for the tiles to be set and to enable the mason to place wooden plank across and squat on it.

9.17.2.3 Over the mortar bedding, neat grey cement slurry of honey like consistency shall be spread at the rate of 3.3 kg. of cement per Sqm area and tiles set as indicated in Para 9.14.4.3 for Glazed Tiles.

9.17.2.4 Checking of surface shall be done as given in Para 9.14.4.4.

9.17.2.5 Use of cut tiles shall be as given in Para 9.14.4.5.

9.17.2.6 The junction between the wall plaster and tile work shall be finished neatly and without waviness. After the tiles have been laid, surplus cement grout that may have come out of the joints shall be cleaned off.

9.17.3 Pointing and Finishing : The operations shall be carried out on the same lines as described in Para 9.14.5.

9.17.4 Measurements - Provisions in Para 9.14.6 will apply.

9.17.5 Rate

The rate for flooring shall include the cost of all materials and labour involved in all the operations described above. Nothing extra

shall be paid for the use of cut tiles in the work.

9.18 CERAMIC / VITREOUS TILES IN SKIRTING AND DADO

9.18.1 Tiles : Provision in Para 9.17.1 will apply.

9.18.2 Preparation of Surface : The procedure described in Para 9.15.2 for Glazed Tiles will be applicable.

9.18.3 Laying : Procedure described in Para 9.15.3 will be applicable.

9.18.4 Curing and Finishing : Provisions in Para 9.15.4 will apply.

9.18.5 Measurements : Provisions in Para 9.15.5 will apply.

9.18.6 Rate : Provisions in Para 9.15.6 will be applicable.

9.19 MARBLE FLOORING

9.19.1 Marble:-It shall be as specified in Annexure 9.3.

9.19.2 Dressing of Slabs

Every stone shall be cut to the required size and shape, fine chisel dressed on all sides to the full depth so that a straight edge laid along the side of the stone shall be fully in contact with it. The top surface shall also be fine chisel dressed to remove all waviness. In case machine cut slabs are used, fine chisel dressing of machine cut surface need not be done provided a straight edge laid any where along the machine cut surfaces is in contact with every point on it. The sides and top surface of slabs shall be machine rubbed or table rubbed with coarse sand before paving. All angles

and edges of the marble slabs shall be true, square and free from chippings and the surface shall be true and plane.

The thickness of the slabs shall be 20, 30 and 40 mm or as specified in the description of the item. Tolerance of ± 3 percent shall be allowed for the thickness. In respect of length and breadth of slabs a tolerance of ± 2 percent shall be allowed.

9.19.3 Laying

9.19.3.1. Base concrete or the RCC slab on which the slabs are to be laid shall be cleaned, wetted and mopped. The bedding for the slabs shall be with cement mortar

1 : 4 (1 cement : 4 coarse sand) or with lime mortar (1 lime putty: 1 surkhi : 1 coarse sand) as given in the description of the item.

9.19.3.2. The average thickness of the bedding mortar under the slab shall be 20 mm and the thickness at any place under the slab shall be not less than 12 mm.

9.19.3.3 The slabs shall be laid in the following manner:

Mortar of the specified mix shall be spread under the area of each slab, roughly to the average thickness specified in the item. The slab shall be washed clean before laying. It shall be laid on top, pressed, tapped with wooden mallet and brought to level with the adjoining slabs. It shall be lifted and laid aside. The top surface of the mortar shall then be corrected by adding fresh mortar at hollows. The mortar is allowed to harden a bit and cement slurry of honey like consistency shall be spread over the same at the rate of 4.4 kg. of cement per sqm of area. The edges of the slab already paved shall be buttered with grey or white cement with or without admixture of pigment to match the shade of the marble slabs as given in the description of the item.

The slab to be paved shall then be lowered gently back in position and tapped with wooden mallet till it is properly bedded in level with and close to the adjoining slabs with as fine a joint as possible. Subsequent slabs shall be laid in the same manner. After each slab has been laid, surplus cement on the surface of the slabs shall be cleaned off. The flooring shall be cured for a minimum period of seven days. The surface of the flooring as laid shall be true to levels and slopes as instructed by the Engineer.

Due care shall be taken to match the grains of slabs which shall be selected judiciously having uniform pattern of Veins/streaks or as directed by the Engineer.

9.19.3.4. The slabs shall be matched as shown in drawings or as instructed by the Engineer.

9.19.3.5. Slabs which are fixed in the floor adjoining the wall shall enter not less than 12 mm under the plaster skirting or dado. The junction between wall plaster and floor shall be finished neatly and without waviness.

9.19.4 Curing, Polishing and Finishing

Slight unevenness at the meeting edges of slabs shall then be removed by fine chiseling and finished in the same manner as specified in para 9.10.3. except that cement slurry with or without pigments shall not be applied on the surface before each polishing.

9.19.5 Measurements

Marble stone flooring with different kind of marble shall be measured separately and in square metre correct to two places of decimal. Length and breadth shall be measured correct to a cm before laying skirting, dado or wall plaster. No deduction shall be made nor extra paid for voids not exceeding 0.20 square metre. Deductions for ends of dissimilar materials or other articles embedded shall not be made for areas not exceeding 0.10 square metre. Nothing extra shall be paid for laying the floor at different levels in the same room. Steps and treads of stairs paved with marble stone slabs shall also be measured under the item of Marble stone flooring. Extra shall, however, be paid for such areas where the width of treads does not exceed 30 cm. Nosing for treads shall be measured in running metre and paid for extra. The width of treads shall be measured from the outer edge of the nosing, as laid, before providing the riser.

9.19.6 Rate

The rate shall include the cost of all materials and labour involved in all the operations described above.

9.20 MARBLE STONE IN RISERS OF STEPS AND SKIRTING

9.20.1 General:- Marble Stone Slabs and Dressing of Slabs shall be as specified in paras 9.19.1 and 9.19.2 except that the thickness of slabs shall be 30 mm or as laid down in the item. A tolerance of ± 3 mm shall be allowed, unless otherwise specified in the description of the item.

9.20.2 Preparation of Surface

It shall be as specified in para 9.15.2. Where necessary, the wall surface shall be cut uniformly to the requisite depth so that the skirting face shall have the projection from the finished face of wall as shown in the drawings or as required by the Engineer.

9.20.3 Laying

The risers of steps and skirting shall be in grey or white cement admixed with or without pigment to match the shade of the stone, as specified in the description of the item, with the line of the slab at such a distance from the wall that the average width of the gap shall be 12 mm and at no place the width shall be less than 10 mm. If necessary, the slabs shall be held in position by temporary M.S. hooks fixed into the wall at suitable intervals. The skirting or riser face shall be checked for plane and plumb

and corrected. The joints shall thus be left to harden. Then the rear of the skirting or riser slab shall be packed with cement mortar 1: 3 (1 cement : 3 coarse sand) or other mix as specified in the description of the item. The fixing hooks shall be removed after the mortar filling the gap has acquired sufficient strength.

The joints shall be as fine as possible. The top line of skirting and risers shall be truly horizontal and joints truly vertical, except where otherwise indicated.

The risers and skirting slab shall be matched as shown in drawings or as instructed by the Engineer.

9.20.4 Curing, Polishing and Finishing

It shall be as specified in para 9.10.3 as far as applicable, except that cement slurry with or without pigment shall not be applied on the surface and polishing shall be done only with hand. The face and top of skirting shall be polished.

9.20.5 Measurements

Length shall be measured along the finished face of riser or skirting, correct to a cm. Height shall be measured from the finished level of tread or floor, to the top (the underside of tread, in the case of steps) correct to 1 mm. The areas shall be calculated in square metre correct to two places of decimal.

Dado and lining of pillars etc., shall be measured as "Marble work in wall lining" if the thickness is up to 25 mm or as "Marble Work" in jambs, walls, columns and other plain work' if the thickness is more.

9.20.6 Rate

The rate shall include the cost of all materials and labour involved in all the operations described above.

9.21 KOTA / CUDDAPPAH / SHAHABAD / TANDUR STONE FLOORING

9.21.1 Stone Slabs

The slabs shall be of selected quality, hard, sound, dense and homogeneous in texture free from cracks, decay, weathering and flaws. They shall be hand or machine cut to the requisite thickness. They shall be of the colour indicated in the drawings or as instructed by the Engineer.

The slabs shall have the top (exposed) face polished before being brought to site, unless otherwise specified. The slabs shall conform to the size required. Before starting the work the contractor shall get the samples of slabs approved by the Engineer. Where slabs are

used for treads of steps, the exposed surfaces shall be rough chisel dressed to full depth and cut to uniform thickness.

9.21.2 Dressing

Every slab shall be cut to the required size and shape and fine chisel dressed on the sides to the full depth so that a straight edge laid along the side of the stone shall be in full contact with it. The sides (edges) shall be table-rubbed with coarse sand or machine rubbed before paving. All angles and edges of the slabs shall be true, square and free from chippings and the surface shall be true and plane.

The thickness of the slab after it is dressed shall be 20, 25, 30 or 40 mm or as specified in the description of the item. Tolerance of ± 2 mm shall be allowed for the thickness. In respect of length and breadth of slabs, tolerance of ± 5 mm for hand cut slabs and ± 2 mm for machine cut slabs shall be allowed.

9.21.3 Preparation of Surface and Laying

The specification shall be as described in para.9.18.3 except that the edges of the slabs to be jointed shall be buttered with grey cement, with admixture of pigment to match the shade of the slab.

9.21.4 Curing, Polishing and Finishing

The specifications shall be as described in para 9.10.3. except that (a) first polishing with coarse grade carborundum stone shall not be done, (b) cement slurry with or without pigment shall not be applied on the surface before polishing.

9.21.5 Measurements and Rate : These shall be as described in paras 9.18.5 and 9.18.6.

9.22 KOTA/ CUDDAPPAH/ SHAHABAD / TANDUR STONE IN RISERS OF STEPS, SKIRTING AND DADO

9.22.1 Stone Slabs:- Stone Slabs and Dressing shall be as specified in paras 9.21.1. and 9.21.2 except that the thickness of the slabs shall be 25 mm or as specified in the description of the item. The slabs may be of uniform size if required.

9.22.2 Preparation:- Preparation of surface shall be as specified in para 9.20.2.

9.22.3. Laying:- Laying shall be as specified in para 9.20.3 except that the joints of the slabs shall be set in grey cement mixed with pigment to match the shade of the slabs.

9.22.4. Curing etc:- Curing, Polishing and Finishing shall be as specified in para

9.20.4 except that first polishing with coarse grade carborundum stone shall not be done.

9.22.5 Measurements

Length shall be measured along the finished face of riser, skirting or dado correct to a cm. Height shall be measured from the finished level of tread of floor to the top (the underside of tread in the case of steps). This shall be measured correct to a mm in the case of risers of steps and skirting and correct to a cm in the case of dado. The area shall be calculated in square metre correct to two places of decimal.

Lining of pillars etc., shall also be measured under this item.

9.22.6 Rate

The rate shall include the cost of all materials and labour involved in all the operations described above.

9.23 RED OR WHITE ROUGH DRESSED SAND STONE FLOORING

9.23.1 Stone Slabs

The slabs shall be red or white as specified in the description of the item. The stone slabs shall be hard, sound, durable and tough, free from cracks, decay and weathering. In case of red sand stone, white patches or streaks shall not be allowed. However, scattered spots up to 10 mm diameter will be permitted. Before starting the work the contractor shall get samples of slabs approved by the Engineer.

The slabs shall be hand or machine cut to the requisite thickness along planes parallel to the natural bed of stone and should be of uniform size if required.

9.23.2 Dressing of Slabs

Every slab shall be cut to the required size and shape, and rough chisel dressed on the top, so that the dressed surface shall not be more than 6 mm from a straight edge when placed on it. The edge of depressions or projections shall be chisel dressed in a slant so that the surface does not have sharp unevenness. The sides shall also be chisel dressed to a minimum depth of 20 mm so that the dressed edge shall at no place be more than 30 mm from a straight edge butted against it. Beyond this depth the sides may be dressed slightly splayed so as to form inverted 'V' shaped joint with adjoining slabs. All angles and edges of the slabs shall be true, square and free from chippings and the surface reasonably true and plane.

Where slabs are used for treads without nosing, the exposed edges shall be rough

chisel dressed to full depth and cut to uniform thickness. The thickness of the slabs after it is dressed shall be 40 mm or as specified in the description of the item with a permissible tolerance of ± 2 mm.

9.23.3 Laying

9.23.3.1. Base concrete on which the slabs are to be laid shall be cleaned, wetted and mopped. The bedding for the slabs shall be with cement mortar 1:5 (1 cement : 5 coarse sand) or with the lime mortar 1:1:1 (1 lime putty: 1 surkhi: 1 coarse sand) or as given in the description of the item.

9.23.3.2. The average thickness of the bedding mortar under the slabs shall be 20 mm and the thickness at any place under the slabs shall not be less than 12 mm.

9.23.3.3 The slab shall be laid in the following manner :

Mortar of specified mix shall be spread under each slab. The slab shall be washed clean before laying. It shall then be laid on top and pressed, so that all hollows underneath get filled and surplus mortar works up through the joints. The top shall be tapped with a wooden mallet and brought to level and close to the adjoining slabs, with thickness of joint not exceeding 5 mm. Subsequent slabs shall be laid in the same manner. After laying each slab surplus mortar on the surface of slabs shall be cleaned off and joints finished flush.

9.23.3.4. In case pointing with other mortar mix is specified, the joint shall be left raked out uniformly and to a depth of not less than 12 mm when the mortar is still green. The pointing shall be cured for a minimum period of 7 days. The surface of the flooring as laid shall be true to levels and slopes as instructed by the Engineer.

9.23.3.5. Slabs which are fixed in the floor adjoining the wall shall enter not less than 12 mm under the plaster, skirting or dado. The junction between wall plaster skirting and floor shall be finished neatly and without waviness.

9.23.3.6 The finished floor shall not sound hollow when tapped with wooden mallet.

9.23.3.7 Finishing - Any unevenness existing between the edges of slabs joints shall be removed by chiseling in a slant.

9.23.3.8 Measurements - These shall be as specified in para 9.19.5.

9.23.3.9 Rate

The rate shall include the cost of all materials and labour involved in all the operations described above. Where pointing

is to be done, this will be paid extra unless specifically included in the description of the item.

9.24 RED OR WHITE FINE DRESSED SAND STONE FLOORING

9.24.1 Stone Slabs:- Stone slab shall be as specified in para 9.23.1.

9.24.2 Dressing

Every slab shall be cut to the required size and shape and chisel dressed on all sides to a minimum depth of 20 mm. The top and the joints shall be fine tooled so that a straight edge laid along the face is fully in contact with it. In case machine cut stones are used, chisel dressing and fine tooling of machine cut surface need not be done provided a straight edge laid anywhere along the machine cut surface is in contact with every point on it.

The thickness of the slabs after dressing shall be 40 mm or as specified in the description of item with a permissible tolerance of ± 2 mm.

9.24.3 Laying

Shall be as specified in para 9.23.3.

9.24.4. Finishing : In case of chisel dressed stone flooring slight unevenness, if any existing between the edges of slabs at joints shall be removed by chiseling in a slant.

9.24.5 Measurements and Rate:- Measurements and Rate shall be as specified in paras 9.23.5 and 9.23.6.

9.25 RED OR WHITE FINE DRESSED AND RUBBED SAND STONE FLOORING

9.25.1 Stone Slabs:- Stone slabs shall be as specified in para 9.23.1.

9.25.2 Dressing

The specifications for dressing the top surface and the sides shall be as described in para 9.23.2. In addition the dressed top and sides shall be table rubbed with coarse grade carborundum stone before paving, to obtain a perfectly true and smooth surface free from chisel marks. The thickness of the slabs after dressing shall be as specified with a permissible tolerance of ± 2 mm.

9.25.3 Laying

The slabs shall be laid with 3 mm thick or 5 mm thick joints as specified in the description of the item.

Where the joints are to be limited to 3 mm thickness, the slabs shall be laid as specified

in para 9.19.3 except that the bedding mortar shall be as specified in para 9.23.3. and sides of the slabs to be jointed shall be buttered with cement mortar 1:2 (1 cement : 2 stone dust) admixed with pigment to match the shade of the slab. Where the slabs are to be laid with 5 mm thick joints the specifications for laying shall be as described in para 9.23.3.

9.25.4 Finishing:- Finishing shall be as specified in para 9.23.4 except that chisel marks and unevenness shall be removed by rubbing with coarse grade carborundum stone.

9.25.5 Measurements and Rate:- Measurement and Rate shall be as specified in paras 9.23.5 and 9.23.6.

9.26 PVC SHEET/TILES FLOORING

(Note: For PVC Asbestos Floor Tiles also same specifications will apply except that the materials, dimensions, Tolerances, colour finish physical requirements and Tests shall be as per IS 3461).

9.26.1 General:- PVC Flooring material is normally used for covering floor from decorative point of view in residential and non-residential buildings. This material gives a resilient and non-porous surface which can be easily cleaned with a wet cloth as dust and grime do not penetrate the surface. Since even a burning cigarette will damage the neat surface of the PVC sheet, special care should be taken to prevent burning cigarette stumps etc to come in contact with the PVC flooring materials.

It shall be laid on a base that is finished even and smooth such as concrete, metal or timber boarding. Unevenness or undulations in the base will show badly on the surface and are liable to damage the PVC sheet/tiles.

9.26.2 Materials

9.26.2.1. The PVC flooring material shall conform to IS : 3462 . It may be in the form of tiles, sheets or rolls as specified. It shall consist of a thoroughly blended composition of thermoplastic binder, filler and pigments. The thermo plastic binder shall consist substantially of one or both of the following :

- (a) Vinyl chloride polymer
- (b) Vinyl chloride copolymer

The poly-metric material shall be compounded with suitable plasticizers and stabilizers.

Thickness : The preferred thickness of PVC tiles for normal floor covering shall be 1.5, 2.0, 2.5, 3.0 or 4.0 mm.

9.26.2.2. Thickness of PVC sheets shall be measured with micrometer of Ratchet type or a dial gauge graduated to 0.02 mm. The micrometer shall have flat bearing surface of at least 6.5 mm diameter at both contact points.

For sheets and rolls the thickness of the specimen shall be measured at twenty scattered points.

9.26.2.4 Tolerance

(a)	Thickness	± 0.15 mm	
(b)	Width	(i)	300 mm square tiles ± 2 mm
		(ii)	600 mm square tiles ± 0.4 mm
		(iii)	900 mm square tiles ± 0.6 mm
		(iv)	Sheets and rolls ± 0.1 percent

9.26.2.5. Adhesive: Rubber based adhesives are suitable for fixing PVC flooring over concrete, wooden and metal sub-floors. PVA based adhesives may also be used for concrete and wooden sub-floors. PVA based adhesives are not suitable for metallic surfaces and also for locations where there is constant spillage of water.

9.26.3 Preparation of Sub-floors

Before laying PVC sheets/tiles, it is essential to ensure that the base is thoroughly dry and damp proof as evaporation of moisture cannot take place once the PVC flooring is laid. Moisture slowly damages the adhesive resulting in PVC sheet/tiles being separated from the base and curling up. In case of new work a period of 4 to 8 weeks shall be allowed for drying the sub-floor under normal conditions.

Concrete sub-floors on the ground floor shall be laid in two layers. The top surface of the lower layer of concrete shall be painted with two coats of A-90 grade (conforming to IS : 1580) applied at the rate of 1.5 kg/sqm. The top surface of the lower layer shall be finished smooth while laying the concrete so that the bitumen can be applied uniformly. The bitumen shall be applied after the concrete has set and is sufficiently hard. Bitumen felt conforming to IS : 1322 shall be sand-wiched in the sub-floor laid in two layers.

In new concrete floor, the smooth finish required shall be produced by using cement slurry spread on fresh concrete floor and finished smooth. If the concrete floor is old

9.26.2.3. The width of flooring sheets and rolling in continuous length shall be 1000, 1500 and 2000 mm. When supplied in rolls the length of the rolls shall not be less than 10 metres.

The measurement shall be carried out with a traveling microscope or suitable scale graduated to 0.02 mm. Each tile shall be measured for length and width at the three quarter points in each direction.

and surface not even, the surface should be made smooth by first clearing it free of all foreign material and then a layer of cement mortar 1:2 (1 cement : 2 coarse sand) of average thickness of 6 mm shall be applied on the surface finishing the surface smooth. The finished surface shall be cured for 7 days and then allowed to dry thoroughly.

Where it is expected that the dampness may find its way from the surrounding walls, the same shall also be effectively damp-proofed up to at least 150 mm above the level of the sub-floor and the damp-proof treatment below the floor shall be extended over the walls.

9.26.4 Laying and Fixing

9.26.4.1. Prior to laying, the flooring tiles/rolls/sheets shall be brought to the temperature of the area in which it is to be laid by stacking in a suitable manner within or near the laying area for a period of about 24 hours.

9.26.4.2. Where air-conditioning is installed, the flooring shall not be laid on the sub-floor until the conditioning units have been in operation for at least seven days. During this period the temperature shall neither fall below 20°C nor exceed 30°C. These conditions shall be maintained during laying and for 48 hours, there after.

9.26.4.3. Before commencing the laying operations, the sub-floor shall be examined for evenness and dryness. The sub-floor shall then be cleaned with a dry cloth. The PVC flooring shall not be laid on a sub-floor unless the sub-floor is perfectly dry. Methods

of testing for dryness are specified in **Annexure 9.4**.

9.26.4.4. The layout of the PVC flooring on the sub-floor to be covered should be marked with guidelines. The PVC flooring shall be first laid for trial, without using the adhesive, according to the required layout.

9.26.4.5. The adhesive shall be applied by using a notched trowel (**Figure 9.4**) to the sub-floor and to the back side of the PVC sheet or tile flooring. When set sufficiently for laying, the adhesive will be sticky to touch, but will not mark the fingers. In general, the adhesive will require about half an hour for setting. It should not be left after setting for too long a period as the adhesive properties will be lost owing to dust films and other causes.

9.26.4.6. Care should be taken while laying the flooring under high humidity conditions so that condensation does not take place affecting the adhesive. It is preferable to avoid laying under high humidity conditions.

9.26.4.7 The area of adhesive to be spread at one time on the sub-floor depends entirely upon local circumstances. In case of a small room, adhesive may be spread over the entire area but relatively small areas of tiles/sheets flooring should be treated in a larger room.

9.26.4.8. When the adhesive is just tack free the PVC flooring sheet shall be carefully taken and placed in position from one end onwards slowly so that the air will be completely squeezed out between the sheet and the background surface. After laying the sheet in position, it shall be pressed with suitable roller weighing about 5 kg. to develop proper contact with the sub-floor. The next sheet with its back side applied with the adhesive shall be laid edge to edge with the sheet already laid and fixed in exactly the same manner as the first sheet was fixed. The sheets shall be laid edge to edge so that there is minimum gap between joints.

9.26.4.9. The alignment should be checked after laying of each row of sheet is completed. If the alignment is not perfect, the sheets may be trimmed by using a straight edge.

9.26.4.10. The tiles shall be fixed in exactly the same manner as for the sheets. It is preferable to start laying of the tiles from the center of the area. Care should be taken that the tiles are laid close to each other with minimum gap between joints. The tiles should always be lowered in position and

pressed firmly on to the adhesive. Care should be taken not to slide them as this may result in adhesive being squeezed up between the joints. PVC tiles after laying shall be rolled with a light wooden roller weighing about 5 kg to ensure full contact with the under-layer. Any undulations noticed on the PVC surface shall be rectified by removing and relaying the tiles after thorough cleaning of the underside of the affected tiles. The adhesives applied earlier in such places shall be thoroughly removed by using proper solvents and the surface shall be cleaned to remove the traces of solvents used. Work should be constantly checked against guidelines in order to ensure that all the four edges of adjacent tiles meet accurately.

9.26.4.11. Any adhesive which may squeeze up between sheets or tiles should be wiped off immediately with a wet cloth before the adhesive hardens. If, by chance, adhesive dries up and hardens on the surface of the sheet or tile, it should be removed with a suitable solvent. A solution of one part of commercial butyleacetate and three parts of turpentine oil is a suitable solvent for the purpose.

9.26.4.12. A minimum period of 24 hours shall be given after laying the flooring for developing proper bond of the adhesive. During this period, the flooring shall not be put to service. It is preferable to lay the PVC flooring after completion of plastering, painting and other decorative finish works so as to avoid any accidental damage to the flooring.

9.26.4.13. When the flooring has been securely fixed, it shall be cleaned with a wet cloth soaked in warm soap solution (two spoons of soap in 5 litres of warm water).

9.26.4.14. Where the edges of the PVC sheets or tiles are exposed, as for example, in doorways and on stair treads, it is important to provide protection against damage of flooring materials. Metallic edge strips may be used and should be securely fastened to the sub-floor to protect edges of the flooring.

9.26.5. Precautions in Maintenance

9.26.5.1. PVC flooring subject to normal usage may be kept clean by mopping with soap solution using a clean damp cloth. Water shall not be poured on the PVC flooring for cleaning purpose as the water may tend to seep through the joints and cause the adhesive to fail. To maintain a good wearing surface and a good appearance, the flooring may be periodically

polished. When polish is applied frequently, a thick layer builds up which collects dirt and dust and is tacky to walk on.

9.26.5.2. If the traffic is light, the floor shall be given frequent brushing and regular polishing by an application of new polish every 4 to 6 weeks. Under moderate traffic conditions the floor shall be given an occasional wash with a wet mop but no detergents shall be used so that the polish is not removed.

Application of polish may be done every one to three weeks. PVC flooring should not be over-waxed. When this condition develops, the coatings should be cleared off with white spirit or paraffin and a light even coat of polish applied.

When the PVC flooring has been polished, it will remain bright for a considerable period if dry mop is applied each day. It is this daily 'dry polish' that maintains the glossy surface. After exceptionally heavy traffic PVC flooring should be swept with a hair broom, rubbed with a mop or cloth frequently rinsed in clean water and finally rubbed dry.

9.26.6. Measurements

Length and breadth shall be measured correct to a cm and its area shall be calculated in sqm correct to two places of decimal. No deduction shall be made nor extra paid for voids not exceeding 0.20 square metre. Deductions for ends of dissimilar materials or other articles embedded shall not be made for areas not exceeding 0.10 square metre. Nothing extra shall be paid for providing PVC flooring in borders and margins, irrespective of their width.

9.26.7 Rate

The rate shall include the cost of all materials and labour involved in all the operations described above, except those described in para.9.26.5. The rate does not include the cost of sub-floor or damp proof treatment if any. It also does not include the cost of metallic edge strip to protect edge of flooring. Wherever provided, it shall be paid separately.

9.27 RUBBER FLOORING

9.27.1 General: Rubber flooring and skirting may be laid with rubber sheets, or rubber tiles.

Rubber sheets or tiles may be (i) Plain or Marbled, (ii) Rubbed or fluted, (iii) With fabric backing or fabric insert, (iv) With sponge

rubber backing or (v) With plain rubber backing, as specified. (see **Figure 9.5**)

Rubber flooring shall not be used in situations exposed to direct sunlight or rain as the flooring is likely to deteriorate quickly.

In maintaining rubber flooring, lavish use of water, scrubbing with strongly alkaline soaps and cleaning with rough brushes should be avoided. Rubber flooring made from natural rubber shall not be used in situations where it is likely to come in contact with fats, grease, oil or petrol. To meet such conditions rubber flooring made from certain synthetic rubber will have to be used.

9.27.2 Materials

9.27.2.1. Rubber Tiles: Rubber tiles shall conform in all respect to IS : 809. These shall be of standard sizes, such as 200 x 200 mm, 300 x 300mm or as shown in the drawings or as directed by the Engineer. Where the room length and width are not exact multiples of the size of the tiles, the end rows shall be with cut sizes of tiles. The thickness of the tiles shall be 3.2 mm, 4.8 mm or 6.4 mm as specified in the description of the item, with permissible tolerance of plus 0.8 mm and minus 0.2 mm.

The tiles shall be 'plain' or 'Marbled', unless otherwise specifically described in the item. The colour of the tiles shall be as shown in the drawings or as directed by the Engineer.

Before starting the work, the contractor shall get the samples of rubber tiles approved by the Engineer.

9.27.2.2. Adhesive: The adhesive shall be a rubber adhesive of approved quality of the type and make recommended by the manufacturers of rubber tiles. It shall be got approved by the Engineer. It shall be a rubber solvent preparation with a reasonably short drying time and shall give a tough adhesive film. The surplus adhesive should not be allowed to remain longer than 24 hours.

9.27.3 Laying - Shall generally conform to IS : 1197.

9.27.3.1. Rubber tiles shall be laid to margins and pattern as shown in the drawings or as directed by the Engineer.

9.27.3.2. Rubber flooring may be laid on any base that is finished even and smooth, such as concrete, timber boarding or mastic asphalt. A rough surface makes for poor adhesion of the rubber and its consequent separation from the base in due course.

It is important that the base is thoroughly dry and damp proof as dampness causes failure

of the adhesive, leading to the curling of tiles. Nothing extra shall be paid for the rubber used in sealing the edges at the entrance. Damp proofing of the base can be effected in any of the ways suggested in **Annexure 9.4.**

9.27.3.3. The base shall be smooth, thoroughly clean and dry. Adhesive shall be applied to the base, and to the back and edges of the tiles and allowed to become surface dry. The tiles shall then be firmly pressed and smoothened down with a suitable tool. Weights shall be used to keep the tiles flat if any tendency to curl is noticed. Care shall be taken to ensure that no air pockets are left under the tiles. If any air pocket is left, the tiles shall be removed and re-laid after applying more adhesive on the base and back of tiles and pressed in position. The tile shall be laid with butt joints throughout and the joints shall be very fine.

Coves of wood or metal may be formed to cover or mask the joints between the rubber flooring and the wall facing where so required, but these shall be paid for separately.

9.27.4 Finishing

After laying, any adhesive sticking on the face of the tiles shall be removed immediately, since if allowed to harden, solvent may be required to remove it and this will harm the rubber. The surface shall be cleaned with a mild soap and wet cloth after a week of its laying. After drying, the surface shall be polished with an approved emulsion type polish to give a smooth shining surface.

9.27.5 Measurements

Lengths and breadths of superficial area of the finished work shall be measured correct to a cm. The area shall be calculated in square metre correct to two places of decimal. No deduction shall be made nor extra paid for any opening in the floor up to 0.20 sqm in area. Deduction for ends of dissimilar materials or other articles embedded shall not be made for areas not exceeding 0.10 square metre. Nothing extra shall be paid for borders and margin, irrespective of their width. Nothing extra shall be paid for the use of cut tiles in the work.

9.27.6 Rate

The rate shall include the cost of all materials and labour involved in all the operations described above but shall not include the cost of the base or damp proof treatment or the cost of coves.

9.28 STONE SETTS FLOORING

9.28.1 Stone Setts : The stone setts shall be 250mm x 125mm x 100mm or of any other standard size. These shall be of the hardest procurable Granite, Trap or other stone of igneous origin. The stone setts must have a dense and clear section. Those discoloured or distorted with boulder skin or earthy and porous matter or showing signs of decay shall be rejected. All stones must be uniformly rectangular, smooth on the top surface and evenly hammer dressed on the other five sides, and shall be laid flat with the continuous vertical joints not in the direct line of traffic.

9.28.2 Base : Base may consist of dry rammed sand or moorum or dry rammed brick- ballast or stone-ballast or kankar or quarry refuse or lime concrete or cement concrete, as specified by the Engineer. On new embankments which have not fully settled, the base may consist of dry rammed sand or moorum only. The consolidated thickness may be anything from 7 cm to 15 cm depending upon the requirement.

9.28.3 Laying : A layer of 10mm to 20mm sand shall be spread over the base concrete to allow for the irregularities in the stones. The vertical joints shall be 5mm to 10mm, wide which may be later filled in with 1:3 cement sand mortar / bituminous mixed sand unless otherwise ordered. If the stone setts are to be laid dry without jointing, they shall be laid as close to each other as possible with sand spread over the top to work into the services.

9.28.4 Measurements : Work shall be measured in square metres correct to two places of decimal. Length and breadth shall be measured correct to a cm.

9.28.5 Rate : Rate will include labour and materials (except cement) for all the above operations.

{FOR TYPES OF FLOORING RECOMMENDED FOR DIFFERENT LOCATIONS - Annexure 9.5 may be referred to}

ANNEXURE 9.1**ABRASION TEST FOR CONCRETE HARDENING COMPOUNDS****1. Preparation of Sample**

25 mm cylinder shall be prepared in ratio 1: 2 (1 cement : 2 graded stone aggregate 6 mm nominal size) by weight, one each with and without the admixture of concrete hardening compound. The concrete hardening compound shall be used in the proportion by weight of cement as recommended by the firm. The cylinder shall be placed inside a damp box for 24 hours and then cured in water for 27 days. After that, they shall be subject to abrasion test on 'Dorry' Type Avery Abrasion Testing Machine, using Emery Powder No.80 as the abrading medium under the condition given in para 2 below.

2. Conditions of Test

- (a) Area of rubbing surface shall be same in both the cylinders.
- (b) Age of cylinder 28 days
- (c) Duration of Test 60 minutes
- (d) Total distance traversed during rubbing About 2.4 km
- (e) Pressure on rubbing surface 0.04 kg/cm^2

3. Results of Tests

The following observations shall be made in both the cases:-

- (a) Composition of the Test specimen
- (b) Mean thickness rubbed away
- (c) Percentage loss in weight

4. Remarks

Percentage loss in weight in the case of cylinder with concrete hardening compound, should not be more than 40 percent of the percentage loss in the case of cylinder without concrete hardening compound.

ANNEXURE 9.2**TEST REQUIREMENTS AND PROCEDURE FOR TESTING "PRECAST CEMENT CONCRETE / TERRAZZO TILES"****1 Sampling**

The tiles required for carrying out test described below shall be taken by 'random sampling'. Each tile sample shall be marked to identify the consignment from which it was selected.

Minimum quantity of tiles for carrying out the test and frequency of test shall be as specified in the Recommended list of Tests. The number of tiles selected for each test shall be as follows:

- (a) For conformity to requirements on shape and dimensions, wearing layers, and general quality - 12 tiles.
- (b) For wet transverse strength test - 6 tiles
- (c) For resistance to wear test - 6 tiles
- (d) For water absorption test - 6 tiles

NOTE – (a) The tests on the tiles shall not be carried out earlier than 28 days from the date of manufacture.

(2) The tiles selected for (a) may as well after verification of requirements, be used for (b).

2 Wet Transverse Strength Test

Six full size tiles shall be tested for the determination of wet transverse strength. When tested according to the procedure laid down in Appendix 'E' of IS : 1237, the average wet transverse strength shall not be less than 3 N/mm^2 (30 kg/cm^2).

3 Resistance to Wear Test

3.1 Not less than twelve specimens shall be prepared as described in Para -3.2 from the tiles selected in accordance with Para 1. When tested in the manner specified in Paras 3.3.1 to 3.3.4, their average wear shall not exceed 3.5 mm and the wear on any individual specimen shall not exceed 4 mm.

3.2 Preparation of Test Specimens

The test specimens shall be square in shape and of size $7.06 \text{ cm} \times 7.06 \text{ cm}$ (i.e. 50 sq.cm . in area). They shall be sawn off one only from each tile, preferably from the central

part of the tile. The deviation in the length of the specimen shall be within ± 2 percent . The surface to be tested shall be ground smooth and filling removed.

3.3. Apparatus and Accessories

3.3.1. Abrasion Testing Machine

The abrasion test of specimens shall be carried out in a machine conforming essentially to the requirements described in IS : 1237 (Appendix 'F'). The abrasive powder used for the test shall conform to the specification given below:-

The abrasive shall have an aluminium oxide content of not less than 95 percent by weight. The grains shall be of rounded shape and shall generally pass through IS Test Sieve 25 and be retained on IS Test Sieve 20. The combined content of larger grains retained in IS Tests Sieve 25 and of smaller grains whose fineness is not limited, shall not exceed 10 percent. The specific gravity of the grains shall be between 3.9 and 4.1. The grains shall generally have a hardness of 9 in Mohr's scale.

3.3.2. Measuring Instruments

A suitable instrument capable of measurement to an accuracy of 0.01 mm shall be used for determining the change in the thickness of the specimen after abrasion.

3.3.3. Procedure of Test

The specimen shall be dried at 110°C for 24 hours and then weighed to the nearest 0.1 gm. The specimen after initial drying and weighing shall be placed in the thickness measuring apparatus with its wearing

$$t = \frac{10 \times (W_1 - W_2) V_1}{W_1 \times A}$$

Where

t = Average loss in thickness, in mm;

W_1 – Initial weight, in gm of the specimen;

W_2 – Final weight, in gm of the abraded specimen;

V_1 . Initial volume, in CC of the specimen and

A = Surface area in sq./ cm. of the specimen.

4 Water Absorption

4.1. At the time of delivery to the site of the work, not less than six full tile specimens, selected in accordance with Para 1 shall be prepared and when tested as described below, their average percentage of water absorption shall not exceed ten.

4.2. Preparation of Specimen

Full size tiles shall be used for this test. They shall be immersed in water for 24 hours, then taken out, wiped dry and tested for water absorption.

surface uppermost and the reading of the measuring instrument taken.

The grinding path of the disc of the abrasion testing machine shall be evenly strewn with 20 gm of the abrasive powder. The specimen shall then be fixed in the holding device with the surface to be ground facing the disc and loaded at the center with 30 kg. The grinding disc shall then be put in motion at a speed of 30- rpm. After every 22 revolutions, the disc shall be stopped, the abraded tile powder and the remainder of the abrasive powder shall be removed from the disc and fresh abrasive powder in quantities of 20 gm applied each time. After 110 revolutions, the specimen shall be turned about the vertical axis through an angle of 90 ° and then the test continued under the same conditions until 220 revolutions have been completed altogether. The disc, the abrasive powder and the specimen shall be kept dry throughout the duration of the test. After the abrasion is over, the specimen shall be reweighed to the nearest 0.1 gm. It shall then be placed in the thickness measuring apparatus once again in the identical manner and the reading taken with the same position and setting of the dial gauge as for the measurement before abrasion.

3.3.4. Determination of Wear

The wear shall be determined from the difference in readings obtained by the measuring instrument before and after the abrasion of the specimen. The value shall be checked up with the average loss in thickness of the specimen obtained by the following formula.

4.3. Procedure of Test

Each tile shall be weighed immediately after saturation and wiping as in Para 4.2. The tile shall be oven dried at a temperature of $65 \pm 1^{\circ}\text{C}$ for a period of 24 hours, cooled to room temperature and reweighed.

4.4. Determination of Water Absorption

The water absorption per cent by weight for each tile shall be determined as follows:

On oven dry basis water absorption per cent by weight $(W_1 - W_2) \times 100$

 W_2

Where

W_1 – Weight in gm of the saturated specimen; and

W_2 . Weight in gm of the oven dried specimen.

The average value for percentage water absorption shall be calculated for the whole number of tiles tested.

ANNEXURE 9.3 MARBLE

1.0 Marble shall be hard, sound, dense and homogeneous in texture with crystalline texture as far as possible. It shall generally be uniform in colour and free from stains, cracks, decay and weathering.

1.0.1 Marbles are metamorphic rocks capable of taking polish, formed from the recrystallization of lime stones or dolomitic lime stones and are distinguished from lime stone by even visibly crystalline nature and non-flaggy stratification.

Note: Marble is a product of nature and hence it is difficult to guarantee uniformity of colour, veining or other characteristics that may be represented in any sample submitted. A sample will indicate only an average of colour, veining and other general texture and specified finish.

1.1 Classification

The marble blocks, slabs and tiles shall be classified broadly in the following two categories:-

- (i) White Marble
- (ii) Coloured Marble such as black, green, pink, brown, grey marble etc.,

(i) White Marble

1.1.1. Plain White Marble

- (a) Makrana first quality White Marble: Plain white marble without streaks available at Chosira pahar Kuwan, Doongri and Bhat.
- (b) Makrana second quality white Marble: White marble having lighter shades or spots

available at Chosira Pahar Kuwan, Doongri and Lodhi Doongri.

(c) Abu White Marble: White marble with blue and grey shades available at Ambaji.

(d) Raj Nagar Marble: It shall be plain white marble with coarse grains predominantly showing mica particles giving reflection in bright light.

1.1.2. Abu Panther Marbles

White marble with irregular blue black spots available in Ambaji.

1.1.3. White Veined Marbles

(a) Makrana Doongri Adanga Marble: Light greyish white having grey and brown veins available at Doongri and Pahar Kuan.

(b) Makrana chak Doongri Marble: White marble having black streaks available at Chak Doongri

(c) Abu White Veined Marble

(d) White marble with grey or black veins available at Ambaji.

(ii) Coloured Marble

1.1.4 Black Marble

1.1.4.1. Plain Black Marble: Black marble sawn along veins locally known as 'Peta Pasu sawing' available at Bhainslana.

1.1.4.2. Black Zebra Marble

(a) Bhainslana Black Zebra Marble: Black marble having grey or white veins available at Bhainslana.

(b) Kishangarh Black Zebra Marble: Black marble having white patches and streaks available at Abu.

(c) Narnaul Black Zebra Marble: Black marble with thin white veins available at Narnaul.

(d) Makrana Dhobi Doongri Zebra Marble: Greyish black marble with white flowery pattern available at Dhobi Doongri.

1.1.5 Green Marble

(a) Baroda Green Marble: Dark Green marble with flowery pattern available at Baroda.

(b) Abu Green Marble: Light green marble with green and/or brown streaks on white ground available at Ambaji.

(c) Falna Green Marble: Green marble with prominent yellowish pattern available at Falna.

(d) Bundi Green Marble: Green marble with pinkish shades available at Umar, (Bundi).

1.1.6. Pink Marble

1.1.6.1. Plain Pink Marble: Pink Marble with light or dark shades available at Makrana and Bar.

1.1.6.2. Pink Adanga Marble

(a) Makrana Pink Adanga Marble: Pink marble with brown or greenish and white

streaks available at Makrana. It has both light and dark shades of pink.

(b) Bar Pink Adanga Marble: Pink marble with green veins available at Bar.

(c) Bundi Pink Adanga Marble: Pink marble with great streaks available at Umar (Bundi).

1.1.7. Grey Marble

(a) Kumari Grey Marble: Grey marble having light blue shades available at Makrana.

(b) Narnaul Brown Marble: Brown marble having teak wood shades available at Narnaul.

1.1.8 Brown Marble

(a) Bar Brown Marble / Brown Marble with light and dark brown shades available at Bar.

(b) Narnaul Brown Marble: Brown marble having teak wood shades available at Narnaul.

1.2. Sizes and Tolerances

The size of marble blacks, slabs and tiles shall be as mentioned in Table below.

TABLE : Sizes of Marble Blocks, Slabs and Tiles

	Length	Width	Thickness
1. Blocks	30 to 250	30 to 100	30 to 90
2. Slabs	70 to 250	30 to 100	2 to 15
3. Tiles	10 to 60	10 to 60	0.8 to 2.4

Notes :

- (1) All dimensions are in centimeter.
- (2) The length and width, of the blocks shall be in multiple of 30 cm.
- (3) Length and width of slab shall be in multiple of 10 cm. And thickness in multiple of 1 cm.
- (4) Tiles shall be square cut and linear dimensions shall be in multiple of 10 cm.
- (5) Only slabs and tiles shall be machine cut and factory made.
- (6) For 8 mm thick tiles, special precautions will be required for fixing them like using special adhesive as per manufacturer's specifications. Such tiles are not suitable for outside veneering work exposed to rains/sun if used in large areas in continuous stretches. For tiles of thickness 20 mm and above cramps may be provided if approved by the Engineer.

Tolerance - Following tolerances shall be allowed in dimension of blocks, slabs and tiles :

Blocks	Tolerance
(a) Length	+ 2 per cent
(b) Width	+ 2 per cent
(c) Thickness	+ 2 per cent
Slabs	
(a) Length	+ 2 per cent
(b) Width	+ 2 per cent

(c) Thickness Tiles	+ 3 per cent
(a) Linear dimension	+ 3 per cent
(b) Thickness	+ 1 per cent

The sizes other than those mentioned above may be provided as directed by the Engineer and nothing extra shall be payable on this account.

ANNEXURE 9.4

DETERMINATION OF SUB-FLOOR DRYNESS

1 General

1.1. Different tests for determining concrete sub-floor dryness are given in this Annexure. It is intended that the first test should be carried out as a preliminary test as it is an approximate method only and while adequate to separate very wet slabs from those which are dry or nearly dry, it will not discriminate satisfactorily between the latter two conditions. Should this preliminary test indicate that the floor is 'dry' confirmatory test should be made by one of the other two procedures given in Paras 3 and 4.

2 Preliminary Test

2.1. Materials

The following materials are required: -

- (a) A sheet of glass about 30 x 30 cm or rubber mat or a sheet of polyethylene (not less than 0.1 mm thick) or the PVC flooring material of about 60 x 60 cm and
- (b) Putty adhesive plasticine or other suitable mastic for sealing the edges of the sheet material.

2.2. Procedure

2.2.1. A sheet of glass rubber or plastic materials shall be placed on the concrete floor slab to be tested and sealed thoroughly around all edges, using the mastic material.

2.2.2. After a period of not less than 24 hours, the covered portion of the concrete slab shall be inspected for signs of dampness. If this area is even slightly darker in colour than the remainder of the slab, the floor shall be considered too wet. A careful inspection is required, as in conditions of good ventilation, the difference in colour may rapidly disappear after the sheet has been lifted.

2.2.3. The test shall be made in several places on the slab, and repeated at regular intervals until no sign of dampness appears. The floor should then be tested at several points by either surface hygrometer method or the electrical resistance method until satisfactory results of floor dryness are obtained before the floor should be considered sufficiently dry.

3 Hygrometer Test

3.1 Apparatus

A hygrometer is so constructed that when sealed to the floor with mastic or by other suitable means, the relative humidity of a small quantity of air confined between the slab and the case of the instrument is measured.

3.2. Procedure

The case of the hygrometer shall be carefully sealed to the slab and left for a period not less than 16 hours. The relative humidity reading shall then be taken.

3.3. Results

The dryness of the concrete slab shall be considered satisfactory for conditions of laying the PVC flooring, if the relative humidity reading does not exceed 70 per cent.

NOTE: The instrument shall be so placed that sunlight does not fall on it, as this may produce a false low reading.

4 Electrical Resistance Test

4.1. Apparatus

The apparatus shall comprise the following:

- (a) Resistance Meter

One, of suitable range to be calibrated in terms of the moisture content of the slab in the range of 4 to 8 percent and having sufficient sensitivity to clearly distinguish changes of 0.5 percent.

ANNEXURE 9.5**TYPE OF FLOORING RECOMMENDED FOR DIFFERENT LOCATIONS**

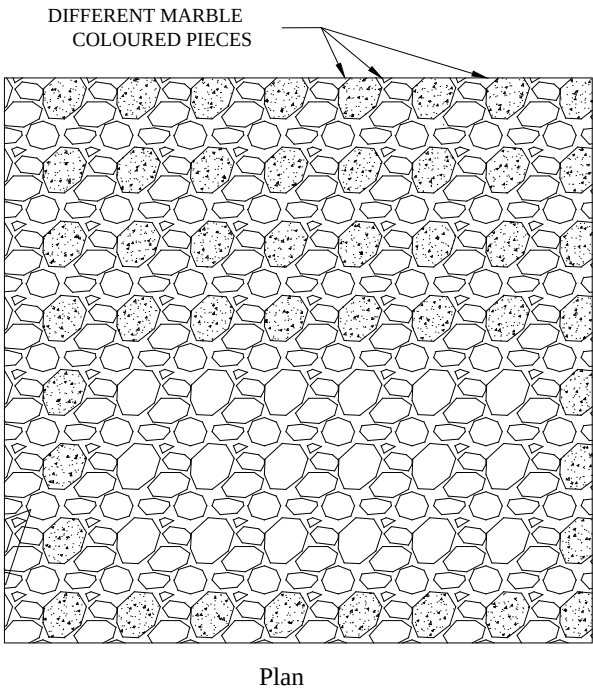
1. Bed Rooms	i) Cement concrete flooring with neat cement finish ii) Terrazzo tiles iii) Terrazzo-in-situ (grey or white) iv) Kota or similar stone v) Marble Crazy flooring
2. Drg.-cum-Dining room	i) White Terrazzo-in-situ flooring ii) Kota or similar stone iii) Marble tiles
3. Office rooms (for general staff)	i) Cement concrete flooring with neat cement finish ii) Terrazzo flooring (grey) iii) Terrazzo tiles
4. Library, Computer rooms	i) PVC flooring
5. Toilet flooring / Kitchen flooring	i) Ceramic tiles / Vitrified tiles ii) Marble tiles or slab iii) Terrazzo tiles iv) Cement Concrete flooring with neat cement finish v) Kota or similar stone vi) Terrazzo in situ flooring
6. Staircase flooring	i) Kota or similar stone ii) Slate stone iii) Terrazzo tiles iv) Cement concrete flooring with neat cement finish v) Marble stone
7. Walkways flooring	i) Plain concrete tiles (precast) ii) Chequered concrete tiles (precast and coloured) iii) Sand stone slab iv) Cement concrete flooring in panels
8. Lobby, Reception Main Lounge flooring in offices	i) Ceramic tiles / Vitrified tiles ii) Terrazzo tiles iii) Kota or similar stone iv) Granite stone
9. Wall cladding, Pillars cladding, Beam cladding in offices in main circulation and reception areas	i) Granite ii) Teak ply
10. Kitchen counter slab	i) Cudappah Black stone ii) Marble slab iii) Granite iv) Cement Concrete flooring with neat cement finish
11. Roof	i) Brick tiles ii) CC Tiles iii) CC flooring in panels iv) Terrazzo tiles

RECOMMENDED LIST OF TESTS ON MATERIALS

Material	Para	Test	Field/ Laboratory Test	Test Proce- dure	Minimum quantity of material for carrying out the test	Frequency of testing
1	2	3	4	5	6	7
Terrazzo Tiles	9:11:1 9:12:1	1. Trans verse strength 2. Water absorption 3. Abras ion test	Laboratory	IS: 1237	5000 Nos. (no testing need be done if total number of tiles of all types of all sizes from all manufacturers used in a work is less than 5000 Nos.)	One test for every 10,000 Nos. or part thereof for each type and size from a single manufacturer. (One test to be done even if the number of terrazzo tiles of any type and size from a single manufacturer is less than 5000 Nos. provided the total number of terrazzo tiles of all types and sizes from all manufacturers used in a work exceeds 5000 Nos.)
White Glazed tiles (for floor & wall)	9:15:1 9:16:1	1. Water absorption 2. Crazi ng test 3. Impact strength 4. Chemical resistant test	Laboratory	IS:777	3000 Nos.	3000 Nos. or part thereof

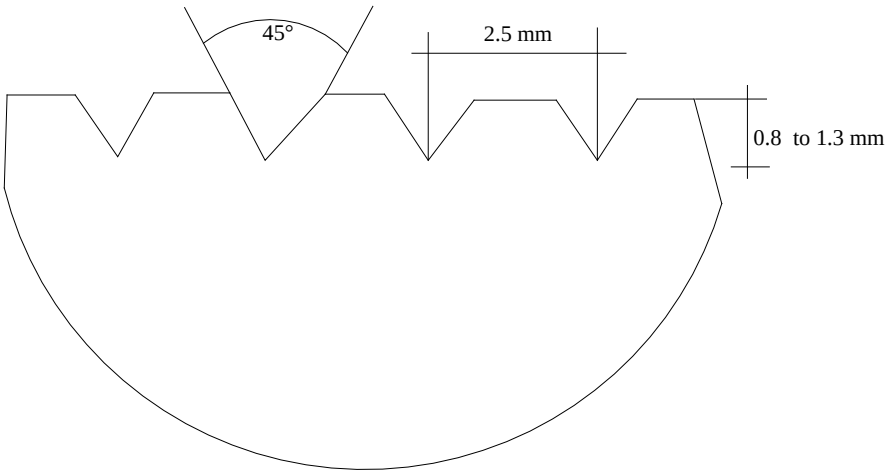
CRAZY MARBLE FLOORING

FIGURE 9.1



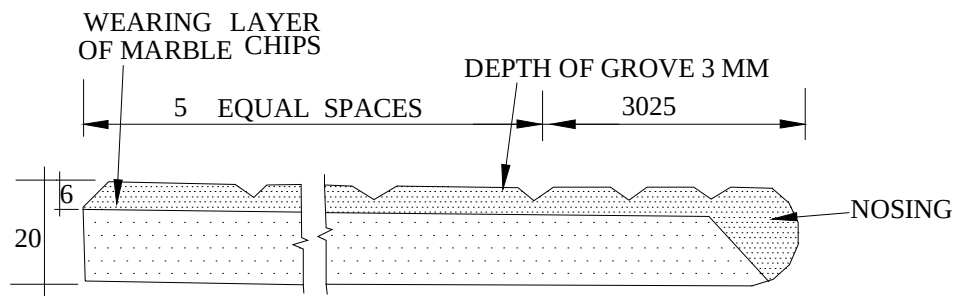
DETAILS OF A TYPICAL NOTCHED TROWEL

FIGURE 9.4

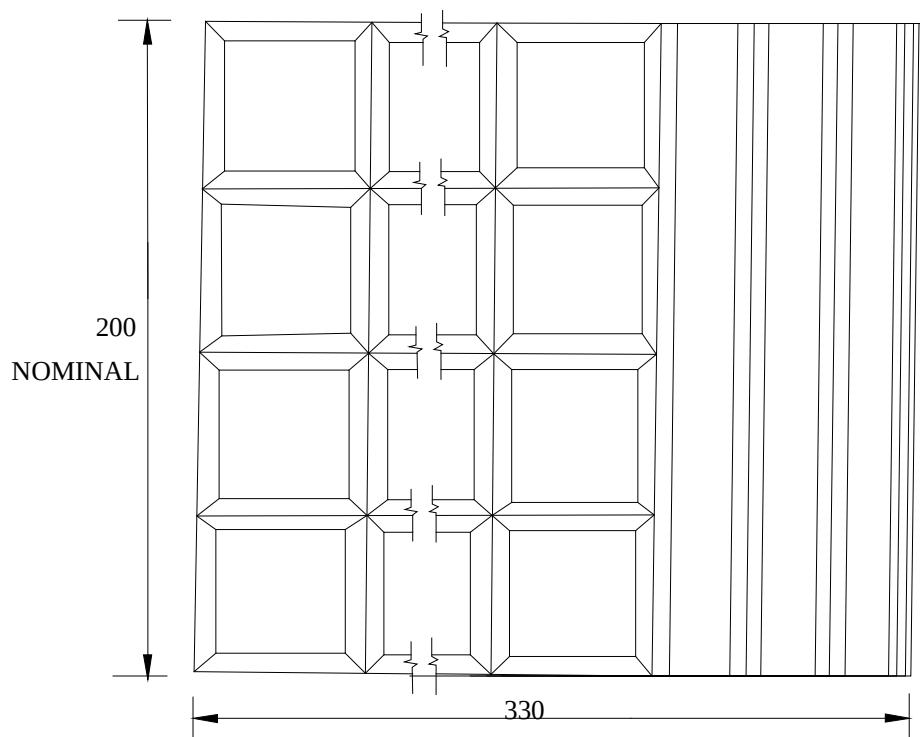


CHEQUERED TILES IN STAIR TREADS

FIGURE 9.2



SIDE ELEVATION



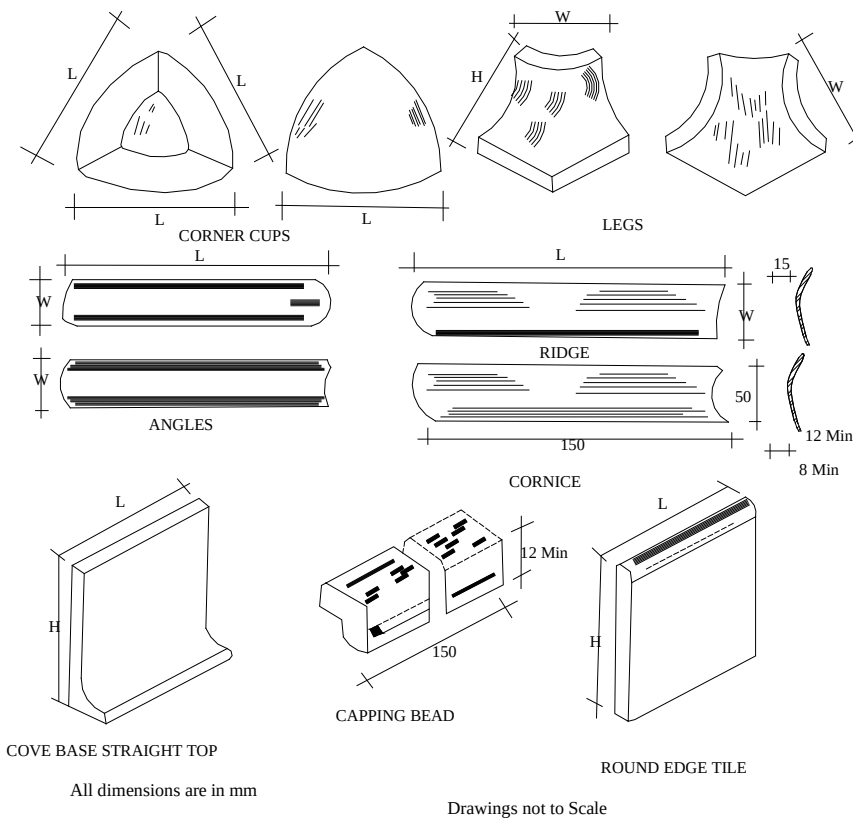
PLAN
TILE FOR STAIR TREADS

All dimensions are in mm

Drawings not to Scale

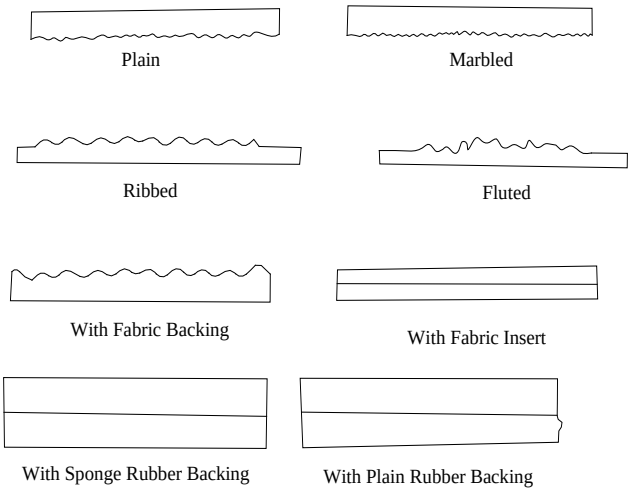
GLAZED EARTHENWARE TILES - SPECIALS

FIGURE 9.3



DIFFERENT TYPES OF RUBBER FLOORING

FIGURE 9.5



DIFFERENT TYPES OF RUBBER FLOORING

Chapter 10

Roofing And Ceiling

10.0 TERMINOLOGY

10.0.1 Accessories

Purpose made fittings, such as apron flashing pieces, barge boards, bottom glazing flashing, corner piece (corner flashing), eaves filler pieces, expansion joints, hip capping, hip tile or cap, ridge capping, ridge finials, roof lights, ventilators, with which the roof is furnished.

10.0.2 Eaves

The lower edge of the inclined roof.

10.0.3 Finial

A decorative fitting used at the junction of ridges and hips to form a waterproof covering and at the top of conical, pyramidal, or dome roofs.

10.0.4 Flashing

A strip of impervious material, usually metal, used to exclude water from the junction between a roof covering and another part of the structure.

10.0.5 Gable

Part of wall above the general eaves level at tie end of ridged or partially hipped roof.

10.0.6 Gutter

Any form of roof water channel.

10.0.7 Hip

The outer angle (more than 180 degree) formed by the inclined ridge between two intersecting roof slopes.

10.0.8 Pitch

10.0.8.1 The angle of inclination with the horizontal of the rafters or substructure surface on which the roof coverings are laid.

10.0.8.2 In patent glazing, the angle at which the plane of a stretch of glazing is inclined to the horizontal.

10.0.9 Pitched Roof

A roof the pitch of which is greater than 10 degree to the horizontal.

10.0.10 Ridge

The horizontal inter-section at the apex of the two rising roof surfaces inclined in opposite directions.

10.0.11 Valley

The re-entrant angle formed by the inter-section of two inclined roof surfaces.

10.0.12 Verge

Free edge of a roof surface ending at a gable.

10.1 CORRUGATED GALVANISED STEEL SHEET ROOFING (Refer FIGURE 10.1)

10.1.1 C.G.S. Sheets

These shall be of the thickness specified in the description of the item and shall conform to IS:277. The sheets shall be of 750 grade of coating (Refer **ANNEXURE 10.1**) unless otherwise specified in the description of item.

The sheets shall be free from cracks, split edges, twists, surface flaws etc. They shall be clean, bright and smooth. The galvanising shall be without any injury and in perfect condition. The sheets shall not show signs of rust or white powdery deposits on the surface. The corrugations shall be uniform in depth and pitch and parallel with the side.

10.1.2. Purlins : Purlins of the specified material or M.S. rolled sections of requisite size shall be fixed over the principal rafters. In case of fabricated roof trusses, these shall not be spaced at more than the following distances shown in **Table 10.1**.

TABLE 10.1

Thickness of C.G.S. Sheet	Maximum spacing of purlins
1.60 mm	2.80 metre
1.25 mm	2.40 metre
1.00 mm	2.00 metre
0.80 mm	1.80 metre
0.63 mm	1.60 metre

The top surfaces of the purlins shall be uniform and plane. They shall be painted before fixing on top. Embedded portions of wooden purlins shall be coal tarred with two coats. _ painting/coal tarring will be paid extra in the relevant items.

10.1.3 Slope : Roof shall not be pitched at a flatter slope than 1 vertical to 5 horizontal. The normal pitch adopted shall usually be 1 vertical to 3 horizontal.

10.1.4 Laying and fixing

10.1.4.1 The sheets shall be laid and fixed in the manner described below, unless otherwise shown in the working drawings or directed by the Engineer. Relevant IS Specification is IS:12093 on laying and fixing of sloped roof covering using plain and corrugated galvanised steel sheets.

10.1.4.2 The sheets shall be laid on the purlins to a true plane, with the lines of corrugations parallel or normal to the sides of the area to be covered unless otherwise required as in special shaped roofs.

10.1.4.3 The sheets shall be laid with a minimum lap of 15 cm at the ends and 2 ridges of corrugations at each side. The above minimum end lap of 15 cm shall apply to slopes of 1 vertical to 2 horizontal and steeper slopes. For flatter slopes the minimum permissible end lap shall be 20 cm. The minimum lap of sheets with ridge, hip and valley shall be 20 cm measured at right angles to the line of the ridge, hip and valley respectively. These sheets shall be cut to suit the dimensions or shapes of the roof, either along their length or their width or in a slant across their lines of corrugations at hips and valleys. They shall be cut carefully with a straight edge chisel to give a smooth and straight finish.

10.1.4.4 Lapping in C.G.S sheets shall be painted with a coat of approved steel primer and two coats of painting with approved paint suitable for G.S. sheet, before the sheets are fixed in place without any extra payment.

10.1.4.5 Sheets shall not generally be built into gables and parapets. They shall be bent up along their side edges close to the wall and the junction shall be protected by suitable flashing or by a projecting drip course, the later to cover the junction by at least 7.5 cm.

10.1.4.6 The laying operation shall include all scaffolding work involved.

10.1.4.7 Sheets shall be fixed to the purlins or other roof members such as hip or valley rafters etc. with galvanised J or L hook bolts and nuts, 8 mm diameter, with bitumen and

G.I. limpet washers or with a limpet washer filled with white lead as directed by the Engineer. J hooks are used for fixing sheets on angle iron purlins, and L hooks are used for fixing to R.S. joists, timber or precast concrete purlins. The length of the hook bolt shall be varied to suit the particular requirements. The bolts shall be sufficiently long so that after fixing they project above the top of the nuts by not less than 10 mm. The grip of J or L hook bolt on the side of the purlin shall not be less than 25 mm. There shall be a minimum of three hook bolts placed at the ridges of corrugations in each sheet on every purlin and their spacing shall not exceed 30 cm. Coach screws shall not be used for fixing sheets to purlins.

10.1.4.8 The galvanised coating / nylon coating on J or L hooks, and bolts shall be continuous and free from defects such as blisters, flux stains, drops, excessive projections or other imperfections which would impair serviceability.

The galvanised coating should conform to IS 1367 (Pt. XIII) (See **ANNEXURE 10.1**).

10.1.4.9 Where slopes of roofs are less than 21.5 degrees (1 vertical to, 2.5 horizontal) sheets shall be joined together at the side laps by galvanised iron bolts and nuts 25 x 6 mm size, each bolt provided with a bitumen and a G.I. limpet washer or a G.I. limpet washer filled with white lead. As the overlap at the sides extends to two corrugations, these bolts shall be placed zig zag over the two overlapping corrugations, so that the ends of the overlapping sheets shall be drawn tightly to each other. The spacing of these seam bolts shall not exceed 60 cm along each of the staggered rows. Holes for all bolts shall be drilled and not punched in the ridges of the corrugations from the underside, while the sheets are on the ground.

10.1.5 Wind Tie

Wind ties shall be of 40 x 6 mm flat iron section or of other size as specified. These shall be fixed at the eaves of the sheets. The fixing shall be done with the same hook bolts which secure the sheets to the purlins. The ties shall be paid for separately unless described in the item of roofing.

10.1.6 Finish

The roof when completed shall be true to lines, and slopes and shall be leak proof.

10.1.7 Measurements

10.1.7.1 The length and breadth shall be measured correct to a cm. Area shall be

worked out in sqm correct to two places of decimal.

10.1.7.2 The superficial area in general plane of the roof shall be measured on the flat without allowance for laps and corrugations. Portion of roof covering overlapping the ridge, hip or flashing pieces etc. shall be included in the measurement.

10.1.7.3 Roof with curved sheets shall be measured and paid for separately. Measurements shall be taken in the general plane of the roof without allowance for corrugations. .

10.1.7.4 No deduction in measurement shall be made for opening upto 0.4 sqm and nothing extra shall be allowed for forming such openings. For any opening exceeding 0.4 sqm in area, deduction in measurements for the full opening shall be made and in such cases the labour involved in making these openings shall be paid for separately. Cutting across corrugation shall be measured on the flat and not girthed. No additions shall be made for laps cut through.

10.1.8 Rate

The rate shall include the cost of all the materials and labour involved in all the operations described above including a coat of approved steel primer and two coats of approved steel paint on overlapping of C.G.S. sheets. This includes the cost of roof sheets, galvanised iron J or L hooks, bolts and nuts, galvanised iron seam bolts and nuts, bitumenous and galvanised iron limpet washers etc.

10.2 RIDGES AND HIPPS OF PLAIN GALVANISED STEEL SHEETS

10.2.1 Ridges and Hips : Ridges and hips of C.G.S. roof shall be covered with ridge and hip sections of plain G.S. sheet with a minimum lap of 20 cm on either side over the C.G.S. sheets. The end laps of the ridges and hips and between ridges and hips shall also be not less than 20 cm. The ridges and hips shall be of 60 cm overall width plain G.S. sheet, 0.6 mm or 0.8 mm thick as given in the description of the item and shall be properly bent in shape.

10.2.2 Fixing

10.2.2.1 Ridges shall be fixed to the purlins below with the same 8 mm dia G.I. hook bolts and nuts and bitumen and G.I. limpet washers which fix the sheets to the purlins.

10.2.2.2 Similarly, hips shall be fixed to the roof members below such as purlins, hip and valley rafters with the same 8 mm dia G.I.

hook bolts and nuts and bitumen and G.I. limpet washers which fix the sheets to those roof members. At least one of the fixing bolts shall pass through the end laps of ridges and hips, on either side. If this is not possible, extra hook bolts shall be provided.

10.2.2.3 The end laps of ridges and hips shall be joined together by galvanised iron seam bolts 25 x 6 mm size each with a bitumen and G.I. washer or white lead as directed by the Engineer. There shall be at least two such bolts in each end lap.

10.2.2.4 Surface of C.G.I. sheets of ridge and hip sections and the roofing sheets which overlap shall be painted with a coat of approved primer and two coats of approved paint suitable for painting G.S. Sheets before they are fixed in place without any extra payment.

10.2.3 Finish

The edges of the ridges and hips shall be straight from end to end and their surfaces should be plane and parallel to the general plane of the roof. The ridges and hips shall fit in squarely on the sheets.

10.2.4 Measurements

The measurements shall be taken for the finished work in length along the centre line of ridge or hip, as the case may be, correct to a cm. The laps in ridges and hips and between ridges and hips shall not be measured.

10.2.5 Rate

The rate shall include the cost of all labour and materials specified, above, including painting, cost of seam bolts and any extra G.I. hook bolts, nuts and washers, required.

10.3 VALLEY AND FLASHING OF PLAIN GALVANISED STEEL SHEETS

10.3.1 Valley and flashing

Valley shall be 90 cm wide overall plain G.S. sheet 1.6 mm thick or other size as specified in the item bent to shape and fixed. They shall lap with the C.G.S. sheets not less than 25 cm width on other side. The end laps of valley shall also be not less than 25 cm.

Valley sheets shall be laid over 25 mm thick wooden boarding if so required. Flashing shall be of plain G.S. sheet of 40 cm overall width 1.25 mm thick or 1.00 mm thick as specified in the item bent to shape and fixed. They shall lap not less than 15 cm over the roofing sheets. The end laps between flashing pieces shall not be less than 25 cm.

10.3.2 Laying and Fixing

Flashing and valley sheets shall be fixed to the roof members below, such as purlins and valley rafters with the same 8 mm dia G.I. hook bolts and nuts and bitumen and G.I. limpet washers which fix the sheets to those roof members.

At least one of the fixing bolts shall pass through the end laps of the valley pieces on other side. If this is not possible extra hook bolts shall be provided. The free end of flashing shall be fixed at least 5 cm inside masonry with the mortar of mix 1 : 3 (1 cement : 3 coarse sand). Refer **Figure 10.2**.

10.3.3 Painting

Surface of G.S. sheets under overlaps shall be painted with a coat of approved primer and two coats of approved paint suitable for painting G.S. sheets without any extra payment.

10.3.4 Finish

The edges of valley and flashing should be straight from end to end. The surfaces should be true and without bulges and depressions.

10.3.5 Measurements

The length of the valleys and flashing shall be measured for the finished work correct to a cm. The laps along the length of the valley or flashing- pieces, including the portion embedded in masonry shall not be measured.

10.3.6 Rates

The rate for valleys, shall be for all the labour and materials specified above, including painting, cost of seam bolts and the cost of requisite G.I. hook bolts, nuts and washers required over and above those needed for connecting the roof sheets to the roof members. The rate for valleys shall exclude the cost of boarding if any, underneath which shall be paid for separately. The rate for flashing shall be for all the labour and materials specified above, and shall include the cost of painting and mortar for fixing in wall.

10.4 GUTTERS OF PLAIN GALVANISED STEEL SHEETS (Refer FIGURE 10.3)

10.4.1 Gutters

Gutter shall be fabricated from plain G.S. Sheets 1.25 mm thick or other size as specified in the item. Eaves gutters shall be of the shape and section specified in the description of the item. The overall width of the sheet referred to therein shall mean the peripheral width of the gutter including the rounded edges. The longitudinal edges shall

be turned back to the extent of 12 mm and beaten to form a rounded edge. The ends of the sheets at junctions of pieces shall be hooked into each other and beaten flush to avoid leakage.

10.4.2 Slope

Gutter shall be laid with a minimum slope of 1 in 120.

10.4.3 Laying and Fixing

10.4.3.1 Gutter shall be supported on and fixed to M.S. flat iron brackets bent to shape and fixed to the requisite slope. The maximum spacing of brackets shall be 1.20 metres. Surface of G.S. sheets under overlaps shall be painted with a coat of approved primer and two coats of approved paint suitable for painting G.S. sheets without any extra payment

10.4.3.2 Where these brackets are to be fixed to the sides of rafters, they shall be of 40 x 3 mm section bent to shape and fixed rigidly to the sides of rafters with 3 Nos. 10 mm dia bolts, nuts and washers. The brackets shall overlap the rafter not less than 30 cm and the connecting bolts shall be at 12 cm centres

10.4.3.3 Where the brackets are to be fixed to the purlins, the brackets shall consist of 50 x 3 mm M.S. flat iron bent to shape with one end turned at right angle and fixed to the purlin face with 2 Nos. of 10 mm dia bolts nuts and washers. The bracket will be stiffened by provision of 50 x 3 mm. M.S. flat whose over hung portion is bent to right angle shape with its longer leg connected to the bracket with 2 Nos. 6 mm dia M.S. bolts, nuts and washers and its shorter leg fixed to face of purlin with 1 No. 10 mm dia, bolt, nut and washer. The over hang of the vertical portion of the bracket from the face of the purlin shall not exceed 22.5 cm with this arrangement. The spacing of the brackets shall not exceed 1.20 metres.

10.4.3.4 The gutter shall be fixed to the brackets with 2 Nos. G.I. bolts and nuts 6 mm dia, each fitted with a pair of G.I. and bitumen washers. The connecting bolts shall be above the water line of the gutters.

10.4.3.5 For connection to down take pipes, a proper drop end or funnel shaped connecting piece shall be made out of G.S. sheet of the same thickness as the gutter and rivetted to the gutter, the other end tailing into the socket of the rain-water pipe. Wherever necessary, stop ends, angles etc., should be provided.

10.4.4 Finish

The gutters when fixed shall be true to line and slope and shall be leak proof.

10.4.5 Measurements

Measurements shall be taken for the finished work along the centre line of the top width of the gutter correct to a cm. The hooked lap portion in the junctions and gutter lengths shall not be measured. The number of brackets which are fixed to purlins with stiffener flats should be measured.

10.4.6 Rate

The rate shall include the cost of all labour and materials specified above, including all specials such as angles, junctions, drop ends or funnel shaped connecting pieces, stop ends etc as well as flat iron brackets and bolts and nuts required for fixing the latter to the roof members. Brackets of 50 x 3 mm flats fixed to purlins with stiffener flats will be paid extra.

10.5 ASBESTOS AND NON-ASBESTOS CEMENT CORRUGATED SHEET ROOFING (Refer FIGURES 10.4A to 10.4E)

10.5.1 Asbestos & Non-Asbestos cement corrugated sheets

The sheets shall be of the approved quality and shall conform to IS : 459 for Asbestos and IS : 14871 for Non-Asbestos cement corrugated sheets. The sheets shall be free from cracks, chipped edges or corners and other damages. Salient Dimensional details are at **ANNEXURE 10.2**. Although the use of AC sheets is being discouraged now a days due to use of Asbestos Fibre, the specifications are broadly laid down for maintenance purposes.

10.5.2. Slope

The roof shall not be pitched at flatter slope than 1 vertical to 5 horizontal. The normal pitch adopted shall usually be 1 vertical to 3 horizontal.

10.5.3. Laying

10.5.3.1 The sheets shall be laid on the purlins and other roof members as indicated in the working drawings or as instructed by the Engineer.

10.5.3.2 The maximum spacing of purlins under the sheets shall be 1.40 metres in the case of 6 mm thick sheets and this shall in no case be exceeded. Ridge purlins shall be fixed at 75 mm to 115 mm from the apex of roof.

10.5.3.3 The top bearing surfaces of all purlins and of other roof members shall be in one plane so that the sheets when being fixed shall not require to be forced down to

rest on the purlins. The finished roof shall present a uniform slope and the line of corrugations shall be straight and true. The sheets shall be laid with the smooth side upwards.

10.5.3.4 The sheets shall be laid with a side overlap of half a corrugation and an end lap of 15 cm minimum in the case of roofs with a pitch flatter than 1 vertical to 2.5 horizontal (approx. 22 degree) and in the case of very exposed situations, the minimum permissible end lap shall be 20 cms. Side laps should be laid on the side facing away from the prevailing monsoon winds.

10.5.3.5 The free overhang of the sheets at the eaves shall not exceed 30 cm. Corrugated sheets shall be laid from left to right starting at the eaves. The first sheet shall be laid uncut but the remaining sheets in the bottom row shall have the top left hand corners cut or mitred. The sheets in the second and other intermediate rows except the first and the last sheets, shall have both the top left hand corner and bottom right hand corner cut. The last or top row sheets shall all have the bottom right hand corner cut with the exception of the last sheet which shall be laid uncut. If for any reason such as on considerations of the direction of prevailing winds, laying is to be started from the bottom right hand corner, then the whole procedure should be reversed.

10.5.3.6 The Mitre described above is necessary to provide a snug fit where four sheets meet at a lap. It is cut from a point 15 cm (or whatever the length of the end lap may be) up the vertical side of the sheet to a point 5 cm along the horizontal edge. This cutting may be done with an ordinary wood saw at site.

10.5.4. Fixing

10.5.4.1 Sheets shall be secured to the purlins and other roof members by means of 8 mm diameter galvanized/polymer coated iron J or L hook bolts and nuts. While J hooks are used for fixing to angle iron purlins, L hooks are used for fixing to R.S. joists, timber or precast concrete purlins.

The grip of the J or L hook bolt on the side of the purlin shall not be less than 25 mm. Each galvanized/ polymer coated iron J or L hook bolt shall have a bitumen washer and a galvanised iron washer placed over the sheet before the nut is screwed down from above. On each purlin there shall be one hook bolt on the crown adjacent to the side lap on either side. Bitumen washer shall be of approved manufacture. Galvanising of G.I.

J or L hooks and washers shall be as provided in para 10.1.4.8.

10.5.4.2 The G.I. flat washer shall be 25 mm in diameter, 1.6 mm thick and the bitumen

washer shall be 35 mm in diameter and 1.5 mm thick. The length of J bolt or crank bolt shall be as specified in **Table 10.2** below.

TABLE 10.2

SL	Situation	No. of Bolts & Washers	Length of Bolts
1.	At horizontal (end) laps of Sheets. At eaves when filler pieces are used. At ridge when sheets and ridge pieces are secured by the same bolt.	Twice the No. of sheets in one horizontal course	Depth of purlin plus 90mm.
2.	At eaves when filler pieces are not used. At ridge when corrugated sheets and ridge pieces are not secured by the same bolt.	Twice the No. of sheets in the horizontal course.	Depth of purlin plus 75mm.
3.	At intermediate purlins where horizontal laps do not occur	Twice the No. of sheets in the horizontal course	Depth of purlin plus 75mm.

10.5.4.3 Each nut shall be screwed lightly at first. After a dozen or more sheets are laid, the nuts shall be tightened to ensure a leak proof joint.

10.5.4.4 Holes for hook bolts etc. shall be drilled and not punched, always through the crown of the corrugation and not in valleys, in locations to suit the purlins while the sheets are on the roof in their correct position. The diameter of holes shall be 2 mm more than the diameter of the fixing bolts. No hole shall be nearer than 40 mm to any edge of a sheet or any accessory.

10.5.4.5 Roof ladders or planks shall always be used when laying and fixing the sheets, to avoid damage to the sheets, and to provide security to the workmen.

10.5.5 Wind Ties & Expansion Joints

a) Wind ties may be provided where the situation justifies their provision. These shall be of 40 x 6 mm flat iron section or of other size as specified. These shall be fixed at the eave ends of the sheets. The fixing shall be done with the same hook bolts which secure the sheets to the purlins. Wind ties shall be paid for separately unless described as included in the items of the roof work.

b) No expansion joints are required to be provided in AC Corrugated sheet roofing.

10.5.6 Finish - The completed roof shall present a neat and uniform appearance and be leakproof.

10.5.7 Measurements

10.5.7.1 Length and breadth shall be measured correct to a cm and its area shall be calculated in square metres correct to two places of decimal.

10.5.7.2 The superficial area in general plane of the roof shall be measured on the flat without allowance for laps and corrugations. Portion of roof covering overlapping the ridge, hip or flashing pieces etc. shall be included in the measurement. The overlaps of the corrugated sheets over valley gutters, roof light sheets, and eaves filler pieces and the underlay of the corrugated sheets below ridges, hips, north light curves, apron flashing pieces, roof light sheets and barge boards shall be included in the measurements. Deductions will be made in the measurements for roof light sheets, if any, but no deduction shall be made for holes cut for extractors or cowl type ventilators.

10.5.7.3 Roof with curved sheets shall be measured and paid for separately. Measurements shall be taken on the flat and not girthed. The breadth of the roof shall be measured along the rest of the curved sheets.

10.5.7.4 No deductions in measurements shall be made for opening upto 0.4 sqm and nothing extra shall be allowed for forming such opening. For any opening exceeding 0.4 sqm in area, deduction in measurements for the full opening shall be made and in such cases the labour involved in making these openings shall be paid for separately. Cutting across corrugation shall be measured on the flat and not girthed.

10.5.8 Rate

The rate shall include the cost of all the materials and labour involved in all the operations described above except otherwise stated. This includes the cost of

roof sheets, galvanized / polymer coated iron J or L hook bolts and nuts, bituminous and galvanized iron washers.

10.6 ASBESTOS CEMENT SEMI CORRUGATED SHEET ROOFING (Refer FIGURES 10.5A to 10.5D)

10.6.1 Asbestos Cement Semi Corrugated Sheets

These shall be of the specified thickness and of approved quality and shall conform to IS: 459. They shall be free from cracks, chipped edge corners or other damages. Salient Dimensional details are at **ANNEXURE 10.2.**

10.6.2 Laying

The specifications for laying shall be the same as described in para 10.5.3 except that (a) the sheets shall be laid with the end stamped 'Top' on the smooth side pointing towards the ridge, (b) the sheets shall invariably be laid from right to left starting at the eaves with the procedure for mitring etc. described under paras 10.5.3.5 and 10.5.3.6 reversed, (c) the side laps provided will be of one corrugation, the left hand small corrugation of each sheet being covered by the right hand large corrugation of the next

sheet and (d) asbestos cement expansion joints shall be inserted every 45 metres or so in the length of the roof. Specially manufactured expansion joint pieces shall be used for the purpose. The end lap of expansion joints shall not be less than 150 mm. If the expansion joints are between the purlins, these should be stitched with seam bolts.

10.6.3 Fixing

The specifications shall be same as described in para 10.5.4 except that along each line of purlin there shall be a hook bolt in every vertical side lap corrugation and at the two verges and there shall be an additional hook-bolt through one of the two intermediate corrugations on each sheet. When sheets are supported over intermediate purlins as in the case of length over 1.60 metres for 7 mm thick sheets and over 1.40 metres for 6 mm thick sheets, fixing accessories are required on the intermediate purlin, through each side lap and the verges only. The number and length of bolts and number of bituminous felt and galvanized iron washers are given in **Table 10.3.**

TABLE 10.3

SL	Situation	No. of Bolts and Washers	Length of Bolts
1	At horizontal (end) laps of Sheets. At eaves when filler pieces are used. At ridge when sheets and ridge pieces are secured by the same bolt.	Short bolts: The number of sheets in one horizontal course plus two. Long bolts: The number of sheets in one course less one.	Depth of purlin plus 75mm Depth of purlin plus 90mm.
2	At eaves when filler pieces are not used. At ridge when sheets and ridge pieces are not secured by the same bolt.	Twice the No. of sheets in one horizontal course plus one.	Depth of purlin plus 75mm.
3.	At intermediate purlins when horizontal laps do not occur.	The No. of sheets in one horizontal course plus one.	Depth of purlin plus 75mm.

10.6.4 Wind Ties & Finish/ Expansion Joints

a) The specifications shall be as described in paras 10.5.5 and 10.5.6 respectively for Wind Ties and Finish.

b) In roofs with semi-corrugated sheets where there is likelihood of some movement of the structure due to variation in climatic

conditions expansion joints shall be provided. These shall be inserted at every 40 to 50 metres length of roof. Special manufactured expansion joints pieces shall be used for this purpose.

10.6.5 Measurements

It shall be as described in para 10.5.7. In addition, the end lap of the sheets under

asbestos cement expansion joints where provided shall also be included in measurements. Gap between the sheets under expansion joint shall not be measured. The expansion joint sheets shall be measured for the finished work correct to one cm.

10.6.6 Rate

The rate shall include the cost of all the materials and labour involved in all the operations described above except otherwise stated. This includes the cost of roof sheets, galvanized/polymer coated iron J or L hook bolts and nuts as well as bituminous and galvanised iron washers. The rate does not include cost of expansion joint sheet which shall be paid for separately.

10.7 RIDGES AND HIPS OF ASBESTOS CEMENT (Refer FIGURES 10.6A to 10.6H)

10.7.1 General:- Ridges and hips shall be of the same manufacturer as the corrugated or semi corrugated sheets used for roof, unless otherwise permitted in writing by the Engineer. The sections shall be free from cracks, chipped edges or corners or other damages.

Ridges shall be of the type specified in the item, such as :

1. One piece plain angular.
2. Serrated or plain wing adjustable. 3. Close fitting adjustable.
4. Northlight adjustable and appropriate for the corrugated or semi-corrugated roof which is to be covered.
5. Unserrated adjustable

NOTE:- "Plain Wind Angular" type ridges can be used only if the slope of the roof is exactly 30 degree, Hips shall be of "unserrated adjustable for hips" sections.

10.7.2. Laying

The ridge sections shall be laid as per manufacturer's instructions with the rolls of the two wings in the case of adjustable ridges fitting closely and with the serrations of serrated ridges registering correctly with the sheets underneath. The stagger lapping of two wings of an adjustable ridge section and the laps between adjacent pieces on the same wing of the ridges shall be as per manufacturer's instructions. The end portions of the wings of the adjustable ridges which project beyond the verges of the roof shall be cut and trimmed off neatly. Asbestos cement expansion joint ridge pieces shall be provided every 45 metres (approx.) of ridge where the latter is of the semi-corrugated

serrated adjustable type. In laying hip pieces, serrations to suit the corrugations in the sheets below should be cut in them so that they will be a snug fit over the sheets.

10.7.3 Fixing

10.7.3.1 The wings of ridges shall be fixed to the sheets below with the seam bolts and nuts 8 mm diameter G.I. J or L hook bolts and nuts and bitumen and G.I. washers which fix the sheets to the purlins. In addition, in Northlight adjustable ridges the curves of the two wings shall be joined together at their crown with 8 mm dia G.I. seam bolts and nuts, at the rate of 2 numbers per pair of wings. Each seam bolt shall be provided with one bitumen and a pair of G.I. washers.

10.7.3.2 Where 'Plain wing angular' or 'Plain wing adjustable' ridges are used, the gaps formed by the roofing corrugations and the wings shall be filled with cement concrete 1:2:4 (1 cement : 2 coarse sand : 4 graded stone aggregate 12.5 mm nominal size) upto the full length of the overlap. The exposed face shall be finished perpendicular to the sheeting.

10.7.3.3 Wing of hips shall be fixed to the roof members below with the same 8 mm dia G.I./polymer coated J or L hook bolts and nuts which fix the sheet to those members. In addition, they shall be secured to the sheets below with 8 mm dia G.I. seam bolts, nuts and washers, so that taken together with hook bolts, there shall be a bolt on each wing at atleast every fifth corrugation of the sheet below in the case of 'Corrugation' and at least every second corrugation of the sheet below in the case of 'semi-corrugated' sheets. The seam bolts shall each be provided with one bitumen and a pair of G.I. washers.

10.7.4 Measurements

The measurements for ridges and hips shall be taken for the finished work along the centre line of the ridge and hip lines in length, correct to a cm. The laps in adjacent ridges or hip pieces shall not be measured. The underlay of ridges under asbestos cement expansion joint pieces where the latter are provided shall however be measured.

10.7.5 Rate

The rate shall include the cost of all materials and labour specified above, but does not include (a) the cost of required G.I. hook bolts and nuts and their washers, (b) the cost of supplying and fixing asbestos cement expansion joint pieces, c) the cost of closing

the gaps between plain ridge and the sheet corrugations with concrete. Item (a) above will be covered by the rate for the asbestos cement sheet roofing while items (b) and (c) will be paid for separately unless specifically included in the description of the ridge or hip item.

10.7A Other Roofing Accessories of Asbestos Cement (Refer FIGURES 10.7A to 10.7R)

10.7B.1 Accessories

The other accessories that may be required to be used on a roof are (a) finishing pieces, eaves filler pieces, northlight and ventilator curves, barge boards and expansion joint sheets (b) ridge finials, cowl type ventilators, curved boards for northlight, curves, roof light expansion joints for northlight curves and (c) 'S' type louver. The accessories shall be of the type appropriate for use with corrugated or semi corrugated sheets which form the roofing. The accessories shall be of the same manufacturer as the corrugated or semi-corrugated sheets used for the roof. The pieces shall be free from cracks, chipped edges or corners and other damages.

10.7A.2. Laying & Fixing

These shall be laid and secured with the same G.I. hook bolts which secure sheets to the roof members below where possible or with separate G.I. hook bolts to the roof members below and/or with 8 mm dia G.I./polymer coated seam bolts, nuts and washers to the sheeting, generally as per manufacturer's printed instructions and as ordered by the Engineer. 'S' type louvers shall be fixed to ventilators to timber, M.S. angle or flat iron verticals spaced not more than 1.65 metre centres. The laps of adjacent pieces over the verticals shall not be less than 10 cm. The upper flat of the top most row of louvers shall be fixed to the vertical by 10 mm dia G.I. bolts and nuts and bitumen and G.I. washers.

The lower flats of the top and intermediate rows of louvers and the flat of the louvers pieces below shall be secured together to the verticals behind by 10 mm dia G.I. separating bolts threaded at both ends and of suitable length. Each of these bolts shall be equipped with 2 pairs of nuts, G.I. and bitumen washers. The louver flats of the lowest line of louvers shall also be fixed to the verticals at the proper distance from the same by the use of similar separating bolts and nuts.

10.7A.3 Measurements

The accessories listed under group (a) in para 10.8.1 shall be measured for finished work in length correct to a cm. Laps between adjacent pieces shall not be measured. The accessories listed under group (b) in para 10.8.1 shall be measured and paid for in number. This applies in the case of finial too where the unit shall consist of a pair of inter locking pieces. The 'S' type louvers listed under group (c) in para 10.8.1 shall be measured for the finished work in length of each row of louvers correct to a cm. The laps between adjacent pieces of louvers will not be taken into account in the measurements.

10.7A.4 Rate

10.7A.4.1 The rates for supplying and fixing, asbestos cement accessories listed in groups (a) & (b) of para 10.8.1 shall include the cost of all materials and labour involved in all the operations described in A.C. roofing accessories, bolts, nuts, washers and other fixing accessories but does not include the members.

10.7A.4.2 The rate for supplying and fixing roof lights shall not unless otherwise described in the item, include the glazing which shall be paid for separately.

10.7A.4.3 The rate for supplying and fixing 'S' type louvers shall include all fixing accessories such as ordinary and separating G.I./polymer coated bolts, nuts, and bitumen washers including drilling the holes for the same in the vertical supporting member behind but shall not unless otherwise described in the item include the cost of supplying and fixing the supporting members which shall be paid for separately.

10.7B EAVES AND VALLEY GUTTERS OF ASBESTOS CEMENT (Refer FIGURES 10.8A to 10.8H)

10.7B.1 Gutters and Accessories

Eaves gutters shall be of the type specified in the item such as (1) plain ended eaves, (2) boundary wall, (3) socketed eaves ogee and (4) socketed half round. These shall be of standard size as stipulated in the item. Valley gutters shall be of the 'Plain' ended valley types and of size as stipulated in the item. These shall be of manufacture, approved by the Engineer. The gutter sections and their accessories such as drop ends, stop ends, nozzle, angles and union clips shall be free from cracks, chipped edges or corners and other damages.

10.7B.2 Laying and Fixing

10.7B.2.1 Gutters shall be laid with a minimum slope of 1 in 120, which should be

increased where possible. Gutters shall be true to line and slope and shall be laid, with the requisite accessories such as drop ends, stop ends, nozzles, angles and union clips as shown in the working drawing or as ordered by the Engineer.

10.7B.2.2 The size of outlet of drop ends and nozzles shall be of the same size as the size of the rain water pipes into which they shall be discharging the water.

10.7B.2.3 Gutters and their accessories shall be supported by M.S. flat iron brackets. Where these brackets are to be fixed to the sides of rafters, they shall be of 40 x 3 mm section bent to shape and fixed rigidly to the sides of the rafter with 3 Nos. 10 mm diameter bolts, nuts and washers. The brackets shall overlap the rafter not less than 30 cm and the connecting bolts shall be at 11.5 cm centres.

10.7B.2.4 Where the brackets are to be fixed to the purlins they shall consist of 50 x 3 mm M.S. flat iron bent to shape with one end turned at a right angle, and fixed to the purlin face with a 10 mm dia bolt, nut and washer. The perpendicular over hang portion of 50 x 3 mm bracket shall be stiffened by another 50 x 3 mm flat, bent to right angle shape with its lower leg connected to the bracket with 2 Nos. 6 mm dia M.S. bolts, nuts and washers and its shorter leg fixed to face of purlin with one number 10 mm dia bolt, nuts and washers. The overhang of the vertical portion of the flat iron bracket from the face of the purlin shall not exceed 22.5 cm with this arrangement.

10.7B.2.5 The requisite slope in the gutters shall be given in the line of the bracket. The brackets shall be placed at not more than 90 cm centres.

10.7B.2.6 The gutters shall be fixed to the brackets with 2 Nos. 8 mm dia G.I. seam bolts and nuts, each bolt and nut being equipped with a pair of bitumen and G.I. washers. These connecting bolts shall be above the water line of the gutters.

10.7B.2.7 Spigot and socket ends of gutters of 'socketed eaves ornamental' or 'socketed

half round' type and their accessories shall be connected together at their laps with one row of 8 mm dia G.I. bolts and nuts, each bolt and nut being provided with a pair of bitumen and a pair of G.I. washers. The gap between the socket and spigot shall be packed with approved plastic roofing compound, flanked on both sides with 6 mm dia asbestos rope. The connecting G.I. bolts are then tightened so that the lapped joints become leak proof. The outer faces of the packed asbestos rope shall not be farther than 6 mm from the edges of the spigot and socketed ends.

10.7B.2.8 Where both ends of gutters and or their accessories to be connected together are of spigot ends they shall be laid as butt joints with 1.5 mm gap in between over union clips (loose socket pieces). The union clip shall be connected to the two butt ends of the gutter or other section with two rows (one row per ends) of 8 mm dia G.I. bolts and nuts, each bolt and nut being provided with a pair of bitumen and a pair of G.I. washers. The gap between the union clips and the butt ends of the gutter sections or accessories shall be packed with approved plastic roofing compound flanked at both edges by 6 mm dia asbestos rope as before. The whole joint shall be made leak proof by tightening the bolts.

10.7B.2.9 The ends of 'Plain' ended eaves or boundary wall type and 'Plain' ended valley type gutters and their accessories shall be laid with butt joints over union clips and connected together in the same manner as for connecting spigot and socket ends described in the preceding sub-para.

10.7B.2.10 The number of connecting bolts, nuts and washers and the quantities of 6 mm diameter asbestos rope and plastic roofing compound required per spigot socket of 'ornamental' and 'half round' gutters of different sizes and butt joint of plain ended 'Boundary wall or eave' and 'valley' type gutters of different sizes shall be as shown in **TABLE 10.4**.

TABLE 10.4

Type of Gutter	Nominal sizes	6mm dia Asbestos rope	Required per joint			
			Plastic roofing compound	8mm dia nuts and bolts	GI Washer 25mm dia.	Bitumen washer 25mm dia
Socketed ornamental	125mm	0.57m	170 g	1 No. 45mm long	2 Nos.	2 Nos.

Socketed ornamental	200mm	0.98m	255 g	3 Nos. 45mm long	6 Nos.	6 Nos.
Socketed half round	150mm	0.57m	170 g	1 No. 45mm long	2 Nos.	2 Nos.
Socketed half round	250mm	0.92m	567 g	3 Nos. 45mm long	6 Nos.	6 Nos.
Socketed half round	300mm	1.07 m	709 g	3 Nos. 45mm long	6 Nos.	6 Nos.
Plain ended boundary wall or eaves	275 x 125 x 175mm	0.97m	737 g	8 Nos. 40mm long	16 Nos.	16 Nos.
Plain ended boundary wall or eaves	300 x 150 x 225mm	1.15m	850g	8 Nos. 50mm long	16 Nos.	16 Nos.
Plain ended boundary wall or eaves	450 x 150x 300mm	1.38m	1020g	8 Nos. 50mm long	16 Nos.	16 Nos.
Plain ended boundary wall or eaves	500 x 150 x 250 mm	1.43m	1049g	10 Nos. 50mm long	20 Nos.	20 Nos.
Plain ended valley	400x 125x 250mm	1.12m	850g	8 Nos. 50mm long	16 Nos.	16 Nos.
Plain ended valley	500 x 125	1.12m	850g	8 Nos. 50mm long	16 Nos.	16 Nos.
Plain ended valley	600 x 150 x 225mm	1.48m	1105g	8 Nos. 50mm long	16 Nos.	16 Nos.
Plain ended valley	900 x 200 x 225mm	2.08m	1531g	12 Nos. 50mm long	24 Nos.	24 Nos.

10.7B.3 Finish

The gutters and accessories when fixed shall be true to line and slope and shall be ridged. All the joints shall be leak proof.

10.7B.4 Measurements

The measurement of gutters shall be taken for the finished work in length correct to a cm along the centre line of the gutters. The measured length of the finished gutters will include the length over accessories such as drop ends, stop ends, nozzles and angles, though the rate for the same shall not include the cost of the accessories unless specially described in the item. Laps between the adjacent pieces of gutter and gutter section or between gutter section and accessories shall not be measured. Accessories such as drop ends, stop ends, nozzles and angles shall be measured and paid for separately. Union clips (loose sockets) shall not be measured and paid for separately as they are included in the rate for gutters.

10.7B.5. Rate : The rate for the gutters shall not, unless otherwise specified in the description of item, include the cost of providing and fixing accessories such as drop ends, stop ends, nozzles and angles. The rate shall include the cost of providing and fixing all union clips (loose sockets), all connecting. G.I./polymer coated bolts, nuts and bitumen and G.I. washers, M.S. flat iron brackets and their fixture to the gutter sections and to the roof members, asbestos rope and plastic roofing compound.

Extra over the rate for the gutter shall be paid for providing and fixing accessories, stop ends, drop ends, angles and nozzles. Where brackets of 50 x 3 mm size are provided in place of brackets of 40 x 3 mm size as indicated in para 10.9.2.3 extra rate will be paid for separately.

10.8 ROOFING WITH MANGALORE TILES**10.8.1 Tiles**

The tiles used shall be of the best of their respective kinds, well burnt, true in shape and manufactured by machine pressing process. Roofing tiles conforming to IS:654 and ridge and ceiling tiles conforming to IS:1464 will be generally acceptable. In all cases, samples of each kind of tile shall be submitted to and got approved by the Engineer or his representative, and the tiles actually used on the work shall conform to the approved samples.

10.8.2 Pitch of roof:- Unless otherwise specified, Mangalore tiled roof surfaces shall be pitched at an angle of 30 degrees to the horizontal. Where climatic conditions so warrant, the slope may be reduced to a minimum of 24 degrees or increased to a maximum of 45 deg., to be specified specially in the drawings, which shall also indicate any special protective measures necessary.

10.8.3 Rafters, Reepers, Ridges and Eaves:- The rafters shall be fixed at right angles to the ridge lines, which shall be laid horizontal. The eaves shall also be worked horizontal. The reepers shall be nailed to the upper surface of the rafters and exactly at right angles to their direction. The lowest reeper (or the "tilting fillet") shall be of greater height than all the rest, the height being such that the lowest course of tiles gets the same inclination to the horizontal as the remaining courses.

The spacing of rafters shall not generally exceed 60 cm unless the reepers are specially designed against sagging. The reepers shall normally be battens of size 5 x 2.5cm for Mangalore tiles laid over flat tiles over reepers and of size 5 x 1.5cm for Mangalore tiles over reepers or over ceiling tiles laid on reepers. The battens for reepers shall be straight and of length sufficient to cover at least 3 rafter spacings. The spacing of the reepers shall be exactly equal to the gauge of the tile. Joints in reepers shall be butt joints and shall come directly over the rafters. Joints in adjacent rows of reepers shall be staggered. The nails fixing the reeper shall penetrate at least 2cm into the rafter.

10.8.4 Laying Tiles:- Roofing tiles shall be laid in courses from the eaves towards the ridge. The tiles shall be laid fair and square and properly fitting, with the catches (nibs) resting against the edges of the reepers. Each course shall break joint by half tile width with the course below and all tiles shall be perfectly parallel to the rafters. Any cutting of tiles required, as at hips, valleys,

gables, chimneys etc. shall be done accurately, and for this no extra payment shall be admissible. The jointing and edge-bedding of ridge, hip and ventilating tiles shall be done securely in cement mortar of mix 1:4. Gaps in the troughs of roof tiles shall, if large enough, be packed water tight with the use of chips of broken tiles, well soaked in water and set in the mortar. The edges of mortar shall be finished off with a mixture of red ochre and Portland cement to match the colour of the tiles.

10.8.5 Valleys

All valleys shall generally be laid with gutters formed out of 1.25mm thick (18 S.W.G.) galvanised iron sheets, cut and bent to the required shape. The gutters shall be fixed over reepers at the two edges and seated at the centre on wooden valley boards 25mm thick, fixed to the valley and common rafters. The gutter shall have an overlap of at least 30 cm with the tiles. The gap between the tiles and the GI sheet shall be filled with cement mortar 1:3 for a width of 20 cm on either side out of the total overlap of 30 cm. Where so directed the edges of the roof shall also be plastered over with cement mortar for a width of 20 cm on either side, as an additional precaution against water from the gutter percolating through the tiles; and this shall be payable extra.

10.8.6 Wind Ties

The tiles along the eaves shall, wherever required, be protected against lifting due to high winds by the provision of a galvanized steel flat 40 x 3 mm fixed over the tiles and screwed into the end reeper at every third tile through a small hole drilled in the central ridge of the tile.

10.8.7 Verges and gables

Verges shall be protected by provision of barge boards and also cement mortar borders 20 to 25 cm wide and 5 cm thick to be paid extra, laid over the tiles at the exposed end of the roof and finished with cement and red ochre to match. Alternatively, the ends of gabled roofs may be protected by the provision of a gable parapet, with the edges of the tiles housed into it to a depth of not less than 5 cm and well grouted. The method to be followed in each case will depend on the architectural features shown in the drawing.

10.8.8 Additional protective measures

In areas subject to heavy winds, the tiles of the bottom most course and any intermediate course, as may be directed by the Engineer, shall be tied down to the

reepers by means of GI wires of dia 1.6mm (16 S.W.G), passed through the lugs on the underside of the tiles. In addition, cement mortar bands 20 to 25cm wide and 5cm thick shall be paid extra, if required, be provided over the roof, running along the slope at a spacing of 2.5 to 3m and finished with a mixture of red ochre and cement to match the colour of the tile. These special protective measures need be provided only where ordered by the Engineer.

10.8.9 Measurements

Measurements shall be taken of the area of the finished tiled roof surface in its own plane. No allowance shall be made for laps between tiles; but portions of the roof tiling housed into walls shall be included in the measurement. Unless stipulated otherwise, the portions of roof covered by ridges or hips shall be included in the measurements of the roof itself. No deduction shall be made for openings upto 0.4sqm in the plane of the roof.

10.8.10 Rate

Unless otherwise stated in the description of the item, the rate for Mangalore tiled roofing shall be for the complete tiling work, including ridges and hips and forming junctions with walls; but shall exclude the cost of all wood work, GI valley gutters, glass tiles and wind ties, cement mortar borders and any additional protective measures as per para 10.8.8.

10.8.11 Use of ceiling tiles

Where Mangalore tiles are to be laid in conjunction with ceiling tiles, the ceiling tiles shall first be laid over the reepers and over these the Mangalore tiles shall be laid, with their catches held in the gaps formed between the rows of ceiling tiles. In other respects the work shall be similar to ordinary tiled roofing.

10.9 PAINTING OF ROOF SLAB WITH HOT BITUMEN

10.9.1 Preparing the Surface

The surface shall be painted only when it is thoroughly dry. The surface to be painted shall be cleaned with wire brushes and cotton or gunny cloth. All loose materials and scales shall be removed and the surface shall be further cleaned with a piece of cloth lightly soaked in kerosene oil.

10.9.2 Painting with Bitumen

10.9.2.1 The contractor shall bring the bitumen to site in its original packing and shall open and use it in the presence of the

Engineer or his authorised representative. The containers shall not be removed from the site until the painting job is completed and the Engineer has satisfied himself regarding the quantity of bitumen actually used and has given his permission to remove the empty containers.

10.9.2.2 The surface prepared and treated shall be painted uniformly with bitumen of approved quality such as residual type petroleum bitumen of penetration 80/100, hot cut back bitumen or equivalent as per specifications of the manufacturer. The coat of bitumen shall be continued 15 cm along the vertical surfaces joining the roof. In case of parapet walls it shall be continued upto the drip courses.

10.9.2.3 Residual type petroleum bitumen of penetration 80/100 shall be heated to a temperature of not less than 180 degree C and not more than 190 degree C and shall be applied on the roof surface at not less than 180 degree C. Similarly, hot cut back bitumen shall be heated to a temperature of not less than 165 degree C and not more than 170 degree C and shall be applied on the surface at not less than 165 degree C.

10.9.2.4 Care shall be taken to see that no blank patches are left. The quantity of bitumen to be applied per 10 square metres of roof surface shall 17 kg, unless otherwise stipulated in the description of the item and shall be carefully regulated so that the application is uniform at the stipulated rate of 17 Kg. per 10 square metre.

10.9.3 Spreading Sand

Immediately after painting, dry, clean sharp coarse sand at the rate of 60 cubic decimetre per 10 sqm shall be evenly spread and levelled over the surface when the bitumen is still hot. On vertical surfaces the spreading of sand may be omitted and no deductions made on this account.

10.9.4 Measurements

The superficial area of the surface painted shall be measured in square metres. No deduction in measurements shall be made for unpainted areas of roof slab occupied by chimney stacks, roof lights etc. of areas, each upto 0.40 sqm. The measurements of length and breadth shall be taken correct to a cm.

10.9.5 Rate

The rate shall include the cost of all materials and labour involved in all the operations described above.

10.10 MUD PHUSKA TERRACING WITH TILE BRICK PAVING

10.10.1 Mud Phuska

Mud Phuska treatment is a common insulating cum water proofing treatment used in comparatively hot dry regions i.e. Punjab, UP etc. where rainfall is not heavy. Comprehensive details on Mud Phuska Treatment are available in Para 3.3 of Annexure 2.7 referred to in Para 226 (d) of Indian Railways Works Manual 2000. Brief details extracted from the provisions in the Works Manual are given in subsequent subparas. For complete information IS 2115 Code of Practice for Flat Roof finish, Mud Phuska may be referred to.

10.10.2 Courses involved in the Treatment

Para 3.3.1 of Annexure 2.7 of Works Manual may be referred to.

10.10.3 Materials

For Specifications on soil for Mud Phuska, soil for Mud Plaster and Mud Mortar, Mud Plaster, Mud Mortar and Brick Tiles Para 3.3.2 of Annexure 2.7 of Works Manual may be referred to.

10.10.4 Application Procedure

For details of Application Procedure including preparatory works, cleaning of Roof Surface, Application of bitumen over cleaned roof surface, Laying of Mud-Phuska, Applying Mud Plaster, Paving with Brick Tiles and Curing Para 3.3.3 of Annexure 2.7 of Works Manual may be referred to. For Typical details of Mud-Phuska treatment Figure 4 of Annexure 2.7 of Works Manual may be referred to.

10.10.5 Measurements

Length and breadth shall be measured correct to a cm. The measurements shall be taken for the finished work over the tiled surface, in superficial area.

No deductions in measurements shall be made for either openings or recesses for chimney stacks, roof lights or khurras, of area upto 0.40 sqm. No extra shall be paid either for any extra materials or labour involved in forming such openings, recesses etc. For areas exceeding 0.40 sqm deductions will be made in the measurements for the full opening but no extra shall be paid for any extra labour, materials etc. in forming such openings.

For plus or minus deviation from the average thickness stipulated for the mud phuska in the item, payments will be adjusted in the rate admissible to the contractor for the

relevant schedule item provided that such deviations were authorised by the Engineer in writing.

10.10.6 Rate

The rate shall include the cost of all materials and labour involved in all the operations described above.

10.11 PAVING OVER MUMTY ROOFS WITH TILE BRICKS

The work involves paving with tile bricks laid flat and grouted with cement mortar.

10.11.1 Tile Bricks - These shall conform to the specifications detailed in para 5.1 of Chapter 5.

10.11.2 Cement Mortar

The cement mortar shall be of 1:3 mix and made out of fine sand grade IV sand unless otherwise specified in the description of the item and shall conform to the specifications described in Mortar chapter.

10.11.3 Preparing the surfaces

The surface shall be hacked, roughened and cleaned of all dust and other foreign matter. It shall then be wetted before applying the mortar.

10.11.4 Paving and Grouting

Cement mortar shall be spread in 12 mm layer over the surface evenly and to required slope. Tile bricks which had been soaked as in brick work in water for at least an hour before hand shall then be laid open jointed and flat on the mortar and lightly pressed, and set to plane surface true to slopes etc. using a trowel and wooden straight edge. The tile bricks shall be laid with their joints not more than 10 mm wide. They shall be laid with their longitudinal lines of joints truly parallel and horizontal and at right angles to the sloping edges of the roof.

Transverse joints in alternate rows should come directly in line with one another. Transverse joints in adjacent courses shall not break joints by less than 5 cm. As soon as the paving is done, the open joints shall be grouted with cement mortar 1:3 (1 cement : 3 fine/ grade IV sand). Cement used for grouting mortar shall be mixed with 2% (by unit of cement or as specified by the manufacturer) water proofing compound conforming to IS: 2645. Care shall be taken to see that no joints are left unfilled or inadequately filled. The joints shall be finished flush with the brick surface.

10.11.5 Curing

The tile paving shall be cured for at least 7 days during which period it shall be suitably protected from damage.

10.11.6 Measurements

Length and breadth shall be measured correct to a cm. Measurement shall be taken for the finished work in superficial area covered.

No deduction in measurement shall be made for either openings or recesses for chimney stacks, roof lights, or for khurras, for areas upto 0.40 sqm nor any thing shall be paid for forming such openings.

For similar areas exceeding 0.40 sqm deduction shall be made in measurements for all openings but nothing extra shall be paid for forming such openings.

10.11.7 Rate

The rate shall include the cost of materials and labour involved in all the operations described above.

10.11.8 Polycarbonate sheets as per IS 14443:1997.

The relevant paras of IS 14443:1997 for Polycarbonate sheets are reproduced below for guidance

1. SCOPE

1.1 This standard covers the requirements, methods of sampling and tests for polycarbonate sheets of solid section as well as multi-wall variety and also thinner gauge sheets (films), multi-layer composite laminates of polycarbonate compact sheets and composites of polycarbonate compact sheets and glass sheets. Sheets containing glass fiber or any other reinforcement are, however, not covered by this standard.

1.2 This standard establishes a system for designating various possible polycarbonate sheets and films. Since the system is not based on application, end use condition and performance requirement, it can not be used for selection of any sheet or film for specific end use. For selection of material for specific used, experts well versed with the applications, design and performance criterion as well as polycarbonate sheets and films should be consulted. Similarly the code of good fabrication practices covered in this standard is intended to act as a guide. For specific end use and type of sheet or film, expert opinion should be sought for fabrication details.

1.3 The classification system for various types of polycarbonate sheets and films is based on important properties like:

- Weight per sq. metre,
- Dart drop impact
- Light transmission, and
- Surface texture, surface coating colour profile and some specific performance requirements.

Before the polycarbonate sheets are used specific approval as to rate and quality of sheets should be obtained

10.12 WATER PROOFING USING POLYETHYLENE FILM

10.12.1 General

This system is suitable for use in old and new-sloped roof surface. Comprehensive details on this system are available in Para 3.4. of Annexure 2.7 referred to in Para 226(d) of Indian Railways Works Manual, 2000. Brief details extracted from the provisions in the Works Manual are given in subsequent subparas. For complete information on this system IS: 7290 on "Recommendations for use of Polyethelene film for water proofing of roofs" may be referred to

10.12.2 Materials

For details of specifications of materials and the courses involved, Para 3.4.1 of Annexure 2.7 of the Works Manual may be referred to

10.12.3 Application Procedure

For details of Application Procedure including provision of slope and completion of preparatory works, method of laying, treatment at the junction of roof with parapet wall and surface finish, Para 3.4.2 of Annexure 2.7 of the Works Manual may be referred to. Typical details of Water Proofing Treatment using polyethylene film for new roof and for old roof are available respectively in Fig. No.5 and No.6 of Annexure 2.7 of the Works Manual.

10.12.4 Precaution in laying

Special precautions are required to be taken while carrying out this work and for details Para 3.4.3 of Annexure 2.7 of the Works Manual may be referred to.

10.12.5 Measurements

Length and breath shall be measured correct to a cm along the finished surface area covered by the film and calculated in square metres correct to 0.01 sqm. No deduction in measurement shall be made for either openings or recesses for Chimney stack, roof light, khurras etc., of area upto 0.40 sqm. No extra shall be paid either for

any extra materials or labour involved in forming such opening, recess etc. For areas exceeding 0.40 sqm, deductions will be made in the measurements for the full opening but no extra should be paid for any extra labour, materials etc., in forming such opening. Overlaps, if any, in tucking into flashing grooves shall not be measured.

10.12.6 Rate

The rate shall include the cost of all materials and labour involved in all the operations described above.

10.13 WATER PROOFING BY POLYMER MODIFIED CEMENTIOUS SLURRY COATING

10.13.1 General

Use of Polymer Modified Cementitious slurry for coating over concrete roof surface is one of the latest techniques of water proofing of flat roofs. Since this slurry has a coefficient of expansion similar to concrete, it does not get cracked due to thermal variation of concrete. Further polymer imparts significant improvement in impermeability. Comprehensive details on this system are available in Para 3.5 of Annexure 2.7 referred in Para 226 (d) of Indian Railways Works Manual. Brief details extracted from the provisions in the Works Manual are given in subsequent subparts. There is no IS Code as yet available for this system. But the system is in use in CPWD in the recent past and relevant details extracted from Para 25.6 to Chapter 25 of CPWD specifications on "Water Proofing" have also been referred to in the subparas below.

10.13.2 Materials

For details of the specifications of materials and the courses involved in this system, Para 3.5.1 of Annexure 2.7 of the Works Manual may be referred to. In the works being carried out by CPWD, for first layer of slurry per Sqm of area, mix of 0.488 kg of grey cement and 0.253 kg of Armoucrete or Tape-crete (Patented product) is used. For second layer of slurry, per Sqm of area, mix of 1-289 kg of grey cement with 0.67 kg of Armoucrete or Tapecrete and 1.289 kg of coarse sand is used. Fibre Cloth shall be of approved proprietary brand and shall be a thin, flexible uniformly bonded mat composed of chemically resistant borosilicate glass fibre distributed in random open porous structure bonded together with a thermosetting phenolic type resin.

10.13.3 Application Procedure

For details of Application procedure including preparation of roof surface, preparation of polymer modified slurry and application of different courses, Para 3.5.2 of Annexure 2.7 of the Works Manual may be referred to. Figure 7 of Annexure 2.7 of the Works Manual gives details of a typical arrangement with this system.

10.13.4 Precaution

(i) **Cement Slurry Mix:** The consistency of slurry should be just that of oil paint and the quantity of slurry should be just adequate for covering the desired area by one coat. The quantity of water to be used in the mix should be determined by trial and error. The slurry coating should be completed within 1/2 hour of mixing the components.

(ii) Application of Slurry :

The first coat shall be applied over the specified and dampened area carefully including the corners, holes and joints of pipes in the concrete and the application should continue up to 100 mm height of fixtures of pipes from the surface. Also the slurry shall be applied upto a height of 300 mm on parapet walls and also the groove on top where the fibre cloth has to be tucked. The second coat of slurry should also be done as above covering the entire surface of fibre cloth for 1.5 mm thickness.

(iii) Spreading Fibre Cloth

The fibre cloth shall be spread evenly on the first layer of slurry without any kink and pressed to see that no air space exists. The fibre cloth should be taken to a height of 300 mm on parapet wall and tucked into the groove. A minimum overlap of 100 mm is to be provided when the fibre cloth has to be joined. Fibre cloth is to be for 100 mm height of pipes projecting from the surface.

10.13.5 Measurements - Provision in Para 10.12.5 will apply.

10.13.6 Rate - Provision in Para 10.12.6 will apply.

10.14 WATER PROOFING USING POLYMER MODIFIED BITUMINOUS MEMBRANE

10.14.1 General

A recent technique for water proofing of old and new roofs is use of Polymer modified bituminous membrane obtained by sandwiching non-woven polyester fabrics or fibre glass mat between layers of high quality polymer modified bitumen. There is no IS Code currently available on this

system. The Polymer Modified Bitumen Membranes are manufactured by specialized agencies and correct method of application of product for best water proofing result should be ascertained from Manufacturer of Product. The latest advanced method of application is with torch-on application of membrane over primer.

10.14.2 Materials

10.14.2.1 Bitumen Primer

A Bitumen based Primer which is manufactured by the same manufacturer

whose APP Membrane is applied must be used. This is to ensure proper compatibility of Primer and Membrane so that effective bond is achieved and warranty is composite. Manufacturer will provide Test Certificate of Primer.

Primer packaging must have proper labels describing product name and features and must be supplied in good quality new containers. Primer is brush applied at the rate of 250 grams per sqm uniformly over cleaned surface of roof. Physical properties of Primer shall be as follows :

Bitumen Primer

Characteristics	Procedure	Specifications
Density	Measurement	0.9 – 1 g/cc
Viscosity by Saybolt Furol Viscometer	IS - 3117	20 – 100 seconds
Drying Time	Observation	30 minutes
Solid content as per IS 8887 (2004) annex 'J'	IS 8887	Minimum 60%

10.14.2.2 Atactic Polypropylene Modified Polymeric Membrane :

It is a polymeric water proofing membrane manufactured to high standards. APP Waterproofing Membrane 3mm thick, Seven Ply and having following layers, sandwiched together :

1st layer of 15 Micron thick HMHDPE (High Molecular High Density Polyethylene Film) Plastic film (top surface)

2nd layer of Polymeric Asphalt Mix

3rd layer of Non Woven Polyester Mat

4th layer of Polymeric Asphalt Mix

5th layer of 90 Micron HMHDPE Plastic Film

6th layer of Polymeric Asphalt Mix

7th layer of 10 Micron HMHDPE Plastic Film

APP Membrane manufacturer must be an ISO Certified and must have a track record of supplying atleast 10 successful years in the Indian APP Waterproofing field. Manufacturer shall have a proper and valid document to prove this condition.

APP Membrane manufacturer will submit manufacturers' Test Certificate and should be in a position to arrange 3rd party Testing and Inspection in their Quality Control Department. Application of APP Membrane shall be carried out only by the original manufacturers' authorized applicators and as per their standard recommendations.

Physical properties of APP Membrane shall be as follows :

SL	Characteristics	Procedure	Specifications
i)	Softening Point, °C, Min	ASTM D - 36	150
ii)	Penetration at 25°C, 100 g, 5 Sec, dmm	ASTM D - 5	20 – 35
iii)	Pliability	ASTM D - 228	2 ⁰ C to 5 ⁰ C - Does not Break
iv)	Heat Resistance	ASTM D - 146	Does not Drip at 125 °C
v)	Tensile Strength – Lengthwise, N/5cm Crosswise, N/5cm	DIN – 52123	> 650 > 450
vi)	Elongation - Lengthwise, %	DIN - 52123	> 40%

	Crosswise, %		> 35%
vii)	Tear Strength - Lengthwise, N Crosswise, N	ASTM D -5147	> 300 > 250
viii)	Reinforcements	Solubility Test in Petrol	90 Micron HMHDPE Polyethylene Film and Non- Woven Polyester Mat
ix)	Total Number of Layers (Ply)	Solubility Test in Petrol	Seven
x)	Water Absorption %	ASTM D - 5147	< 0.15
xi)	Thickness	ASTM D - 5147	3mm ± 0.1 mm

10.14.2.3 Five Layer Item : It is a polymeric water proofing membrane manufactured to high standards. It is five-layered APP modified polymeric membrane with centre core as 20 micron HMHDPE/100 micron HMHDPE high Molecular High Density Polyethylene Film, the centre core is the heart of the membrane and protects against water and moisture. The centre core is sandwiched on both sides by high quality polymeric mix with properties of high

softening point, high heat resistance and cold resistivity to make it ideal for all water proofing treatment. The polymeric mix is protected on both sides with 20 micron HMHDPE film. This is available in variable thickness and weights; usually width is 1.0 m.

Important physical and chemical parameters of the membrane shall be as given in Table for guidance.

Centre Core	Film	Thickness	Weight
20 micron HMHPDE	20 micron HMHPDE	1.5 mm	2.25 kg/sqm
100 micron HMHPDE	20 micron HMHPDE	2.0 mm	3.00 kg/sqm

Where proprietary brand Atactic Polypropylene modified polymeric membrane is proposed to be used by the contractor, they shall conform in all respects to the specification in the preceding Para and manufactured by a company of repute.

10.14.2.4 Topping :

The APP Membrane may be topped with a layer of 85/25 Grade Hot Bitumen at 1.2 kg/sqm uniformly. A layer of Bituminous Aluminium Paint is brush applied at 100 gram/sqm over Bitumen layer to protect the system from U – V layers

10.14.3 Preparation of Surface

The Surface to be waterproofed must be even and a minimum slope of 1 : 100 is achieved before application of APP Membrane. Surface must be free of sharp projections and particles that can damage APP Membrane.

10.14.4 Treatment

Water proofing treatment shall be four layer treatment with following courses :

- 1.First course of bitumen primer.
- 2.Second layer of APP modified polymeric membrane of specified thickness applied with Torch-on application system.
- 3.Third layer of topping up layer of hot bitumen of 85/25 Grade Hot Bitumen at 1.2 kg/sqm uniformly.
- 4.Fourth layer of Bituminous Aluminium Paint, brush applied at 100 gram/sqm over Bitumen layer to protect the system from U– V layers

10.14.5 Measurement

Measurements shall be as specified in Para 10.15.8 below,

10.14.6 Rate

Rate shall be as specified in Para 10.15.9 below.

10.15 WATER PROOFING WITH BITUMEN FELTS

10.15.1 General:- Water proofing treatment with self finished felt shall be four courses or six courses as described in the item. Four courses water proofing treatment with self finished felt is a normal duty treatment suitable for buildings where the cost of roof treatment is required to be restricted.

Six course water proofing treatment with self finished felt is a heavy duty treatment suitable for important structures.

10.15.2 Materials**10.15.2.1 Self finished felt: (Refer Annexures 10.3)**

This shall be of brand and manufacture conforming to the type and grade given in the description of the item. This shall be one of the following types :

- a) Type 2 grade 1 is a glass fibre base bitumen felt conforming to IS: 7193.
- b) Type 2 grade 1 is a fibre (vegetable or animal) base felt conforming in all respects to IS: 1322.
- c) Type 2 grade 2 is a fibre (vegetable or animal) base felt conforming in all respects to IS: 1322.

10.15.2.2 Bonding Materials: This shall consist of blown type petroleum bitumen conforming to IS 702 or residual petroleum bitumen conforming to IS : 73 or a mixture thereof. The bonding material shall be so selected as to withstand the local condition of maximum and minimum temperatures and gradient of Temperature satisfactorily. The penetration of bitumen used shall not exceed 40 in any case. Suitable residual type petroleum bitumen is of penetration 30/40 (IS grade S-35).

Generally, blown type petroleum bitumen of S90 shall be used for the base and intermediate layers of bonding material and for flashing, while residual type petroleum bitumen with higher penetration and low softening point shall be used for the finishing layer. Suitable blown type petroleum bitumen is of IS grade 85/25 of approved quality.

Where proprietary brands of bonding materials are proposed to be used by the contractor they shall conform in all respects to the specifications in Para 10.15.2.1 and quantity of Bonding material that will be required is indicated below.

	1 st Course kg/sqm	3 rd course kg/sqm	5 th course kg/sqm
I. Four course treatment	1.45	1.45	--
II. Six course treatment			
a) With type 3 grade 1 hessian base self finished bitumen felt	1.45	1.20	1.45
b) With felts other than type 3 grade 1 hessian base	1.45	1.20	1.70

10.15.2.3 Stone Grit and Pea-sized Gravel

: Stone grit shall be as specified in para 3.1 and shall be 6 mm and down size. Where pea-sized gravel is used it shall be hard, round and free from dust, dirt etc. The stone grit or pea-sized gravel shall not be spread over vertical and sloping faces of flashings and at drain mouths. At these places the surface shall be painted with two coats of bitumenous solution.

The quantity of stone grit or pea-sized gravel required for the final course of four or six course treatment with hessian base self finished bitumen, felt type 3 grade 1 shall be 6 cubic decimetre. For six course treatment with felt other than type 3 grade 1, the stone

grit or pea sized gravel at 8 cubic decimetre per sqm shall be used.

10.15.3 Preparation of Surface:

10.15.3.1 The surface to be treated shall have a minimum slope of 1 in 120. This grading shall be carried out with lime concrete, cement concrete or cement plaster with coarse sand, as ordered to the average thickness required and finished smooth. Such grading shall be paid for separately.

10.15.3.2 Junctions between the roof and vertical faces of parapet walls, chimneys etc. shall be cased by running triangular fillets 7.5 x 7.5 cm size, in lime concrete or cement concrete. At the drain mouths, the fillets shall be suitably cut back and rounded off for easy application of water proofing treatment and

easy flow of water. Lime concrete where used shall conform to specifications described in para 3.3 except that the brick aggregate shall be 20 mm nominal size. Cement concrete where used shall be 1:2:4 mix (1 cement : 2 coarse sand: 4 graded stone aggregate 20 mm nominal size). The provision of fillets shall be deemed to be covered by the item of water proofing and shall not be measured or paid for separately.

10.15.3.3 In existing roof where gola and drip course are provided at the junction of roof and vertical face of parapet wall, chimney stacks etc., these shall be dressed suitably and finished smooth so as to ensure an easy and gradual turning of the flashing. Any dismantlement or forming and finishing smooth the junction for forming the base of the flashing shall not be measured or paid for separately and shall be deemed to form part of the preparation of the surface in the water proofing treatment.

10.15.3.4 While the grading of roof surface is being done, it shall be ensured that the outlet drain pipes have been fixed and mouths at the entrances have been eased and rounded off properly for easy flow of water.

10.14.3.5 When any pipe passes through the roof to be treated, angular fillet of shape shown in **Figure 10.10B** shall be built around it for the water proof treatment to be taken over it. These fillets shall not be measured or paid for separately.

10.15.3.6 For carrying over and tucking in the water proofing felts into the parapet walls, chimney stacks etc. a horizontal groove 6.5 cm deep, 7.5 cm wide section with its lower edge at not-less than 15 cm above the graded roof surface shall be left on the inner face of the same during construction if possible. When such groove has not been left, the same shall be cut out neatly and the base at rear of the groove shall be finished smooth with cement plaster 1:4 (1 cement : 4 coarse sand). Such cutting of the groove and its finishing smooth shall be deemed to be part of the water proofing item and shall not be measured or paid for separately. No deduction shall be made for not making the groove when the later has already been left in the masonry by the construction agency.

10.15.3.7 Tucking in the water proofing felt will be required where the parapet wall exceeds 45 cm in the height from the graded surface. Where the height is 45 cm or less, no groove will be required as the water proofing treatment will be carried over the top of the parapet wall to its full thickness. In

the case of low dividing walls of height 30 cm or less, outlets therein shall be cut open for full height and the bottom and sides shall be rendered smooth and corners rounded and such treatment shall not be measured and paid for separately.

10.15.3.8 Where expansion joints are left in the slab, the provision of dwarf walls and or RCC slabs for covering them and finishing the surface smooth shall be the responsibility of the construction agency, which had laid the roof slab and will not be included in the operation of water proofing.

10.15.3.9 The graded surface of the roof and concrete fillets and the faces of walls shall be thoroughly cleaned with wire brushes and all loose scales etc. removed. The surface shall then be dusted off. Any crack in the roof shall be cut to 'V' section, cleaned and filled up flush with cement mortar slurry 1:4 (1 cement : 4 coarse sand) or blown type petroleum bitumen of IS grade 85/25, or approved quality conforming to IS 702. Such cleaning of the surface or treating the cracks shall not be paid for separately.

10.15.4 Priming Coat

Where so specified, or required by the Engineer as for example under slightly damp conditions, a priming coat consisting of a bitumen primer conforming to IS: 3384 shall be applied with brush on the roof and wall surface at 0.24 litres per sqm to assist adhesion of the bonding material (i.e. bitumen).

Such application of primer shall be paid for separately, unless specifically included in the water proofing item.

10.15.5 Underlay

Where a floating treatment of water proofing with self finished bitumen felt is required i.e. where water proofing treatment is required to be isolated from the roof structure, a layer of bitumen saturated felt (underlay) shall be spread over the roof surface and tucked into the flashing groove. No bonding material shall be used below the underlay in order to keep the underlay free of the structure. The adjoining strips of the underlay shall overlap to a minimum of 7.5 cm at sides and 10 cm at ends. The overlaps shall be sealed with the same bonding material as used for the self finished felt treatment. Unless specifically included in the water proofing item, the underlay treatment shall be paid for separately.

The underlay shall be of type 1 saturated felt conforming to IS: 1322 in all respects and having a total minimum weight of the finished

bitumen felt in dry condition with mica dusting powder @ 6.8 kg per 10 sqm. The roll shall not be damaged or cracked on being unrolled on a fairly smooth and flat surface.

10.15.6 Treatment

10.15.6.1 The water proofing shall consist of a four or six course treatment, as given in the description of the item, each layer of bonding materials, self finished bitumen felt or stone grit or pea sized gravel being counted as a course.

10.15.6.2 The choice of a four or six course treatment will depend on the climatic condition, the importance of the building, the durability required, cost and other relevant considerations.

10.15.6.3 A four course treatment shall consist of the following layers :

- i) Initial layer of bonding material applied hot at specified weight per unit area.
- ii) 2nd layer of self finished bitumen felt of specified brand and manufacture conforming to the type and grade given in the description of the item.
- iii) Third layer of bonding material.
- iv) Final layer of stone grit or pea sized gravel spread at specified volume of material per unit area.

10.15.6.4 In a six course treatment, the first, second and third layer shall be the same as in the four course treatment. The fourth and fifth layers shall consist of self finished felt and bonding material respectively. The sixth layer shall consist of stone grit or pea sized gravel.

10.15.6.5 The primer or under lay where required to be provided shall not count against the number of courses specified.

10.15.7 Laying

10.15.7.1 Bitumen bonding material of required grade shall be heated to the working temperature specified for the particular grade by the bitumen manufacturers and conveyed to the roof in buckets or pouring cans in weighed quantities.

Suitable working temperatures for different grades of bitumen are as under :

- i) Blown type petroleum bitumen of IS grade 85/25 180 degree C.
- ii) Residual type petroleum bitumen of penetration 30/40 180 degree to 190 degree C (IS grade S-35).

10.15.7.2 Drain outlets shall be given a four or six 'course treatment as specified for the

roof in the description of the item in the manner specified for the flat roof surface. Water proofing treatment shall be carried into the drain pipe or outlets by atleast 10 cm. The water proofing treatment laid on the roof surface shall overlap the upper edge of the water proofing treatment in the drain outlets by at least 10 cm.

10.15.7.3 The self finished felt shall be cut to the required length, brushed clean of dusting material and laid out flat on the roof to eliminate curls and subsequent stretching. The felt shall normally be laid in length at right angles to the direction of the slope and laying shall be commenced at the lowest level and worked upto crest. The felt shall not be laid in single piece of very long lengths as they are likely to shrink. 6 to 8 m are suitable lengths. The roof surface shall be clean and dry before the felt treatment is begun. Each length of felt shall be laid in position and rolled up for a distance of half its length. The hot bonding material shall be poured on the roof across the full width of the rolled felt as the later is steadily rolled out and pressed down. The pouring shall be so regulated that the correct weight of bonding material per unit area is spread uniformly over the surface. Excess bonding material that gets squeezed out at the ends shall be levelled up as laying proceeds. When the first half of the strip of felt has been bonded to the roof, the other half shall be rolled up and then unrolled on the hot bonding material in the same way. Subsequent strips shall also be laid in the same manner. Each strip shall overlap the preceding one by at least 7.5 cm at the longitudinal edges and 10 cm at the ends. All overlaps shall be firmly bonded with hot bitumen. Streaks and trailings of bitumen near edges of laps shall be levelled by heating the overlap with a blow lamp and levelling down unevenness.

The third layer of bonding material in the four course treatment shall be carried out in a similar manner after the flashing has been completed.

10.15.7.4 In a six course treatment the third and fourth layers of bonding material and self finished felt shall be laid in the manner already described, taking care that laps in the felt are staggered from those in the second layer. The fifth layer of bonding material shall be carried out after the flashing is done.(See **Figure 10.10B**).

10.15.7.5 High Parapet Walls, Chimney Stacks etc.: Felts shall be laid as flashings wherever junctions of vertical and horizontal surfaces occur. Longitudinal laps shall be 10

cm. The lower layer of flashing felt in a six course treatment shall overlap the roof water proofing by not less than 20 cm while the upper layer shall overlap the roofing felt by 10 cm. The minimum overlap of the flashing felt in four course specification over the roofing felt shall be 10 cm.

The flashing shall consist of the same four or six course treatment as for the roof except that the final course of stone grit or pea-sized gravel shall be replaced by an application of bituminous solution of approved quality in two coats on the vertical and sloping faces only, of the flashing. The overlap along the length of flashing shall stagger with those in the second layer of flashing felt in a six course treatment and with the joints in the roof felt.

The upper edge of the flashing felt shall be well tucked into the flashing grooves in the parapet, chimney stacks etc. to a depth of not less than 6.5 cm. Corresponding applications of bonding material shall also be made. The flashing treatment shall be firmly held in place in the grooves with wood edges at intervals and the grooves shall filled up with cement mortar 1:4 (1 cement : 4 coarse sand) or cement concrete 1:2:4 (1 cement : 2 coarse sand : 4 graded stone aggregate 6 mm nominal size) and surface finished smooth with the rest of the wall. The cement work shall be cured for 7 days. When dry, the exposed plaster joints of grooves shall be painted with bitumen and two coats of bituminous solution shall be applied on the vertical and sloping surface of flashing (see **Figure 10.10B**).

After the top flashing felt layer has been fixed, the penultimate layer of bonding material shall be applied over the roofing felt and the horizontal overlaps and vertical and sloping surfaces of the flashings at the specified rate. Stone grit or pea sized gravel shall then be spread uniformly over the hot bonding material on the horizontal roof surface at the specified quantity per unit area and pressed into it with a wooden roller.

10.15.7.6 Low Parapet Walls

Where parapet walls are of height 45 cm or less, bitumen felt flashings shall be provided in the same manner as for flashings in the case of high parapet walls except that the upper edge shall be carried upto the full height of the wall and taken right across the top of the parapet and down on the external vertical faces to a minimum distance of 5 cm (see **Figure 10.10B**).

10.15.7.7 Low Dividing Walls

Where low dividing walls or inverted beams are met with, the same shall be covered with a four or six layer treatment as for the main roof, the latter bearing carried down both sides of the wall and overlapping the roofing treatment as in the case of flashing of high parapet walls.

Drain outlets where formed in the low dividing walls, shall be given water proofing treatment of the same number of courses as specified for the flat roof surface. The bottom and sides shall be so treated that all overlaps are in the direction of flow of drainage.

10.15.7.8 Expansion Joints

Where the expansion joints are provided in the slabs, the joints and their cover slabs shall be suitably treated with water proofing. A typical sketch of an expansion joint with the RCC slabs on either side of the joint turned vertically up and covered with precast RCC cover slabs is given in **Figure 10.10B**. The cover slabs shall cover the vertical turned up dwarf walls by not less than 7.5 cm and are provided with throatings on their underside along their length. The water proofing treatment shall be taken up the sloping junction fillets and the vertical faces of the walls to the underside of the cover slabs. The cover slabs are given the water proofing treatment like the roof slabs, after the cross joints between adjacent cover slabs are first sealed with 15 cm width of roofing felt struck to them with bitumen. The water proofing treatment shall be carried down the sides of the cover slabs to their full thickness. Care shall be taken to see that overlaps if any in the roofing over the cover slabs stagger with the joints between cover slabs.

The formation of the expansion joints and provision of cover slabs shall be the responsibility of the construction agency. The formation of the junction fillets and the water proofing treatment of the joint and cover slabs shall be carried out by the water proofing agency. No extra shall be paid for the junction fillers or for the sealing of the cross joints in the cover slab with 15 cm width of bitumen strips.

10.15.7.9 Pipes

Where vertical pipe outlets are met with 7.5 x 7.5 cm fillets of lime or cement concrete of the type and section shown in **Figure 10.10B** shall be provided and flashing of four or six course treatment, same as for the roofing treatment shall be laid.

The upper edge of the flashing shall be laid sloping down forward and butted against the pipe and annular depression so formed shall be filled with hot bitumen. A circular metal collar in the shape of an inverted truncated cone shall be fixed on the pipe to throw off the rain water clear of the flashing and this shall be paid for separately.

10.15.7.10 Terrace

Where roof surfaces are expected to be used, precast cement concrete tiles or 40 mm thick cement concrete shall be laid on the water proofing treatment. In such cases, no final course of stone grit or pea sized gravel shall be laid in the water proofing treatment. Suitable adjustment in the rates will be effected for not providing the stone grit or pea sized gravel layer. Cement concrete in situ flooring shall be laid in panels not exceeding 0.4 square metres each. Precast tiles or in situ concrete flooring where laid shall be paid for separately unless included in the description of the water proofing item.

10.15.8 Measurements

10.15.8.1 Length and breadth shall be measured correct to a cm. The area shall be calculated in square metres correct to two places of decimal.

10.15.8.2 Measurements shall be taken over the entire exposed area of roofing and flashing treatment including flashing over low parapet walls, low dividing walls and expansion joints and at pipe projections etc. Overlaps and tucking into flashing grooves shall not be measured.

10.15.8.3 Vertical and sloping surfaces of water proofing treatment shall also be measured under the four or six course treatment as the case may be, irrespective of the fact that the final course of grit or pea sized gravel is replaced by bitumen primer.

10.15.8.4 Primer or saturated felt underlay, where provided, shall also be measured in the same manner as the water proofing treatment and paid for separately. No deduction in measurements shall be made for either openings or recesses for chimney stacks, roof lights and the like, for areas upto 0.40 sqm. nor anything shall be paid for forming such openings. For similar areas exceeding 0.40sqm deductions will be made in measurements for full opening and nothing extra shall be paid for forming such openings.

10.15.9 Rate

The rate shall include the cost of all labour and materials involved in all the operations

described above and the particular specifications given under the different items, with the corrections noted in the relevant sub-paras.

10.16 WATER PROOFING WITH FIBRE TISSUE REINFORCED BITUMEN

10.16.1 General:- In-situ water proofing treatment of roofs with glass fibre tissue reinforced bitumen shall be of five-course, seven-course or nine-course type as specified. In selecting the combinations of layer of glass fibre tissue membrane, consideration shall be given to the type and construction of buildings, climatic and atmospheric conditions and the degree of permanence required. Five-course treatment is a normal duty treatment suitable for moderate rainfall conditions (annual less than 50 cm), seven-course treatment is a heavy duty treatment suitable for severe conditions of rain fall (50 to 150 cm) and nine-course treatment is extra heavy duty treatment suitable for very heavy conditions of rain fall (more than 150 cm.)

10.16.2 Materials

10.16.2.1 Bitumen Primer: The primer shall conform to the requirements laid down in IS: 3384. Unless otherwise specified, each coat of bitumen primer shall be applied at the rate of 0.40 kg per square metre of the surface area.

10.16.2.2 Glass Fibre Tissue: The glass fibre tissue shall be thin, flexible, uniformly bonded mat composed of chemically resistant borosilicate staple glass fibre distributed in a random open porous structure, bonded together with a thermosetting resin (phenolic type) and reinforced with continuous filament glass yarn at 10 mm pitch in the longitudinal direction. The minimum weight of the tissue shall be 40 gm per square metre and the nominal thickness shall be 0.50 ± 0.1 mm. The minimum tensile strength of the tissue shall be 45 kg/150 mm width in the longitudinal direction.

10.16.2.3. Bonding Material : This shall consist of blown type bitumen conforming to IS: 702 or residual bitumen conforming to IS:73 heated to the correct working temperature. The penetration of the bitumen shall not be more than 40 when tested in accordance with IS: 1203. Unless otherwise specified, each coat of bonding material shall be of blown type bitumen of grade 85/25 heated to a working temperature of 180

degree C and applied at the rate of 1.60 kg per square metre of the surface area.

10.16.2.4 Surface finish : Surface finish shall depend upon whether the roof is flat or sloping and whether the terrace is accessible or not. Pea size gravel, stone grit, burnt clay tiles, cement concrete flooring tiles, broken pieces of ceramic glazed tile or bitumen based aluminous mastics may be used as specified. Pea size-gravel/stone grit, where specified, shall be spread at the rate of 0.006 cubic metre per square metre of the surface area. Materials used for surface finish shall be dry and free from dust.

10.16.3 Preparation of Surface

The preparation of the surface shall be done as specified in para 10.15.3 except that water proofing felt wherever mentioned shall mean glass fibre tissue. To ensure good adhesion between the structural surface and water-proofing treatment, suitable methods to dry the surface shall be adopted where necessary.

10.16.4 Treatment

10.16.4.1 The water proofing treatment shall be five, seven or nine-course as specified. The first coat of bitumen primer, each coat of bonding material, each layer of glass fibre tissue and the top layer of surface finish shall be counted as a course.

10.16.4.2 A five course treatment shall consist of the following :

- i) First coat of bitumen primer.
- ii) Second coat of bonding material.
- iii) Third layer of glass fibred tissue
- iv) Fourth coat of bonding material.
- v) Fifth and top most layer of surface finish as specified.

10.16.4.3 In seven-course treatment, the first four courses shall be the same as for five course treatment. The fifth course shall be a layer of glass fibre tissue. The sixth course shall be a coat of bonding material and the top most seventh course shall be of specified surface finish.

10.16.4.4 In nine course treatment, the first six courses shall be the same as for seven course treatment. The seventh course shall be a layer of glass fibre tissues, the eighth course shall be a coat of bonding material and the top most ninth course shall be of specified surface finish.

10.16.5 Laying

Laying shall be done as specified in para 10.15.7 except that the glass fibre tissue

shall be used instead of self finished felt and the first course shall be a coat of bitumen primer followed by subsequent courses as per the treatment required.

10.16.6 Measurements & Rates

Measurements and rates shall be as specified in paras 10.15.8 and 10.15.9 respectively except that the rate shall be inclusive of the first coat of bitumen primer.

10.17 CEMENT CONCRETE GOLA (Refer FIGURE 10.11A)

10.17.1 Cement Concrete : The specifications for concrete shall be the same as described in Cement Concrete chapter.

10.17.2 Gola

A chase 75mm wide by 75 mm deep shall be cut in the parapet wall just above the junction of mud phuska or lime concrete with parapet wall and it shall be filled with cement concrete 1:2:4 (1 cement : 2 coarse sand : 4 stone aggregate 10 mm and down gauge) with the external face finished to a slope of 1 : 0.75. The exposed surface of the Gola shall be plastered with cement mortar 1 : 3 (1 cement : 3 fine sand).

Expansion joint at every 3.5 to 4.5 metres shall be provided and filled with bitumen filler. The bitumen filler shall be prepared by mixing bitumen, cement and coarse sand in the ratio 80 kg of hot bitumen: 1 kg of cement and 0.25 cum of coarse sand.

10.17.3 Curing

The finished surface shall be cured for at least 7 days.

10.17.4 Measurements

The length of the finished gola shall be measured at its junction with the wall face correct to a cm. No deduction shall be made in measurements for gaps for water outlets.

10.17.5 Rate

The rate shall include the cost of all materials and labour involved in all the operations described above including the cost of bitumen filler in expansion joint. The rate includes for all turnings and roundings at all the corners and risers.

10.18 PARNALAS

10.18.1 Parnalas : These are shallow channels formed on the face of the wall, for the rain water from the roof to run down, by plastering the masonry face to the required width with cement mortar of the specified mix to 20 mm thickness, the channel portion of the width of the parnalas being edged along both sides with projected fillets of cement

mortar of the same mix, of trapezoidal section, base width at wall plaster face 6.5cm tapering to 2.5cm width at front, and projected 2.5cm above the channel plaster face. The width of parnalas stipulated in the description of the items shall mean the width over the channel and the fillets included. The mortar for the plaster and the fillets shall be 1:4 mix (1 cement: 4 ordinary sand), unless otherwise specified.

10.18.1 Preparation of Surface

The joints in the masonry wall surface shall be raked and the joints and the surface cleaned and prepared as for "Cement Plastering".

10.18.2 Application

The surface shall then be plastered 20mm thick with the specified mortar, to the required width of the parnala. When the plaster is still fresh, two cement mortar fillets of size and section as stated above shall be made on the two sides of the channel width with the same mortar mix as the backing plaster. The junction of the sloping face of the fillets with the wall plaster shall be finished true and straight. The interior side faces of the fillets shall be at right angles to the channel backing plaster, and their junction with the same shall be slightly rounded. The entire parnala shall be finished smooth with a floating coat of neat cement.

10.18.4 Curing - The parnala shall be cured for a period of 7 days.

10.18.5 Measurements :

The parnala shall be measured by length, in running metres correct to a cm. Where the two side fillets of the parnalas are connected together across the width at its top end, with a similar horizontal fillet, the length shall be taken from the outside edge of the horizontal fillet. The horizontal fillet shall not be measured or paid for separately.

10.18.7 Rate

The rate shall include the cost of all labour and materials involved in all the operations described above and is for the entire finished parnala, inclusive of the side fillets, channel, horizontal fillet etc.

10.19 KHURRAS (Refer FIGURE 10.11B)

10.19.1 General : The khurras shall be constructed before the brick masonry work in parapet wall is taken up and it shall be 45 cm x 45 cm unless otherwise specified in the description of the item and shall be formed of cement concrete 1:2:4 mix (1 cement : 2

coarse sand : 4 graded stone aggregate 20 mm nominal size) or other mix as stipulated in the description of the item.

10.19.2 Laying

10.19.2.1 A PVC sheet 1 m x 1 m x 400 micron shall be laid under the khurra and then cement concrete shall be laid over it to average thickness of 50 mm with its top surface lower than the level of adjoining roof surface by not less than

- a) 20 mm in case of roof surface finished with lime concrete terracing
- b) 70 mm in case of roof surface finished with lime concrete terracing covered with brick tiles.
- c) 50 mm in case of roof surface finished with mud phuska with brick tile covering.

10.19.2.2 The concrete shall be laid to a size greater than the stipulated size of the khurra in such a way that the adjoining terracing whether of lime concrete or of the tile bricks shall overlap the concrete on its three edges by not less than 7.5 cm. The concrete will slope uniformly from the edges to the outlet the slope being as much as possible and in no case with less than 20 mm of cement concrete at the outlet. The concrete shall be continued at the same slope, through the width of the wall into the outlet opening to ensure a water tight joint.

10.19.2.3 The khurras and the sides of the outlet shall then be rendered with 12 mm coat of cement plaster 1:3 mix (1 cement : 3 coarse sand) or other mix as stipulated in the description of the item. This shall be done when the concrete is still green and shall be finished with a floating coat of neat cement. The sides of the khurras and sides of the outlet opening shall be well rounded. The size of the finished outlet opening shall be 10 cm wide by 20 cm high or as directed by the Engineer.

10.19.2.4 In cases where rain water is to be disposed off through rain water pipes, iron grating shall be provided at the outlet as a safeguard against choking, if so directed by the Engineer. Iron gratings, where provided, shall be of overall size 20 x 25 cm. with an outer frame of 15 x 3 mm M.S. flat to which 4 nos. M.S. bars of 10 mm dia shall be welded in a vertical direction keeping equal clear spacing of 2.5 cm. or as directed by the Engineer.

10.19.3 Measurements - Khurras shall be counted in numbers.

10.19.4 Rate

The rate is for each completed khurra of the specified size and is inclusive of the cost of all materials and labour involved in forming the khurras and outlet opening as described above, except for iron gratings which shall be paid for separately.

10.20 RED OR WHITE SAND STONE ROOFING

10.20.1 Sand Stone Slabs

The stone slabs shall be hard, even, sound and durable. They shall not absorb more than 5% of their dry weight of water after twenty four hours immersion. Slabs shall have been sawn or chiselled in a plane parallel to the natural bed of the stone. The slabs shall be rough chisel dressed on the top so that the dressed surface shall not be more than 6 mm from a straight edge placed on it. The edges of the depressions or projections shall be chisel dressed in a slant,

so that surface does not have sharp unevenness. The sides shall also be chisel dressed to a minimum depth of 20 mm so that the dressed edges shall at no place be more than 3 mm from a straight edge butted against it. The thickness of the slab shall be uniform and as specified in the item with a permissible tolerance of 2 mm. The slabs shall be uniform in length, the length being 5 to 8 mm less than the centre to centre spacing of the supporting wooden Joists (Karries) or RCC battens. Unless the design required some other shape the slabs shall be rectangular. The width of the slabs may vary unless otherwise stipulated but shall not be less than 40 cm.

10.20.2 Rafter spacing

The maximum spacing of rafters (karries) or RCC battens supporting the slabs shall not exceed figures given in **Table 10.5**.

TABLE 10.5

Thickness of slabs	Maximum spacing of rafters
40mm	52.5 cm
45 mm	60 cm
50 mm	68 cm

The bearing of slabs over the karries shall not be less than 30 mm. Where a karri supports a slab from one side only, the bearing of such slab shall be for full width of the karri. For bearing over the wall, the stone slabs shall be bedded over a layer of cement mortar 1: 4 (1 cement : 4 fine sand) of thickness not less than 12 mm.

10.20.3 Laying

The slabs shall be washed clean and wetted before being laid. The stone slabs shall be jointed in cement mortar 1:4 (1 cement : 4 coarse sand). The width of joints shall not be more than 8 mm not less than 5 mm. The top joints shall be finished flush and ceiling joints pointed with the cement mortar 1:3 (1 cement : 3 fine sand).

10.20.4 Finish

The finished surface shall be true, level or sloped as shown in the plan or as directed by the Engineer. It shall be cleaned of all mortar droppings and cement markings both on top and on the under side.

10.20.5 Curing

The slabs and their joints shall be kept wet during progress of work and for 7 days after completion.

10.20.6 Measurements

Length and width of finished stone slab work including bearing shall be measured correct to a cm. The area shall be calculated in sqm correct to two places of decimal.

No deduction in area shall be made for openings in roof slab for chimney stacks, roof lights etc. of area upto 0.40 sqm nor shall any extra be paid for extra labour, materials etc. in cutting and wastage, in forming such openings. For openings exceeding 0.40 sqm. in area, deduction shall be made in measurements for the full opening but no extra shall be paid for extra labour, material etc. in forming such openings.

10.20.7 Rate

The rate shall include the cost of all materials and labour involved in all the operations described above.

10.21 WOODEN CEILING

10.21.1 Boards

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10.21.1.1 Boards shall be of the class of timber and of finished thickness as specified in the description of the item and shall be in accordance with the general specifications for wood work. Only selected boards of uniform width shall be used. Unless otherwise specified in the description of the item or shown in the drawings, the width of boards selected for use shall not be less than 100 mm nor more than 150 mm.

10.21.1.2 The specific width of boards once selected within these two limits shall be maintained through out and shall not be varied except in the first and last lines of boards adjacent to the two walls, where remaining odd width shall be adjusted equally on both sides. The maximum length of the board in the finished work shall be 180 cm. The minimum length of board in the finished work shall be such that it will span at least two spacings of the supporting frame work except where shorter lengths are unavoidable, depending on the arrangements of the lines of heading joints which shall be carried out to the pattern ordered by the Engineer.

The boards shall be planed true on the exposed side.

10.21.1.3 Unless stipulated otherwise in the description of the item, the longitudinal joints of the boards shall be tongued and grooved, while the heading joints shall be of the square butt type and shall occur under the centre line of the supporting joint. Heading joints in adjacent boards shall not be placed over the same joists, those in alternate boards being arranged in the same line, except where the joints are to be concealed by beadings.

10.21.2 Frame

Timber frame of the class of wood and section specified in the description of the item for frame or as ordered by the Engineer shall be provided. The width of the frame scantling shall not be less than 50 mm. The arrangements and spacing of the frame scantling shall be as per design furnished. The frame shall be given two coats of approved preservative paint before the boarding is screwed. The frame and painting thereof shall be paid for separately unless specifically included in the description of the item. MS. angles or other sections shall be used for suspending the frame and paid for separately

The bottom surface of the frame shall be checked and corrected to true planes and slopes.

10.21.3 Mild Steel Screws

Screws shall be got approved from the Engineer before fixing. They shall be of the slotted counter sunk head type of length not less than the thickness of the board plus 20 mm. The designation number shall not be less than 9 for screws of length 40 to 50 mm and shall not be less than 6 for screws of length 25 to 35 mm.

10.21.4 Fixing The outer lines of boards shall be accurately fixed, parallel and close to the wall. Each subsequent plank shall be carefully jointed up. The boards shall be fixed to the frame scantling above with two screws at each of frame and one at every intermediate joist. The screws shall be counter sunk and the screw holes filled with putty or sloping out wax.

The unexposed faces of planks shall be painted with wood preservative before fixing but this treatment will be paid for separately.

10.21.5 Finishing

The exposed side of the boards shall be truly level and plane. The joints shall be truly parallel and/or perpendicular to the walls.

Beadings shall then be fixed to the ceiling, to the size and pattern required. These shall be measured and paid for separately unless specifically included in the description of the ceiling item.

10.21.6 Measurements

Length and breadth shall be measured correct to a cm. Areas shall be worked out to nearest 0.01 sqm. The ceiling shall be measured in square metres of superficial area of the finished work.

No deduction in measurements shall be made for openings of areas upto 0.40 sqm. Nothing extra shall be payable either for any extra material or labour involved in forming such openings. For openings exceeding 0.40 sqm in area, deductions in measurements for the full opening will be made and in such case any labour involved in making these openings shall be paid for separately in running metres. Boardings fixed to curved surfaces in narrow widths shall be measured and paid for separately and shall be included for making the joints to proper splay. Circular cutting and waste shall be measured and paid for separately in running metres.

10.21.7 Rate

The rate shall include the cost of all materials and labour involved in all the operations described above.

10.22 CEILING WITH INSULATING BUILDING BOARDS**10.22.1 Insulating Building Boards**

The insulating building boards shall be of approved quality as per IS code 3348 and,

unless otherwise specified, shall have square edges. The dimensions shall be subjected to the tolerances given in the **Table 10.6** below.

TABLE 10.6
DIMENSIONS AND TOLERANCES

SL	Type of Board	Nominal thickness mm	Tolerance on thickness mm	Length cm	Width cm	Tolerance on length and width
(i)	Fibre insulation board, ordinary or flame retardant type	9	± 0.75	365,300	180, 150	120 cm and below ± 3 mm; Above 120 cm ± 6 mm
		12	± 0.75	270,240	120,100	
		18	± 1.00	210,180	90,60	
		25	± 1.25	150,120	45 and 30	
				100,90 60,45 and 30		

10.22.2 Frame

Timber frame of the class of wood and section specified in the description of the relevant item for the frame or as ordered by the Engineer shall be provided. The width of the scantlings provided shall be sufficient to provide a minimum nailing surface of 50 mm. The longitudinal and header scantlings shall be so arranged that (a) the boards can be fixed to form the panel arrangements required as per drawings or as ordered by the Engineer (b) the longitudinal scantling to which the boards are mainly fixed are spaced at 30 to 45 cm centres, the actual spacing selected depending on the width of the cut board in the panel arrangement, (c) all edges of the cut board units are supported either on the longitudinal scantlings or on the header scantlings.

The frame shall be given two coats of approved preservative paint (to be paid for separately) before the board is nailed on. M.S. angles or other sections shall be used for suspending the frame and will be paid for separately. Where the joints in the board are to be covered with beadings the framing centres should be increased by 3 to 6 mm to allow for space between boards. The framing and painting thereof shall be paid for separately unless specifically included in the description of the ceiling item. The bottom surface of the frame shall be checked and corrected to true planes and slopes.

10.22.3 Nails

The sheets shall be fixed to the frame scantling with G.I. headless nails 2.24 mm dia when the joints are to be left exposed. Where the joints will be covered with beadings, the sheets are to be fixed to the frames scantlings with G.I. felt headed (clout) nails 2.5 mm dia. The length of the nails shall generally be equal to thickness of sheet plus 25 mm so that their grip on the framing members will not be less than 25 mm.

10.22.4 Fixing

The boards shall be laid with lengths parallel to all joints centered over the framing members. Where joints are to be covered, the boards may be spaced 3 to 6 mm apart as described in the respective manufacturers' specifications. Where joints are to be left exposed the sheets shall be butt laid with their edges abutting in moderate contact, but without having to force them into place. The boards shall be supported and held tight to the grounds with timber pieces the later being moved outwards as the nailing proceeds. The boards are first nailed to the intermediate framing member proceeding from the centre of the board outwards, the edges being nailed last.

Where the joints are to be left exposed, the outer rows of nails are placed at 10 cm centres and about 12 mm from the edge of the sheet. In the rows in the middle of the sheets, the nails are placed 20 cm apart. The nails should be counter sunk in the

under side of board with a suitable punch. Care shall be taken in driving the nails so that the sheets are not marked by hammer blows.

Where the joints are to be covered with beadings, felt headed (clout) nails shall be used instead of lost head nails. The spacing of the nails in the interior rows in boards shall be the same as in the preceding para. In the outer rows at edges to be covered by beadings, the nails will be spaced at 20 cm centres in each row but with the nails staggered. The Beadings will then be fixed over the sheets with screws at 20 cm centre in each row with the screws in the two rows staggered and passing through beading, sheet and framing so that ultimately the spacing of the fixing nails and screws taken together in each row will be at 10 cm centres so far as the sheets and frames are concerned.

10.22.5 Finishing

The exposed side of the board shall be truly level and plane without any local bulges or sags. The joints shall be truly parallel and/or perpendicular to the walls. The width of joints shall be uniform. Care shall be taken to see that the uniformity of colour of the sheets is not spoilt during the fixing operations.

Where the joints are required to be covered, beadings of size, pattern and material as ordered shall then be fixed with screws. These shall however be measured and paid for separately, unless specifically included in the description of the ceiling item.

The ceiling shall be treated with distemper or painting if so required but such surface treatment will be paid for separately, unless specifically included in the description of the ceiling item.

10.22.6 Measurements and Rate

These shall be the same as described in paras 10.21.6 and 10.21.7.

10.23 HARD BOARD / PARTICLE BOARD

10.23.1 Boards

10.23.1.1 Particle Board : The specifications for particle board shall be the same as per Paras 7.2.3A to 7.2.3C.

10.23.1.2 Hard Boards: The specification for hard boards shall be the same as per para 7.2.5.

10.21.2 10.23.2 Frame

The specifications as described in para 10.22.2 shall apply except that the maximum spacing of the longitudinal

scantlings shall be 40 cm centres. In case of hard board the sheets shall be damped with water on the textured face before they are fixed. This shall be carried out by brushing the textured face evenly and liberally with a sponge or swab soaked in water. After this, the sheets are stacked with the damped sides against each other, in pairs and left to remain for a period of 24 or 48 hours as recommended by the manufacturer. During this conditioning the sheets should be sheltered from the sun and strong heat. The specifications for cutting and chamfering etc will be same as in para 10.22.2.

10.23.3 Nails - The specification shall be the same as in para 10.22.3.

10.23.4 Fixing - The specifications as in para 10.22.4 shall apply.

10.21.5 10.23.5 Finishing

The specifications as in para 10.22.5 shall apply with the exception that normally no surface treatment like painting, varnishing, etc is necessary.

10.23.6 Measurements and Rate - These shall be the same as under paras 10.21.6 and 10.21.7.

10.24 CLOTH CEILING

10.24.1 Materials : Cloth ceiling shall be either of textile cloth or hessian cloth, fixed to a light wooden frame. The frame work shall be paid for separately.

10.24.1.1 The textile cloth shall be double warped "Dasuty" cloth weighing about 270 gm per sqm. Before use the textile cloth shall be thoroughly washed to free it from chemicals. In case hessian cloth is used, the same shall weigh not less than 320 gm per sqm.

10.24.2 Fixing : The cloth shall be first damped, stretched and mailed to the light wooden frame. Wooden beading 50mm x 12mm shall then be screwed through the cloth to the frame to form square or oblong panels, not more than 1.5 metres long.

10.24.3 Finishing : Cloth shall be white washed or distempered or finished as ordered and the same shall be paid for separately.

10.24.4 Measurements : Same as under para 10.21.6.

10.24.5 Rate : The through rate shall include the cost of all materials and labour involved as described above. The frame work and beading as also finishing on the underside (white washing, distempering etc)

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shall be paid for separately unless otherwise specified in the description of the item.

10.22.10.25 PLASTER OF PARIS (GYPSUM ANHYDROUS) CEILING OVER WOODEN STRIPS

10.25.1 Frame

The frame work shall be of the specified wood wrought and framed. In case of sloping roofs wooden battens of suitable section (depending upon the span and load to be carried) shall be firmly fixed as main supports, to the under side of the tie beams of the trusses at required centres by means of bolts and nuts of proper size. In case of flat roofs, the battens shall be securely fixed to the walls and pillars by holding down bolts and shall be fastened to the slabs above with iron straps or M.S. bars of suitable sections and encased therein. Cross battens of 50 x 40 mm sections at 40 cm centres or so, shall then be fixed at right angles to the main battens. The frame work shall be treated with approved wooden preservative before it is covered with ceiling. The underside of the frame work shall be true to planes and slopes. The frame work for ceiling / preservation treatment shall be paid for separately unless specifically included in the description of the ceiling item.

10.25.2 Wooden Strips

Wooden strips 25 x 6 mm of first class kailwood, (unless otherwise stipulated specifically in the description of the item) shall be fixed to the cross battens, in parallel rows with gaps of 10 mm in between adjacent rows, by means of felt headed (clout) nails. The strips shall be fixed butt jointed and not overlapped. The joints shall be staggered. The minimum length of strips to be used shall be 1.5 m.

10.22.310.25.3 Rabbit Wire Mesh

Rabbit Wire mesh shall then be fixed to the underside of wooden strips and their junctions with the battens fixed with nails at pitch of 15 to 20 cm or as ordered by the Engineer. The rabbit wire mesh shall be straight, tight and perfectly true to planes and slopes and without any sagging and shall be at a level slightly below the underside of the laths to allow the plaster to encase the metal all round.

10.22.410.25.4 Plaster of Paris

The plaster of Paris shall be of the calcium-sulphate semi-hydrate variety. Its fineness shall be such that when sieved through a sieve of IS sieve designation 3.35 mm for 5

minutes after drying, the residue left on it shall be not more than 1% by weight. It shall not be too quick setting. Initial setting time shall not be less than 13 minutes. The average compressive strength of material determined by testing 5 cm cubes after removal from moulds after 24 hours and drying in an oven at 40 degree C till weight of the cubes is constant, shall not be less than 84 kg per square metre.

10.22.510.25.5 Applications

The material will be mixed with water to a workable consistency. Plaster of Paris shall be applied to the underside of the laths over the rabbit wire mesh in suitable sized panels and finished to a smooth surface by steel trowels. The plaster shall be applied in such a manner that it fully fills the gaps between the laths and the thickness over the laths is as specified in the description of the item. The joints shall be finished flush to make the ceiling in one piece. The finished surface shall be smooth and true to plane, slopes or curves as required.

10.22.610.25.6 Measurements

10.25.6.1 Length and breadth of superficial area of the finished work shall be measured correct to a cm. Area shall be calculated in square metre correct to two places of decimal. No deduction will be made of openings of areas upto 0.40sqm nor shall extra payment be made either for any extra material or labour involved in forming such openings.

10.25.6.2 For openings exceeding 0.40 sqm in area, deduction in measurements shall be made but extra will be payable for any extra material or labour involved in making such openings.

10.25.6.3 Curved surfaces shall be measured and paid for separately from flat surfaces. The work shall be deemed to comprise of flat surfaces only unless specifically stated otherwise in the description of the item.

10.25.6.4 Any sunk or raised mouldings in the plaster shall be measured and paid for separately, deductions being made from plastering on ceiling only if the width exceeds 15 cm. Ceiling at a height greater than 5 metres shall be so described and measured separately stating the height.

10.25.7 Rate

The rate shall include the cost of all materials and labour involved in all the operations described above including all scaffolding, staging etc. The frame work mentioned in para 10.25.1 supporting the

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ceiling will be paid for separately unless otherwise stipulated in the description of the item.

The rate does not include for any raised or sunk mouldings or for any patterned finishing of the surface which will be measured and paid for extra over the plaster work.

10.26 PLASTER OF PARIS (GYPSUM ANHYDROUS) TILES CEILING

10.26.1 Frame

Timber frame of the class of wood and section as specified in the description of relevant item for the frame or as ordered by the Engineer shall be provided. The width of the scantlings provided shall be sufficient to provide a minimum nailing surface of 6 cm. The longitudinal and header scantlings shall be so arranged that the tiles can be fixed to form the panel arrangement required as per drawings, or as ordered by the Engineer and there is supporting scantling under each and every edge of the tiles. The framing shall be paid for separately unless specifically included in the description of the item.

10.26.2 Materials : Plaster of Paris shall be as specified in para 10.25.4.

10.26.3 Preparation of tiles: Tiles of plaster of Paris reinforced with hessian cloth shall be prepared /procured in suitable sizes as shown in drawings or as ordered by the Engineer. The maximum sizes of tiles shall be limited to 75 cm in each direction. Wooden forms of height equal to the thickness of tiles shall be placed on a truly level and smooth surface such as a glass sheet.

The section of form sides shall be such that the edges of the tiles shall be provided with a neatly formed chamfer allround of 5 mm width and 8 mm depth, unless the tiles are to be provided with cover fillets over joints in which case the edges of the tiles shall be truly square. The glass sheet or surface on which form is kept and the form sides shall be given a thin coat of non staining oil to facilitate the easy removal of the tiles. Plaster of Paris shall be evenly spread into the form upto about half the depth and hessian cloth weighing not less than 230 gm per square metre shall be pressed over the Plaster of Paris layer. The ends of the hessian cloth shall be turned over at all edges to form a double layer to a width of 5 cm. The hessian cloth shall be of an open webbed texture so as to allow the plaster

below and above to intermix with each other and form an integral whole. The form shall then be filled with plaster of Paris which shall be uniformly pressed and then wire cut to an even and smooth surface. The tile so moulded shall be allowed to set initially for an hour or so and then removed from the form and allowed to dry and harden for about a week. A good tile after drying and hardening shall give a ringing sound when struck. The tiles shall be true to shape and size and with clean and regular chamfers. The exposed face shall be truly plane and smooth.

10.26.4 Fixing

The tiles so prepared shall be fixed to the cross battens of the ceiling frame with 40 mm brass screws at spacings not exceeding 20 cm centre to centre on all edges. The tiles shall be laid with their edges in just close position to the adjoining tiles without any gap in between. The line of screws shall be not less than 15 mm away from the edge of the tiles. The screws shall be slightly counter sunk into the tiles. Holes for screws shall be drilled. The counter sunk heads of screws shall be covered up with Plaster of Paris and smooth finished.

When a surface unbroken by visible joints is required, then the joints shall be filled with Plaster of Paris and trowelled smooth so that the whole surface appears as one without any joint. Nothing extra shall be paid for this closing of joints.

10.26.5 Measurements

These shall be the same as in para 10.25.6. All special sizes and shapes of tiles necessitated by the openings referred to in the above para shall have to be made without any extra cost. The work at a height greater than 5 metres shall be paid for separately.

10.26.6 Rate

The rate shall include the cost of all materials, labour, form work, scaffolding etc. involved in all the operations described above. The rate does not include for covering the joints with beading, unless specifically stipulated in the item. The rate applies for plain faced tiles only and does not include tiles with sunk or moulded face.

10.27 WOODEN COVER FILLETS BEADING FOR CEILING

10.27.1 Beading

The beadings shall be of the specified wood and of size as given in the description of the

item. Unless otherwise described the beading shall be of the plain variety with square edges. The arrangement of the beading shall be as per drawings or as ordered by the Engineer and shall be fixed normal over the joints to be covered.

10.27.2 Fixing

The beading shall be planed smooth over all exposed faces and true on the rear face fixed centrally over the butt joints between the two boards with iron wood screws in two rows on either side of the joint. The spacing of screws in each row shall be 20 cm centres. The screws thus shall pass through the beading, ceiling board and then into the ceiling rafters with a minimum grip of 25 mm in the latter and where the beading is to be fixed to the board above for ornamental purpose there being no frame work scantling above, then the beading shall be fixed with screws which will be driven through the full depth of the board and their spacing shall be same as before. The screws to be fixed shall be got approved by the Engineer before fixing. These shall be slotted counter sunk head type and their designation number shall not be less than 8. The screws shall be oiled before insertion and shall be screwed in by means of a screw driver and in no case the use of hammer for fixing the screws is permissible. The screws shall be driven slightly counter sunk below the surface of the beading.

10.27.3 Finishing

The beading shall be finished smooth and fixed in such a workmen like manner that there is absolutely no gap left between the beading and the ceiling board nor in the joint faces. The beading line shall be absolutely straight and parallel and the plane of the under side of the beading shall be uniform.

The junction of the beading shall be of fully mitred or of partly mitred kind as shown in the drawings or as ordered by the Engineer. Where joints are to be fully mitred both the longitudinal as well as the cross beading shall be to the exact length as required by the panel arrangement. Where the joints are to be partly mitred variety and the length of the beading in one direction can run continuously over more than one panel then the minimum length of these beadings shall be 1.8 metres and the joints shall come at a corner of a panel and not in the middle of the panel side.

10.27.4 Measurements - Beading shall be measured in length in running metres correct to a cm.

10.27.5 Rate

The rate shall include the cost of all materials, labour and scaffolding involved in all the operations and shall apply to square edges beading unless otherwise stipulated in the description of the item. Chamfering edges, if payable, will be separately measured and paid as extra per running metre of beading.

10.28 RAIN WATER SPOUTS

10.28.1 General : The sectional area of rain water spouts provided shall be generally at the rate of 1 square cm per 70 to 80 square decimetre of roof area drained. However in locations subject to excessive and high intensities of rainfalls, the area of spouts provided may be suitably increased to suit local conditions. No spout shall be less than 80 mm in diameter. The spacing of spouts shall be arranged to suit the positions of openings in the wall.

10.28.2 Stone Ware Spouts - The spouts shall be 100 mm in diameter and 60 cm long.

10.28.2.1 The stone ware pipe shall be perfectly sound, free from fire cracks, imperfections of glazing etc. They must be straight cylindrical and of standard nominal diameter and length and depth of socket. Full length of pipes shall be used on the work. They must be thoroughly salt glazed inside and outside and shall generally conform to IS: 651.

10.28.2.2 Fixing : These shall be provided at the mouths of khurras and shall be fixed in cement mortar 1:3 (1 cement : 3 coarse sand) with the socket embedded in the masonry and the spigot end projecting outside. The masonry around the pipe and socket shall be thoroughly wetted and the holes shall be given a coat of cement mortar around. The S.W. pipe shall then be inserted and fixed with a surround of mortar. In case the hole is made much larger than the size of the pipe, cement concrete 1:2:4 (1 cement : 2 coarse sand : 4 graded stone aggregate 12.5 mm nominal size) shall be used to fill in the annular space. The spouts shall slope downward at a slope of 1 in 6. The projection outside the wall shall be uniform and not less than 40 cm. The entrance into the pipe shall be smoothly rounded to meet the internal bore of the pipe to facilitate easy flow. Care shall be taken to ensure that the vertical plane through the centre line of the spouts is at

right angles to the plane of the wall. Spouts in a row shall be true to line.

10.28.2.3 Measurements: Spouts shall be measured in numbers.

10.28.2.4 Rate: The rate shall include the cost of all materials and labour involved in all the operations described above including scaffolding.

10.28.3 Cement Concrete Spouts - These shall be 100 mm in diameter and 60 cm. long.

10.28.3.1 All pipes shall be new and perfectly sound, free from cracks, cylindrical, straight and of standard nominal diameter, length and depth of socket. They shall conform to IS: 458. They shall be of un reinforced cement concrete manufactured by pressure process and shall have smooth texture. The length of the pipe shall be the length of barrel exclusive of the internal depth of the socket.

10.28.3.2 Fixing, Measurements and Rate shall be as specified under para 10.28.2.

10.29 CAST IRON RAIN WATER PIPES

10.29.1 Cast Iron Pipes

Pipes shall conform to IS: 1230 and shall be true, smooth and cylindrical, their inner and

outer surfaces being as nearly as practicable concentric. These shall be sound and uniform castings, free from laps, pin holes or other imperfections and shall be neatly finished and carefully fitted both inside and outside. The ends of pipes shall be reasonably square to their axes

10.29.2 Dimensions

C.I. rain water pipes shall be of the dia specified in the description of the item and shall be in full length of 1.8 metres including socket ends of the pipes, unless shorter lengths are required at junctions with fittings. The pipe lengths shall in each case be with socket. The pipes shall be supplied without ears unless otherwise specifically mentioned.

The pipes supplied shall be factory painted (with a tar base composition) both inside and outside which shall be smooth and tenacious.

Every pipe shall ring clearly when struck all over with a light hand hammer. When shorter pipes are cut from full lengths they shall be cut with a hacksaw. The sizes, weights, sockets and tolerances of pipe shall be as shown in **Table 10.7**.

TABLE 10.7
DIMENSIONS AND WEIGHT OF C.I. RAIN WATER PIPES

Nominal size of pipes (Internal diameter in mm)	50	75	100	125	150
1.PIPE					
(a) External diameter in mm	53	79	104	130	156
Tolerance in mm	± 3	±3	±3.50	±3.50	±4.00
(b) Thickness in mm	3.00	3.00	3.00	3.00	4.00
Tolerance in mm	± 1	± 1	± 1	± 1	± 1
(c) Nominal weight of 1800mm long pipe without ears in kg	7.50	11.00	14.00	20.00	26.00
Tolerance in weight	(-) 10%	(-) 10%	(-) 10%	(-) 10%	(-) 10%
Tolerance in length in mm	± 13.00	± 13.00	± 13.00	± 13.00	± 13.00
2.SOCKET					
(a) Internal diameter in mm	63	89	114	139	167
Tolerance in mm	± 3.00	± 3.00	± 3.00	± 3.00	± 3.00
(b) Thickness in mm	4.00	4.00	4.00	4.00	4.00
Tolerance in mm	± 1.00	± 1.00	± 1.00	± 1.00	± 1.00
(c) Internal depth in mm	60	65	65	75	75
Tolerance in length in mm	± 10	± 10	± 10	± 10	± 10

Note: 1. All dimensions are in mm.

2. Pipes weighing more than the nominal weight may be accepted provided they comply in every other respect with the requirements of this standard.
3. The above table applies only to rain water pipes fixed on wall face.
4. For pipes and fittings which are to be embedded in masonry, specifications shall correspond with those of pipes for soil, waste, and vent pipes.

10.29.3 Fixing and jointing

10.29.3.1 Pipes shall be either fixed on face of wall or embedded in masonry, as required in the description of the item.

10.29.3.2 Plain pipes (without ears) shall be secured to the walls at all joints with M.S. holder bat clamps. The clamps shall be made from 1.6 mm thick galvanised M.S. sheet of 30 mm width, bent to the required shape and size so as to fit tightly on the socket of the pipe, when tightened with screw bolts. It shall be formed out of two semi-circular pieces, hinged with 6 mm dia M.S. bolt on one side and provided with flanged ends on the other side with hole to fit in the screw bolt and nut, 40 mm long. The clamp shall be provided with a hook made out of 27.5 cm long 10 mm diameter M.S. bar, rivetted to the ring at the centre of one semi circular piece. The details of the clamps are shown in **Figure 10.11**. The clamps shall be fixed to the wall by embedding their hooks in cement concrete block 10 x 10 x 10 cm in 1:2:4 mix (1 cement : 2 coarse sand : 4 graded stone aggregate 20 mm nominal size) for which necessary holes shall be made in the wall at proper places. The clamps shall be kept about 25 mm clear off finished face of wall, so as to facilitate cleaning and painting of pipes (**Figure 10.12**).

Note : Where G.I. sheet clamps are not provided, M.S. sheet strips 3 mm thick and 20 mm wide shall be used for making the clamps.

10.29.3.3 The pipes shall be fixed perfectly vertical or to the lines as directed. The spigot of the upper pipe shall be properly fitted in the socket of the lower pipe such that there is a uniform annular space for filling with the jointing material. The annular space between the socket and the spigot shall be filled with a few turns of spun yarn soaked in neat cement slurry. These shall be pressed home by means of caulking tool. More spun yarn shall be wrapped if necessary and shall be rammed home. The joint shall then be filled with stiff cement mortar 1:2 (1 cement : 2 fine sand) well

pressed with caulking tool and finished smooth at top at an angle of 45 degree sloping up. The joints shall be kept wet for not less than 7 days by tying a piece of gunny bag, four fold, to the pipe and keeping it moist constantly. .

10.29.3.4 Where pipes are to be embedded in masonry, these shall be fixed in masonry work as it proceeds. In such cases care shall be taken to keep the pipes absolutely vertical or to the line as directed by the Engineer. The pipe shall have a surrounding of 12 mm minimum thickness of mortar at every portion of the external surface. The mortar shall be of the same mix as is used in the masonry. The joint shall be caulked with lead as soon as the next length of pipe is placed in position. The open end (socket end) of the pipe shall be kept closed till the next length is fitted and jointed, to prevent any brick bats or concrete or pieces of wood falling in and choking the pipe.

The depth of lead from the lip of socket shall be 25 mm minimum. In case of 100 mm dia. 75 mm pipes, the quantity of lead required per joint shall be 1.00 kg, 0.66 kg respectively for purpose of reckoning theoretical consumption. In order to ensure that required quantity of lead is poured into the joint and to control wastage of lead, at the beginning, three or four samples shall be made and the quantum of lead per joint approved by the Engineer.

The actual consumption of lead should be within $\pm 5\%$, of the approved sample job subject to the provision that a variation of $\pm 20\%$ shall be allowed over the theoretical quantity of lead due to dimensional tolerances allowed as per Indian Standards. This variation includes allowances of wastage also.

10.29.3.5 The spigot end shall butt the shoulder of the socket and leave no gap in between. The annular space between the socket and the spigot will be first well packed in with spun yarn leaving 25 mm from the lip of the socket for the lead. The joint shall then be lead caulked as described

in detail under jointing of S.C.I soil, waste and vent pipes.

10.30 CAST IRON FITTINGS FOR RAIN WATER PIPES

10.30.1 C.I. Fittings

C.I. fittings such as bends of various degrees, heads, offsets of different projections, branches and shoes shall conform to IS: 1230. The general specifications for these as described in 10.29 shall apply.

Bends shall be of the nearest standard degree as actually required at site. Heads shall be of the flat or corner type as required. Offsets shall be of the projection as stipulated in .tie description of the item. Branches shall be single or double as described in the item and shall be of the nearest standard degree as actually required. Standard shoes shall be of overall vertical length, 180 mm for 75 mm dia., 205

mm for 100 mm dia and 275 mm for 150 mm dia size pipe from top of socket to lowest tip of shoe. Shoes of longer lengths if used shall be in lengths from top of socket to lowest tip of shoe of 300 mm, 375 mm, 450 mm, or 600 mm, as actually required at site.

10.30.2 Dimensions

The fittings shall be of the diameter specified in the description of the item. The thickness of the fittings and details of spigots and sockets shall be same as those of corresponding size of straight pipes. The fittings shall be supplied without ears unless otherwise specifically mentioned in the item. The fittings shall be factory painted with a tar based composition both inside and outside which shall be smooth and tenacious. Every fitting shall ring clearly when struck all over with a light hard hammer. The fittings shall be of standard size and their individual weights shall conform to weights given in the **Table 10.8**.

TABLE 10.8
WEIGHT OF CI RAIN WATER PIPE FITTINGS

SL	Description	75mm dia (weight in kg)	100 mm dia (weight in kg)	150mm dia (weight in kg)	Unit
1.	Bends (Plain)	3.20	4.50	9.10	Each
2.	Offsets (Plain)				
	(a) 55mm projection	2.70	5.00	8.20	Each
	(b) 75mm projection	3.20	5.50	9.10	Each
	(c) 115 mm projection	4.10	5.90	9.50	Each
	(d) 150mm projection	4.50	6.50	10.40	Each
	(e) 225 mm projection	5.00	7.30	11.80	Each
	(f) 300mm projection	6.00	8.60	12.70	Each
3.	Branches (Plain)				
	Single	5.00	7.30	14.50	Each
	Double	6.80	10.00	19.10	Each
4.	Standard Shoes (Plain)	3.20	4.10	8.60	Each
5.	Longer shoes (Plain)				
	(a) 300mm	3.20	5.00	-	Each
	(b) 375 mm	4.10	5.50	-	Each
	(c) 450mm	5.50	6.40	-	Each
	(d) 600mm	7.30	8.60	-	Each
6.	Heads	6.40	6.80	11.30	Each
7.	Extras				
	(a) For ears cast on any fitting short pipes	0.90	0.90	1.35	Each

	(b) For inspection doors fitted or any fitting	1.80	1.80	2.25	Each

Note: 1. The above table applies only to rain water fittings which are part of pipe lines fixed on wall face. Permissible tolerance in weight of fittings shall be 5%

2. For fittings to be used with pipe lines to be embedded in masonry, specifications shall correspond with those of pipe fittings for soil, water and vent pipes. For their weights, specifications under SCI soil, waste and vent pipes may be referred to.

10.30.3 Fixing and Jointing:- Fixing and jointing shall be as specified in para 10.29.3.

10.30.4 Finish : Finish shall be as specified in para 10.29.3.5.

10.30.5 Measurements

The fittings shall be measured by numbers. Where longer shoes are used in lieu of standard shoes specified in the description of the item, they shall be measured as standard shoes of 180 mm, 205 mm and 275 mm for 75 mm dia, 100 mm dia and 150 mm dia respectively in number and the extra lengths of the shoes shall be measured and paid for under the corresponding size of pipes.

10.30.6 Rate

The rate shall include in the case of fittings fixed on the face of wall, the cost of all materials and labour involved in all the operations described above including jointing but excluding the supply and fixing the M.S. holder bat clamps in walls and the anchoring concrete. Unless otherwise

specified in the description of the item, the rate shall apply for fittings without access doors. In the case of fittings forming part of a rain water pipe line embedded in masonry, the rate shall be for supplying and embedding the fittings in masonry but shall not include for the jointing and lead caulking which shall be paid for separately.

~~10.29~~ 10.31 Thermal Insulation For Roofing With Bonded Mineral Wool

10.31.1 Material : The material shall be mineral wool made from rock slag or glass processed from a molten state into fibrous form and shall be bonded with a suitable binder. Bonded mineral wool shall conform to specifications of group I of IS : 8183.

10.31.2 Dimensions : The bonded mineral wool shall be supplied in width of 50, 60, 75 and 100 cms, length of 100, 120 and 140 cms and the thickness of the bonded mineral wool shall be 25, 40, 50, 65 or 75 mm.

10.31.3 Tolerances : For width and length, the dimensional tolerances of the bonded mineral wool slabs shall be 1/2% or 3 mm and for thickness, the tolerance shall be 3 mm. An excess in all dimensions is permitted.

10.31.4 Requirements for Bonded Mineral Wool : This shall be as given in **Table 10.12**.

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TABLE 10.12

SL	Characteristics	Group I	Test Reference
1	Bulk density	12 to 15 kg/cum	IS 3144
2	Recovery after compression	90% of original thickness	Appendix A of IS:8183
3	Shot content max	500 micron – 5%	IS 3144
		250 micron – 15%	
4	Moisture content and absorption	2%	IS 3144
5	Incombustibility	Incombustible	IS 3144
6	Thermal conductivity degree C at mean temperature 50 deg.C	0.49 mw per cm	IS 3346
7	Sulphur Content	Not more than 0.6%	IS 3144

10.31.5 Sampling : The number of slabs as per the **Table 10.13** will be selected at random from the lot. Tests for determination of all characteristics specified above shall be conducted on each of the test specimens as drawn above. The lot shall be declared as

conforming to the requirements of this specification, if the different tests results obtained under para 10.31.4 meet the corresponding requirements given in the standard individually.

TABLE 10.13

Lot Size (N)	No. of slabs to be selected (n)
Upto 200	5
201 to 300	6
301 to 500	7
501 to 800	8
801 to 1300	9
1301 and above	10

10.31.6 General : Bonded mineral wool insulation can be either laid over false ceiling or alternatively it can be fixed to the ceiling when the space above false ceiling is being used for carrying return air. In the first case the bonded mineral wool can either be fixed with suitable adhesive to the false ceiling board or else it can simply be rolled over the suspended false ceiling.

In the second case when space above false ceiling is to be used for carrying return air 40mm x 40mm slotted angle (7.5cm length) shall be fixed to the ceiling by means of rawl plugs at 60 cms spacing. 14 gauge tie wires shall be drawn from the slots. A mat is made of mineral wool insulation backed with scrim cloth with a light coating of Plaster of Paris or polythene faced hessian and 24g x 1" wire mesh netting. The joints of wire netting should be butted and tightly laced down with G.I. wire. Stretch the mat tightly across the angles holding it in place by means of tie wires.

10.31.7 Measurements : Length and breadth of the roofing insulation shall be measured correct to a cm and the surface area worked out in square metre of the finished work.

No deduction shall be made for openings of areas upto 0.40 sqm. No extra payment will be made for any extra material or labour involved in forming such openings. For openings exceeding 0.40 sqm in area, deduction for the full opening will be made, but no extra will be paid for any extra material or labour involved in forming such openings.

Boarding fixed to curved surfaces in narrow widths shall be measured and paid for

separately. Circular cutting and waste shall be measured and paid for separately in running metres.

10.31.8 Rate : The rate shall include the cost of all materials and labour in providing bonded mineral wool.

10.32 UNPLASTICISED POLYVINYL CHLORIDE (UPVC) RAIN WATER PIPES & FITTINGS

10.32.1 U.P.V.C. Pipes

Pipes shall conform to IS 13592 : 1992 (TYPE A). The internal and external surfaces of the pipes shall be smooth and clean and free from grooving and other defects. The end shall be clearly cut and shall be square with the axis of the pipe. The end may be chamfered on the plain sides. Slight shallow longitudinal grooves or irregularities in the wall thickness shall be permissible provided the wall thickness remains within the permissible limit.

10.32.2 Colour of Pipe - Surface colour of the pipes shall be as specified.

10.32.3 Marking - Each pipe shall be clearly and indelibly marked with the following information at intervals not more than 3 metres. The pipes may also be marked with standard mark.

- Manufacturer's name or trade mark
- Nominal outside dia of pipe
- Type
- Batch Number

10.32.4 Dimensions (Refer Fig.10.13)

UPVC rain water pipes shall be of the dia, specified in the description of the item and

shall be in nominal lengths of 2,3,4 or 6 metres either plain or with sliding/grooved sockets, unless shorter lengths are required at junctions with fittings. The sizes, weights,

sockets and tolerances of pipes shall be as shown in **Table 10.16 to 10.19**. Tolerances on specified length shall be +10 mm and -0 mm.

TABLE 10.16
DIMENSIONS OF PIPES
(All dimensions in mm)

Nominal Outside Diameter	Mean Outside Diameter		Outside Diameter at any Point		Wall Thickness S Type A	
	Min.	Max.	Min.	Max.	Min.	Max.
75	75.0	75.3	74.1	75.9	1.8	2.2
110	110.0	110.4	108.6	111.4	2.2	2.7

TABLE 10.17
MAXIMUM WALL THICKNESS OF SOCKETS ON PIPES
(All dimensions in mm)

Nominal Outside Diameter	S2 Min. Type A	S 3 Min. Type A
75	1.6	1.0
110	2.0	1.2

TABLE 10.18
DIMENSIONS FOR SLIDING SOCKETS
(All dimensions in mm)

Nominal Outside Diameter	Socket Depth, C Min.	Mean Inside Diameter of Socket at Midpoint, D1	
		Min.	Max.
75	40.0	75.1	75.3
110	48.0	110.1	110.4

TABLE 10.19
DIMENSIONS OF GROOVED SOCKET
(All dimensions in mm)

Nominal Outside Diameter	Inside Diameter of Socket, D1		Inside Diameter of Beading, D2		Length of Beading and Neck	Neck of socket	Length beyond Beading
					A	B	C
	Min.	Max.	Min.	Max.	Max.	Min.	Min.
75	75.3	76.2	84.5	85.5	20	5	35
110	110.4	111.3	120.3	121.3	26	6	32

10.32.5 Fixing and Jointing: Pipes shall be either fixed on face of wall or embedded in masonry as required in the description of the item.

Plain pipes shall be secured to the walls at all joints with PVC pipe clips by means of

50x50x50mm hard wood plugs, screwed with M.S. Screws of required length including cutting brick work and fixing in cement mortar 1:4 (1 cement : 4 coarse sand). The clips shall be kept about 25mm clear off

finished face of wall, so as to facilitate cleaning of pipes.

Pipes shall be fixed perfectly vertical or to the lines as directed. The pipes shall be fixed to fittings with seal ring conforming to IS 5382 allowing 10mm gap for thermal expansion

10.32.6 Installation in Wall/Concrete : The walls/ concrete slots should allow for a stress free installation. Pipes and fittings to be inserted into the slots without a cement base, have to be applied first with a thin coat of PVC solvent cement followed by sprinkling of dry sand (medium size) and allowed to dry. The process gives a sound base for cement fixation. This process is repeated while joining PVC material to CI/AC materials.

10.32.7 Fittings : Fittings used shall be of the same make as that of the PVC pipes, Injection moulded or fabricated by the manufacturer and shall have a minimum wall thickness of 3.2mm. The Fittings shall be supplied with grooved socketted ends with square grooves and provided with Rubber Gasket conforming to IS : 5382. The plain ends of the fittings should be chamfered. The fittings shall be joined with the help of Rubber lubricant. For details of fittings refer **FIGURE 10.14.**

10.32.8 Measurements

The fittings shall be measured by numbers. The pipes shall be measured net when fixed correct to a cm. excluding all fittings along its length.

10.32.9 Rate

The rate shall include the cost of all materials and labour involved in all the operations described above including jointing but excluding the supply and fixing of wall

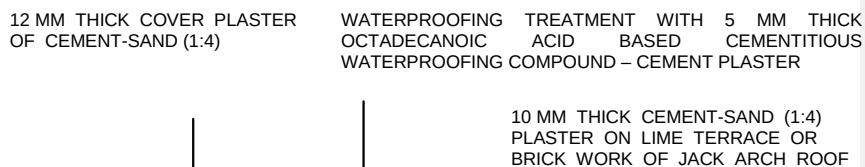
plugs and PVC clips which shall be paid for separately. These pipes shall be used only in shaft or unexposed location to avoid damage to these pipes due to wilful act.

10.33 Surface Protection of Jack Arch Roofs :

10.33.1 Surface protection of jack arch roofs with cementitious waterproofing compound

10.33.1.1 Reinstating missing or loose tie rods at end bays of arches and tightening the tie rods (all at extra cost); removing existing tarfelt and other damaged waterproofing systems; replacing soft or damaged lime terrace, if at isolated locations, with cement concrete (1:2:4); sealing cracks on the roof surface with sealing compound of acrylic-styrene copolymer having density of 0.9, pH 7.0 to 8.0 and having properties (on setting) of excellent bond, waterproofing and a minimum expandability of at least 200%; providing a 10 mm thick cement-sand (1:4) plaster on the entire surface; curing for 7 days; waterproofing the surface with a two-layer plaster; the first layer shall be 5 mm thick with cement (OPC or slag), admixed with an octadecanoic acid based cementitious waterproofing compound (bulk density not greater than 0.5 gm/cc, moisture content not greater than 2.0% and free fatty acid not greater than 0.2%) in the weight ratio of 50:3 for cement and waterproofing compound; finally providing a 12 mm thick cement-sand (1:4) plaster, enriched with polyester fibre @ 0.2% by weight of cement and curing the plastered surface; the waterproofing treatment shall be impermeable under a waterhead of 20.0 metres.

10.33.1.2 Other Details :



SCHEMATIC VIEW

10.33.1.3 MATERIAL : The waterproofing material shall be a powder that can be uniformly mixed with cement (OPC or slag) and it must have been in use in projects of Indian Railways for at least 6 years. The acrylic-styrene based copolymer must have a solid content of at least 49%.

10.33.1.4 TEST : The two-layer plaster type waterproofing system shall be tested according to test provisions of IS:2645-2003 under a waterhead of 20m. The test shall be conducted at National Test House or at any other laboratory approved by the Engineer-in-charge.

10.33.1.5 PREPARING CRACKS FOR SEALING : The cracks in the roof are cleaned to remove materials of all earlier treatments, all soft and loose materials, etc.

10.33.1.6 PREPARING THE SURFACE FOR PLASTER : The surface of the lime terrace, after the removal of tarfelt, etc. shall be prepared for the application of the 10 mm thick base plaster by wetting the surface thoroughly, to avoid excessive loss of water from the base plaster. The base plaster is cured for at least 3 days prior to the application of the two-layer waterproofing treatment

10.33.1.7 PREPARING THE PASTE OF CEMENT AND WATERPROOFING COMPOUND : 3 kgs of the waterproofing compound is mixed uniformly with 50 kgs of OPC or slag cement. Water (@ an approximate water/cement ratio of 0.35), small quantities at a time, is added to and mixed with the admixture of cement – waterproofing compound. A paste is thus formed.

10.33.1.8 PREPARING THE MORTAR FOR COVER PLASTER : The cement (OPC or slag)-sand mortar in the ratio of 1:4 is prepared in the normal way with the addition of water (@ a water-cement ratio of not higher than 0.4). Polyester fibre @ 0.20% by weight of cement is added as secondary reinforcement in making the cement-sand mortar. This mortar for the cover plaster is kept ready before the application of the paste of cement-waterproofing compound.

10.33.1.9 APPLICATION OF CRACK SEALING COMPOUND : The acrylic-styrene sealing compound is diluted with water in a ratio of 1:10. The crack is filled up (without repetition) with the diluted sealing compound. As the material is soaked in, the crack is filled up with the application of repeated coats of the undiluted sealing compound. Each coat is

applied after the previous coat will have dried up. Dry coarse sand is sprayed on the last coat when it will still be wet. Excess sand is removed on the following day

10.33.1.10 APPLICATION OF WATER-PROOFING TREATMENT : The base plaster is properly wetted. A 5 mm thick layer of the plaster of the cement-waterproofing compound is provided on the wet surface, followed by the application of the 12 mm thick cement-sand cover plaster when the first layer plaster of cement-waterproofing compound starts developing surface cracks. It normally takes about 10-20 minutes after the application of this first layer of plaster. The cracks in the first layer plaster are healed with the application of a gentle pressure with a trowel before the application of the cover plaster and an even finishing of the surface.

10.33.1.11 CURING : The treatment is cured with water for at least 7 days in the case of work with OPC and at least 14 days in the case of work with slag cement.

10.33.1.12 Missing or loose tie rods shall be reinstated at extra cost. Removal of debris will be paid separately as per relevant item.

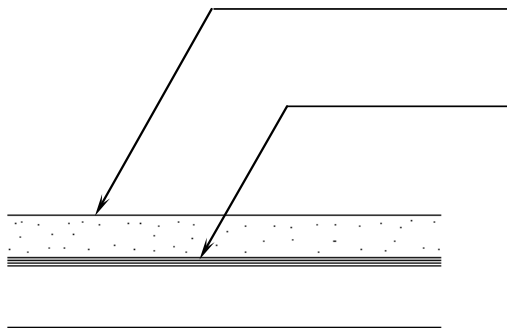
10.33.2 Surface Protection Of Jack Arch Roofs With Polymer

10.33.2.1 Reinstating missing or loose tie rods and tightening the tie rods (all at extra cost); removing damaged or soft waterproofing systems (e.g. tarfelt etc.); replacing soft or damaged lime terrace, if at isolated locations, with cement concrete (1:2:4); sealing cracks on the roof surface with a sealing compound (initially diluted and then undiluted) of acrylic-styrene copolymer having a density of 0.9, pH 7.0 to 8.0 and having properties (on setting) of excellent bond, waterproofing and a minimum expandability (of dry film) of at least 200%; waterproofing the surface with three coats (each subsequent coat to be provided immediately after the previous coat will have become tackfree) of a slurry of the aforesaid sealing compound (undiluted) of acrylic-styrene copolymer, admixed with an octadecanoic acid based cementitious waterproofing compound (bulk density not greater than 0.5 gm/cc, moisture content not greater than 2.0% and free fatty acid not greater than 0.2%) in the weight ratio of 3:1 (i.e. 10 litres of polymer to 3 kg of cementitious waterproofing compound) to build up a thickness of about 1.0 mm; spreading dry coarse sand immediately on application of the third coat before it will

become tacky; removing excess sand on the following day or later; permitting the coatings to harden for at least two more days; finally providing a 6 mm thick cement-sand (1:4) plaster, enriched with polyester fibre @ 0.2% by weight of cement, and curing the

plastered surface for at least 14 days for work with slag cement or 7 days for work with OPC (the waterproofing treatment shall be impermeable when tested under a waterhead of 20.0 metres for 8.0 hours as in IS 2645:2003).

10.33.2.2 Other Details :



SCHEMATIC VIEW

10.33.2.3 MATERIAL : The waterproofing material shall be a powder of octadecanoic acid compound that cement (OPC or slag) must have been in use in projects of Indian Railways for at least 6 years. The acrylic-styrene based copolymer must have a solid content of at least 49%.

10.33.2.4 PREPARING CRACKS FOR SEALING : The cracks in the roof are cleaned to remove materials of all earlier treatments, all soft and loose materials, etc.

10.33.2.5 PREPARING THE SURFACE FOR PLASTER : The surface of the lime terrace, after the removal of tarfelt, etc. shall be cleaned thoroughly to remove all loose materials.

10.33.2.6 PREPARING THE SLURRY COAT OF WATERPROOFING COMPOUND AND POLYMER : 3 kgs of the waterproofing powder is mixed uniformly with 10 litres (9 kg) of the acrylic-styrene copolymer to form a thick paste. No water is added.

10.33.2.7 APPLICATION OF CRACK SEALING COMPOUND : The acrylic-styrene sealing compound is diluted with water in a ratio of 1:10. The crack is filled up (without repetition) with the diluted sealing compound. As the material is soaked in, the crack is filled up with the application of repeated coats of the sealing compound without dilution. Each coat is applied after the previous coat will have dried up. Dry coarse sand is sprayed on the last coat when it will

still be wet. Excess sand is removed on the following day.

10.33.2.8 PREPARING THE PASTE OF CEMENT AND WATERPROOFING COMPOUND : 3 kgs of the waterproofing compound is mixed uniformly with 50 kgs of OPC or slag cement. Water (@ an approximate water/cement ratio of 0.35), small quantities at a time, is added to and mixed with the admixture of cement – waterproofing compound. A paste is thus formed.

10.33.2.9 APPLICATION OF WATER-PROOFING COATINGS : Three coats of the slurry is provided. The second and third coat of slurry is provided after the first and second coat will have dried up but before these will be tack free. Dry coarse sand is sprayed immediately on application of the third coat before it will be tacky.

10.33.2.10 PREPARING THE MORTAR FOR COVER PLASTER : The cement (OPC or slag)-sand mortar in the ratio of 1:4 is prepared in the normal way with the addition of water (@ a water-cement ratio not higher than 0.4). Polyester fibre @ 0.20% by weight of cement is added as secondary reinforcement in making the cement-sand mortar.

10.33.2.11 APPLICATION OF COVER PLASTER : Loose sand on the coating is removed a day after its application. The coatings are permitted to harden for at least three days. The 6 mm thick cover plaster is

provided after providing cement slurry on the sanded surface.

10.33.2.12 CURING : The treatment is cured with water for at least 7 days in the case of work with OPC and at least 14 days in the case of work with slag cement.

10.33.2.13 Missing or loose tie rods shall be reinstated at extra cost. Removal of debris will be paid separately as per relevant item. No screed concrete shall be provided on the treatment

10.34 Arresting Water Leakages At Isolated Locations (Tunnels, Subways etc.)

10.34.1 Arresting water leakages at isolated locations (point leakage), at cracks and at

construction joints by cutting grooves and by filling the grooves by pressing tight a putty of cement (OPC or slag), modified with a cementitious quick setting compound (bulk density 0.80 to 0.85 gm/cc and a pH of 7.5 – 8.0 for a 20% aqueous solution at 35°C) in a weight ratio of 1:10 (1 part of the compound and 10 parts of cement), which is further modified with a silica waterproofing compound (density not less than 1.53 and a pH of 10.0 – 10.5 for a 5% aqueous solution at 35°C), having the properties of making cement quick setting and non-shrinking in quantities to suit the water pressure conditions at the site; finally topping the plugged material with a surface waterproofing treatment (paid separately).

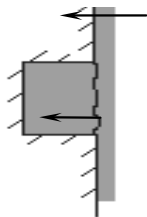
10.34.2 Other Details :

SURFACE TREATMENT WITH OCTADECANOIC ACID BASED CEMENTITIOUS WATERPROOFING COMPOUND AND COVER PLASTER

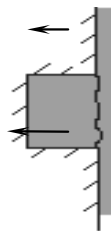
AREA AROUND POINT LEAK CHIPPED AND PLUGGED WITH QUICK SETTING CEMENTITIOUS CALCIUM WATERPROOFING COMPOUNDS, CEMENT AND LIQUID NON-SHRINKING, SILICA WATERPROOFING COMPOUND

SURFACE TREATMENT WITH OCTADECANOIC ACID BASED CEMENTITIOUS WATERPROOFING COMPOUND AND COVER PLASTER

AREA AROUND CONSTRUCTION JOINT CHIPPED AND PLUGGED WITH QUICK SETTING CEMENTITIOUS CALCIUM WATERPROOFING COMPOUNDS, CEMENT AND LIQUID NON-SHRINKING, SILICA WATERPROOFING COMPOUND



POINT LEAK



CONSTRUCTION JOINT

SCHEMATIC VIEW

10.34.3 MATERIAL : The cementitious waterproofing compound, that can be uniformly mixed with cement (OPC or slag), shall be a powder of the same colour as that of cement and it should have been in use in projects of Indian Railways for at least 6 years. The translucent viscous silica waterproofing compound should have been in use in projects of Indian Railways for at least 6 years.

10.34.4 PREPARING THE SURFACE : In the case of a point leakage a groove 15-30 mm deep is made at the leakage area. A similar groove is made into concrete

along a construction joint in the case of leakage at a construction joint

10.34.5 PREPARING THE PUTTY : The powder compound is uniformly mixed with cement (OPC or slag) in the specified ratio; water is added and a stiff putty (in small quantities) is made. Quickly, about 10% to 30% (by weight of cement) liquid waterproofing compound is added to the stiff putty and the putty is remoulded for use as a plugging material

10.34.6 APPLICATION : The putty is quickly put into position at the groove at a point leakage or at a part of the groove at a construction joint. The putty is held in

position with hand-held pressure for a few minutes until water will stop flowing. The putty is observed on the following day for its success in stopping water leakage. There shall not be any visible leakage or sweating, if found successful on the following day, it is given the surface treatment for waterproofing on the same day.

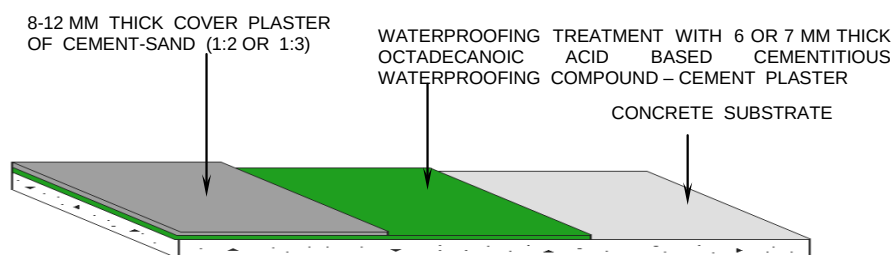
10.34.7 CURING : With or without the surface protection system, the treated area is given the wet curing for a week.

10.35 Water proofing, Surface Treatment of Tunnels, Subways, Water Reservoir, Swimming Pools, Sunken Floors, etc. :

10.35.1 Cleaning the surface to remove all loose materials and laitance; arresting all leakages and sealing all visible cracks (as separate items); wetting the surface thoroughly (if polymer will not be used for improved bond with substrate); etching (not required in the case of brick walls) the wet surface with muriatic acid; mopping up excess acid and washing the surface thoroughly; mixing thoroughly a cementitious waterproofing compound of octadecanoic acid, conforming to test

provisions of IS 2645:2003, but with zero permeability, having a bulk density not greater than 0.50 gm/cc; moisture content not greater than 2.0%, free fatty acid not greater than 0.2% and having the additional properties of making cement plasticized and less porous, in the weight ratio of 50 cement (OPC or slag) and 3 waterproofing compound; wetting the surface to be waterproofed (unless polymer bonding agent will be used); adding water (small quantities at a time) to the same mixture to achieve a consistency for plaster work; treating the surface with a two-layer plaster; the first layer shall be 7 mm thick in case of inside walls and floors of water reservoirs and swimming pools, 6 mm thick for sunken slabs/toilet floors and inside of tunnels, basements, etc. with the paste of cement and waterproofing compound; the second layer is of cement-sand (1:2 on floors of basements and tunnels, 1:3 elsewhere) plaster (12 mm thick on floor, 8 mm thick on vertical surfaces and at ceiling); curing the plastered surface (7 days for work with OPC or 14 days for work with slag cement). (Note : In lieu of etching with acid, the surface can be roughened or bond improved by other appropriate means)

10.35.2 Other Details :



SCHEMATIC VIEW

10.35.3 WATERPROOFING MATERIAL : The material shall be a powder that can be uniformly mixed with cement (OPC or slag) and it must have been in use in projects of Indian Railways for at least 6 years.

10.35.4 TEST : The two-layer surface protection system shall be tested according to test provisions of IS:2645-2003 under a waterhead of 20 metres. The test shall be conducted at National Test House or at any other laboratory approved by the Engineer-in-charge.

10.35.5 CLEANING THE SURFACE : Surfaces shall be thoroughly cleaned to remove all growths, plaster, dirt, laitance,

any other loose or soft material and all other non-structural work. Any grease, oil, paint, etc. shall be removed

10.35.6 PREPARING THE SURFACE : The concrete surface shall be prepared for the waterproofing treatment by wetting the surface (to prevent absorption of acid) thoroughly and etching the surface by a liberal application of muriatic acid. Should a single application of the acid fail to lead to a rough texture (similar to the texture of a fine grained sand paper), the acid may have to be re-applied. In between applications of acid, the surface should be rubbed with a stiff brush and washed. Excess acid shall be removed when it will stop reacting

(formation of gas bubbles) with cement mortar in concrete, which may take 5-10 minutes. The surface shall be washed. Alternatively, the concrete surface is roughened with a water jet or by sand blasting, or the bond can be improved with the use of a polymer bonding agent.

10.35.7 PREPARING THE PASTE OF CEMENT AND WATERPROOFING COMPOUND : 3 kgs of the waterproofing compound is mixed uniformly with 50 kgs of OPC or slag cement. Water (@ an approximate water/cement ratio of 0.35), small quantities at a time, is added to and mixed with the admixture of cement – waterproofing compound to make a paste suitable for plaster work.

10.35.8 PREPARING THE MORTAR FOR COVER PLASTER : The cement (OPC or slag)-sand mortar in the specified ratio is prepared in the normal way with the addition of water (@ a water-cement ratio not higher than 0.4). In the case of outdoor work, this mortar for the cover plaster shall be kept ready before the application of the paste of cement-waterproofing compound.

10.35.9 APPLICATION : The cleaned and etched surface is properly wetted and the excess water is removed. A layer of the required thickness of plaster of cement-waterproofing compound is provided on the wet surface, followed by the application of the cement-sand cover plaster of the required ratio and thickness before the first layer plaster of cement-waterproofing compound starts developing surface cracks. The cracks in the first layer plaster are healed with the application of a gentle pressure with a trowel before the application of the cover plaster and an even finishing of the surface.

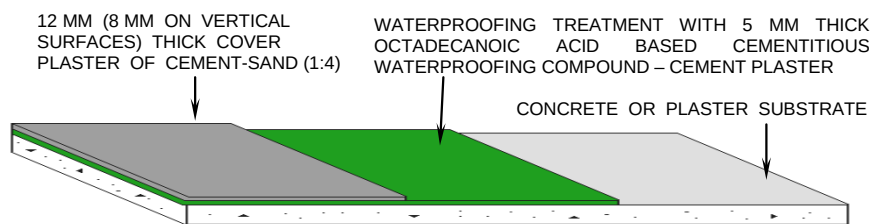
10.35.10 CURING : The treatment is cured with water for at least 7 days in the case of work with OPC and for at least 14 days in the case of work with slag cement.

10.36 Waterproofing Of Roofs & Exposed Concrete Surface :

10.36.1 With Cementitious Waterproofing Compound :

10.36.1.1 Cleaning the surface to remove all loose materials and laitance; sealing all visible cracks (as a separate item); wetting the surface thoroughly; etching (not required in the case of brick walls) the wet surface with muriatic acid; mopping up excess acid and washing the surface thoroughly; mixing thoroughly a cementitious waterproofing compound of octadecanoic acid, conforming to test provisions of IS:2645-2003, but with zero permeability, having a bulk density not greater than 0.50 gm/cc and having the additional properties of making cement plasticized and less porous, in the weight ratio of 50 cement (OPC or slag) and 3 waterproofing compound; wetting the surface to be waterproofed unless polymer agent will be used; adding water (small quantities at a time) to the same mixture to achieve a consistency for plaster work; followed by the application of a 5 mm thick paste of the admixture of cement and the waterproofing compound; the waterproofing treatment will be covered with a 12 mm thick cement-sand (1:4) plaster, containing polyester fibre as secondary reinforcement @ 0.20% by weight of cement; curing for at least seven days (in the case of plastering with OPC) or fourteen days (in the case of plastering with slag cement); where slope will be required to prevent water logging on roofs, this can be provided following the waterproofing treatment with a 1:3:4 concrete of appropriate thickness at extra cost, followed by curing as above. (Note : In lieu of etching with acid, the surface can be roughened or bond improved by other appropriate means.).

10.36.1.2 Other Details :



SCHEMATIC VIEW

10.36.1.3 MATERIAL : The material shall be a powder that can be uniformly mixed with cement (OPC or slag) and it must have been in use in projects of Indian Railways for at least 6 years.

10.36.1.4 TEST : The two-layer surface protection system shall be tested according to test provisions of IS:2645-2003 under a waterhead of 20 metres. The test shall be conducted at National Test House or at any other laboratory approved by the Engineer-in-charge.

10.36.1.5 CLEANING THE SURFACE : Surfaces shall be thoroughly cleaned to remove all growths, lime terrace, leveling concrete, plaster, dirt, laitance, any other loose or soft material and all other non-structural work to expose the surface of the structural concrete. Any grease, oil, paint, etc. shall be removed.

10.36.1.6 PREPARING THE SURFACE : The concrete surface shall be prepared for the waterproofing treatment by wetting the surface (to prevent absorption of acid) thoroughly and etching the surface leading to a rough texture similar to the texture of a fine grained sand paper. Excess acid shall be removed when it will stop reacting (formation of gas bubbles) with cement mortar in concrete, which may take 5-10 minutes. The surface shall be washed. Alternatively, the concrete surface is roughened with a water jet or by sand blasting or a polymer can be used to improve bond.

10.36.1.7 PREPARING THE PASTE OF CEMENT AND WATERPROOFING COMPOUND : 3 kg of waterproofing compound is mixed uniformly with 50 kgs of OPC or slag cement. Water (@ an approximate water/cement ratio of 0.35), small quantities at a time, is added to and mixed with the admixture of cement – waterproofing compound. A paste is thus formed.

10.36.1.8 PREPARING THE MORTAR FOR COVER PLASTER : The cement (OPC or slag)-sand mortar in the ratio of 1:4 is prepared in the normal way with the addition of water (@ a water-cement ratio of not higher than 0.4). Polyester fibre @ 0.20% by weight of cement is added as secondary reinforcement in making the cement-sand mortar. This mortar for the cover plaster is kept ready before the application of the paste of cement-waterproofing compound.

10.36.1.9 APPLICATION : The cleaned and etched surface is properly wetted and the excess water is removed. A 5 mm thick layer of the plaster of the cement-waterproofing compound is provided on the wet surface, followed by the application of the 12 mm thick cement-sand cover plaster when the first layer plaster of cement-waterproofing compound starts developing surface cracks. It normally takes about 10-20 minutes after the application of this first layer of plaster. The cracks in the first layer plaster are healed with the application of a gentle pressure with a trowel before the application of the cover plaster and an even finishing of the surface.

10.36.1.10 CURING : The treatment is cured with water for at least 7 days in the case of work with OPC and at least 14 days in the case of work with slag cement.

10.36.1.11 BRICK WALL : For the waterproofing of brick masonry surface, old plaster, if any, shall be removed. Then a 10 mm thick base plaster of cement-sand (1:4) mortar shall be applied and thoroughly cured for at least 3 days.

10.36.1.12 Prior to the application of the waterproofing treatment, all old grade concrete or screed concrete, old plaster and or waterproofing treatment, etc. shall be removed to expose the parent concrete surface. Removal and disposal of old screed concrete, plaster, old treatment, etc. will be paid for separately.

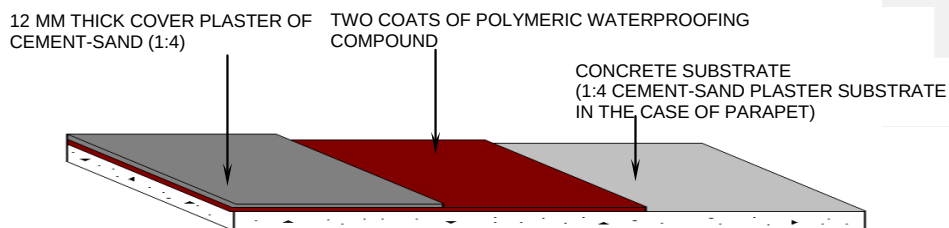
10.36.2 With Polymeric Waterproofing Compound :

10.36.2.1 Thorough cleaning of the surface to remove all loose materials, dirt, laitance, etc.; sealing all visible cracks (as a separate item); drying the surface naturally or mechanically; blowing away dust particles by electrically operated blower or sweeping with a cleaning brush; providing two coats (the second coat will be provided before the first coat becomes tack free) of a high performance polymeric waterproofing compound (sp. gr. 0.875, rosin content nil and a solid content of minimum 0.47%) of modified phenolic resins, which shall have the additional properties of resistance to chlorides and acids, @ 0.6 litre per square metre; preparing the surface of the second coat for the protective cover plaster by spraying and bonding dry coarse sand to the coated surface immediately on application of the second coat; removing

loose unbonded sand on the following day by light brushing or brooming; permitting the coatings to harden naturally for 3 - 7 days; the waterproofing treatment will be covered with a cement-sand (1:4) plaster 12 mm thick on roof, 8 mm thick on wall, containing polyester fibre as secondary reinforcement @ 0.20% by weight of cement; curing for at least seven days (in the case of plastering with OPC) or fourteen

days (in the case of plastering with slag cement); where slope will be required to prevent water logging on roofs, this can be provided, following the curing of the cover plaster, with a 1:3:4 concrete of appropriate thickness at extra cost; followed by curing as above. (Note : the cement-sand plaster is preceded by the application of a cement slurry)

10.36.2.2 Other Details :



SCHEMATIC VIEW

10.36.2.3 MATERIAL : The phenolic resin based material is miscible with MTO. It must have been in use in projects of Indian Railways for at least 3 years.

10.36.2.4 TEST : The waterproofing system shall have zero permeability when tested in accordance with test provisions of IS:2645-2003 under a waterhead of 20 metres. The test shall be conducted at National Test House or at any other laboratory approved by the Engineer-in-charge.

10.36.2.5 CLEANING AND PREPARING THE SURFACE : The concrete surface is cleaned thoroughly to remove all loose materials, dirt, laitance, etc., and it is permitted to dry naturally or mechanically. Dust particles are removed with an electrically operated blower or sweeping off with a hand brush.

10.36.2.6 SEALING CRACKS : All visible cracks shall be sealed (as a separate item).

10.36.2.7 APPLICATION : Honeycombed areas of the concrete surface are repaired and permitted to dry. A coat of the translucent brown coloured modified phenolic resin based single component polymeric waterproofing compound is applied with a bristle brush or a spray gun. As the coating dries naturally but before it becomes tackfree a second coat of the same material is applied with a bristle brush or a spray gun. Dry coarse sand is applied on the second coat when it is still wet. The

coatings are permitted to dry naturally for at least a day and excess sand is removed with a hand brush before the application of the cement-sand plaster. The coatings are permitted to dry naturally for at least two more days. In the event there will be rain before the application of the top coat, the rain water shall be removed, the surface permitted to dry, and the first coat pressed (not rubbed) with a piece of the finest grained emery paper before the application of the second coat. Before the application of the cover plaster, a cement slurry is provided. The cover plaster is cured for at least 7 days in the case of OPC, and for fourteen days in the case of slag cement.

10.36.2.8 PREPARING THE MORTAR FOR COVER PLASTER : The cement (OPC or slag)-sand mortar in the ratio of 1:4 is prepared in the normal way with the addition of water (@ a water-cement ratio of not higher than 0.4). Polyester fibre @ 0.20% by weight of cement is added as secondary reinforcement in making the cement-sand mortar.

10.36.2.9 CURING OF COVER PLASTER : The cover plaster is cured with water for at least 7 days in the case of work with OPC and for at least 14 days in the case of work with blended cement.

10.36.2.10 Prior to the application of the waterproofing treatment, all old grade concrete or screed concrete, old plaster and

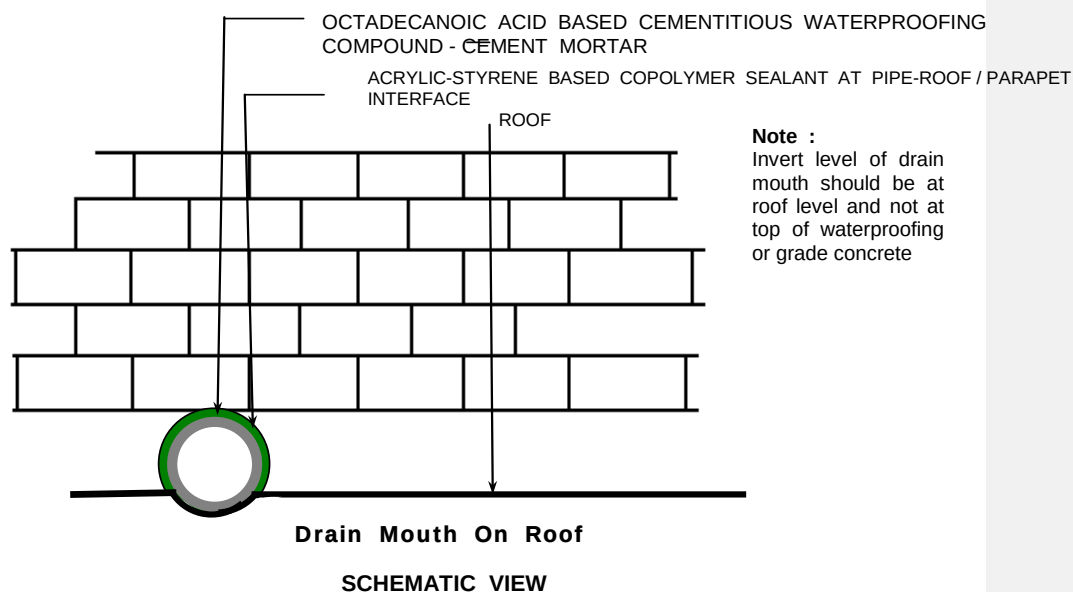
or waterproofing treatment, etc. shall be removed to expose the parent concrete surface. Removal and disposal of old screed concrete, plaster, old treatment, etc. will be paid for separately.

10.37 Making Drain Mouth On Roofs :

10.37.1 Lowering the drain mouth to the level of the concrete roof, where required; chipping off plaster around the drain mouth area; thorough cleaning; mixing thoroughly a cementitious waterproofing compound of octadecanoic acid, conforming to test provisions of IS:2645-2003, but with zero permeability, having a bulk density not more than 0.50 gm/cc, moisture content less than

2.0%, free fatty acid less than 0.2% and having the additional properties of making cement plasticized and less porous, in the weight ratio of 50 cement (OPC or slag) and 3 waterproofing compound; adding water (small quantities at a time) to the mixture to achieve a consistency for plaster work; wetting the surface to be waterproofed, fixing the drain piece; filling the annular space between the pipe and the structure with the paste of waterproofing compound and cement; sealing the edges of the drain mouth with acrylate-styrene based copolymer waterproofing compound, possessing excellent properties of resistance to water.

10.37.2 Other Details :



10.37.3 MATERIAL : The waterproofing material should be a powder that can be uniformly mixed with cement (OPC or slag) and it must have been in use in projects of Indian Railways for at least 6 years. The acrylic-styrene based copolymer must have a solid content of at least 49% and its elongation at break must be a minimum of 400%.

10.37.4 TEST : The waterproofing material shall have demonstrable property of waterproofing of structures; a 5 mm thick plaster of the material, when admixed with cement (OPC or slag) in the weight ratio of 3:50 and topped with a cement-sand cover plaster, shall prove to be impermeable

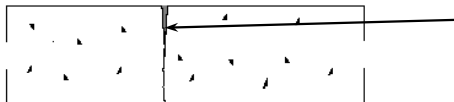
under a waterhead of 20 metres as in IS:2645-2003.

10.37.5 APPLICATION : A piece of the drain pipe is lowered at the roof level and put in position. In case it will be a plastic pipe, the outer surface of the pipe shall be treated to improve bond with cement. The surface of the structure surrounding the pipe is wetted with water. The annular space between the pipe and the surrounding structure is filled with a paste of cement, admixed with the waterproofing compound in the weight ratio of compound 3 and cement 50. Two coats of the acrylic-styrene copolymer are applied at the pipe-structure interface.

10.38 Sealing Of Cracks :

10.38.1 Making a V-shaped groove 8-10 mm wide and 3-5 mm deep; cleaning the surface; filling the groove with an acrylate-styrene copolymer waterproofing compound (initially diluted and then undiluted) having a density of 0.9, pH 7.0 to 8.0 and having properties (on setting) of excellent bond,

waterproofing and a minimum expandability (of dry film) of at least 200%; spreading dry coarse sand when the last application of the sealing compound will still be wet; removing the excess sand on the following day and letting the treatment to cure for at least a day before any surface waterproofing treatment on the roof.

10.38.2 Other Details :

Sealing Of Cracks

SCHEMATIC VIEW

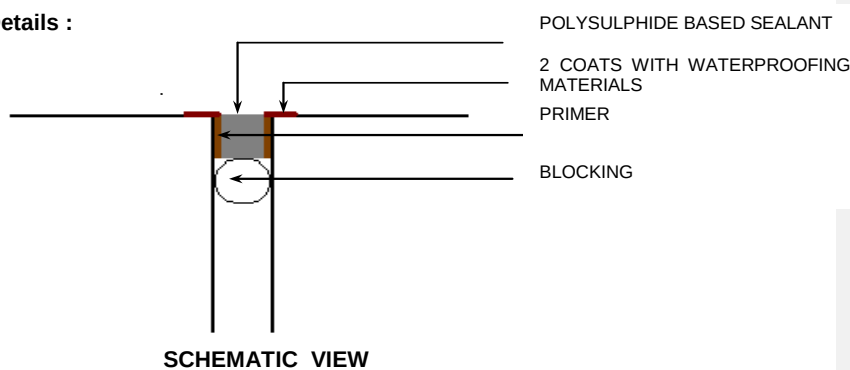
10.38.3 MATERIAL : The sealing material shall be a two-compound polymer in the case of the polysulphide or a single-component in the case of the acrylate-styrene copolymer. The acrylic-styrene based copolymer must have a solid content of at least 49% and its elongation at break must be a minimum of 400%.

10.38.4 APPLICATION : In the case of a polysulphide sealant, primer is applied on the surface of the groove, followed by filling of the groove with an intimate mix of the two component sealant. In the case of the acrylate-styrene copolymer, a 10% solution of the material is prepared in water. Filling the groove ensuring that there will be excess solution in the groove for at least 30 minutes, thereafter removing the excess quantity of the polymer in the groove and filling up the groove by repeated application of a 50% solution (in water) of the waterproofing compound. Each successive layer is provided when the previous layer will have dried up but would still be tacky. Dry coarse sand will be sprayed when the last application of the sealing compound will

still be wet. Excess sand is removed on the following day and the treatment is permitted to dry up for at least a day before the provision of any surface treatment on the roof.

10.39 Treatment of Expansion Joints :

10.39.1 Cleaning the joint and surfaces abutting the expansion joint, applying two coats of primer on the cleaned surfaces at the opening of the joint, filling the joint (to a depth equaling half the width) with the paste of a two-component polysulphide based sealant (with base-curing agent weight ratio of 12.33:1 and a sp. gr. of 1.60 ± 0.10 gm/cc, adhesion strength of over 0.40 N/mm² and a minimum elongation of 250% on curing for 24 hours); permitting the sealant to cure in natural air for at least a day, providing the edges of the treatment with two coats of a paste of octadecanoic acid based cementitious waterproofing compound and acrylic-styrene based copolymer waterproofing material in the weight ratio of 1:3.

10.39.2 Other Details :

10.39.3 SEALANT MATERIAL : It shall be a two component polysulphide sealant in the form of pastes. The two components shall have distinctly different colours to help as a guide to achieve uniform mixing prior to application.

10.39.4 CLEANING THE JOINT : The joint shall be cleaned to remove all foreign materials to a depth of at least half the width of the joint. All soft materials are removed from the two structural faces at the joint. The surface is permitted to dry completely.

10.39.5 PREPARING THE JOINT : The joint is provided with a backing material to facilitate filling up the outer part (to a depth equal to half the width of the joint) of the joint with the polysulphide sealing compound.

10.39.6 APPLICATION : the joint is permitted to dry completely. The two components of the sealing compound are mixed intimately to yield a uniform colour. Two coats of the primer are provided on each of the two structural faces at the joint. The joint, to a depth equalling half the width of the joint, is filled up with the paste of the sealing compound before the priming coats will lose their tackiness. The sealing compound is permitted to cure naturally for at least a day.

10.40 Roofing And Ceiling With Bamboo Mat Products : These are the New Eco-friendly construction materials in the market and relevant IS:- Code should be strictly followed. The brief description of materials is as below.

(1) **PRODUCT** : BAMBOO MAT BOARD (BMB) : ISI : 13958-1994 certified product

PRODUCT APPLICATIONS : False Ceiling & Ceiling Tiles

PRODUCT SIZES : 2' x 2' OR 0.595m X 0.595m, 6' x 3' OR 1.83m X 0.92m, 6' x 4' OR 1.83m X 1.22m & 8' x 4' OR 2.44m X 1.22m

PRODUCT THICKNESS : 4 MM

TECHNICAL DETAILS :



SL	Properties	4 MM
1.	Density	700kg/m ³
2.	Moisture Content	9%
3.	Internal Bond Strength	
	a) Dry State :	
	(i) Average	0.85 N/mm ²
	(ii) Minimum Individual	0.83 N/mm ²
	a) Wet State :	
	(i) Average	0.56 N/mm ²
	(ii) Minimum Individual	0.43N/mm ²
4.	Modulus of Rupture (Avg.)	74 N/mm ²
5.	Screw Withdrawal Strength	3200 N
6.	Tensile Strength	29 N/mm ²
7.	Thermal Conductivity	0.182 k.cal/m-°c

(2) **PRODUCT** : BAMBOO MAT CORRUGATED ROOFING SHEET (BMCS) – AS PER IS: 15476-2004

PRODUCT APPLICATIONS : Roofing

PRODUCT SIZES : 8' X 3½' OR 2.44m X 1.05m & 6' X 3½' OR 1.83m X 1.05m

PRODUCT THICKNESS : 3.5 MM – 4.0 MM

TECHNICAL DETAILS :



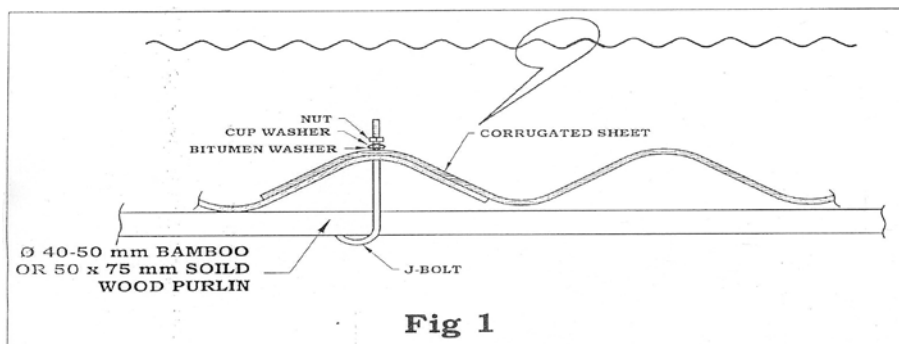
Properties	BMCS - IS: 15476 – 2004
Density	0.89 g/cm ³
Water Absorption (24 hrs)	2.9 %
Load Bearing Capacity: a) Dry State b) Wet State	5.65 N/mm 4.75 N/mm
Fire Resistance a) Flame penetration b) Rate of Burning c) Surface spread of flame, maximum area of char in mm ²	14 minutes 22 minutes 2353 mm ²
Impermeability	Conforms
Resistance to rolling weight	Conforms
Cyclic Test	No de-lamination
Thermal Conductivity	0.1928 k.cal/m-°c for BMCS and 0.3422 k.cal/m-°c for ACCS

10.40.1 FITTING & MAINTENANCE OF BAMBOO MAT CORRUGATED ROOFING SHEET (BMCS) :

- Coloured Polyurethane (P.U.) coated side should face the sun to resist severe heat and rain (Exterior).
- BMCS should be fixed to the purlins of structural members with J or L hook, bolt only and with proper nut, cup washer and

bituminous washer. No Nails or Screws to be used of any kind under any circumstances.

- All holes for fixing the J / L hook should be made with hand drill or Electric Drill machine. It should never be punched. Holes should be of exact size. No hammer to be used for fixing J – Hooks.



(3) PRODUCT : VENEERED BAMBOO PARTICLE BOARD – Both Side Commercial

Veneer SOGP GRADE II (Interior) : ISI : 3097 – 1980 certified product

PRODUCT APPLICATIONS : False Ceiling
& Ceiling Tiles

PRODUCT THICKNESS : 12 MM

TECHNICAL DETAILS :

PRODUCT SIZES AVAILABLE: 2' x 2' OR
0.595m X 0.595m & 8' x 4' OR 2.44m X
1.22m

SL.	Properties	Interior Grade Type (Grade II)
1.	Moisture Content	9 %
2.	Water Absorption	
	a) 2 Hr. Soaking	4 %
	b) 24 Hr. Soaking	30 %
3.	Swelling due to Surface Absorption (2 Hrs. immersion)	5.0 %
4.	Modulus of Rupture	32 N/mm ²
5.	Modulus of Elasticity (Avg. Value)	3000 N/mm ²

10.41 Roofing And Ceiling With Bamboo Jute Composites :

Bamboo mat / coir fibre felt / jute hessian shall be impregnated with resin by suitable means, dried and assembled (number of layers and combination of materials shall be

depending on thickness and end use) and hot pressed to get a final product in the density range of 1100-1500 kg/m³. After hot pressing, the sheets shall be conditioned at least for 24 hrs.

Table : 1 Dimensions and Tolerances

SL	Parameter	Dimension		Tolerances
		Corrugated	Semi-Corrugated	
1.	Depth of corrugation	25mm (min.)	25mm (min.)	± 2mm
2.	Pitch of per corrugation	120mm (min.)	150mm (min.)	± 3mm
3.	Nominal uniform thickness	2.5mm (min.)	2.5mm (min.)	+ 0.2/-0.0mm
4.	Length of sheet	1800mm (min.)	1800mm (min.)	± 10mm
5.	Width of sheet	900mm (min.)	900mm (min.)	± 10mm

Finish

The surface of the sheets shall be reasonably smooth and shall not have blisters or cracks.

The sheets shall not warp, split or delaminate.

The sheets shall be weather proof and durable against termites, borers and decay.

Specifications of Bamboo-Jute Composite Sheet

SL	Property	Requirement	Method of Test
i)	Specific Gravity g/cm ³	1.1 Minimum	Annexure 'B' (IS 15476)
ii)	Load Bearing Capacity a) Dry State b) Wet State	2.5 N/mm(min) 2.5 N/mm(min)	IS 5913
iii)	Water Absorption percent, Max	3	IS 15476
iv)	Impermeability	The lower surface shall not show any formation of drops of water except for traces of moisture.	IS 15476
v)	Resistance of Impact	To pass the test	Annexure 'C'
vi)	Resistance to Boiling Water, Max		

	a) Water Absorption percent. b) Increase in thickness percent	6.0 10.0	Annexure 'D' Annexure 'D'
vii)	Resistance to Frost	Shall not show signs of cracking	IS 5913
viii)	Cyclic Test	No delamination	IS 15476
ix)	Resistance to fire: 1) Flame penetration 2) Rate of Burning 3) Surface spread of flame maximum area of char in mm ²	Not less than 10 min Not less than 20 min 4500	Annexure 'E' (IS 15476)

10.42 ROOFING WITH ALUMINIUM SHEETS :

Aluminium standing seam or other trapezoidal sheeting, covered in Indian

Railways Schedule Of Rates should be governed by the properties given in the following table :

SL	Description of Sheet	Thickness	Width	Profile	Coating	Fixing Arrangement	Relevant Code
1.	Aluminium sheet made of 988 alloy	0.91 mm	1000 mm	Conforming to IS:254-1975	Mill finish	Fixed with G.I. J or L hooks with G.I. or Fibre washers etc. supported with M.S. wind ties	Alloy conforms to 48880 of IS-737-1974
2.	Aluminium sheet made of aluminium manganese alloy 5754 grade	0.70 mm	550 mm	46 mm crest height	Mill finish	Fixed to purlins with antistatic, Polyamide / Acetate brackets	
3.	Aluminium sheet made of aluminium manganese alloy 5754 grade	0.50 mm	975 mm	32 mm crest height	Mill or Stucco finish	Fixed to purlins with self drilling/self tapping zinc coated screws of required TPI	
4.	Aluminium sheet made of alloy EN-AW-3004	0.90 mm	400 mm	65 / 400 Profile	PIDF coating	Fixed to tophat or purlins with stainless steel ST clip L-50	BSEN 1396-2007

10.43 ROOFING WITH GALVALUME SHEETS :

10.43.1 MATERIAL :

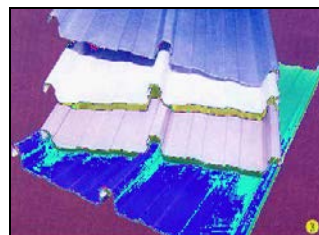
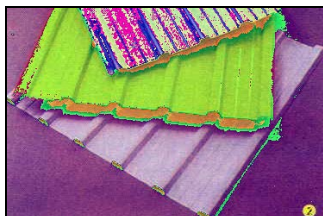
For Pre-painted Al-Zn alloy coated (GALVALUME) Sheeting the base metal i.e. CRCA steel thickness shall be 0.50 (+ / - 0.02) mm and steel shall comply with requirements of Gr. 60 as per ASTM A 792 M in terms of yield strength, ultimate tensile strength and percentage elongation. Basic steel shall be coated with an alloy of 55% Aluminium plus 43.5% Zinc by hot dip process to grade AZ 150 (150 gsm of alloy mass total both sides) as per ASTM A 792 M, skin passed to suitability for colour coating to achieve uniform high class paint finish and without burrs and / or edge defects. The Galvalume coils shall be pre-

painted by continuous coil coating process as detailed hereafter.

10.43.2 Colour Coating of GALVALUME SUBSTRATE :

The pre – treatment process shall be exclusively through dip tanks without use of any chemical coater at any stage and shall comprise of pre-cleaning by chemical soap water rinse, hot air-jet drying, tension levelling, activation dip, water cleaning, chromate conversion and final activation dip, in sequence. Pre-treatment shall be followed by a coat of special flexible primer (non epoxy) of avg. DFT 5 microns each on both surfaces, and, finished with a finish coat of Special Polyester with Anti-dirt property of avg. DFT 20 micron of standard colour and shade on the exposed surface, and Special Polyester hard coat grade polyester paint in

standard grey shade to an avg. DFT 5 micron on unexposed surface. The total pre-treatment and finish paint system shall be of EPG (external performance guarantee) – 20 grade. Coil coating mill test certificate registered for EPG-20 grade paint system shall be furnished.



ANNEXURE 10.1

GALVANISED STEEL SHEETS

1. Dimensions

1.0 Sizes of Plain Sheet: The plain sheets shall be supplied in any combination of the following lengths, widths and thicknesses.

- (a) Length : 2500 and 3000 mm
- (b) Width : 900 and 1000 mm
- (c) Thickness : 0.50, 0.63, 0.80, 1.00, 1.25 and 1.60 mm

1.1 In case of sheets supplied in coil, the internal diameter of coil shall be 450, 510 and 610 mm and the mass of each coil shall not exceed 12 tonne.

1.1.1 Coils weighing more than 12 tonnes may be supplied subject to mutual agreement between the contracting parties.

1.2 Corrugated Sheets

1.2.1 Length : The length of the corrugated sheets shall be as follows :

2500, 3000 mm

2 Zinc Coating

The weight of coating referred to in this specification shall represent the total weight of Zinc both sides inclusive.

On any sample selected at random from the delivery, one set of three samples each 50 x 50 mm or 50 mm diameter shall be selected at random from one sheet for every 500 G.S. sheets, the coating for the different classes shall be within the limits specified in **TABLE I** below :

TABLE I
MASS OF COATING (TOTAL BOTH SIDES)

Grade of Coating	Minimum average coating Triple spot test g/sqm	Minimum coating single spot test * g/sqm
750	625	550
600	500	425
450	350	300
375	275	250

*Minimum individual value obtained in triple spot test.

3 Mass

The mass of sheets and coils shall be calculated as given in **TABLE II** on the basis of nominal dimensions and mass of zinc coating.

TABLE II
CALCULATION OF MASS OF SHEETS OR COILS

Type of materials	Order of calculation	Method of Calculation	Number of Numerals in resultant value
Sheet	Mass of single sheet	Nominal mass of single sheet plus mass of zinc coating	Rounded off to 4 effective figures
	Total mass	Mass of single sheet (kg) x number of sheets	Rounded off to integral value of kg
Coil	Unit mass of coil	Unit mass of sheet (kg x m ³) x width (mm) x 10	Rounded off to 3 effective figures
	Mass of single coil Total mass (kg)	Unit mass of coil (kg/m) x length (m) Total mass of each coil	Integral number of (kg)

Note : 1. Nominal mass of single sheet shall be calculated by calculating the volume of the sheet and multiplying the same with density of sheet (density 7.85 g/cubic cm) and rounding the same to 4 effective figures.

2. Mass of coating shall be calculated by multiplying the

surface area of single sheet with indicated nominal coating mass (g/square metre) as shown for triple spot test (Table I).

3. For calculation of corrugated sheet mass, the width before corrugation shall be considered while calculating the area.

Sample calculation for mass

(i) 0.63 mm thick sheet (Grade of coating 750)

a) Size 2.50 x 0.90 m with minimum average coating of 625 Gms/Sqm on both sides

$$\begin{aligned} \text{mass of single sheet} &= \left[2.50 \times 100 \times 0.90 \times 100 \times \frac{0.63}{10} \times \frac{7.85}{1000} \right] + \left[\frac{2.50 \times 0.90 \times 625}{1000} \right] \\ &= 11.127 \text{ Kg} + 1.406 \text{ kg} \\ &= 12.533 \text{ kg} \end{aligned}$$

b) Size 3.00 x 0.90 m (Grade of coating 750) with minimum average coating of 625 Gms/Sqm on both sides

$$\begin{aligned} \text{mass of single sheet} &= \left[3.00 \times 100 \times 0.90 \times 100 \times \frac{0.63}{10} \times \frac{7.85}{1000} \right] + \left[\frac{3.00 \times 0.90 \times 625}{1000} \right] \\ &= 13.353 \text{ kg} + 1.688 \text{ kg} \\ &= 15.041 \text{ kg} \end{aligned}$$

4. Corrugations

The depth of corrugation shall be 18 mm and shall have a pitch of 75mm (nominal). The number of corrugations shall be 8, 10 or 11

per sheet. The overall width of the sheet before and after corrugation shall be as the dimensions given in **TABLE III** below :

TABLE III
DETAILS OF CORRUGATIONS

Number of Corrugations	Nominal overall width of sheet measured between crowns of outside corrugations	
	Before corrugation mm	After corrugation mm

(1)	(2)	(3)
10	900	800
11	1000	885

ANNEXURE 10.2**DIMENSIONAL DETAILS OF ASBESTOS ROOFING SHEETS**

SL	Dimension	AC Corrugated Sheet	AC Semi Corrugated Sheet
(1)	(2)	(3)	(4)
1.	Overall Width	1.05 m	1.09m
2.	Laid Width	1.01 m	1.02m
3.	Cover Efficiency		
	(Allowing for side & end laps of 3.05 m sheet)		
	Actual cover for 3.05 m sheet as laid	2.92 sqm	2.94 sqm
4.	9.29 sqm laid area requires sheeting of area... (Allowing for side and end laps with 3.05m sheet)	10.22 sqm (approx.) App 10% for laps	10.59 sqm. (approx.) App 14% for laps
5.	9.29 sqm laid area requires sheeting of area (Allowing for loss by side and end laps with 1.83 m sheet)	10.59 sqm. (approx.) App 15% for laps	10.96 sqm (approx.) App 18% for laps
6.	Weight of 9.29 sqm as laid	161.93 kg	150.59 kg
7.	Standard lengths	1.52m, 1.83m, 2.13m 2.44m, 2.74m, 3.05m	1.52m, 1.83m, 3.05m 2.44m, 2.74m, 3.05m
8.	Maximum Purlin spacing	1.68m	1.68m
9.	Maximum Spacing of Rails for side cladding	1.98m	1.98m
10.	Horizontal laps (Side lap)	0.15m	0.15m

Asbestos – Cement Roofing Accessories

<u>For Association with Corrugated Sheets</u>	<u>For Association with Semi- Corrugated Sheets</u>
Close Fitting Adjustable Ridge	Serrated Adjustable Ridge
Serrated Adjustable Ridge	Unserrated Adjustable Ridge for Hips
Unserrated Adjustable Ridge for Hips	Plain Wing Adjustable Ridge

Plain Wing Adjustable Ridge	Northlight Adjustable Ridge
Northlight Adjustable Ridge	One Piece Plain Angular Ridge
One Piece Plain Angular Ridge	Ridge Finial for all Ridges except BS.2 and TS.17
Ridge Finial for BS.2 Ridge only	Apron Piece
Ridge Finial for all Ridges except BS.2 and TS.17	Eaves Filler Piece
Apron Piece	Northlight Curve
Eaves Filler Piece	Cowl Type Ventilator
Northlight Curve	'S' Type Louvre
Cowl Type Ventilator	Corner Piece or Barge Board
'S' Type Louvre	Left Hand Curved Barge Board for Northlight Curve
Corner Piece or Barge Board	Right Hand Curved Barge Board for Northlight Curve
Left Hand Curved Barge Board for Northlight Curve	Expansion Joint for Northlight Curves
Right Hand Curved Barge Board for Northlight Curve	Expansion Joint for Sheets
Roof Light	Expansion Joint for Ridges
Roof Light used as Northlight Glazing	Roof Light
	Roof Light used as Northlight Glazing

ANNEXURE 10.3**BITUMEN FELT (GLASS FIBRE BASE)****1. Weight**

The weight of the ingredients used in the manufacture of glass fibre felts for 10 square metre shall not be less than those specified in **Table I**.

TABLE I
MINIMUM WEIGHT OF BITUMEN GLASS FIBRE BASE FELT

SL	Type of felt	Untreated base	Treated base	Coatant	Total weight in dry condition including surfacing materials
		(kg)	(kg)	(kg)	(kg)
1.	Type 2 Gr. I	0.4	-	15.3	18.0

2. Sampling

All the rolls of the same type and grade and from the same batch of manufacture, in one consignment shall constitute a lot. The conformity of the lot to the requirements of this standard shall be determined on the

basis of the inspection and test carried out on the samples selected from the lot. The number of rolls to be selected from a lot shall depend upon the size of the lot and shall be in accordance with **Table II**.

TABLE II
SAMPLE SIZE AND CRITERION OF CONFORMITY

No. of rolls in the lot	No. of rolls to be selected in the sample	Permissible no. of defective rolls	Sub-sample size, no. of rolls to be selected
1	2	3	4
Upto 100	5	0	2
101 to 150	8	0	3
151 to 300	13	0	4
301 to 500	20	1	5
501 to 1000	32	2	6
1001 to 3000	50	3	8
3001 and above.	80	5	10

- Note : 1. All the rolls taken as per column 2 shall be inspected for width, length and visible external defects.
2. The rolls taken as per column 4 shall be tested for breaking strength, pliability, storage sticking, heat resistance, water absorption and pressure head.

These rolls shall be taken at random from the lot, and in order to ensure randomness of selection, random number tables may be used. In case random number tables are not available, the following procedure may be adopted for the selection of the rolls.

Starting from any roll in the lot count them as 1,2,3,... r and so on, in one order. Every r^{th} roll thus counted may be selected till the

requisite number of rolls for the sample is obtained, 4 being the integral part of N/n , where N is the number of rolls in the lot and n the number of rolls to be selected in the sample.

From each of these rolls one test sample 3 m long and the full width of the felt shall be cut out for preparing test specimens. Test samples shall not be taken from damaged portion of the rolls, if any. The required number of test specimens shall be taken from each of the test samples and subjected to the corresponding tests.

3. **Tests** - The samples, when tested as per IS: 7193 shall conform to the requirements given in **Table III**.

TABLE III
REQUIREMENTS OF GLASS FIBRE FELTS

SL	Type of Felt	Minimum Breaking strength kg.		Pliability Test	Storage sticking test	Heat Resistance test	Pressure head test	Water absorption test Max.
		Wrap way	Weft way					
1.	Type 2 (Grade 1)	50	30	i) The roll shall not show cracks on unrolling ii) Consider any surface rupture exceeding 5mm in length as failure	The test pieces shall be examined after cooling After release of the load, the layers of felt shall be capable of being separated without damaging the coatant in any way	The test pieces shall show no sign of melting of the bitumen compound --	The test pieces shall show no sign of leakage --	2.0% --

4. Criteria for conformity

The lot shall be considered to be in conformity with the requirements of the standard if the following conditions are satisfied.

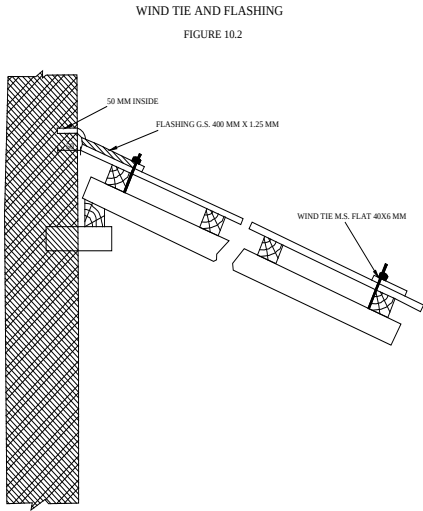
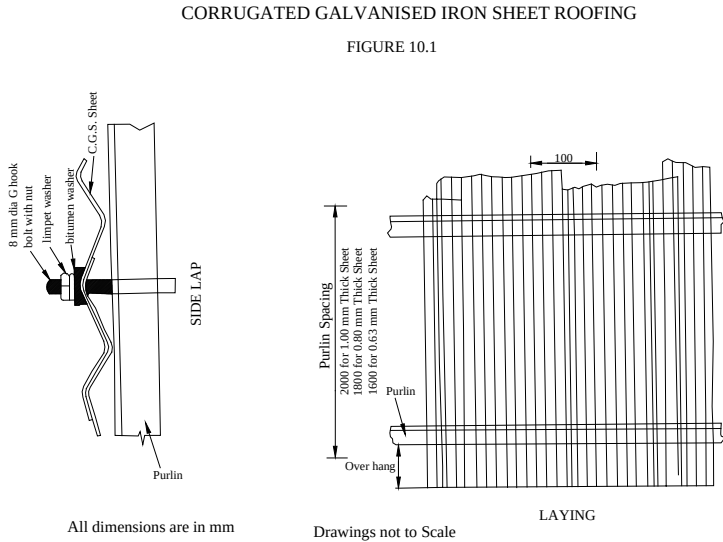
- (a) The number of rolls found defective with respect to width, length and visible external defects do not exceed the corresponding number given in column 3 of Table II.
- (b) From the observed values of breaking strength, the average X and the range R are calculated for each direction (that is, warp way and weft way) separately and the value of the expression $X - 0.6 R$ is

found to be greater than or equal to the applicable specified value.

Note 1. Average X is the value obtained by dividing the sum of the observed values by the number of observed values.

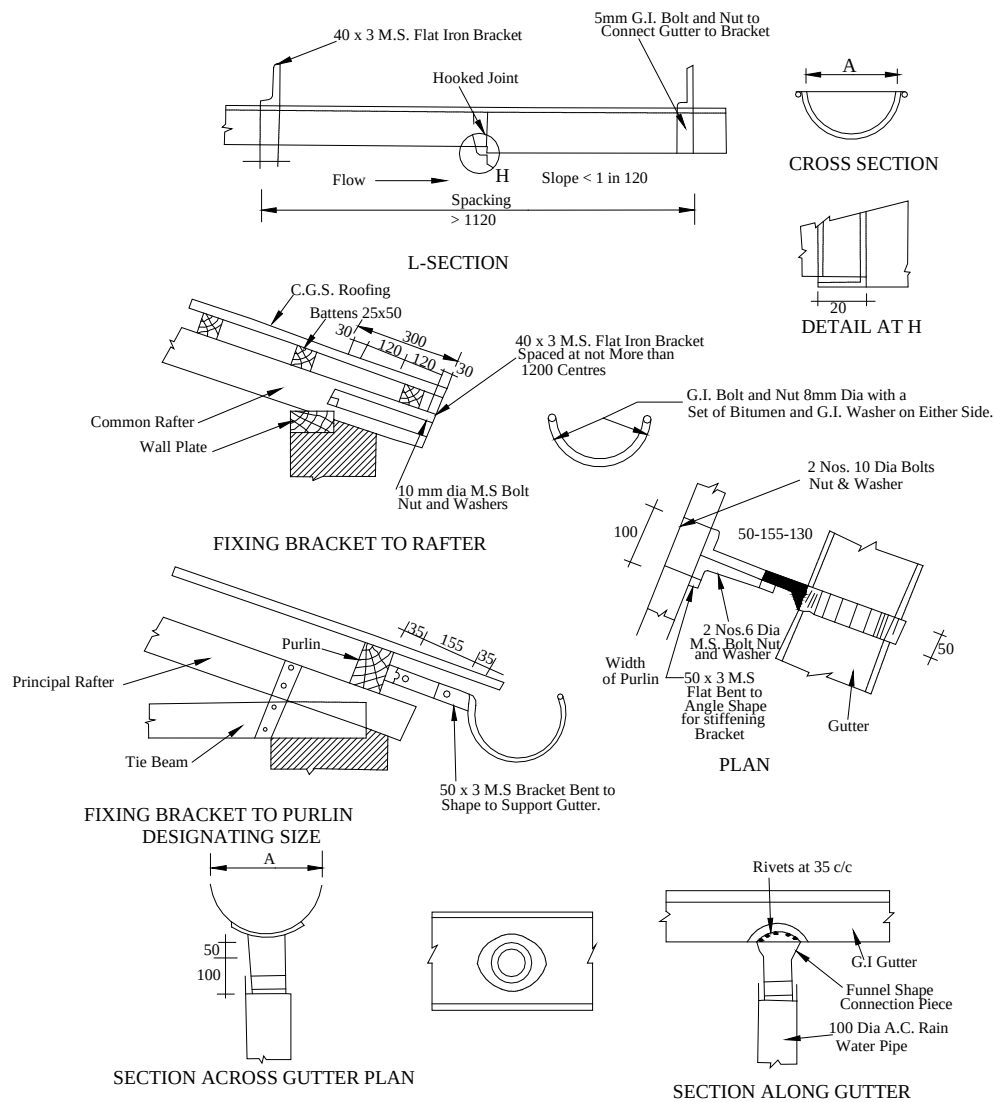
2. Range R is the difference between the maximum and minimum in a set of observed values.

- (c) For all the other characteristics (except breaking strength) all the test pieces satisfy all the requirements of the characteristics individually.



GUTTERS OF PLAIN GALVANISED STEEL SHEETS

FIGURE 10.3



All dimensions are in mm

Drawings not to Scale

AC CORRUGATED SHEET ROOFING
EXPLANATORY FIGURES

FIGURE 10.4 A to E

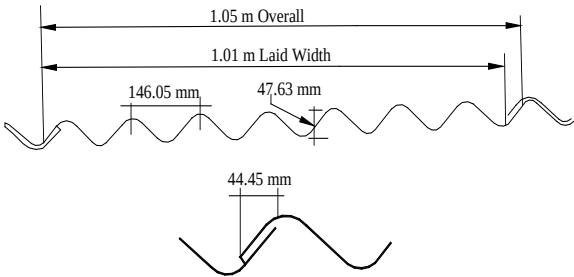


FIG. 10.4 (A) SECTION OF A.C. CORRUGATED SHEET SHOWING SIDE LAP

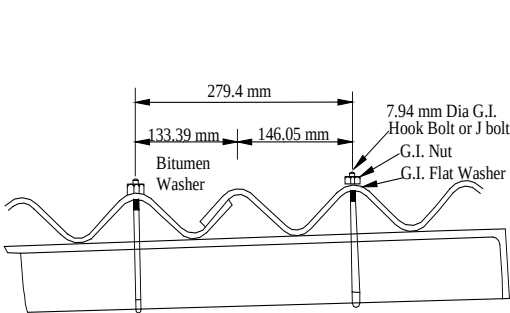


FIG. 10.4 (B) FIXING A.C. CORRUGATED SHEET

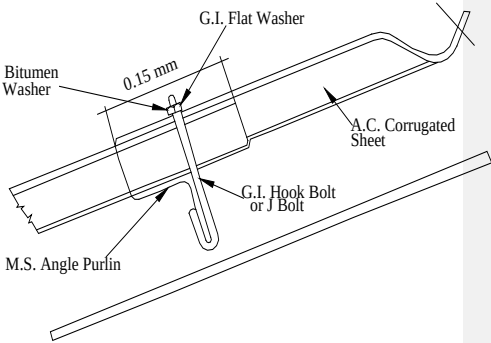


FIG. 10.4 (C) METHOD OF FIXING G.I. HOOK BOLT

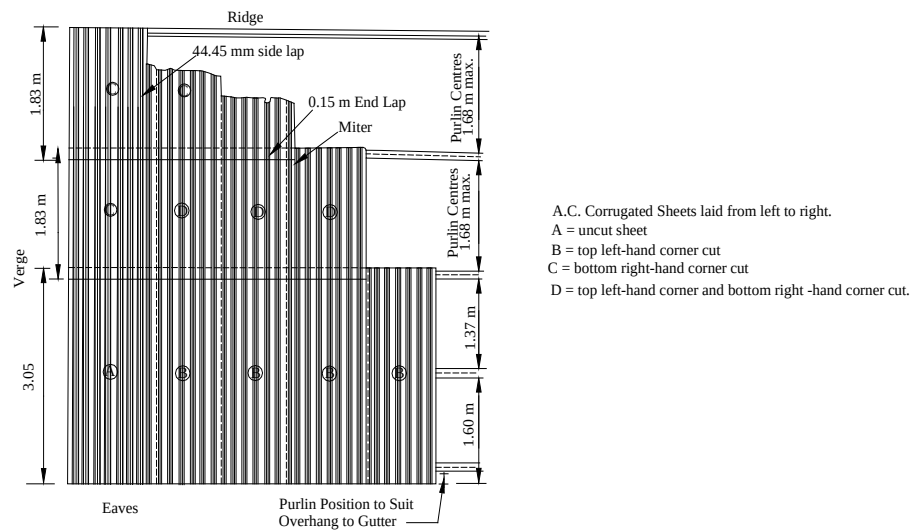


FIG. 10.4 (D) METHOD TO BE ADOPTED FOR LAYING A.C. CORRUGATED SHEETS

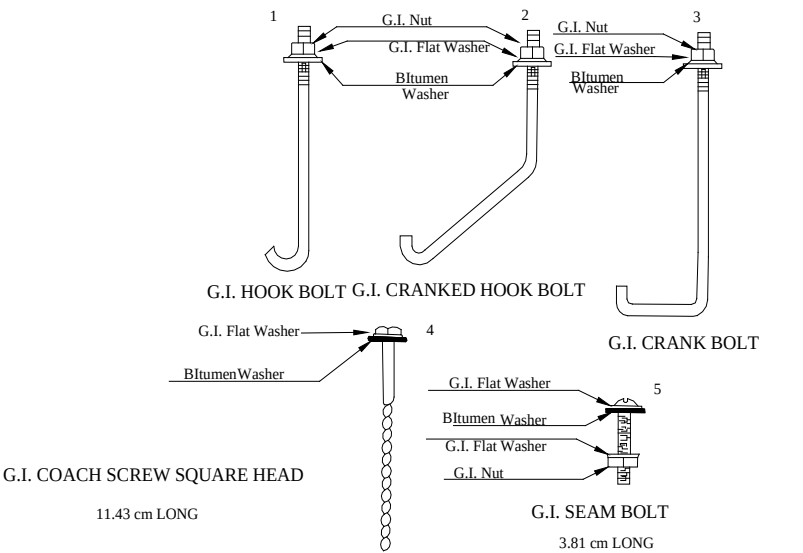


FIG. 10.4 (E) ACCESSORIES FOR FIXING A.C. CORRUGATED & SEMI CORRUGATED SHEETS

AC SEMICORRUGATED SHEET ROOFING
EXPLANATORY FIGURES
FIGURE 10.5 A to D

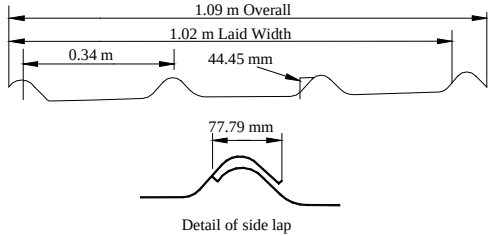


FIG.10.5 (A) SECTION OF SEMI CORRUGATED TRAFFORD SHEET SHOWING SIDE LAP
Method of Fixing J Bolts to A.C. Semicorrugated sheets

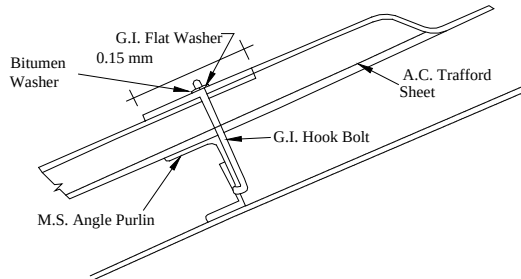


FIG.10.5 (B) FIXING HOOK BOLT / J BOLT TO A.C. SEMI CORRUGATED SHEET

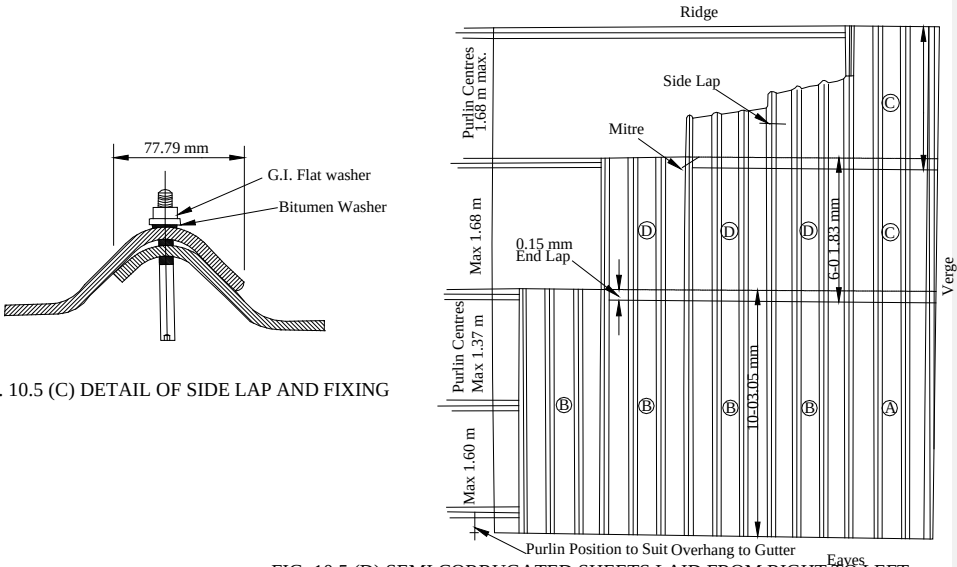


FIG. 10.5 (C) DETAIL OF SIDE LAP AND FIXING

FIG. 10.5 (D) SEMI CORRUGATED SHEETS LAID FROM RIGHT TO LEFT

A = uncut sheet
B = top right-hand corner cut
C = bottom left-hand corner cut
D = top right-hand corner and bottom left -hand corner cut.

RIDGES AND HIPS OF AC SHEET ROOFING
EXPLANATORY FIGURES

FIGURE 10.6 A to H

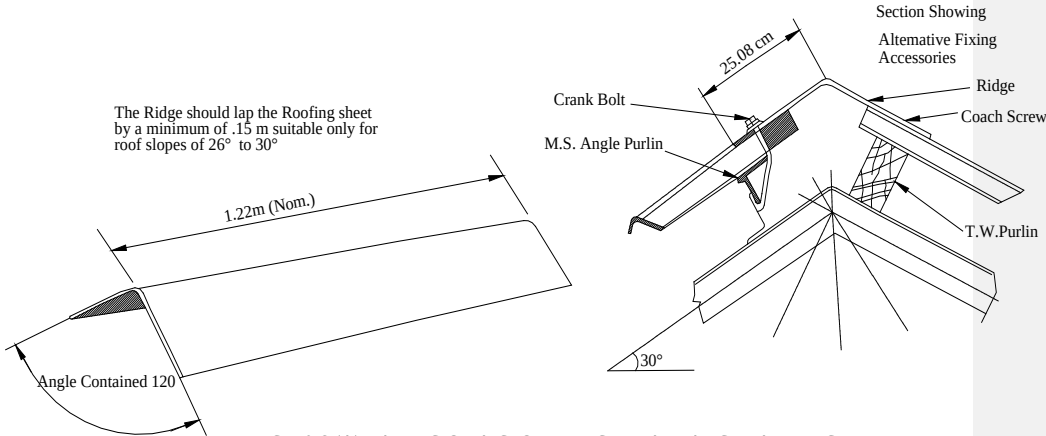


FIG. 10.6 (A) LAYING OF A.C. ONE PIECE PLAIN ANGULAR RIDGE

Adjustable type Ridge Cappings are supplied in pairs-R1 (inner) and R2 (outer). These ridges have certain serrations painted black and when fixing, these serrations should be arranged at side lap joints of the sheets, in which case the stagger-lapping of the two wings of this ridge will be automatic

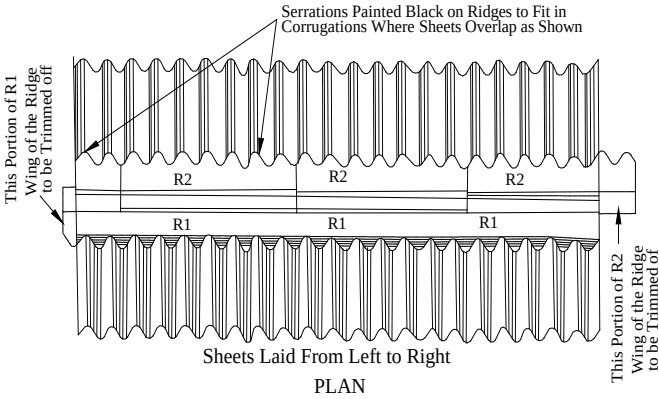


FIG. 10.6 (B) LAYING OF A.C. CORRUGATED SERRATED ADJUSTABLE RIDGES

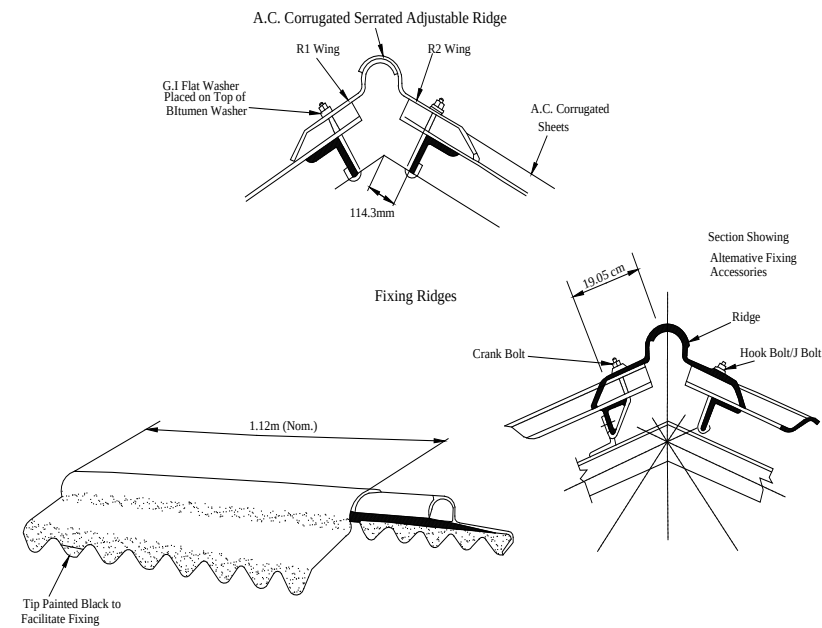


FIG. 10.6 (B) CONTD. LAYING OF A.C. CORRUGATED SERRATED ADJUSTABLE RIDGES

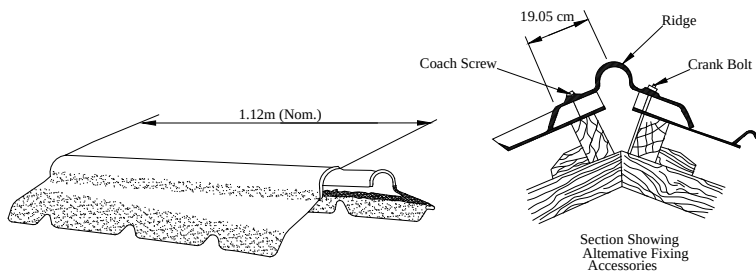


FIG. 10.6 (C) LAYING OF AC CORRUGATED SERRATED ADJUSTABLE RIDGE

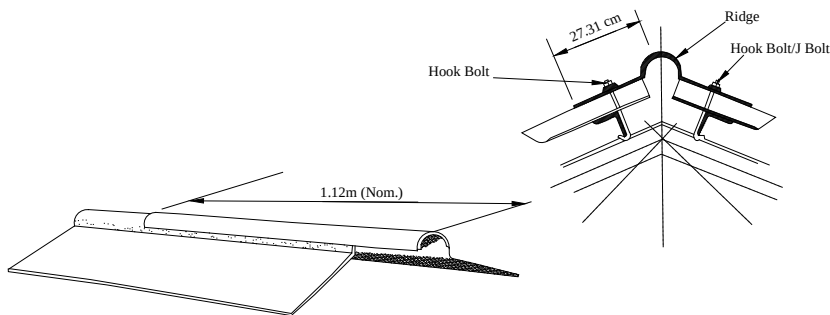


FIG. 10.6 (D) LAYING OF AC PLAIN WING ADJUSTABLE RIDGE

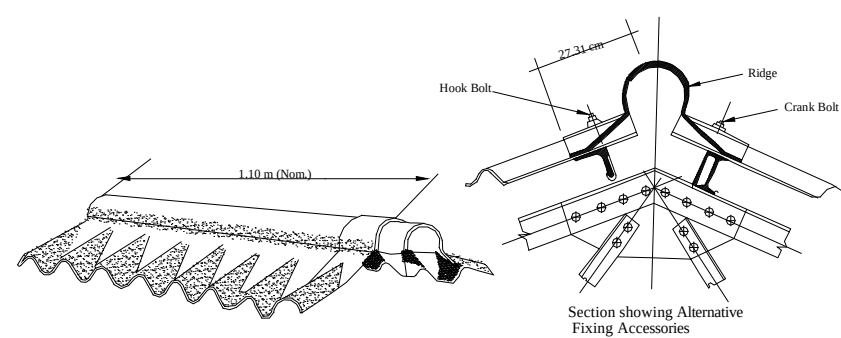


FIG.10.6 (E) LAYING OF AC CORRUGATED CLOSE FITTING ADJUSTABLE RIDGE

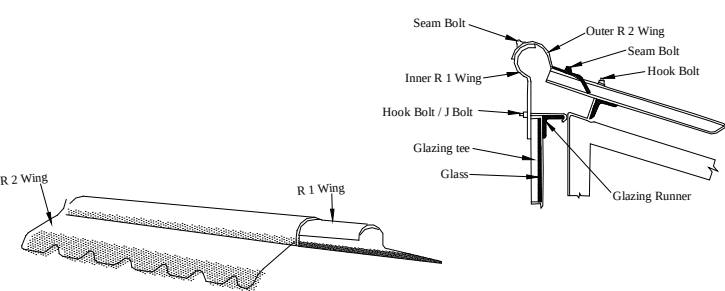


FIG. 10.6 (F) LAYING OF AC CORRUGATED NORTH LIGHT TWO PIECE ADJUSTABLE RIDGE

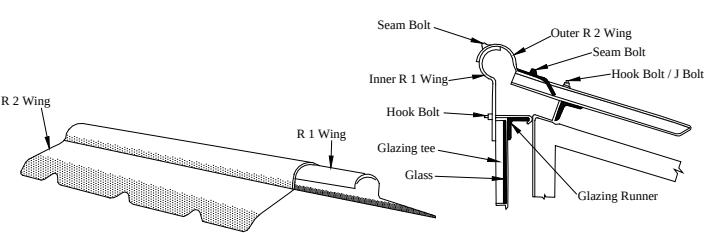


FIG. 10.6 (G) LAYING OF AC SEMI CORRUGATED NORTH LIGHT TWO PIECE ADJUSTABLE RIDGE

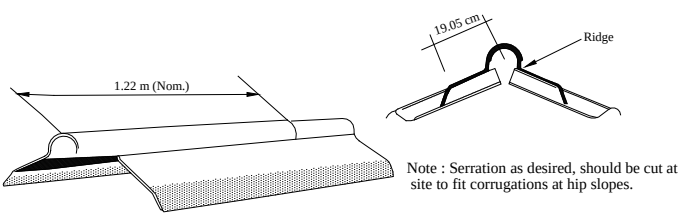
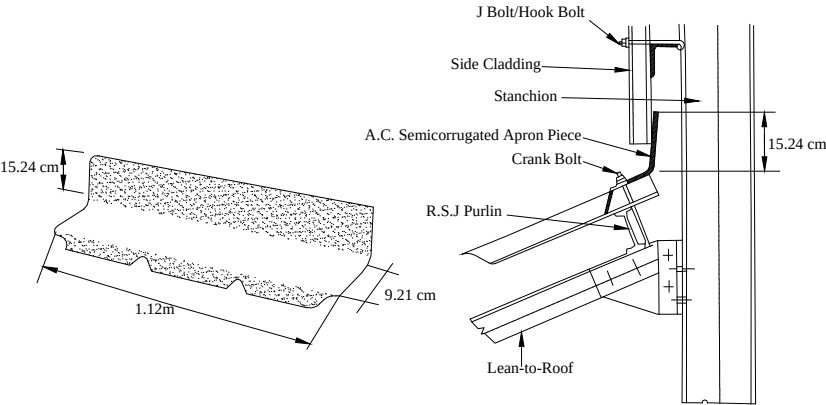
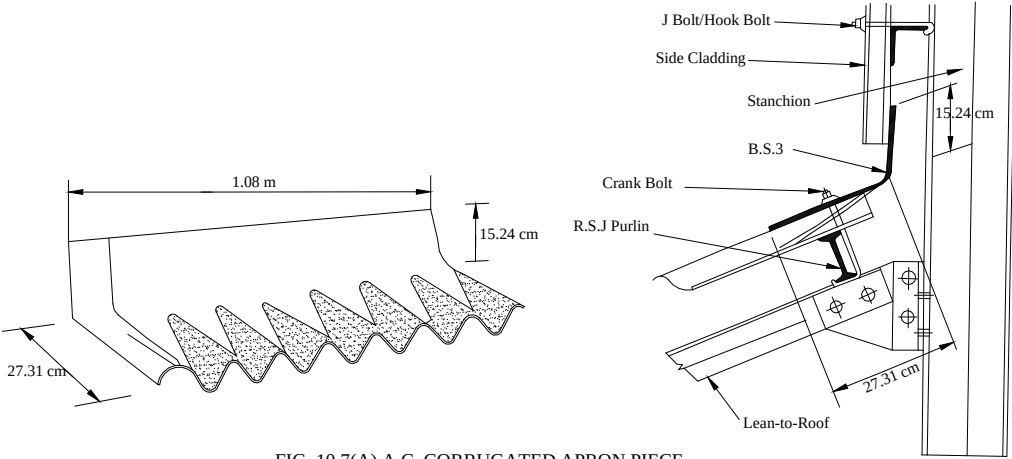


FIG. 10.6 (H) LAYING OF AC UNSERRATED ADJUSTABLE RIDGE FOR HIPS

AC SHEET ROOFING - OTHER ROOFING ACCESSORIES AND
MANNER OF FIXING

FIGURE 10.7 A to R



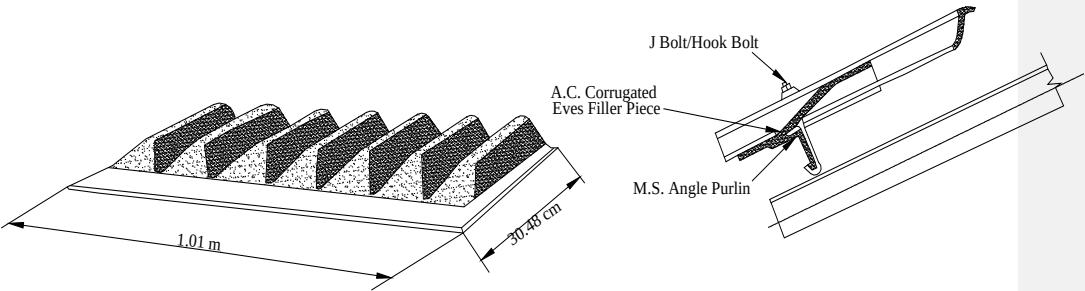


FIG.10.7 (C) A.C. Corrugated Eaves Filler Piece

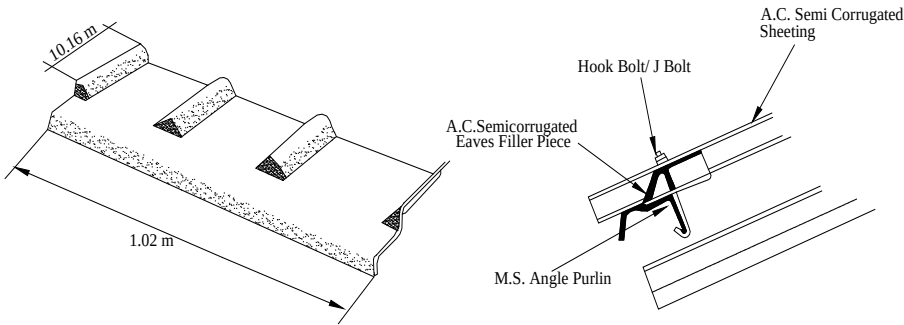


FIG.10.7 (D) A.C Semi-Corrugated Eaves Filler Piece

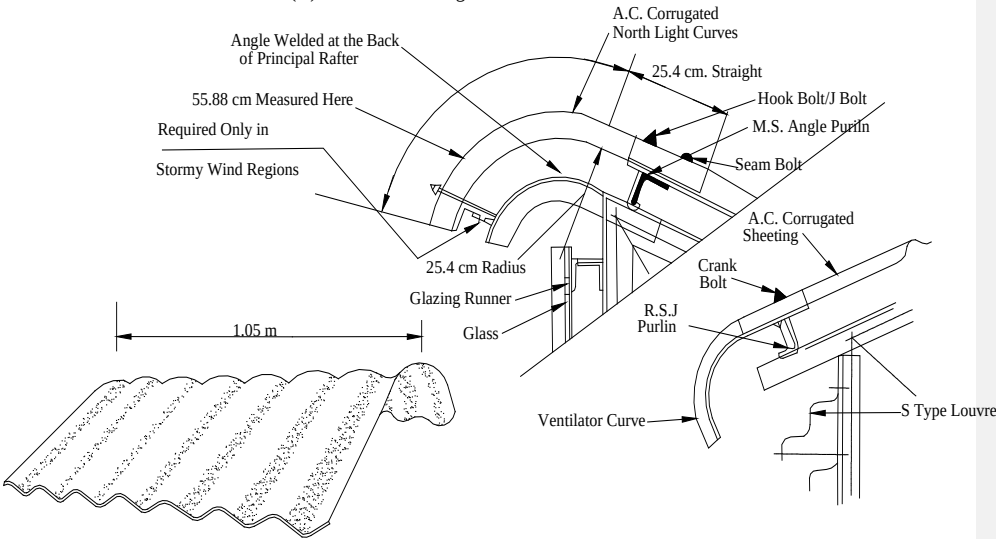


FIG.10.7 (E) A.C. Corrugated North Light Curves

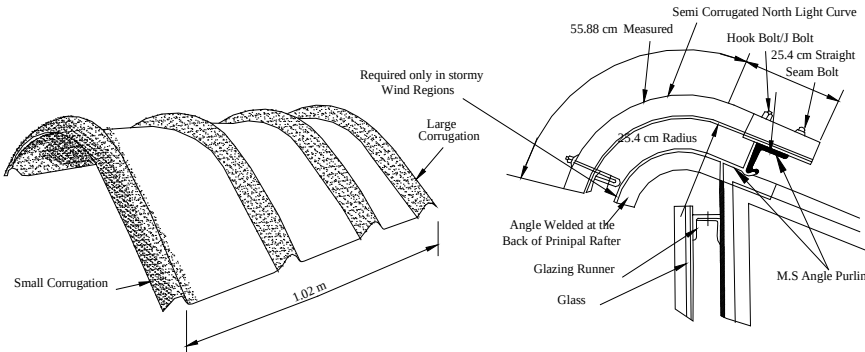


FIG.10.7 (F) A.C. SEMI CORRUGATED NORTH LIGHT CURVE

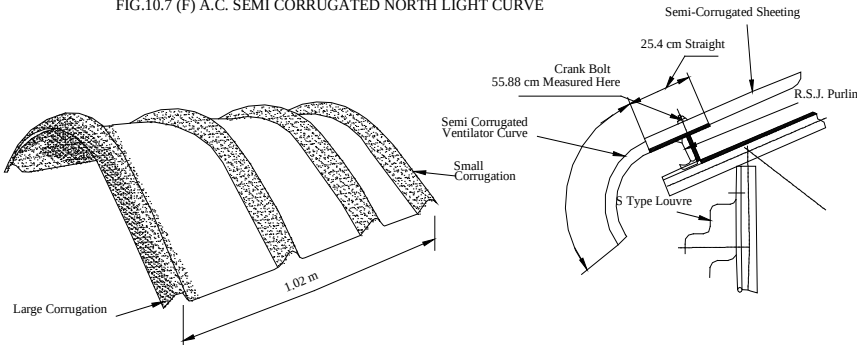


FIG.10.7 (G) A.C. SEMI CORRUGATED VENTILATOR CURVE

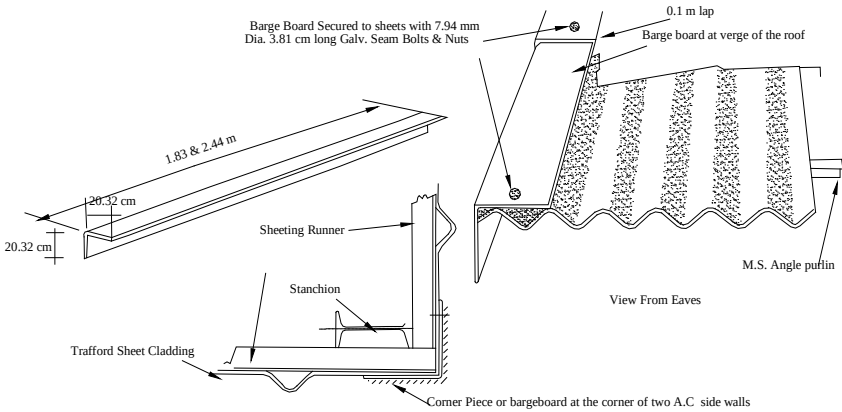


FIG. 10.7 (H) A.C. BARGE BOARD OR CORNER PIECE

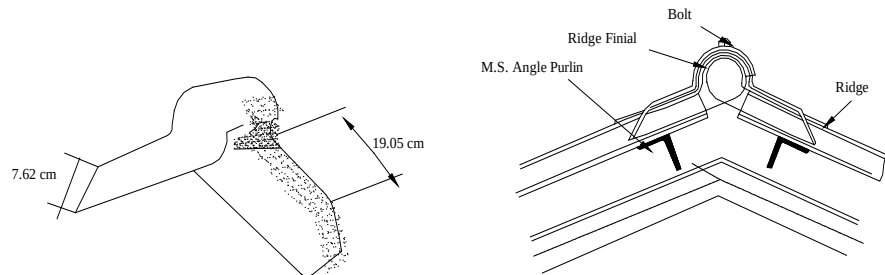


FIG. 10.7 (I) RIDGE FINIAL

For use with all Ridges Except close fitting adjustable ridge and one piece plain angular ridge

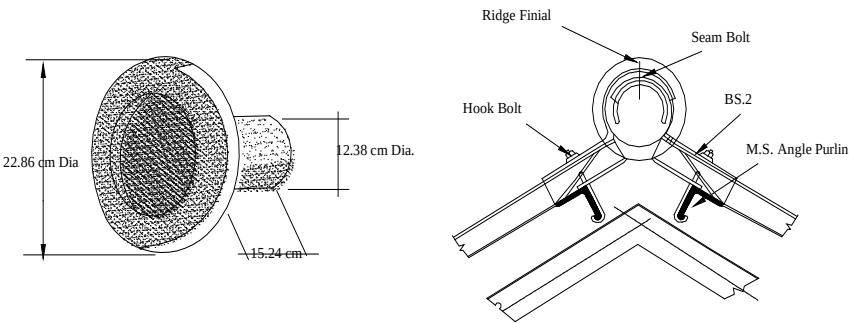


FIG. 10.7 (J) AC RIDGE FINIAL

For use Adjustable Ridge

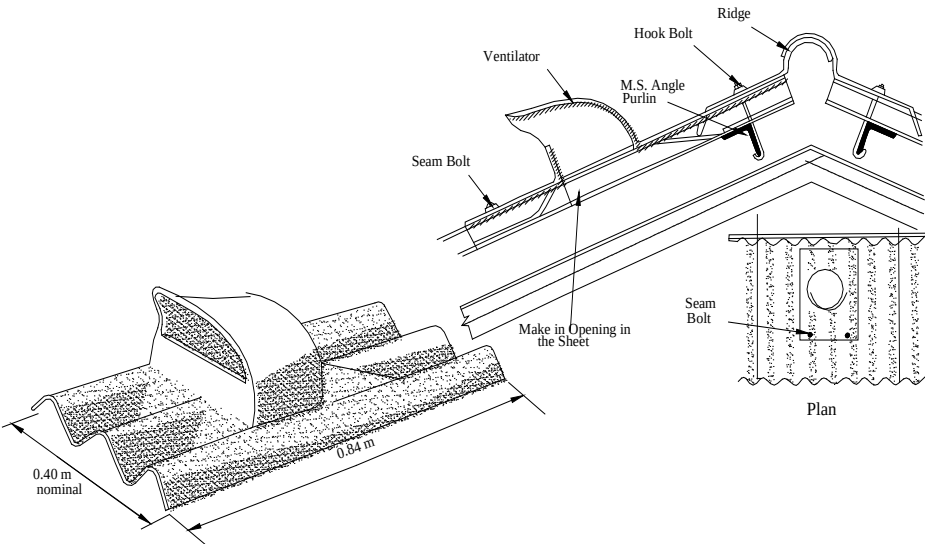


FIG.10.7 (K) AC CORRUGATED COWL TYPE VENTILATOR

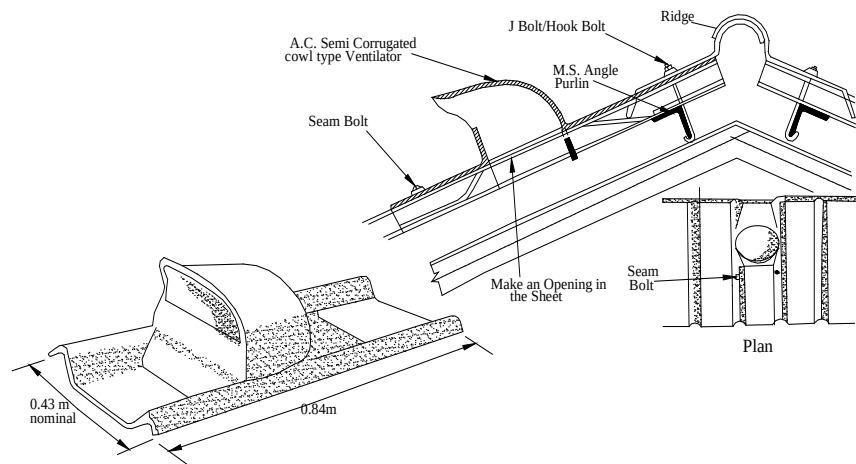


FIG. 10.7 (L) AC SEMI CORRUGATED COWL TYPE VENTILATOR

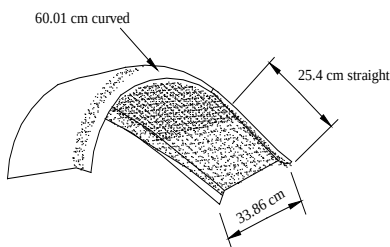


FIG. 10.7 (M) Expansion joint for Northlight Curves

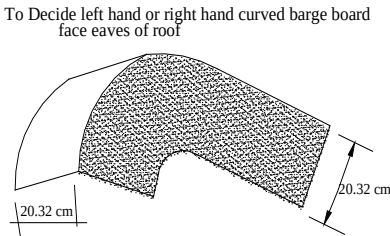


FIG. 10.7 (N) Curved Bargeboards for Northlight Curves
Left Hand/Right hand

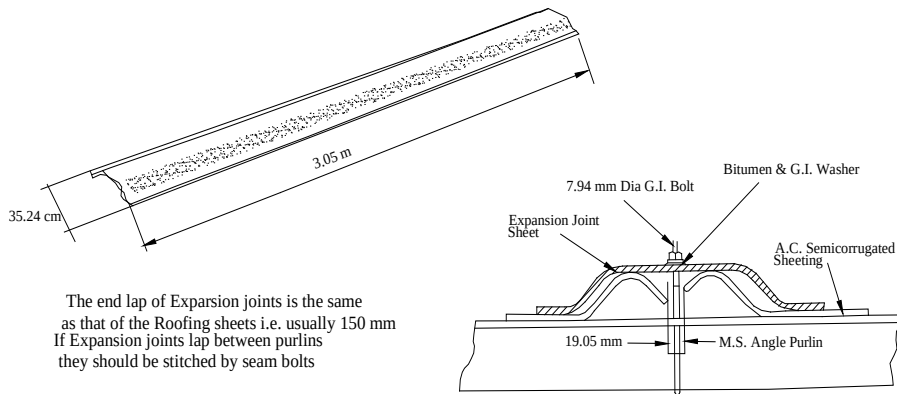


FIGURE 10.7 (O) AC EXPANSION JOINT FOR SEMI CORRUGATED SHEETS

Note : To be used on a semi-corrugated roof alongwith semi-corrugated sheet serrated adjustable ridge

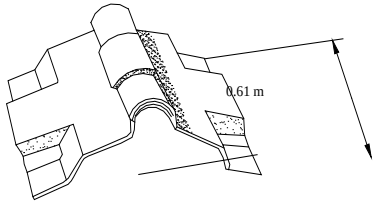


FIG 10.7 (P) AC EXPANSION JOINT FOR RIDGE

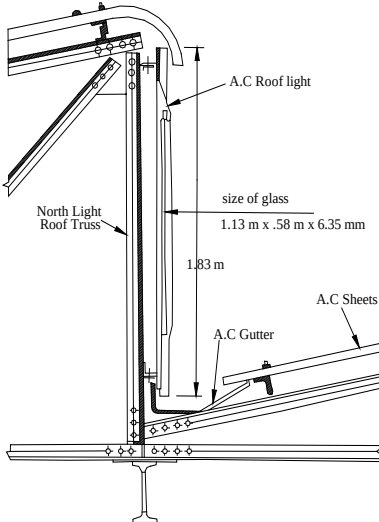


FIG. 10.7 (Q) AC ROOF LIGHTS USED AS NORTHLIGHT GLAZING

The area of opening admitting light is approximately 30% of a Asbestos Cement sheet as laid. By comparison with full glass glazing the advantages of an A.C Rooflight used as glazing are the elimination of glazing tees, putty, pins and clips.

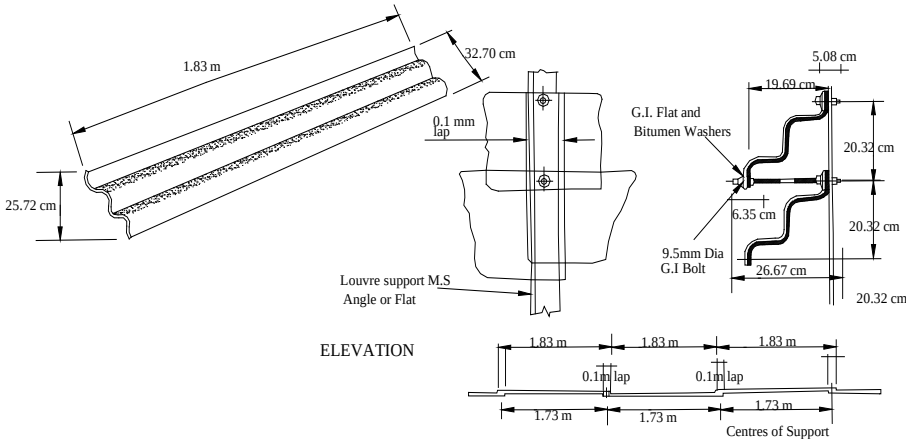
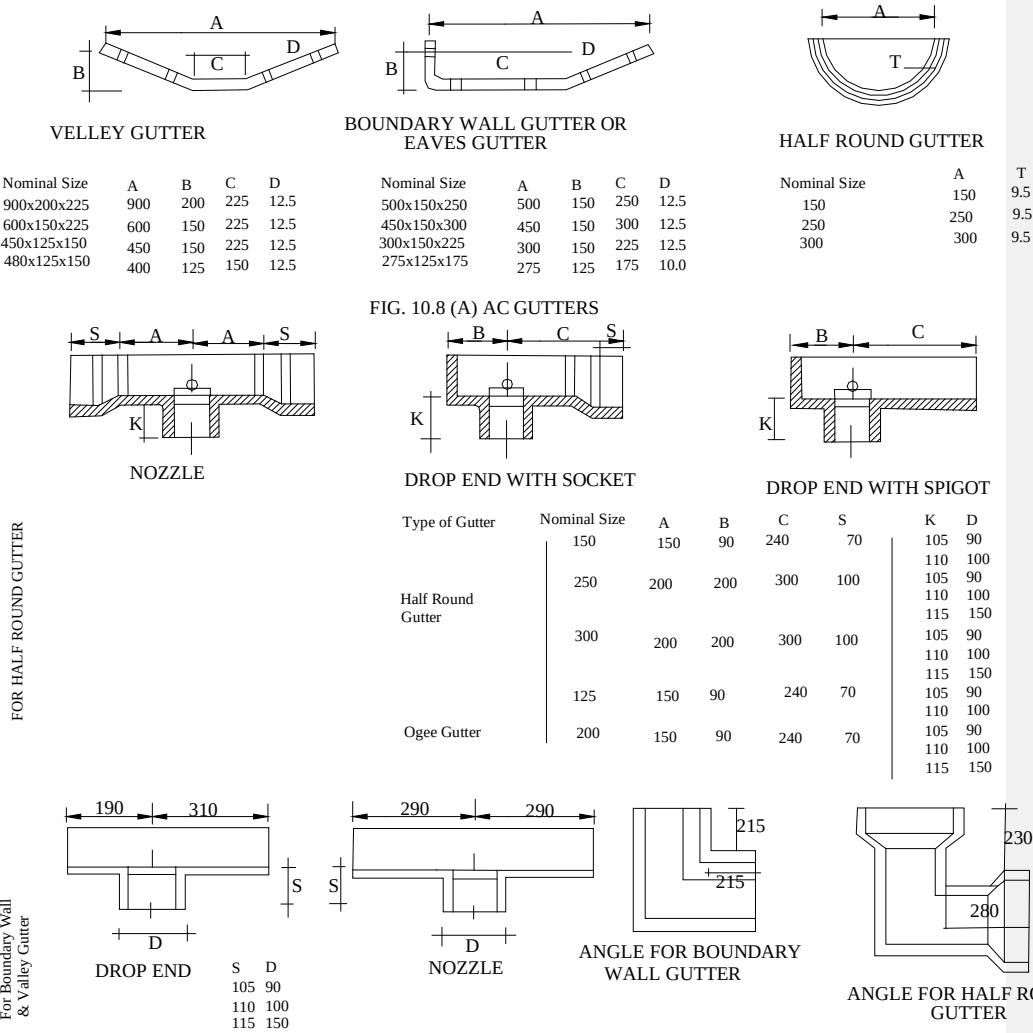


FIG. 10.7 (R) AC 'S' TYPE LOUVRE

LINE DIAGRAM AHOWING LAPPING OF LOUVRES

AC GUTTER AND ACCESSORIES ROOFING
EXPLANATORY FIGURES

FIGURE 10.8 A to H



Drawings are not to scale

FIG.10.8 (B) GUTTER ACCESSORIES

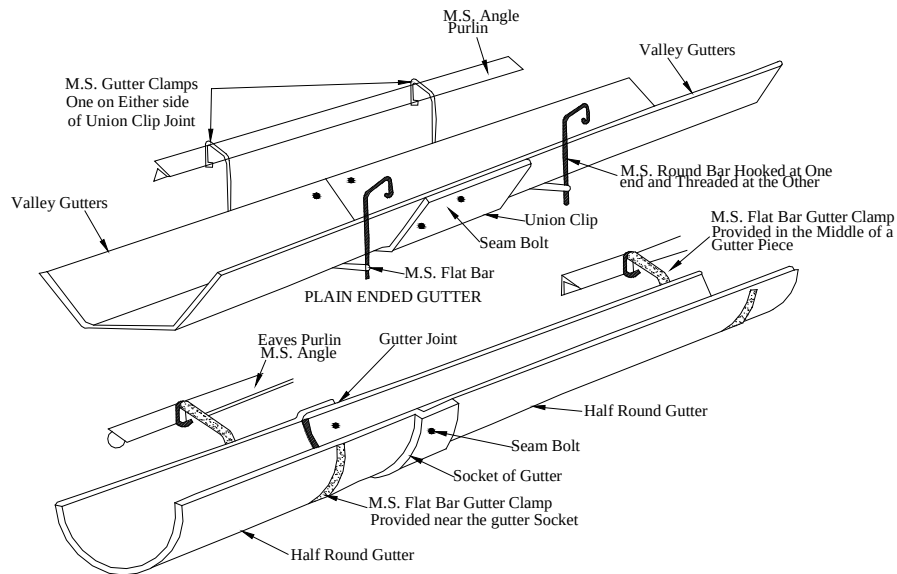


FIG. 10.8 (C) SIPGOT & SOCKET END GUTTER-POSITION OF GUTTER BRACKETS

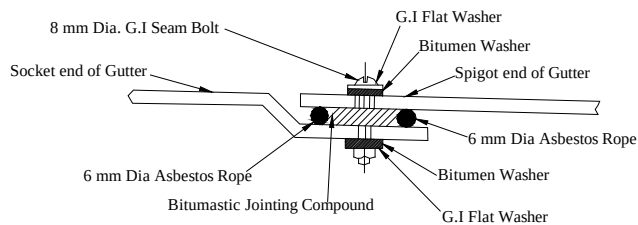


FIG. 10.8 (D) Method of Joing Spigot & Socket end Gutters & Accessories

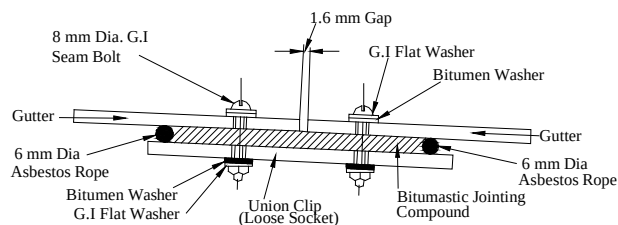


FIG.10.8 (E) Method of Joining Plan Ended Gutters & Accessories

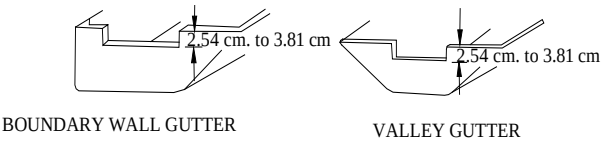


FIG. 10.8 (F) CUTTING OVERFLOW NOTCH FOR DROPENDS AND STOPENDS

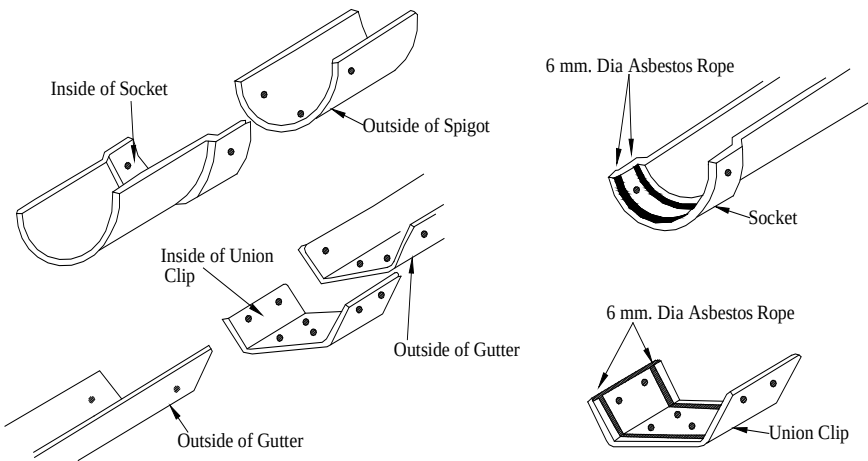


FIG. 10.8 (G) SPIGOT & SOCKET GUTTER & PLAIN END GUTTER WITH UNION CLIP

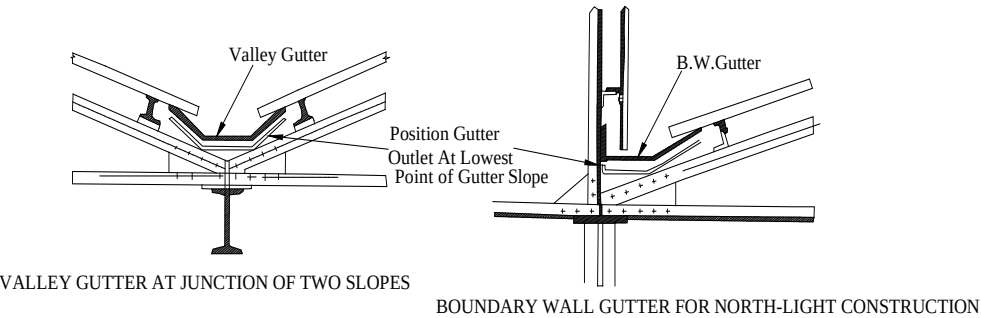
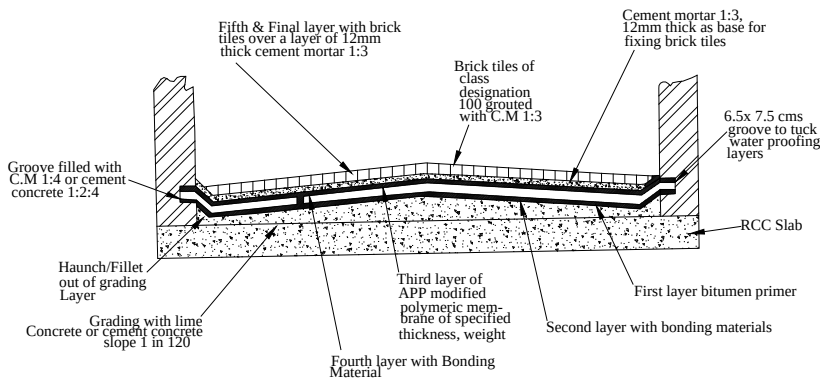


FIG. 10.8 (H) POSITIONING OF GUTTER AT JUNCTION & NORTH LIGHT PORTION

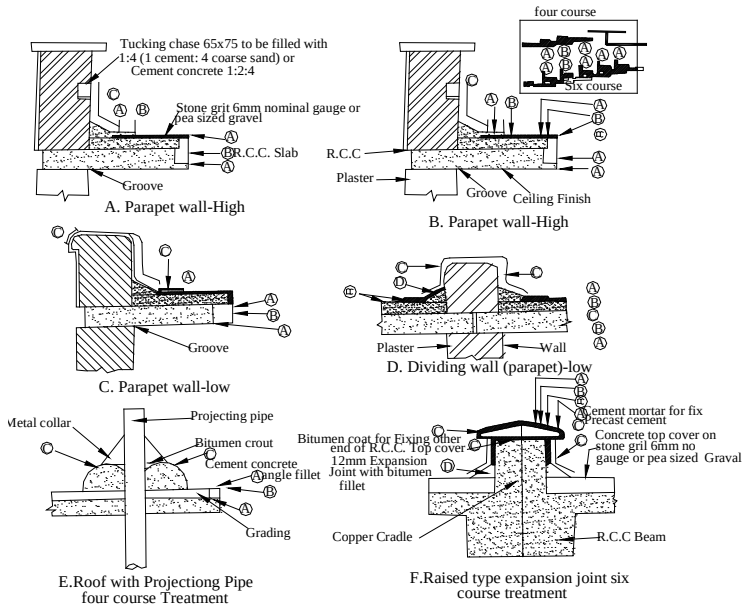
FIGURE 10.10 A



Five Course Water Proofing Treatment with APP Modified Polymeric Membrane

WATER PROOFING WITH BITUMEN FELT

FIGURE 10.10 B



- (A) Bitumen at 1.45 kg/m²
- (B) Bitumen Felt @ Bitumen at 1.20 kg/m²
- (C) Bitumen primer 8 coats
- (D) 75x75 Angle fillet lime concrete concrete/cement concrete

All dimensions are in mm

Drawings not to Scale

CEMENT CONCRETE GOLA & KHURRA

FIGURE 10.11A & B

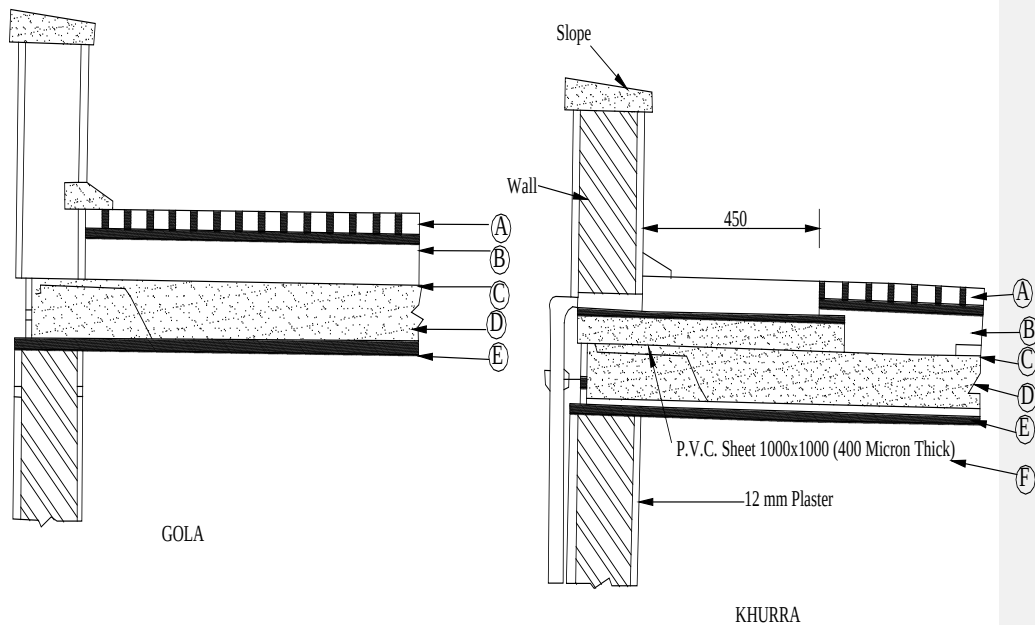


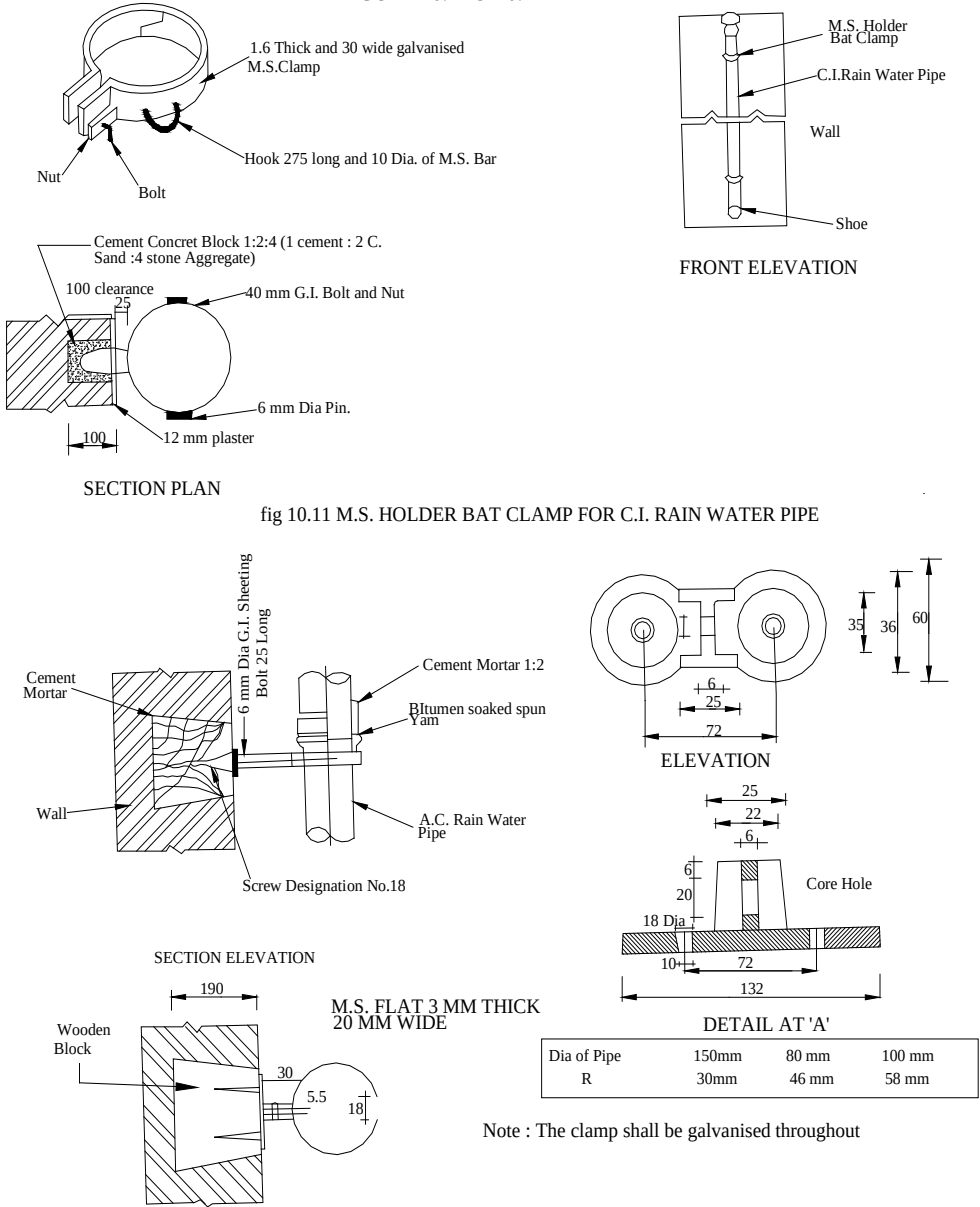
FIG 10.11 A GOLA

FIG. 10.11 B KHURRA

- Ⓐ Brick Tiles
- Ⓑ Mud Phuska/Lime Concrete
- Ⓒ Painting with hot bitumen 80/100 at 1.7 kg/sq. cm
- Ⓓ R.C.C. Slab
- Ⓔ 6mm thick ceiling plaster finished neat and thick coat of white washing or craft paper
- Ⓕ P.V.C. Sheet 1000 x 1000 (400 micron thick)

HOLDING CLAMPS FOR CI & AC RAIN WATER PIPES

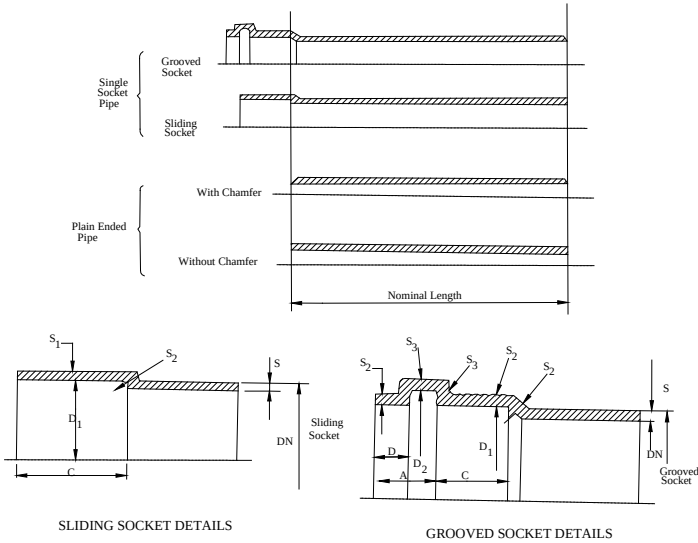
FIGURE 10.11 & 10.12



All dimensions are in mm Drawings not to Scale

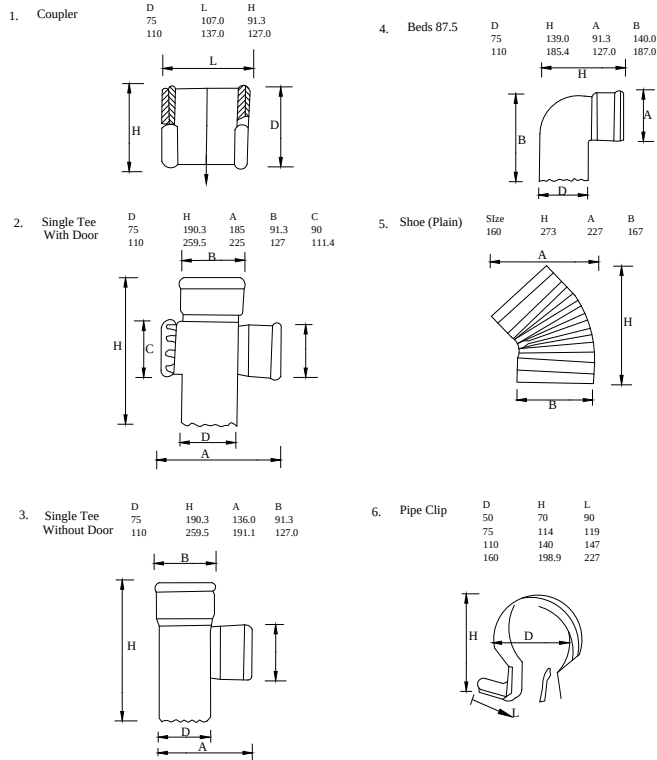
UPVC RAIN WATER PIPES

FIGURE 10.13



FITTING FOR UPVC RAIN WATER PIPES

FIGURE 10.14



Chapter 11

Finishing - Masonry

11.1 GENERAL PLASTER

11.1.1. Scaffolding : For all exposed brick work or tile work in important works, double scaffolding independent of the work having two sets of vertical supports shall be provided. The supports shall be sound and strong, tied together with horizontal pieces over which scaffolding planks shall be fixed.

For all other brick work in buildings, single scaffolding shall be permitted. In such cases the inner end of the horizontal scaffolding pole shall rest in a hole provided only in the header course for the purpose. Only one header for each pole shall be left out. Such holes for scaffolding shall, however, not be allowed in pillars/columns less than one metre in width or immediately near the skew backs of arches. The holes left in masonry works for scaffolding purposes shall be filled and made good before plastering.

In case of special type of brick work, scaffolding shall be got approved from the Engineer in advance.

11.1.2. Preparation of Surface : The joints shall be raked out properly. Chapter on Brick Work and Chapter on Stone Work may be referred to for details. Dust and loose mortar shall be brushed out. Efflorescence if any shall be removed by brushing and scrapping. The surface shall then be thoroughly washed with water, cleaned and kept wet before plastering is commenced.

In case of concrete surface, if a chemical retarder has been applied to the form work, the surface shall be roughened by wire brushing and all the resulting dust and loose particles cleaned off and care shall be taken that none of the retarders is left on the surface.

11.1.3 Mortar : The mortar of the specified mix shall be used.

11.1.4 Application of Plaster -

11.1.4.1 Ceiling plaster shall be completed before commencement of wall plaster.

11.1.4.2 Plastering shall be started from the top and worked down towards the floor. All put-log holes shall be properly filled in advance of the plastering as the scaffolding is being taken down. To ensure even thickness and a true surface, plaster about 15 x 15 cm shall be first applied, horizontally and vertically, at not more than 2 metres

intervals over the entire surface to serve as gauges with the help of aluminium /steel straight edges. The surfaces of these gauged areas shall be truly in the plane of the finished plaster surface. The mortar shall then be laid on the wall, between the gauges with trowel. The mortar shall be applied in a uniform surface slightly more than the specified thickness. This shall be beaten with thin strips of bamboo about one metre long to ensure thorough filling of the joints, and then brought to a true surface, by working a wooden straight edge reaching across the gauges, with small upward and side ways movements at a time. Finally the surface shall be finished off true with trowel or wooden float according as a smooth or a sandy granular texture is required. Excessive troweling or over working the float shall be avoided. During this process, a solution of lime putty shall be applied on the surface to make the later workable.

11.1.4.3 All corners, arrises, angles and junctions shall be truly vertical or horizontal as the case may be and shall be carefully finished. Rounding or chamfering corners, arrises, provision of grooves at junctions etc. where required shall be done without any extra payment. Such rounding, chamfering or grooving shall be carried out with proper templates or battens to the sizes required.

11.1.4.4 When suspending work at the end of the day, the plaster shall be left, cut clean to line both horizontally and vertically. When recommencing the plastering, the edge of the old work shall be scrapped, cleaned and wetted with lime putty before plaster is applied to the adjacent areas, to enable the two to properly join together. Plastering work shall be closed at the end of the day on the body of wall and not nearer than 15 cm to any corners or arrises. It shall not be closed on the body of the features such as pilasters, bands and cornices, nor at the corners or arrises. Horizontal joints in plaster work shall not also occur on parapet tops and copings as these invariably lead to leakages. No portion of the surface shall be left out initially to be patched up later on.

11.1.5. Finish : The plaster shall be finished to a true and plumb surface and to the proper degree of smoothness as required. The work shall be tested frequently as the work proceeds with a true straight edge not

less than 2.5 m long and with plumb bobs. All horizontal lines and surfaces shall be tested with a level and all jambs and corners with a plumb bob as the work proceeds.

11.1.6. Thickness : The thickness of the plaster specified shall be measured exclusive of the thickness of key i.e. grooves or open joints in brick work. The average thickness of plaster shall not be less than the specified thickness, (here 12 mm). The minimum thickness over any portion of the surface shall not be less than the specified thickness by more than 3 mm. The average thickness should be regulated at the time of plastering by keeping suitable thickness gauges. Extra thickness required in dubbing behind rounding of corners at junctions of wall or in plastering of masonry cornices etc. will be ignored.

11.1.7. Curing : Curing shall be started 24 hours after finishing the plaster. The plaster shall be kept wet for a period of seven days. During this period, it shall be suitably protected from all damages at the contractor's expense by such means as the Engineer may approve. The dates on which the plastering is done shall be legibly marked on the various sections plastered so that curing for the specified period thereafter can be watched.

11.1.8. Precaution : Any cracks which appear in the surface and all portions which sound hollow when tapped, or are found to be soft or otherwise defective, shall be cut out in rectangular shape and redone as directed by the Engineer.

i) When ceiling plaster is done, it shall be finished to chamfered edge at an angle at its junction with a suitable tool when plaster is being done. Similarly when the wall plaster is being done, it shall be kept separate from the ceiling plaster by a thin straight groove not deeper than 6 mm drawn by any suitable method in the wall while the plaster is green.

ii) To prevent surface cracks appearing between junctions of column/beam and walls, 150 mm wide chicken wire mesh should be fixed with U nails 150 mm centre to centre before plastering the junction. The plastering of walls and beam/column in one vertical plane should be carried out in one go. For providing and fixing chicken wire mesh with U nails payment shall be made separately.

11.1.9 Measurements

11.1.9.1 Length and breadth shall be measured correct to a cm and the area shall

be calculated in square metres correct to two places of decimal.

11.1.9.2 Thickness of the plaster shall be exclusive of the thickness of the key i.e. grooves, or open joints in brick work.

11.1.9.3 The measurement of wall plaster shall be taken between the walls or partitions (the dimensions before the plaster shall be taken) for the length and from the top of the floor or skirting to the ceiling for the height. Depth of coves or cornices if any shall be deducted.

11.1.9.4 The following shall be measured separately from wall plaster.

(a) Plaster bands 30 cm wide and under

(b) Cornice beadings and architraves or architraves moulded wholly in plaster.

(c) Circular work not exceeding 6m in radius.

11.1.9.5. Plaster over masonry pilasters will be measured and paid for as plaster only.

11.1.9.6 A coefficient of 1.63 shall be adopted for the measurement of one side plastering on honey comb work having 6 x 10 cm. opening. Different coefficient will be applied as determined at site for different size of opening and plastered surface.

11.1.9.7 Moulded cornices and coves.

(a) Length shall be measured at the centre of the girth.

(b) Moulded cornices and coves shall be given in square metres the area being arrived at by multiplying length by the girth.

(c) Flat or weathered top to cornices when exceeding 15 cm in width shall not be included in the girth but measured with the general plaster work.

(d) Cornices which are curved in their length shall be measured separately.

11.1.9.8 Exterior plastering at a height greater than 10 metres from average ground level shall be measured separately in each storey height. Patch plastering (in repairs) shall be measured as plastering new work, where the patch exceeds 2.5 sqm extra payment being made for preparing old wall, such as dismantling old plaster, raking out the joints and cleaning the surface. Where the patch does not exceed 2.5 sqm in area it shall be measured under the appropriate item under sub head 'Repairs to Buildings.'

11.1.9.9 Deductions in measurements, for opening etc. will be regulated as follows:

a) No deduction will be made for openings or ends of joists, beams, posts, girders, steps etc. upto 0.5 sqm in area and no additions shall be made either, for the

jambes, soffits and sills of such openings. The above procedure will apply to both faces of wall.

b) Deduction for opening exceeding 0.5 sqm but not exceeding 3 sqm each shall be made for reveals, jambes, soffits sills, etc. of these openings.

i) When both faces of walls are plastered with same plaster, deductions shall be made for one face only.

ii) When two faces of walls are plastered with different types of plaster or if one face is plastered and other is pointed or one face is plastered and other is unplastered, deduction shall be made from the plaster or pointing on the side of the frame for the doors, windows etc. on which width of reveals is less than that on the other side but no deduction shall be made on the other side. Where widths of reveals on both faces of wall are equal, deduction of 50% of area of opening on each face shall be made from area of plaster and/or pointing as the case may be.

iii) For opening having door frame equal to or projecting beyond thickness of wall, full deduction for opening shall be made from each plastered face of wall.

iv) Different qualities of plastering referred in this para shall not include '18 mm plastering with terrazo finish' as given in para 11.12 as the method of measurement in the case of the later is different. In such cases where the plaster on the other face consists of a plaster with terrazo finish method of addition and deductions for the ordinary plaster face shall be regulated as if that face above is plastered and the other is given an entirely different type of non-comparable treatment.

c) For opening exceeding 3 sqm in area, deduction will be made in the measurements for the full opening of the wall treatment on both faces, while at the same time, jambes, sills and soffits will be measured for payment.

In measuring jambes, sills and soffits, deduction shall not be made for the area in contact with frame of doors, windows etc.

11.1.10 Rate : The rate shall include the cost of labour and materials involved in all the operations described above.

11.1.11 Control of Cracks : The main reasons for cracking of plaster are as follows:

i) Quick drying of the mortar due to hot weather and low atmospheric humidity.

ii) When a strong mix has been used on a weak background.

iii) Lack of bond with the background.

iv) Masonry underneath has not undergone initial shrinkage.

v) Lack of proper raking of joints, and

vi) Discontinuity in background, such as change from wall to ceiling, from concrete to brickwork, from clay brickwork to concrete block work etc.

In case of discontinuity in backgrounds, the best treatment would be to separate the two portions by a neat cut through the plaster at the junction. In case of discontinuity from wall to ceiling, a cornice that would permit slight movement without cracking may advantageously be introduced. If it is not proposed to provide a cornice, a straight cut through the plaster or a groove joint at the junction may be provided.

11.2 CEMENT PLASTER

11.2.1 General:- The cement plaster shall be 12 mm, 15 mm or 20 mm thick as specified in the item.

11.2.2 Scaffolding etc.:- Scaffolding and preparation of surface shall be as specified under para 11.1.

11.2.3 Mortar : The mortar of the specified mix using the type of sand described in the item shall be used. It shall be as specified in Mortar chapter. For external work and under coat work, the fine aggregate shall conform to grading zone IV mentioned in Para 26.1.3.3 or as specified in the item and for finishing coat work the fine aggregate should conform to grading finer than of Grading Zone IV but within grading indicated in Table 26.3 of Para 26.1.3.7. Water Proofing of the Plaster, where so specified, shall be done by the addition of an appropriate brand of cement water proofing compound to the cement used for making the mortar.

11.2.4 Application : The specifications as in para 11.1.4 shall apply except in the following respects :

(a) Beating with thin bamboo strips shall not be done on the cement plaster, and

(b) No lime putty solution shall be applied on the face when finishing.

Further the plastering and finishing shall be completed within half an hour of adding water to the dry mortar.

11.2.5 Thickness

Where the thickness required as per description of the item is 20 mm the average

thickness of the plaster shall not be less than 20 mm whether the wall treated is of brick or stone. In the case of brick work, the minimum thickness over any portion of the surface shall be not less than 15 mm while in case of stone work the minimum thickness over the bushings shall be not less than 12 mm.

11.2.6 Curing : Curing shall be started as soon as the plaster has hardened sufficiently and not to be damaged when watered.

The plaster shall be kept wet for a period of at least 7 days. During this period, it shall be suitably protected from all damages at the contractor's expense by such means as the Engineer may approve. The dates on which the plastering is done shall be legibly marked on the various sections plastered so that curing for the specified period thereafter can be watched.

11.2.7 Other Specifications : Specifications, for Finish, Precautions, Measurements and Rate shall be as described under para 11.1.

11.2.8 Control of Cracks : Para 11.1.11 may be referred to.

11.3 CEMENT PLASTER WITH A FLOATING COAT OF NEAT CEMENT

11.3.1 General : The cement plaster shall be 12, 15 or 20 mm thick, finished with a floating coat of neat cement, as described in the item

11.3.2 Other Specifications : Specifications for this item of work shall be same as described in 11.2 except for the additional floating coat which shall be carried out as below.

When the plaster has been brought to a true surface with the wooden straight edge (Para 11.2.4) it shall be uniformly treated over its entire area with a paste of neat cement and rubbed smooth, so that the whole-surface is covered with neat cement coating. The quantity of cement applied for floating coat shall be 2.2 kg per sqm. Smooth finishing shall be completed with trowel immediately and in no case later than half an hour of adding water to the plaster mix. The rest of the specifications described in para 11.2.4 shall apply.

11.4 18 mm CEMENT PLASTER (TWO COATS WORK)

11.4.1 General : The specification for scaffolding and preparation of surface shall be as described in para 11.2.

11.4.2. Mortar : The mix and type of fine aggregate specified in the description of the item shall be used for the respective coats. It

shall be as specified in Mortar chapter. Generally the mix of the finishing coat shall not be richer than the under coat unless otherwise described in item.

Generally coarse sand shall be used for the under coat and fine sand for the finishing coat, unless otherwise specified. For external work and under coat work, the fine aggregate shall conform to grading zone IV. For finishing coat work the fine aggregate conforming to grading finer than that of Zone IV shall be used.

11.4.3 Application

11.4.3.1 The plaster shall be applied in two coats i.e. 12 mm under coat and then 6 mm finishing coat and shall have an average total thickness of not less than 18 mm.

11.4.3.2 12 mm Under Coat: This shall be applied in the manner specified in para 11.2.4 except that when the plaster has been brought to a true surface with a wooden straight edge, the surface shall be left rough and furrowed 2 mm deep with a scratching tool diagonally both ways to form key for the top coat. The scratched lines shall be at not more than 15 cm apart. The surface shall be kept wet till the finishing coat is applied.

11.4.3.3 6mm Finishing Coat : 6 mm finishing coat : The finishing coat shall be applied after the under coat has sufficiently set but not dried and in any case within 48 hours and finished in the manner specified in para 11.2.4.

11.4.4. Other Specifications : Specifications for Curing, Finishing, Precautions, Measurements and Rate shall be as described under para 11.2.

11.5 CEMENT PLASTER ON CEMENT CONCRETE AND REINFORCED CEMENT CONCRETE WORK IN CEILINGS.

11.5.1. Scaffolding : Stage scaffolding shall be provided for the work. This shall be independent of the walls.

11.5.2. Preparation of Surface : Projecting burrs of mortar formed due to the gaps at joints in shuttering shall be removed. The surface shall be scrubbed clean with wire brushes. In addition concrete surfaces to be plastered shall be pock marked with a pointed tool, at spacing of not more than 5 cm. centres, the pock being made not less than 3 mm deep. This is to ensure a proper key for the plaster. The mortar shall be washed off and surface, cleaned of all oil, grease etc. and well wetted before the plaster is applied.

11.5.3. Mortar : Mortar of the specified mix using the types of sand described in the item shall be used. It shall be as specified in Mortar chapter.

11.5.4. Application : To ensure even thickness and a true surface, gauges of plaster 15 x 15 cm. shall be first applied at not more than 1.5 metre intervals in both directions to serve as guides for the plastering. Surface of these gauged areas shall be truly in the plane of the finished plaster surface. The plaster shall be then applied in a uniform surface to a thickness slightly more than the specified thickness and shall then be brought to true and even surface by working a wooden/aluminum /steel straight edge reaching across the gauges. Finally the surface shall be finished true with a trowel or with wooden float to give a smooth or sandy granular texture as required. Excess troweling or over working of the floats shall be avoided. The plastering and finishing shall be completed within half an hour of adding water to the dry mortar.

Plastering of ceiling shall not be commenced until the slab above has been finished and centring has been removed. In the case of ceiling of roof slabs, plaster shall not be commenced until the terrace work has been completed. These precautions are necessary in order that the ceiling plaster is not disturbed by the vibrations set up in the above operations.

11.5.5. Finish : The plaster shall be finished to a true and plumb surface and to the proper degree of smoothness as required. The work shall be tested frequently as the work proceeds with a true straight edge not less than 2.5 metre long and with plumb bobs. All horizontal lines and surfaces shall be tested with a level and all jambs and corners with a plumb bob as the work proceeds.

11.5.6. Thickness : The average thickness of plaster shall be 6 mm or 12mm as specified/ ordered. The minimum thickness over any portion of the surface shall not be less than 10mm for 12mm plaster and 5 mm for 6mm plaster.

11.5.7. Curing : The specifications shall be as detailed in para 11.2.

11.5.8 Precautions : These shall be as described in para 11.1.8.

11.5.9 Measurements

11.5.9.1 Length and breadth shall be measured correct a cm. and area shall be calculated in sqm. correct to two places of

decimal. Dimensions before plastering shall be taken.

11.5.9.2 Thickness of plaster shall be exclusive of the thickness of the key i.e. depth or rock marks and hacking.

11.5.9.3 Plastering on ceiling at height greater than 5 metres above the corresponding floor level shall be so described and shall be measured separately stating the height in stages of 1m or part thereof.

11.5.9.3 Plastering on the sides and soffits of the projected beams of ceiling at a height greater than 5 m above the corresponding floor level shall be measured and added to the quantity measured under para 11.5.9.3.

11.5.9.4 Plastering on spherical and groined ceiling and circular work not exceeding 6m radius, shall be measured and paid for separately.

11.5.9.5 Flowing soffits (Viz. portion under spiral stair case etc.) shall be measured and paid for separately.

11.5.9.6 Ribs and mouldings on ceiling shall be measured as for cornices, deductions being made from the plastering on ceiling in case the width of the moulding exceeds 15 cm.

11.5.9.7. The mode of measurement of exterior plaster and patch plastering (in repairs) shall be as laid down in para 11.1.9.8.

11.5.9.8 Deduction shall not be made for openings or for ends of columns, or columns caps of 0.5 sqm each in area and under. No additions will be made either for the plastering of the sides of such openings. For openings etc. of areas exceeding 0.5 sqm deduction will be made for the full opening but the sides of such openings shall be measured for payment.

11.5.10 Rate

The rate shall include the cost of all labour and materials involved in all the operations described above.

11.6 6MM CEMENT PLASTER FOR SLAB BEARING

11.6.1 General:- Cement plaster shall be 6 mm thick finished with a floating coat of neat cement and thick coat of lime wash on top of walls for bearing of slabs.

11.6.2 Application : The plaster shall be applied over the cleaned and wetted surface of the wall. When the plaster has been brought to a true surface with the wooden straight edge (Para 11.2.4) it shall be

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uniformly treated over its entire area with a paste of neat cement and rubbed smooth, so that the whole surface is covered with neat cement coating. The quantity of cement applied for floating coat shall be 1 kg per sqm. Smooth finishing shall be completed with trowel immediately and in no case later than half an hour of adding water to the plaster mix. The rest of the specifications described in para 11.2.4 shall apply.

11.6.3 Lime Wash - This shall be applied in a thick coat after curing the plaster for three days.

11.6.4 Measurements - Length and breadth shall be measured correct to a cm and area worked out in sqm correct to two places of decimal.

11.6.5 Rate - The rate shall include the cost of all labour and materials involved in all the operations described above.

11.10.11.7 NEAT CEMENT PUNNING

11.7.1 General : The specifications given for floating coat described in para 11.3.2 shall apply. Quantity of Cement for the floating coat shall be 2.2 kg. per sqm.

11.7.2 Specifications : Specification for scaffolding and curing shall be as described in paras 11.2.2 and 11.2.6 respectively. Specifications for Finish and Precautions shall be as described in paras 11.1.5. and 11.1.8.

11.7.3. Measurements :

11.7.3.1 The measurements for lime punning shall be taken over the finished work. The length and breadth shall be measured correct to a cm. The area shall be calculated in sqm correct to two places of decimal.

11.7.3.2 Punning over Plaster on bands, skirting, coping, cornices, drip courses, string courses etc. shall not be measured separately but only as wall surfaces. In these cases the measurements shall be taken girthed over the above features.

11.7.3.3 Punning over plaster on circular work also, of any radius shall be measured only as wall surfaces, and not separately.

11.7.3.4 Lime punning in patch repairs irrespective of the size of the patch shall be measured as new work, and in this case the rate shall include for cutting the patch to rectangular shape before lime punning.

11.7.3.5 Deductions in measurements for openings shall be regulated generally as described in para 11.1.9.9.

11.7.4. Rate : The rate shall include the cost of all labour and materials involved in all the operations described above.

11.8. ROUGH CAST PLASTER

11.8.1 General - Rough cast finish comprises of a mixture of sand and gravel in specified proportions dashed over a freshly plastered surface.

11.8.2. Scaffolding : Scaffolding shall be done as specified in para 11.1.

11.8.3. Preparation of Surface : The joints shall be raked out, dust and loose mortar shall be brushed out. The surface shall be thoroughly washed with water, cleaned and kept wet before plastering is commenced.

11.8.4. Mortar: Mortar of specified mix using the type of sand described in the item shall be used; Where coarse sand is to be used, the fineness modulus of the sand shall not be less than 2.5.

11.11.5.11.8.5. Applications

11.8.5.1. The plaster base over which rough cast finish is to be applied shall consist of two coats, under layer 12 mm thick and top layer 10 mm.

11.8.5.2 12 mm under layer: This shall be applied in the same manner as specified in para 11.1.4 except that (a) the finishing after the mortar has been brought to a level with the wooden straight edge, shall be done with wooden float only (b) during the process lime putty solution shall not be applied and (c) the surface shall not be beaten with bamboo strips

The surface shall be further roughened by furrowing about 2 mm deep with a scratching tool diagonally both ways to form a key for the finishing coat. The scratched lines shall be at not more than 15 cm apart. The surface shall be kept wet till the finishing coat is applied.

11.8.5.3 Top Layer : The top layer shall be applied a day or two after the under layer has taken initial set. The latter shall not be allowed to dry out, before the top layer is laid on. The mortar used for applying top layer shall be sufficiently plastic and of rich mix 1 :3 (1 cement : 3 fine sand) or as otherwise specified so that the mix of sand and gravel gets well pitched with the plaster surface. In order to make the base plastic, about 10% of finely ground hydrated lime by volume of cement, shall be added when preparing mortar for the top layer.

11.8.6 Finish : It shall be ensured that the base surface which is to receive rough cast

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mixture is in plastic state. The rough cast mixture shall consist of sand or gravel or crushed stone of uniform colour from 2.36 mm to 12.5 mm or as specified and in the proportions as specified accurately to the effect required. The mixture shall be wetted and shall be dashed on the plaster base in plastic state by hand scoop so that the mix gets well pitched into the plaster base. The mix shall again be dashed over the vacant spaces if any so that the surface represents a homogeneous surface of sand mixed with gravel. A sample of rough cast plaster shall be got approved by the Engineer.

11.8.7 Other Specifications : Specification for other details like precautions, measurements and rate shall be as described under para 11.1.

11.8.8 Coloured Finish : For a coloured rough cast finish, a high grade mineral pigment will be mixed with Portland cement or white cement (as the case may be) to obtain the required shade and tint. organic dyes shall not be used, as they are likely to fade.

11.9 PEBBLE DASH FINISH (INSITU WORK)

11.9.1 General : The specification shall be the same as for rough cast plaster, except that the washed pebble or crushed stone graded from 12.5 mm to 6.3 mm or as specified shall be dashed over the plaster base and the vacant spaces if any shall be filled in by pressing pebbles or crushed stone as specified by hand, so that the finished surface represents a homogeneous surface.

11.9.2 Other Specifications : Specifications for scaffolding, preparation of surface, Mortar, Measurements and Rate shall be as described under para 11.8.

11.10 SAND FACED CEMENT PLASTER

11.10.1 Base Coat : The first coat or the base coat should be approximately 12mm and shall be continuously carried out without break to the full length of wall or natural breaking points such as doors, windows etc. The base coat shall be splashed on to the prepared surface with heavy pressure, brought to true and even surface and then lightly roughened by cross scratch lines, to provide bond for the finishing coat. The mortar proportion for this base coat shall be as specified in the respective item of work. The base coat shall be cured for atleast seven days.

11.10.2 Top Coat : The second coat shall be 6mm thick. Before application of the second coat, the base coat shall be evenly damped. This coat shall be applied from top to bottom in one operation and without joints, finish shall be straight, true and even. The mortar proportion of this coat shall be as specified under the respective item of work. Sand to be used for the second coat and for finishing work shall be as specified in the item description. The second coat shall be finished with sponge. Grooves shall be made as per the drawings.

11.10.3 Curing : The surface shall be kept wet for at least a week

11.10.4 Other Specifications : Specifications for scaffolding, Measurements and Rate shall be as described under Para 11.1.

11.11 WASHED STONE GRIT PLASTER

11.11.1 General:- Scaffolding shall be as specified in para 11.1.1.

11.11.2 Preparation : Preparation of surface shall be as specified in paras 11.1.2 and 11.8.2.

11.11.3. Materials

11.11.3.1 Stone chippings obtained by crushing hard stone shall be free of dust and deleterious material. 10 mm nominal size stone chippings, where specified, shall pass 100% through 12.5 mm sieve and fully retained on 6.3 mm sieve. Stone chippings shall be thoroughly washed with water and sieved before use.

11.11.3.2 Mortar : Cement mortar for under coat and cement mortar to be mixed with stone chippings for top coat shall be as specified in para 11.2.

11.11.4 Application of Plaster

11.11.4.1 12 mm under coat : Under coat of cement mortar 1:4 (1 cement : 4 coarse sand) shall be applied as specified in para 11.2.4 except that the finishing, after the mortar has been brought to level with the wooden straight edge, shall be done with wooden float only. The surface shall be further roughened by furrowing with a scratching tool. Furrowing shall be done diagonally both ways and shall be about 2 mm deep to provide a key for the top coat. The scratched lines shall not be more than 10 cm apart. The surface shall be kept wet till top coat is applied.

11.11.4.2 15 mm top coat : Top coat comprising cement mortar and stone chippings shall have an overall proportion of

1:0.5:2 (1 cement : 0.5 coarse sand : 2 stone chippings 10 mm nominal size) or as specified. The top coat shall be applied a day or two after the under coat has taken the initial set. The surface of the under coat shall be cleaned and a coat of cement slurry at 2 kg of cement per sqm shall be applied before the application of coat. The top coat shall be applied in uniform thickness on the under coat after the application of slurry and sufficiently pressed with wooden float for proper bonding with the under coat. Vacant space, if any shall be filled with the specified mix.

11.11.5 Finish : The top coat of plaster shall be finished to a true and plumb surface. The surface shall be tested frequently as the work proceeds with a true straight edge not less than 2.5 m long and with plumb bobs. All horizontal lines and surfaces shall be tested with a level and all jambs and corners with a plumb bob as the work proceeds. All the corners, angles and junctions shall be truly vertical or horizontal as the case may be. Rounding or chamfering of corners junctions etc. where required shall be true to template.

Finished surface of the top coat after the mix has taken the initial set, shall be scrubbed and washed with suitable brushes and plain water. Scrubbing and washing shall continue till the stone chippings are sufficiently exposed. Stone chippings which may come out while scrubbing shall be replaced using the specified mortar mix. A sample of the washed stone grit plaster shall be got approved from the Engineer.

11.11.6 Grooves : Grooves of size 15 mm x 15 mm or as specified shall be provided as shown on the drawing or as required by the Engineer. Tapered wooden / metallic battens to match the size and shape of the grooves shall be fixed on the under coat with nails before the application of the top coat and these shall be removed carefully so that the edges of the panels of top coat are not damaged. Damage, if any, shall be made good by the contractor.

11.11.7 Curing : Curing shall be done as specified in para 11.1.7 except that the dates are not to be marked.

11.11.8 Measurements :

11.11.8.1 Length and breadth shall be measured correct to the nearest cm and the area shall be calculated in sqm correct to two places of decimal.

11.11.8.2. Measurements shall be taken for the work actually done with deductions for all

openings and addition for all jambs soffits and sills. However, no deduction is to be made for the grooves provided as specified in para 11.11.6

11.11.8.3 Washed stone grit plaster on circular surfaces not exceeding 6m radius and on external surfaces at a height greater than 10 m shall be measured separately.

11.11.9 Rate - The rates shall include the cost of all labour and materials involved in all the operations described above except for providing grooves. The length of grooves shall be measured in running metres and paid for separately.

11.12.11.12. 18mm PLASTERING WITH TERRAZZO FINISH

11.12.1 Scaffolding : Double scaffolding shall invariably be adopted.

11.12.2 Preparation of Surface : The joints shall be raked out properly. Dust and loose mortar shall be brushed out. Efflorescence, if any, shall be removed by brushing and scraping. The surface shall then be thoroughly washed with water, cleaned and kept wet before plastering is commenced.

In case of concrete surface if a chemical retarder has been applied to the form work, the surface shall be roughened by wire brushing and all the resulting dust and loose particles cleaned off and care shall be taken that none of the retarders is left on the surface.

11.12.3. Mortar

11.12.3.1 The mortar shall be prepared as specified for Terazzo flooring in Flooring Chapter.

11.12.3.2 12 mm under coat : This shall generally consist of cement mortar 1 : 3 (1 cement : 3 coarse sand) unless otherwise specified in the item.

11.12.3.3 6 mm Top Coat : The specifications for Terazzo flooring in Flooring chapter shall hold good as far as applicable.

11.12.4 Applications

11.12.4.1 12 mm under coat: This shall be applied in the manner specified in Terazzo Skirting in Flooring Chapter.

11.12.4.2 6 mm top coat: The top coat shall be applied after the under coat has sufficiently set but not dried, and in any case within 48 hours and finished in the same manner as specified under para 9.9.2 as far as applicable.

11.12.4.3 All corners, arrises, angles and junctions shall be truly vertical or horizontal

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as the case may be; arrises shall be carefully and neatly finished and rubbed smooth. Rounding or chamfering corners, arrises, junctions etc. where required shall be true to template and shall be carried out without any extra payment.

11.12.5 Finish : The finished surface shall be smooth, highly polished and absolutely even so that when light from side ways is reflected on it, it does not show any kind of waviness.

11.12.6 Thickness

11.12.6.1 The thickness of the under coat of plaster specified shall be exclusive of the thickness of key. The average thickness of the under coat shall not be less than 12 mm whether the wall treated is of brick or stone. In the case of brick work the minimum thickness over any portion of the surface shall not be less than 10 mm while in the case of stone work, the minimum thickness over the bushing shall not be less than 6 mm.

11.12.6.2 6 mm finishing coat shall be uniformly 6 mm thick over the under coat in the case of both brick and stone masonry.

11.12.7 Curing : Curing shall be started as soon as the plaster has hardened sufficiently not to be damaged when watered.

The plaster shall be kept wet for a period of at least 7 days. During this period, it shall be suitably protected from all damages at the contractor's expense by such means as the Engineer may approve. The dates on which the plastering is done shall be legibly marked on the various sections plastered so that curing for the specified period thereafter can be watched.

11.12.8 Precautions : Any cracks, which appear in the surface and all portions, which sound hollow when tapped, or are found to be soft or otherwise defective, shall be cut out in rectangular shape and redone as directed by the Engineer. In addition care shall be taken that the finish of the rectified work is indistinguishable from the rest of the portions and does not show as a patch.

11.12.9 Measurements

11.12.9.1. Measurements of length and breadth shall be correct to a cm and the area shall be calculated correct to two places of decimal. The measurement of plaster shall be taken between the wall or partition (being the dimension before plastering).

11.12.9.2 Measurement of the work as actually done with all deductions of opening etc., addition of jambs, sills and soffits shall

be taken. However, openings less than 0.50 sqm in area will be ignored.

11.12.9.3 Skirting not exceeding 30 cm in height shall be measured in sqm separately, stating the number of coats, thickness of each coat and whether plain, chamfered or beaded on top.

11.12.9.4 Circular work not exceeding 6 m in radius shall also be separately measured.

11.12.9.5 Moulded cornices and coves shall be measured as follows :

- a) Length shall be measured at the centre of the girth.
- b) Moulded cornices and coves shall be given in sqm the area being arrived at by multiplying length by the girth.
- c) Flat or weathered top to cornices when exceeding 15 cm in width shall not be included in the girth but measured with the general plaster work.
- d) Cornices which are curved in their length shall be measured separately.

11.12.10 Rate : The rate shall include the cost of all labour and materials involved in above operations.

11.13 18 mm ARTIFICIAL RED STONE PLASTER

11.14.1 General : The specification for scaffolding and preparation of surface shall be as described in para 11.2.

11.13.2 Mortar

11.13.2.1. 12 mm under coat: Mortar of the mix and type of sand specified in the description of the item shall be used. This shall be generally (1:4) cement mortar using coarse sand, unless described otherwise

11.13.2.2 6 mm finishing coat : This shall consist of cement, marble dust and stone dust in the ratio of 1:1:3 mixed with red oxide at the rate of 15.4 kg per quintal of cement or as determined at site to obtain a shade matching red sand stone. The red oxide used should be of approved make. The colour shall be mixed thoroughly with dry cement and then the mortar shall be mixed in the same manner as ordinary cement mortar, using the pigmented cement and stone dust and marble dust mixture.

11.13.3 Application etc. : Application, Thickness, Curing, Finishing, and Precaution shall be as specified under para 11.4 except that the surface finish shall be neither too rough nor too smooth but should resemble red stone work in texture.

11.13.4. Measurements and Rate : These shall be as specified in paras 11.12.9 and 11.12.10. Lining out plaster in imitation of stone or concrete block walling shall be given in sqm as extra over general plaster work.

11.14 PLAIN BANDS OF CEMENT MORTAR

11.14.1 General :- 'Plain band' is a plaster strip of uniform width not exceeding 30 cm and of uniform thickness, provided for decorative or other purpose flush with, sunk below or projecting beyond, the wall plaster. A flush band is one where due to the difference in mix or shade of the mortar, the band is executed as a separate and distinct operation from the wall plaster.

11.14.2 Thickness : The thickness of a raised band is the thickness of the projection beyond the plane of the wall plaster. In the case of a flush or a sunk band, the thickness will be the thickness of the plaster measured from the untreated wall surface.

11.14.3 Preparation of Surfaces and Application

11.14.3.1 In the case of flush or sunk bands the joints shall be raked out properly. Dust and loose mortar shall be brushed out. Efflorescence if any shall be removed by brushing the scraping. The surface shall then be thoroughly washed with water, cleaned and kept wet before plastering is commenced.

In case of concrete surface if a chemical retarder has been applied to the form work, the surface shall be roughened by wire brushing and all the resulting dust and loose particles cleaned off and care shall be taken that none of the retarders is left on the surface.

11.14.3.2. In case of raised band, the surface shall be dealt with as specified in para 11.1.4 except in following respects (a) beating with, thin bamboo strips shall not be done and (b) the lime putty solution shall be applied on the surface when Finishing. The surface of the wall plaster behind the band shall be left rough and furrowed 2 mm deep with a scratching tool, diagonally both ways to form key for the band. No reduction in the rate for the above backing wall plaster shall, however, be made for not finishing the same smooth.

11.14.4 Mortar : Mortar of the mix and type of sand specified in the description of the item shall be used.

11.14.5. Finish : The bands shall be finished exactly to the size as shown-in-the drawings. The horizontal or vertical lines of bands shall be truly parallel and straight and the surfaces shall be finished truly plane and smooth. The lines and surfaces shall be checked with fine threads for straightness, level and accuracy.

11.14.6. Scaffolding, Curing and Precaution : These shall be as described under para 11.2.

11.14.7. Measurements : Length will be measured in running metres correct to a cm. The length shall be taken along the finished face. The width shall not be measured by girth. For width of band 30 cm or below, the width shall be measured in cm correct to 5 mm. The quantity shall be calculated in metre-cm units.

11.14.8 Rate : The rate shall include the cost of all labour and materials involved in all the operations described above. Nothing extra shall be paid for mitres, stops nor for bands on curved surfaces of whatever radius, they may be. The rate is also inclusive of all rounding or chamfering at corners, arrisers, providing grooves at junctions etc.

11.15 MOULDED BANDS OF CEMENT MORTAR (SINGLE COAT WORK)

11.15.1 General:- Moulded band is a plaster strip of uniform width but with varying thickness across its section formed over wall plaster for decorative purposes. The sectional periphery of the band is formed by a combination of straight lines or of curves or of straight lines and curves.

11.15.2. Thickness : The higher thickness stipulated in the description of the item shall refer to the upper limiting thickness of the moulding at its most project portion, measured from the wall plaster.

11.15.3 Surface Preparation : Preparation of Surface, Mortar, Scaffolding, Curing and Precautions shall be as specified under para 11.14.

11.15.4 Application and Finish : Proper templates conforming accurately to the sectional periphery of the moulded band shall be got approved, before use. The finished band shall be true to the template at all sections. The lines of the band shall be truly parallel and straight and surfaces smoothly finished.

11.15.5. Measurements : The width of the band 30 cm or below shall be measured in cm correct to 5 mm and shall be measured

along the sectional periphery of the moulded band, from wall plaster face to wall plaster face. The length shall be measured, in running metres correct to a cm. It shall be taken along the finished face of the band at the centre of its girth. The quantity should be calculated in metre-cm units.

11.15.6 Rate : The rate shall include the cost of all labour and materials involved in all the operations described above. Nothing extra shall be paid for mitres, stops nor for bands on curved surfaces of whatever radius, they may be. The rate is also inclusive of all rounding or chamfering at corners, arrises etc.

11.16. MOULDED BANDS OF CEMENT MORTAR (TWO COAT WORK)

11.16.1 General:- Moulded band is a plaster strip of uniform width but with varying thickness across its section formed over wall plaster for decorative purposes. The sectional periphery of the band is formed by a combination of straight lines or of curves or of straight lines and curves.

11.16.2. Thickness : The higher thickness stipulated for the under coat in the description of the item shall refer to the upper limiting thickness of the under. coat of the moulding at its most projected portion from the wall plaster.

The thickness stipulated for the finishing coat is the uniform thickness of the finished peripheral surface of the moulded band from the under coat.

11.16.3 Mortar : The under coat shall consist of cement mortar 1:5 (1 cement : 5 coarse sand) and the top coat shall be of cement mortar 1 : 4 (1 cement : 4 fine sand) unless otherwise specified in the description of item.

11.16.4 Application and finish : Proper templates conforming to the sectional periphery of the moulded band as at the stages of the under coat and the finished final coat shall be made and got approved and used at the proper stages in executing the bands to true and accurate profile. The lines of the bands as finally completed shall be truly parallel and straight and the surfaces smoothly finished.

11.17.511.16.5 Other Specifications : All other details shall be as specified under para 11.15.

11.17 CEMENT WATERPROOFING COMPOUND

11.17.1 General : It shall be used for cement mortar for plastering or concrete work.

11.17.2 Water Proofing Compound :

Integral cement water proofing compound conforming to IS: 2645 and of brand and manufacture approved by the Engineer shall be used.

11.17.3 Materials : The contractor shall bring the materials to the site in their original packing. The containers will be opened and the material mixed with dry cement in the proportion by weight, recommended by the manufacturers or as specifically described in the description of the item. Care shall be taken in mixing, to see that the water proofing material gets well and integrally mixed with the cement and does not run out separately when water is added.

11.17.4 Measurements : It shall be measured by weight.

11.17.5 Rate : The rate shall include the cost of all labour and materials involved in all the operations described above.

11.18. 18mm MUD PLASTER (Two Coats)

11.18.1. Scaffolding : Single scaffolding shall be done as specified under para 11.1.

11.18.2. Preparation of surface : The joints shall be raked out and surface washed of all dust and allowed to dry before plaster is applied.

11.18.3. Mortar : Mud Mortar shall be prepared from good brick earth. This shall be free from grass roots, gravel kankar etc. The earth shall contain no efflorescent salts nor shall it be collected from a locality where there are white ants. The earth shall be reduced to a fine powdered state and mixed with plenty of water in a pit, adding chopped straw at about 33 kg per cum of earth.

The mixture of earth, straw and water shall be allowed to mature for not less than 4 days. During this period it shall be worked up at intervals with foot and/or phawaras so that it is plugged into a homogeneous mixture.

The mortar when ready shall be of such consistency that it will readily slide off the face of trowel but shall not be so wet that the mortar parts into large drops while falling.

11.18.4 Application

Plastering shall be started from the top and worked towards the grounds.

The plaster shall be applied in two coats of 12mm and 6mm thickness. The prepared mixture shall be applied to the surface in a uniform coat of average thickness of 12mm

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and then smoothened and made even with a straight edge and with floats. This shall be allowed to set but not to become dry before the second coat is applied. The latter shall be 6mm thick uniform throughout. It shall be finally polished with a trowel after it has been smoothened with wooden floats.

All corners, arrises, angles and junctions shall be truly vertical or horizontal as the case may be, and shall be carefully and neatly finished. Rounding and chamfering corners, arrises, grooves at junctions etc. where required, shall be done without any extra payments. Such rounding, chamfering and grooving shall be carried out with proper templates or battens to the sizes as required.

11.18.5 Finish

The plaster shall be finished to a true and plumb surface and to the proper degree of smoothness as required. The work shall be tested frequently as the work proceeds with a true straight edge not less than 2.5 m long and with plumb bobs. All horizontal lines and surfaces shall be tested with a level and all jambs and corners with a plumb bob as the work proceeds.

11.18.6 Precautions : No curing shall be done. The surface shall be protected from damage till it dries out. Any cracks that open out during drying shall be opened out and thoroughly repaired with mixture of clay and cow dung. Any portions which sound hollow when tapped shall also be redone after cutting out the hollow portions.

11.18.7 Thickness : The average thickness of the finished plaster excluding the key of the joints shall not be less than 18 mm. The minimum thickness of the plaster over any portion of the wall of brick work shall not be less than 15 mm at any point while in the case of stone walls, this shall not be less than 12 mm over the bushings.

11.18.8. Measurements : The specifications for measurement shall be as described in para 11.1.9 except for the following.

All bands and skirtings irrespective of width, moulded beadings, architrave and archivolt bands and circular work of any radius shall be measured and paid for under plastering areas only and not separately.

11.18.9. Rate : The rate shall include the cost of all labour and materials involved in all the operations described above.

11.19. POINTING ON BRICK WORK, TILE WORK AND STONE WORK

11.19.1 General : Pointing shall be of the type shown in **Figure 11.1**. **Figure 5.5** under Chapter 5 Brick work may also be seen. Generally, the floors of rooms and bridges requiring pointing will be flush pointed while all vertical faces of Brick and Stone work will be rule pointed. The work shall however be executed as directed by the Engineer or as shown in the Drawing. The specifications for Cement pointing on Brick flooring and stone slab pavement shall be the same as for Brick work or Stone work detailed below.

11.19.2. Scaffolding : For all exposed brick work or tile work, independent double scaffolding having two sets of vertical supports shall be provided. The supports shall be sound and strong tied together with horizontal pieces over which scaffolding planks shall be fixed. For all other brick work in building, single scaffolding shall be permitted. In such cases, the inner end of the horizontal scaffolding pole shall rest in a hole provided only in the header course for the purpose. Only one header for each pole shall be left out. Such holes for scaffolding shall, however, not be allowed in pillars/columns less than one metre in width, or immediately near the skew backs of arches. The holes left in masonry works for scaffolding purposes shall be filled and made good before plastering.

In case of special type of brickwork, scaffolding shall be got approved from the Engineer in advance.

11.19.3. Preparation of surface : The joints shall be raked out properly. The joints shall be raked to such a depth that the minimum depth of the new mortar measured from either the sunk surface of the finished pointing or from the edge of the brick shall not be less than 12 mm.

For new work, where subsequent pointing is to be done, the raking of joints shall be done during the progress of work, when the mortar is still green. Dust and loose mortar shall be brushed out. The whole surface shall be thoroughly cleaned and efflorescence if any shall be removed by brushing and scraping. The surface shall then be thoroughly washed with water, cleaned and kept wet before pointing is commenced.

In case of concrete surface if a chemical retarder has been applied to the form work, the surface shall be roughened by wire brushing and all the resulting dust and loose particles cleaned off and care shall be taken that none of the retarders is left on the surface.

11.19.4 Mortar: Mortar of specified mix shall be used. It shall be as specified under Chapter 26. Mortar for pointing may be coloured to match the Brick work or Stone work, if specially ordered.

11.19.5 Application and Finishing

11.19.5.1 The mortar shall be pressed into the raked out joints, with a pointing trowel, either flush, sunk or raised, according to the type of pointing required. The mortar shall not spread over the corner, edges or surface of the masonry. The pointing shall then be finished with the proper tool, in the manner described below:

11.19.5.2 Flush Pointing : The mortar shall be pressed into the joints and shall be finished off flush and level with the edges of the bricks, tiles or stones so as to give a smooth appearance. The edges shall be neatly trimmed with a trowel and straight edge.

11.19.5.3 Ruled Pointing : The joints shall be initially formed as for flush pointing and then while the mortar is still green, a groove of shape and size as shown in drawings or as instructed, shall be formed by running a forming tool, straight along the centre line of the joints. This operation shall be continued till a smooth and hard surface is obtained. The vertical joints shall also be finished in a similar way. The vertical lines shall make true right angles at their junctions with the horizontal lines and shall not project beyond the same.

11.19.5.4 Cut or Weather Struck Pointing : The mortar shall first be pressed into the joints. The top of the horizontal joints shall then be neatly pressed back about 3 mm or as directed, with the pointing tool so that the joints are sloping from top to bottom. The vertical joints shall be ruled pointed. The junctions of vertical joints with the horizontal joints shall be at true right angles.

11.19.5.5 Raised and Cut Pointing : Raised and cut pointing shall project from the wall facing with the edges cut parallel so as to have a uniformly raised band about 6 mm raised and width 10 mm or more as directed.

11.19.5.6 The superfluous mortar shall then be cut off from the edges of the lines and the surface of the masonry shall also be cleaned off all mortar. The finish shall be such that the pointing is to the exact size and shape required and the edges are straight, neat and clean.

11.19.6 Curing : The pointing shall be kept wet for seven days. During this period it shall be suitably protected from all damages. The

pointing lines shall be truly horizontal and vertical except where the joints are slanting as in rubble random masonry. Lines of joints from different directions should meet neatly at the junctions instead of crossing beyond.

11.19.7 Measurements

1.19.7.1 Length and breadth shall be measured correct to a cm and the area shall be calculated in square metres upto two places of decimal.

11.19.7.2 The various types of pointing for example, struck, keyed, flush, tuck, etc. shall each be measured separately.

11.19.7.3 Pointing on different types of walls, floors, roofs etc. shall each be measured separately. The type and material of the surface to be pointed shall be described.

11.19.7.5 For jambs, soffits, sills etc, for opening not exceeding 0.5 sqm each in area, ends of joists, beams, posts, girders, steps etc not exceeding 0.5 sqm each in area and opening not exceeding 3 sqm each deductions and additions shall be made in the following way, in case of pointing on external face only.

a) No deduction shall be made for ends of joists beams, posts etc. and openings not exceeding 0.5 sqm each, and no addition shall be made for reveals, jambs, soffits, sills, etc. of these openings.

b) Deductions for openings exceeding 0.5 sqm but not exceeding 3 sqm each shall be made as follows and no additions shall be made for reveals, jambs, soffits, sills, etc. for these openings.

i) When both the faces of the wall are pointed with the same pointing deduction shall be made for one face only.

ii) When two faces of wall are pointed with different pointings or if one face is plastered and other is pointed or plastered, deduction shall be made from the plaster or pointing on the side of frames for doors, windows, etc. on which the width of the reveal is less than that on the other side, but no deduction shall be made from the other side.

iii) Where widths of reveals on both faces of wall are equal, deduction of **50%** of area of opening on each face shall be made from area of pointing or plaster as the case may be.

iv) For opening having door frame equal to projecting beyond thickness of wall, full deduction for opening shall be made from each pointed face of wall.

11.19.7.6 In case of openings of area above 3 sqm each, deduction shall be made for the

openings, but jambs, soffits and sills shall be measured.

11.19.7.7 The following shall be measured separately.

- a) Raking out joints for old work only shall be measured and given in square metres.
- b) Raking out joints of old work built in mud mortar, lime mortar and cement mortar shall each be measured separately.
- c) Raking out joints of different types of old walls, floors etc. shall each be measured separately.
- d) Raking single detached joints as for flashing old work shall be given in running metres.

11.19.8 Rate : The rate shall include the cost of all materials and labour involved in all the operations described above, except that for old work, raking of joints shall be paid for separately. For new work cost of raking of joints is covered by the rate of brickwork/stonework.

11.20 WHITE WASHING WITH LIME

11.20.1. Scaffolding

11.20.1.1 Wherever scaffolding is necessary, it shall be erected on double supports tied together by horizontal pieces, over which scaffolding planks shall be fixed. No ballies, bamboos or planks shall rest on or touch the surface, which is being white washed.

11.20.1.2. For all exposed brick work or tile work, double scaffolding having two sets of vertical supports shall be provided. The supports shall be sound and strong, tied together with horizontal pieces over which scaffolding planks shall be fixed. In case of special type of brick work, scaffolding shall be got approved from Engineer in advance.

11.20.1.3 Where ladders are used, pieces of old gunny bags shall be tied on their tops to avoid damage or scratches to walls.

11.20.1.4 For white washing the ceiling, proper stage scaffolding shall be erected.

11.20.2 Preparation of Surface: Before new work is white washed, the surface shall be thoroughly brushed free from mortar droppings and foreign matter.

In case of old work, all loose particles and scales shall be scrapped off and holes in plaster as well as patches of less than 50 sq cm area shall be filled up with mortar of the same mix. Where so specifically ordered by the Engineer the entire surface of old white wash shall be thoroughly removed by scrapping and this shall be paid for

separately. Where efflorescence is observed the deposits may be brushed clean and washed. The surface shall then be allowed to dry for atleast 48 hours before white washing is done.

11.20.3 Preparation of lime wash

11.20.3.1 The lime wash shall be prepared from fresh stone white lime (Narnaul or Dehradun or similar quality). The lime shall be thoroughly slaked on the spot, mixed and stirred with sufficient water to make a thin cream. This shall be allowed to stand for a period of 24 hours and then shall be screened through a clean coarse cloth. 40 gm of gum / fevicol dissolved in hot water, shall be added to each 10 cubic decimeter of the cream. The approximate quantity of water to be added in making the cream will be 5 litres of water to one kg of lime.

11.20.3.2 Indigo (Neel) upto 3 gm per kg of lime dissolved in water, shall then be added and stirred well. Water shall then be added at the rate of about 5 litres per kg. of lime to produce a milky solution.

11.20.4 Application

11.20.4.1 The white wash shall be applied with moonj brushes / ordinary brushes to the specified number of coats. The operation for each coat shall consist of a stroke of the brush given from the top downwards, another from the bottom upwards over the first stroke, and similarly one stroke horizontally from the right and another from the left before it dries.

11.20.4.2 Each coat shall be allowed to dry before the next one is applied. Further each coat shall be inspected and approved by the Engineer before the subsequent coat is applied. No portion of the surface shall be left out initially to be patched up later on.

11.20.4.3 For new work, three or more coats shall be applied till the surface presents a smooth and uniform finish through which the plaster does not show. The finished dry surface shall not show any signs of cracking and peeling nor shall it come off readily on the hand when rubbed.

11.20.4.4 For old work, after the surface has been prepared as described in para 11.20.2 a coat of white wash shall be applied over the patches and repairs. Then a single coat or two or more coats of white wash as stipulated in the description of the item shall be applied over the entire surface. The white washed surface should present a uniform finish through which the plaster patches do not appear. The washing on ceiling should be done prior to that on walls.

11.20.5 Protective Measures: Doors, windows, floors, articles of furniture etc. and such other parts of the building not to be white washed, shall be protected from being splashed upon. Splashings and droppings, if any shall be removed by the contractor at his own cost and the surfaces cleaned. Damages, if any to furniture or fittings and fixtures shall be recoverable from the contractor.

11.20.6 Measurements

11.20.6.1 Length and breadth shall be measured correct to a cm. and area shall be calculated in sqm correct to two places of decimals.

11.20.6.2 Measurements for Jambs, Soffits and Fills etc. for openings shall be as described in para 11.1.9.

11.20.6.3 Corrugated surfaces shall be measured flat as fixed and the area so measured shall be increased by the following percentages to allow for the girthed area. Corrugated asbestos cement sheet 20%, Semi corrugated asbestos cement sheet 10%

11.20.6.4 Cornices and other such wall or ceiling features, shall be measured along the girth and included in the measurements.

11.20.6.5 The number of coats of each treatment shall be stated. The item shall include removing nails, making good holes, cracks, patches etc. not exceeding 50 sq. cm. each.

11.20.6.6. Work on old treated surfaces shall be measured separately and so described.

11.20.7. Disinfecting: When lime wash is to be used for disinfecting purpose it should be applied hot, the necessary heat being obtained by placing the quick lime direct into the mixture, and applying the mixture to the walls at once.

11.20.8 Rate: The rate shall include all material and labour involved in all the operations described above.

11.21 WHITE WASHING WITH WHITING

11.21.1 Preparation of mix : Whiting (ground white chalk) shall be dissolved in sufficient quantity of warm water and thoroughly stirred to form a thin slurry which shall then be screened through a clean coarse cloth. Two kg of gum / fevicol as per manufacturer's recommendations, and 0.4 kg of copper sulphate dissolved separately in hot water shall be added for every cum of the slurry which shall then be diluted with water

to the consistency of milk so as to make a wash ready for use.

11.21.2 Other Specifications : Other specifications described in para 11.20 shall apply in this case also.

11.22 COLOUR WASHING

11.22.1 General : The mineral colours, not affected by lime, shall be added to white wash. Indigo (Neel) shall however, not be added. No colour wash shall be done until a sample of the colour wash of the required tint or shade has been got approved from the Engineer. The colour shall be of even tint or shade over the whole surface. If it is blotchy or otherwise badly applied, it shall be redone by the contractor.

For new work, the priming coat shall be of white wash with lime or with whiting as specified in the description of the item. Two or more coats, shall then be applied on the entire surface till it represents a smooth and uniform finish.

For old work after the surface has been prepared as described in para 11.20.2 a coat of colour wash shall be applied over the patches and repairs. Then a single coat, or two or more coats of colour wash, as stipulated in the description of the item shall be applied over the entire surface. The colour washed surface shall present a uniform finish.

The finished dry surface shall not be powdery and shall not readily come off on the hand when rubbed.

11.22.2 Other Specifications : Other specifications as described under para 11.20 will apply.

11.23 CEMENT WASHING

11.23.1 Material : The wash for cement washing shall be prepared by mixing neat portland cement with water. The quantity of cement to be used will depend upon the shade of the wash required. Normally 1.5 kg of cement for 10 sq. metres of the wall surface should give a good finish. Other specifications as for white-washing shall apply so far as applicable.

11.23.2 Where used : Cement washing is sometimes done on outside surfaces in place of white-washing.

11.23.3 Other Specifications : As under para 11.20

11.24 DRY DISTEMPERING

11.24.1. Materials : Dry distemper of required colour (IS.427) and of approved brand and manufacture shall be used. The shade shall be got approved from the Engineer before application of the distemper. The dry distemper colour as required shall be stirred slowly in clean water using 6 decilitres (0.6 litre) of water per kg of distemper or as specified by the makers. Warm water shall preferably be used. It shall be allowed to stand for at least 30 minutes (or if practicable over night) before use. The mixture shall be well stirred before and during use to maintain an even consistency. Distemper shall not be mixed in larger quantity than is actually required for one day's work.

11.24.2 Preparation of Surface

11.24.2.1 Before new work is distempered, the surface shall be thoroughly brushed free from mortar droppings and other foreign matter and sand papered smooth.

11.24.2.2 New plastered surfaces shall be allowed to dry for at least two months, before applying, distemper.

11.24.2.3 In the case of old work, all loose pieces and scales shall be removed by sand papering. The surface shall be cleaned of all grease, dirt, etc.

11.24.2.4 Pitting in plaster shall be made good with plaster of paris mixed with dry distemper of the colour to be used. The surface shall then be rubbed down again with a fine grade sand paper and made smooth. A coat of the distemper shall be applied over the patches. The patched surface shall be allowed to dry thoroughly before the regular coat of distemper is applied.

11.24.3 Priming Coat : A priming coat of whiting (see para 11.21) shall be applied over the prepared surface in case of new work, if so stipulated in the description of the item. No white washing coat shall be used as a priming coat for distemper.

The treated surface should be allowed to dry before distemper coat is given.

11.24.4 Application

11.24.4.1 In the case of new work, the treatment shall consist of a priming coat of whiting followed by the application of two or more coats of distemper till the surface shows an even colour.

11.24.4.2 For old work, the surface prepared as described in para 11.24.2.3 shall be applied one or more coats of distemper till the surface attains an even colour.

11.24.4.3 The application of each coat shall be as follows - The entire surface shall be coated with the mixture uniformly, with proper distemper brushes (ordinary white wash brushes shall not be allowed) in horizontal strokes followed immediately by vertical ones which together shall constitute one coat.

11.24.4.4 The subsequent coats shall be applied only after the previous coat has dried.

11.24.4.5 The finished surface shall be even and uniform and shall show no brush marks.

11.24.4.6 Enough distemper shall be mixed to finish one room at a time. The application of a coat in each room shall be finished in one operation and no work shall be started in any room, which cannot be completed the same day.

11.24.4.7 After each day's work, the brushes shall be washed in hot water and hung down to dry. Old brushes which are dirty or caked with distemper shall not be used.

11.24.5 Other Specifications:-The specifications in respect of scaffolding, protective measures, measurements and rate shall be as described under para 11.20.

11.25 OIL EMULSION (OIL BOUND) WASHABLE DISTEMPERING

11.25.1 Materials: Oil emulsion (Oil Bound washable distemper (IS.428)) of approved brand and manufacture shall be used. The primer, where used as on new work shall be cement primer or distemper primer as described in the item. These shall be of the same manufacture as distemper. The distemper shall be diluted with water or any other prescribed thinner in a manner recommended by the manufacturer. Only sufficient quantity of distemper required for day's work shall be prepared.

The distemper and primer shall be brought by the contractor in sealed tins in sufficient quantities at a time to suffice for a fortnight's work, and the same shall be kept in the joint custody of the contractor and the Engineer. The empty tins shall not be removed from the site of work, till this item-of work has been completed and passed by the Engineer.

11.25.2 Preparation of the Surface

11.25.2.1 For new work the surface shall be thoroughly cleaned of dust, old white or colour wash by washing and scrubbing. The surface shall then be allowed to dry for at least 48 hours. It shall then be sand papered

to give a smooth and even surface. Any unevenness shall be made good by applying putty, made of plaster of paris mixed with water on the entire surface including filling up the undulations and then sand papering the same after it is dry.

11.25.2.2 In the case of old work, all loose pieces and scales shall be removed by sand papering. The surface shall be cleaned of all grease, dirt etc.

Pitting in plaster shall be made good with plaster of paris mixed with the colour to be used. The surface shall then be rubbed down again with a fine grade sand paper and made smooth. A coat of the distemper shall be applied over the patches. The patched surface shall be allowed to dry thoroughly before the regular coat of distemper is applied.

11.25.3 Application

11.25.3.1 Priming Coat : The priming coat shall be with distemper primer or cement primer, as required in the description of the item. The application of the distemper primer shall be as described in para 11.24.4.

Note : If the wall surface plaster has not dried completely, cement primer shall be applied before distempering the walls. But if distempering is done after the wall surface is dried completely, distemper primer shall be applied.

Oil bound distemper is not recommended to be applied, within six months of the completion of new wall plaster. However, newly plastered surfaces if required to be distempered before a period of six months shall be given a coat of alkali resistant priming paint conforming to IS : 109 and allowed to dry for atleast 48 hours before distempering is commenced. For old work no Primer Coat is necessary.

11.25.3.2 Distemper Coat : For new work, after the primer coat has dried for at least 48 hours, the surface shall be lightly sand papered to make it smooth for receiving the distemper, taking care not to rub out the priming coat. All loose particles shall be dusted off after rubbing. One coat of distemper properly diluted with thinner (water or other liquid as stipulated by the manufacturer) shall be applied with brushes in horizontal strokes followed immediately by vertical ones, which together constitute one coat. The subsequent coats shall be applied in the same way. Two or more coats of distemper as are found necessary shall be applied over the primer coat to obtain an even shade.

For old work the distemper shall be applied over the prepared surface in the same manner as in new work. One or more coats of distemper as are found necessary shall be applied to obtain an even and uniform shade. 15 cm double bristled distemper brushes shall be used. After each day's work, brushes shall be thoroughly washed in hot water with soap solution and hung down to dry. Old brushes which are dirty and caked with distemper shall not be used on the work.

11.25.4 Other Specifications : The specifications in respect of scaffolding, protective measurements shall be as described under para 11.20.

11.25.5. Rate : The rate shall include the cost of all labour and materials involved in all the above operations (including priming coat) described above.

11.26 CEMENT PRIMER COAT

11.26.1 General : Cement primer coat is used as a base coat on wall finish of cement, lime or lime cement plaster or on asbestos cement surfaces before oil emulsion distemper paints are applied on them. The cement primer is composed of a medium and pigment which are resistant to the alkalies present in the cement, lime or lime cement in wall finish and provides a barrier for the protection of subsequent coats of oil emulsion distemper paints. Cement Primer of approved brand and manufacture shall be used.

Primer coat shall be preferably applied by brushing and not by spraying. Hurried priming shall be avoided particularly on absorbent surfaces. New plaster patches in old work should also be treated with cement primer before applying oil emulsion paints etc.

11.26.2 Preparation of the Surface

The surface shall be thoroughly cleaned of dust, old white or colour wash by washing and scrubbing. The surface shall then be allowed to dry for atleast 48 hours. It shall then be sand papered to give a smooth and even surface. Any unevenness shall be made good by applying putty, made of plaster of Paris mixed with water on the entire surface including filling up the undulations and then sand papering the same after it is dry.

11.26.2.1 Application : The cement primer shall be applied with a brush on the clean dry and smooth surface. Horizontal strokes shall be given first and vertical strokes shall be applied immediately afterwards. This entire

operation will constitute one coat. The surface shall be finished as uniformly as possible leaving no brush marks. It shall be allowed to dry for atleast 48 hours, before oil emulsion paint is applied.

11.26.3 Other Specifications : The Specifications in respect of scaffolding, protective measures, measurements and rate shall be as described under para 11.20.

11.27 CEMENT PAINT

11.27.1 Material

The cement paint shall conform to IS.5410 and be of approved brand and manufacture.

The cement paint shall be brought to the site of work by the contractor in its original container in sealed condition. The material to be brought in at a time shall be adequate to cover the whole work or atleast a fortnight's work. The materials shall be kept in the joint custody of the Contractor and the Engineer. The empties shall not be removed from the site of work till the relevant item of the work has been completed and permission obtained from the Engineer.

11.27.2 Preparation of Surface : For New Work, the surface shall be thoroughly cleaned of all mortar dropping, dirt dust, algae, grease and other foreign matter by brushing and washing. Pitting in plaster shall be made good and a coat of waterproof cement paint shall be applied over patches after wetting them thoroughly. In the case of old work, all loose pieces and scales shall be removed and the surface shall be scrubbed thoroughly to clear dirt, dust and algae etc by brushing and washing with water. To give an even and smooth surface, sand papering where found necessary shall be used. Holes and pittings in plaster shall be made good by applying cement putty. A coat of water proof cement paint shall be applied over these patches after wetting them thoroughly.

11.27.3 Preparation of mix : Cement paint shall be mixed in such quantities as can be used up within an hour of its mixing as otherwise the mixture will set and thicken, affecting flow and finish. Cement paint shall be mixed with water in two stages. The first stage shall comprise of 2 parts of cement paint and one part of water stirred thoroughly and allowed to stand for 5 minutes. Care shall be taken to add the cement paint gradually to the water and not vice versa. The second stage shall comprise of adding further one part of water to the mix and stirring thoroughly to obtain a liquid of workable and uniform consistency. In all

cases the manufacturer's instructions shall be followed meticulously.

The lids of cement paint drums shall be kept tightly closed when not in use, as by exposure to atmosphere the cement paint rapidly becomes air set due to its hygroscopic qualities.

In case of cement paint brought in gunny bags, once the bag is opened, the contents should be consumed in full on the day of its opening. If the same is not likely to be consumed in full, the balance quantity should be transferred and preserved in an airtight container to avoid its exposure to atmosphere.

11.27.4 Application

11.27.4.1 The solution shall be applied on the clean and wetted surface with brushes or spraying machine. The solution shall be kept well stirred during the period of application. It shall be applied on the surface which is on the shady side of the building so that the direct heat of the sun on the surface is avoided. The method of application of cement paint shall be as per manufacturer's specification. The completed surface shall be watered after the day's work.

11.27.4.2 The second coat shall be applied after the first coat has been set for at least 24 hours. Before application of the second or subsequent coats, the surface of the previous coat shall not be wetted.

11.27.4.3 For new work, the surface shall be treated with three or more coats of water proof cement paint as found necessary to get a uniform shade.

11.27.4.4 For old work, the treatment shall be with one or more coats as found necessary to get a uniform shade.

11.27.5 Precaution : Water proof cement paint shall not be applied on surfaces already treated with white wash, colour wash, distemper dry or oil bound, varnishes, paints etc. It shall not be applied on gypsum, wood and metal surfaces.

If Water Proof Cement Paint is required to be applied on existing surfaces previously treated with white wash, colour wash etc, the surface shall be thoroughly cleaned by scrapping off all the white wash, colour wash etc., completely. Thereafter a coat of cement primer shall be applied followed by two or more coats of water proof cement paint.

11.27.6 Other Specifications : The specifications in respect of scaffolding, protective measures, measurements and rate shall be as described under para 11.20. The coefficient for cement paint on RCC Jalli

shall be the same as for painting trellis or Jaffri work.

11.28 VINYL PAINTING

11.28.1 Material : Paint of approved brand and manufacture shall be used. In case of new work the surface shall be prepared first to apply paint on outside and inside surface according to directions given by the manufacturer. The paint shall be brought by the supplier in sealed containers for the work in sufficient quantity and shall be kept in the custody of Engineer's representative.

11.28.2 Preparation of Surface : The surface shall be prepared by thorough sand papering. Thereafter putty shall be applied to get a proper and smooth finish of the surface. It is necessary to apply putty made by mixing one part by volume of whiting with one part by volume of paint to bring it down to application consistency with a putty knife. Under no circumstances putty made of any oil or oil based medium shall be used.

11.28.2.1 In case of old work, the surface shall be prepared in the same manner as described in paras 11.24.2.3 and 11.24.2.4.

11.28.3 Application : The first and subsequent coat of paint shall be applied as prescribed by the manufacturer over the prepared surface. The paint shall be applied with brushes in horizontal strokes followed by vertical strokes, which together shall constitute one coat.

11.28.3.1 The second and subsequent coat shall be applied atleast one hour after the first coat has been applied so as to permit proper drying of preceding coat.

11.28.3.2 The paint in first and subsequent coat shall be applied over the prepared surface of old work in the same manner as for new work.

11.28.4 Other Specifications:- The specifications in respect of type of brushes,

scaffoldings, protective measures, measurements and rates shall be as described in relevant paras 11.25.3.2 and 11.20.

11.29 SPECIFICATION FOR GYPSUM BUILDING PLASTER As per IS 2547 Part I - Important paras of the code are reproduced below -

3. CLASSIFICATION

3.1 Gypsum plaster shall be classified as follow:

- a) Plaster of paris,
- b) Retarded hemihydrate gypsum plaster :

Type I – Under coat :

- a) Browning plaster,
- b) Metal lathing plaster,

Type II – Final coat plaster :

- a) Finish plaster,
- b) Board finish plaster,
- c) Anhydrous gypsum plasters are for finishing only, and
- d) Keene's plaster is for finishing only.

Note – Keene's plaster is of the anhydrous type. It is characterized by being more easily brought to a smooth and clean finish associated with gradual set. In this standard Keene's plaster is differentiated from a anhydrous gypsum plaster by a higher standard of purity (CaSO_4 not less than 80 percent) and hardness. The special qualities traditionally with this type of plaster be dealt with at present by any convenient direct test.

4. CHEMICAL REQUIREMENTS

4.1 The chemical composition of the plasters shall be given in Table 1.

TABLE 1 : CHEMICAL COMPOSITION

SL	PARTICULARS	REQUIREMENT				
		Plaster of paris β hemihydrate	Retarded Hemihydrate Gypsum Plaster	Anhydrous Gypsum Plaster	Keene's Plaster	Method of Test
(1)	(2)	(3)	(4)	(5)	(6)	(7)
i)	SO_3 , percent by mass, Min.	35	35	40	47	See IS : 1288-1982*
ii)	CaO , Percent by mass, Min.	2/3 of SO_3 content	2/3 of SO_3 content	2/3 of SO_3 content	2/3 of SO_3 content	See IS : 1288-1982*
iii)	Soluble magnesium salt, expressed as percentage of MgO ,	0.3	0.3	0.3	0.3	See Appendix-A

	Max.					
iv)	Soluble Sodium salt, expressed as percentage of Na ₂ O, Max.	0.3	0.3	0.3	0.3	See Appendix-A
v)	Loss of ignition, percent by mass	Not greater than 9 and less than 4	Not greater than 9 & less than 4	3.0 Max.	2.0 Max.	See Appendix-B
vi)	Free lime, Min. percent	-	3 #	-	-	See Appendix-C

* Method of test for mineral gypsum and gypsum products (Second Revision)

Applicable to metal lathing plaster.

5. PHYSICAL REQUIREMENTS

5.1 Purity – No material shall be added to gypsum plasters except those which are necessary to control the setting, such as sodium citrate, break-down products of keratin, potassium sulphate, sodium sulphate, alum and zinc sulphate; or working characteristics such as Alkyl-Aryl sulphonate;

or to impart anti-corrosion such as nitrates and nitrites of alkali metals or fungicidal properties.

5.2 Gypsum plaster shall also satisfy the requirements given in Table 2, when tested according to the procedures given in IS : 2542 (Part I) – 1978*.

TABLE 2 PHYSICAL REQUIREMENTS

SL	PARTICULARS	REQUIREMENT			
		Plaster of Paris		Anhydrous Gypsum Plaster	Keene's Plaster
		Type A (short time setting)	Type B (Long time Setting)		
(1)	(2)	(3)	(4)	(5)	(6)
i)	Setting time minutes:	-	-	-	-
	a) Plaster sand mixture	45-120	120-900	-	-
	b) Neat plaster	20-40	60-180	20-360	20-360
ii)	Transverse strength (kg/cm ²) Min.	5	4*	-	-
iii)	Soundness	Set plaster pats shall not show any sign of disintegration, popping or pitting	Set plaster pats shall not show any sign of disintegration, popping or pitting	Set plaster pats shall not show any sign of disintegration, popping or pitting	Set plaster pats shall not show any sign of disintegration, popping or pitting
iv)	Mechanical resistance of set neat plaster	-	# Diameter of the indentation shall not be less than 3 mm and not more than 4.5 mm	Diameter of the indentation shall not be more than 4 mm	Diameter of the indentation shall not be more than 3.5 mm
v)	Residue on 90 µm sieve percentage, Max.	5.0	5.0* (1.0)#	2.0	2.0
vi)	Expansion on setting percentage, Max.	-	0.20 at 24 h □	-	0.5 at 96 h

* Applicable to undercoat plasters only.

Applicable to final coat plasters.

□ Applicable to board finish plasters only.

7. PACKING AND MARKING

7.1 Gypsum plasters shall be dry and free from lumps and shall be suitably packed in watertight bags or containers. The following information shall be marked legibly on each package:

- a) Name of the manufacturer
- b) Class and type of plaster;
- c) Date of manufacture, batch number, if any and
- d) Net mass.

7.2 BIS Certification Marking

The product may also be marked with Standard Mark.

7.2.1 The use of the Standard Mark is governed by the provisions of Bureau of Indian Standards Act, 1986 and the Rules and Regulations made there under. The details of conditions under which the licence for the use of Standard Mark may be granted to manufacturers or producers may be obtained from the Bureau of Indian Standard.

Chapter 12

Painting, Polishing And Varnishing

12.1 PAINTING- General

The section on 'Painting' in this chapter covers painting of woodwork, steelwork and masonry/plastered surfaces in building construction work. Painting of steel girder bridges and other railway steel structures like platform shelters, turn tables etc are covered in the Chapter on 'Bridge Works – Superstructure – Steel'.

12.1.1 Materials :

(a) Paints, oils, varnishes etc. of approved brand and manufacture shall be used. Only ready to use paint (Exterior grade) as received from the manufacturer without any admixture shall be used.

(b) If for any reason, thinning is necessary in case of ready mixed paint, the brand of thinner recommended by the manufacturer or as instructed by the Engineer shall be used.

(c) Approved paints, oil or varnishes shall be brought to the site of work by the contractor in their original containers in sealed condition. The material shall be brought in at a time in adequate quantities to suffice for the whole work or at least a fortnight's work. The materials shall be kept in the joint custody of the contractor and the Engineer. The empties shall not be removed from the site of work, till the relevant item of work has been completed and permission obtained from the Engineer.

(d) (i) Brushes used shall be of the approved type and of the size suitable for the work in hand. For general wood work including doors, sashes etc, a brush 7.5 to 10 cm wide for the larger areas and 5cm wide for the rails would be considered suitable. For flat wall paint, flat brushes of 10 to 15 cm width are also used.

(ii) For Girder works 10 cm to 20 cm may be used.

(iii) For fine work 1.3cm, 2.5cm, 5 cm and 10 cm wide brushes will be useful.

(iv) For dusting large flat surfaces 30 cm to 33.5 cm wide brushes may be used.

12.1.2 Commencing Work : Painting shall not be started until the Engineer has inspected the items of work to be painted, satisfied himself about their proper quality

and given his approval to commence the painting work. Painting of external surface should not be done in adverse weather condition like hail storm and dust storm.

Painting, except the priming coat, shall generally be taken in hand after practically finishing all other building work.

The rooms should be thoroughly swept out and the entire building cleaned up, at least one day in advance of the paint work being started.

12.1.3 Preparation of Surface : The surface shall be thoroughly cleaned and dusted off. All rust, dirt, scales, smoke splashes, mortar droppings and grease shall be thoroughly removed before painting is started. The prepared surface shall have received the approval of the Engineer after inspection, before painting is commenced.

12.1.4 Application

12.1.4.1 Before pouring into smaller containers for use, the paint shall be stirred thoroughly in its containers; when applying also, the paint shall be continuously stirred in the smaller containers so that its consistency is kept uniform.

12.1.4.2 The painting shall be laid on evenly and smoothly by means of crossing and laying off, the latter in the direction of the grains of wood. The crossing and laying off consists of covering the area over with paint, brushing the surface hard for the first time over and then brushing alternately in opposite direction, two or three times and then finally brushing lightly in a direction at right angles to the same. In this process, no brush marks shall be left after the laying off is finished. The full process of crossing and laying off will constitute one coat.

12.1.4.3 Where so stipulated, the painting shall be done by spraying. Spray machine used may be of (a) high pressure (small air aperture) type, or (b) a low pressure (large air gap) type, depending on the nature and location of work to be carried out. Skilled and experienced workmen shall be employed for this class of work. Paints used shall be brought to the requisite consistency by adding a suitable thinner.

12.1.4.4 Spraying should be done only when dry condition prevails. Each coat shall be

allowed to dry out thoroughly and rubbed smooth before the next-coat is applied. This should be facilitated by thorough ventilation. Each coat, except the last coat, shall be lightly rubbed down with sand paper or fine pumice stone and cleaned of dust before the next coat is laid.

12.1.4.5 Each coat of paint shall differ slightly in tint from the preceding one so as to make each coat readily distinguishable, the last coat being of the tint required for the finished work.

12.1.4.6 No left over paint shall be put back into the stock tins. When not in use, the containers shall be kept properly closed.

12.1.4.7 No hair marks from the brush or clogging of faint puddles in the corners of panels, angles of mouldings etc. shall be left on the work.

12.1.4.8 In painting doors and windows, the putty round the glass panes must also be painted but care must be taken to see that no paint stains etc. are left on the glass. Tops of shutters and surfaces in similar hidden locations shall not be left out in painting. However, bottom edge of the shutters where the painting is not practically possible, need not be done nor any deduction on this account will be done but two coats of primer of approved make shall be done on the bottom edge before fixing the shutters.

12.1.4.9 On painting steel work, special care shall be taken while painting over bolts, nuts, rivets, overlaps etc.

12.1.4.10 The additional specifications for primer and other coats of paints shall be according to the detailed specifications under the respective headings.

12.1.4.11 Generally one coat should be adequate for old work and two coats (excluding priming coat) for new work.

12.1.5 Brushes and containers : After work, the brushes shall be completely cleaned of paint and linseed oil by rinsing with turpentine. A brush in which paint has dried up is ruined and shall on no account be used for painting work. The containers when not in use, shall be kept closed and free from air so that paint does not thicken and also shall be kept safe from dust. When the paint has been used, the containers shall be washed with turpentine and wiped dry with soft clean cloth, so that they are clean, and can be used again.

12.1.6 Measurements

12.1.6.1 The length and breadth shall be measured correct to a cm. The area shall be calculated in sqm (correct to two places of decimal), except where otherwise stated.

12.1.6.2 Small articles not exceeding 10 sq. decimeter (0.1 sqm) of painted surface, where not in conjunction with similar painted work, shall be enumerated.

12.1.6.3 Painting 10 cm in width or in girth and not in conjunction with similar painted work shall be given in running metres and shall include cutting to line where required.

Note : Components of trusses, compound girders, stanchions, lattices and similar work shall, however, be given in sq. metres irrespective of the size or girth of members. Priming coat of painting shall be included in the work of fabrication.

12.1.6.4 In measuring painting, varnishing, oiling etc. of joinery and steel work etc, the coefficients as indicated in **Table 12.1** below shall be used to obtain the area payable. The coefficients shall be applied to the areas measured flat and not girthed.

TABLE 12.1
EQUIVALENT PLAIN AREAS OF UNEVEN SURFACE

SL	Description of work	How Measured	Multiplying coefficients
I	WOOD WORK DOORS, WINDOWS ETC.		
1.	Panelled or framed and braced doors, windows etc.	Measured flat (not girthed) including	1.30 (for each side)
2.	Ledged and battened or ledged, battened and braced doors, windows etc.	Chowkhat or frame. Edge <u>s</u> , Chocks, cleats, etc shall be deemed to be included in the item	
3.	Flush doors etc	-do-	1.20 (for each side)

4.	Part panelled and part glazed or gauzed doors, window etc. (Excluding painting of wire gauze portion)	-do-	1.00 (for each side)
5.	Fully glazed or gauzed doors, windows etc (excluding painting of wire gauze portion)	-do-	0.80 (for each side)
6.	Fully venetianed or louvered doors, windows etc.	-do-	1.80 (for each side)
7.	Trellis (or jaffri) work one way or two way	Measured flat over, no deduction shall be made for open spaces. Supporting members shall not be measured separately	2 (for painting all over)
8.	Carved or enriched work	Measured flat	2 (for each side)
9.	Weather boarding	Measured flat (not girthed) Supporting frame work shall not be measured separately	1.20 (for each side)
10.	Wood Shingle roofing	Measured flat (not girthed)	1.10 (for each side)
11.	Boarding with cover fillets and match boarding	Measured flat (not girthed)	1.05 (for each side)
12.	Tile and slate battening	Measured flat overall. No deductions shall be made for open spaces	0.80 (for painting all over)
II	STEEL WORK DOORS, WINDOWS ETC		
13.	Plain sheeted steel doors or windows	Measured flat (not girthed) including frame edges etc.	1.10 (for each side)
14.	Fully glazed or gauzed steel doors and windows (excluding painting of wire gauze portion)	-do-	0.50 (for each side)
15.	Partly panelled and partly glazed or gauzed doors and windows (excluding painting of wire gauze portion)	-do-	0.80 (for each side)
16.	Corrugated sheeted steel doors or windows	-do-	1.25 (for each side)
17.	Collapsible gates	Measured flat	1.50 (for painting all over)
18.	Rolling shutters of interlocked laths	Measured flat (size of opening) all over; jamb guides, bottom rails and locking arrangement etc. shall be included in the item (top cover shall be measured separately)	1.10 (for each side)
III	GENERAL		
19.	Expanded metal, hard drawn steel wire fabric of approved quality, grill works and gratings in guard bars, balustrades, railing partitions and MS Bars in windows frames	Measured flat overall; no deduction shall be made for open spaces; supporting members shall not be measured separately	1 (for paint all over)
20.	Open palisade fencing and gates including standards, braces, rails stays etc. in timber or steel	-do- (see note no.12)	1 (for paint all over)
21.	Corrugated iron sheeting in roofs, side cladding etc.	-do- Measured flat (not girthed)	1.14 (for each side)
22.	AC corrugated sheeting in roofs, side cladding etc.	-do-	1.20 (for each side)

23.	AC semi-corrugated sheeting in roofs, side cladding etc. or Nainital pattern using plain sheets	-do-	1.10 (for each side)
24.	Wire gauze shutters including painting of wire gauze	-do-	1.00 (for each side)

Explanatory notes for Table 12.1

- Measurements for doors windows etc., shall be taken flat (and not girthed) over all including chowkats or frames, where provided. Where Chowkats or frames are not provided, the shutter measurements shall be taken.
- Where doors, windows etc., are of composite types other than those included in Table 12.1 the different portions shall be measured separately with their appropriate coefficients, the centre line of the common rail being taken as the dividing line between the two portions.
- The coefficients for doors and windows shall apply irrespective of the size of frames and shutter members.
- In case steel frames are used the area of doors, windows shutters shall be measured flat excluding frames.
- When the two faces of a door, window etc. are to be treated with different specified finishes, measurable under separate items, the edges of frames and shutters shall be treated with the one or the other type of finish as ordered by the Engineer and measurement of this will be deemed to be included in the measurement of the face treated with that finish.
- In the case where shutters are fixed on both faces of the frames the measurement for the door frame and shutter on one face shall be taken in the manner already described, while the additional shutter on the other face will be measured for the shutter only excluding the frame.
- Where shutters are provided with clearance at top or / and bottom each exceeding 15 cm height, such openings shall be deducted from the overall measurements and relevant coefficient shall be applied to obtain the area payable.
- Collapsible gates shall be measured for width from outside to outside of gate in its expanded position and for height from bottom to top of channel verticals. No separate measurements shall be taken for the top and bottom guide rails rollers, fittings etc.
- Rolling shutters of interlocked laths shall be measured for the actual shutter width and the height from bottom of opening to the centre of the shaft. No separate measurements shall be taken for painting guides and other exposed features within or outside the shutter area. The painting of top cover or hood shall, however be measured separately.
- Co-efficients for sliding doors shall be the same as for normal types of doors in the table. Measurements shall be taken outside to outside of shutters, and no separate measurements shall be taken for the painting guide rails, rollers, fittings etc.
- The measurements of guard bars, expanded metal, hard drawn steel wire fabric of approved quality, grill work and gratings, when fixed in frame work, painting of which is once measured elsewhere shall be taken exclusive of the frames. In other cases the measurements shall be taken inclusive of the frames.
- For painting open palisade fencing and gates etc., the height shall be measured from the bottom of the lowest rail, if the palisades do not go below it, (or from the lower end of the palisades, if they project below the lowest rail), upto the top of rails or palisades whichever are higher, but not upto the top of standards when the latter are higher than the top rails or the palisades.
- Measurements of painting of doors, windows, collapsible gates, rolling shutters etc., as above shall be deemed to include painting all iron fittings (wire gauze not to be included) in the same or different shade for which no extra will be paid.
- In the case of trellis (or jaffri) work, the measurements shall include the painting of the frame members for which no separate measurement shall be taken. Trellis door or windows shutters shall also be measured under trellis work.
- In the case of asbestos cement corrugated or semi-corrugated sheeting

and iron corrugated sheeting, in roofs, side cladding etc. the work shall be measured flat (not girthed) as fixed.

12.1.6.5 Width of moulded work of all other kinds, as in hand rails, cornices and architraves shall be measured by girth.

12.1.6.6 For trusses, compound girders, stanchions, lattice girders, and similar work, actual areas will be measured in sq. metre and no extra shall be paid for painting on bolt heads, nuts, washers etc. even when they are picked out in a different tint to the adjacent work.

12.1.6.7 Painting of rain water, soil, waste, vent and water pipes etc. shall be measured in running metres of the particular diameter of the pipe concerned. Painting of specials such as bends, heads, branches, junctions, shoes, etc. shall be included in the length and no separate measurements shall be taken for these or for painting brackets, clamps etc.

12.1.6.8 Measurements of wall surfaces and wood and other work not referred to already shall be recorded as per actual.

12.1.6.9 Flag staffs, steel chimneys, aerial masts, spires and other such objects requiring special scaffolding shall be measured separately.

12.1.6.10 The month and year of painting (completion) shall be clearly marked on the steel structure in white or any other colour as specified by the Engineer.

12.1.7 Precautions:

12.1.7.1 All furnitures, fixtures, glazing, floors etc shall be protected by covering and stains, smears, splashings, if any, shall be removed and any damage done shall be made good by the contractor at his cost.

12.1.7.2 The containers of paint, when not in use, shall be kept closed and air tight so that the paint does not thicken and is kept safe from dust.

12.1.7.3 Precautions in using Lead Paints:

- i) White lead, sulphate of lead and all products containing these pigments shall not be used in internal painting of buildings except for priming coat and artistic paintings or fine lining work.
- ii) White lead, sulphate of lead, or products containing these pigments shall not be used in painting operations except in the form of paste or paint ready for use; and measures shall be taken, to prevent danger arising from the application of

paint in the form of spray or from dust caused by dry rubbing down and scraping.

- iii) Paras (i) and (ii) above do not apply to white pigments containing not more than 2% of lead expressed in terms of metallic lead.
- iv) Lead paint and especially white lead, is injurious to those who use it. Entering the pores of the skin, it is absorbed by the system and leads to numbness and a kind of paralysis, and also produces the complaint known as painter's colic. Paint-workers must, therefore, be warned to avoid smearing themselves with paint. As they do not know the difference between the base of one paint and that of another, this warning must apply to all kinds of paint. Any worker found smearing himself with paint after being warned must be sent at once off the work and not re-employed.

12.1.7.4 Where it is necessary to rub down with sand paper, only water proof paper shall be used and the work kept wet. Too much pressure must not be used in rubbing. Slush formed in rubbing shall be frequently washed off with plenty of water.

12.1.8. Rate :

- (a) Rates shall include cost of all labour and materials involved in all the operations described above and in the particular specifications given under the respective items.
- (b) Unless otherwise stipulated, the rates for painting of iron work shall cover the all-inclusive cost of the following:-
 - i) Preparing the surface, except complete removal of existing paint.
 - ii) Providing and applying the prescribed coats of paint.
 - iii) Ladders, scaffolding, cradles, etc as may be necessary upto any height.
 - iv) Other materials and equipment, including scrapers, wire brushes, rust or paint removers, paint-brushes etc.
 - v) Protection of other surfaces and articles from splashes or drops of paint, etc., including moving or covering furniture etc., as may be necessary.
 - vi) Protection of the painted surface till dry.

- vii) Removing any unwanted stain or splash that may have resulted from execution of the work and leaving the premises in a clean state.
- viii) Marking neatly the date of painting according to the instructions of the Engineer's representative.

12.2. PAINTING PRIMING COAT ON WOOD, IRON OR PLASTERED SURFACES

12.2.1 Primer

12.2.1.1 The primer for wood work, iron work or plastered surface shall be as specified in the description of item. Priming coat is the first coat applied to fill the pores of wood or any minute inequalities on the surface to be painted. It should adhere firmly to the unpainted surface and provide a suitable ground to receive and hold the next coat. Special care shall be taken of places where decay or corrosion is likely to occur, such as joints in wood or metal and end grains in wood. Hurried priming should be avoided particularly on absorbent surfaces. Priming coat shall have no turpentine as it impairs the firmness of the paint. The rate for priming coat is inclusive of the cost of the

required treatment of the surface including knotting.

12.2.1.2 (a) Primer for Wood work/Aluminium & Iron, Steel Work / Cement Concrete and Plastered Surface shall be as described below in **Table 12.2** or as directed by the Engineer.

b) _____

c) Plastered and Concrete surface should not be painted before lapse of 12 months from the date of Completion of Plastering or Concreting, unless specially permitted in writing by Engineer. This interval is desirable to enable the surface to be completely free from adverse chemical reaction. It should be possible to manage during this period by use of white wash, colour wash, dry distemper or cement paint. If however painting is to be done within 12 months, priming coat shall be of Cement Primer.

(d) Generally for Railway Steel Structures priming coat is made up of One coat Red Lead Paint (IS 102) Or One Coat of Zinc Chromate Paint (IS 104) and one coat of RedOxide-Zinc Chromate Paint (IS 2074) (For New work, these two coats are taken as equivalent to one coat of Red Lead). Or One coat of Bituminous Black Paint (IS 158)

TABLE 12.2

SL	Surfaces	Primer to be used
1.	Wood work (hard and soft wood)	Pink conforming to IS:3536
2.	Resinour wood and plywood	Aluminium primer conforming to IS:3585
3.	(A) Aluminium and light alloys (B) Iron, Steel and Galvanized steel	Zinc Chromate primer conforming to IS:104 Red Oxide Zinc chromate Primer conforming to IS:2074
4.	Cement/ Conc/ RCC/ brick work. Plastered surfaces, asbestos surfaces to receive oil bound distemper or paint finish	Cement Primer conforming to IS:109

12.2.1.3 The primer shall be ready mixed primer of approved brand and manufacture.

12.2.1.4 Where primer for wood work is specified to be mixed at site, it shall be prepared from a mixture of red lead, white lead and double boiled linseed oil in the ratio of 0.7 kg : 0.7 kg : 1 litre.

12.2.1.5 Where Red Lead primer for steel work is specified to be mixed at site, it shall be prepared from a mixture of red lead, raw linseed oil and turpentine in the ratio of 2.8 kg : 1 litre : 1 litre.

12.2.1.6 The specifications for the base vehicle and thinner for mixed on site primer shall be as follows:

(a) White Lead : The White lead shall be pure and free from adulterants like barium sulphate and whiting. It shall conform to IS: 103.

(b) Red Lead : This shall be in powder form and shall be pure and free from adulterants like brick dust etc. It shall conform to IS: 102.

(c) Raw Linseed Oil : Raw linseed oil shall be lightly viscous but clear and of yellowish colour with light brown tinge. Its specific gravity at a temperature of 30 degree C shall be between 0.923 and 0.928.

Note : The oil shall be mellow and sweet to the taste with very little smell. The oil shall be of sufficiently matured quality. Oil turbid or thick, with acid and bitter taste and rancid

odour and which remains sticky for a considerable time shall be rejected. The oil shall conform in all respects to IS: 75. The oil shall be of approved brand and manufacture.

(d) *Double boiled linseed oil*: This shall be more viscous than the raw oil, have a deeper colour and specific gravity between 0.931 and 0.945 at a temperature of 30 degree C. It shall dry with a glossy surface. It shall conform in all respects to IS: 77. The oil shall be of approved brand and manufacture.

(e) **Turpentine**: Mineral turpentine i.e. petroleum distillate which has the same rate of evaporation as vegetable turpentine (distillate product of oleoresin of conifers) shall be used. It shall have no grease or other residue when allowed to evaporate. It shall conform to IS: 533.

12.2.1.7 All the above materials shall be of approved manufacture and brought to site in their original packing in sealed condition.

12.2.2 Preparation of surface

12.2.2.1 Wooden surface : a) The wood work to be painted shall be dry and free from moisture. The surface shall be thoroughly cleaned. All unevenness shall be rubbed down smooth with sand paper and shall be well dusted. The prepared surface shall be inspected and approved by the Engineer before painting is commenced.

b) **Knotting** : This is done before the application of priming coat to cover all knots in wood to prevent any exudation or resin, or any marks to show through the paint caused by the absorption of the knots. The surface treated for knotting shall be dried before the priming coat of paint is applied. There are three common methods of knotting as described below:-

i) **Lime Knotting**: Knots in deodar or other resinous wood shall be painted over with hot lime and scraped off after 24 hours. The knots are primed with red lead and glue laid hot and one coat of knotting varnish is applied. The surface is then rubbed smooth with pumice stone or sand paper.

ii) **Ordinary size knotting**: This is applied in two coats. The first is made by grinding red lead in water and mixing it with strong glue size used hot. (Dries in about 10 minutes). The second coat consists of red lead ground in oil and thinned with boiled oil and turpentine.

iii) **Patent knotting**: This consists of two coats of a varnish made by dissolving shellac in methylated spirit or naphtha. Knotting may be composed of 250 grams of pure shellac dissolved in 1 litre of methylated spirit and

when thoroughly dissolved, 25 grams of red lead is stirred in.

c) After obtaining approval of Engineer for wood work, the priming coat shall be applied before the wood work is fixed in position. After the priming coat is applied, the holes and indentation on the surface shall be stopped with glazier's putty or wood putty. Stopping shall not be done before the priming coat is applied as the wood will absorb the oil in stopping and the latter is therefore liable to crack.

12.2.2.2 Iron & Steel Surface : All rust and scales shall be removed by scrapping or by brushing with steel wire brushes. Hard skin of oxide formed on the surface of wrought iron during rolling which becomes loose by rusting, shall be removed.

All dust and dirt shall be thoroughly wiped away from the surface. If the surface is wet, it shall be dried before priming coat is undertaken.

12.2.2.3 Plastered Surface : The surface shall ordinarily not be painted until it has dried completely. Trial patches of primer shall be laid at intervals and when drying is satisfactory, painting shall then be taken in hand. Before primer is applied, holes and undulations shall be filled up with plaster of paris and rubbed smooth.

12.2.3 Application : The primer shall be applied with brushes, worked well into the surface and spread even and smooth. The painting shall be done by crossing and laying off as described in para 12.1.4.

12.2.4 Treatment on Steel for Aggressive Environment

12.2.4.1 A second coat of ready mixed red oxide/ zinc chromate primer or as specified may be applied where considered necessary in aggressive environment such as near Industrial Establishment and Coastal regions where the steel members are prone to corrosion. The second coat (which shall be paid for separately) is to be applied after placing the member in position and just before applying paint. The second coat of primer is not necessary in case of painting with synthetic enamel paint as it is applied over an under coat of ordinary paint.

12.2.4.2 The specifications described under para 12.1 shall hold good so far as they are applicable.

12.3 PAINTING WITH READY MIXED PAINT

12.3.1 General:- Ready mixed paints of approved brand and manufacture and of the required shades shall be used. They shall conform in all respects to the relevant IS Specifications.

12.3.2 Painting on New Surface : The surface which has not been painted earlier, or the paint had been removed by paint remover, burning, caustic soda etc. shall be considered to be new surface.

12.3.2.1 Preparation of Surface

a) **Wood Work :** The surface shall be cleaned and unevenness removed as specified in para 12.2.2.1. Knots if visible, shall be done as described under para 12.2.2.1 (b). Holes and indentations on the surface shall be filled in with glazier's putty or wood putty conforming to IS : 419 and rubbed smooth before Painting is done. The surface should be thoroughly dry before painting.

(b) **Iron And Steel Work :** The priming coat shall have dried up completely before painting is started. Rust and scaling shall be carefully removed by scraping or by brushing with steel wire brushes. All dust and dirt shall be carefully and thoroughly wiped away.

(c) **Plastered surface :** The priming coat shall have dried up completely before painting is started. All dust or dirt that has settled on the priming coat shall be thoroughly wiped away before painting is started.

12.3.2.2. Application : (a) The specifications described in para 12.1.4 shall hold good as far as applicable. The number of coats to be applied will be as stipulated in the item. The painted surface shall present a uniform appearance and glossy finish, free from streaks blisters etc.

(b) **For under coats and finishing coats:-** Either oil paints or bitumastic or aluminium paints of approved brand and manufacture shall be used. Bitumastic paints shall be used where appearance is of secondary consideration. The oil paints may be either synthetic enamels or ready mixed oil paints. Where red colour is acceptable, red oxide of iron paints shall generally be used. The red oxide paint shall be prepared by mixing red oxide, raw linseed oil and boiled linseed oil in the ratio of 4.79 kg : 2 litres : 1 litre.

IS Code references for the various types of Ready mixed paints to be applied as one or more coats as directed by the Engineer are as under.

- Red Oxide Paint (IS 123)
- Aluminium Paint (IS 2339)

- Synthetic Enamel Exterior (IS 2932)
- Enamel Exterior (IS 2933)
- Paint for General Purposes, Battleship grey or other Standard colour (IS 117)
- Bituminous Black Paint (IS 158)
- Bituminous Emulsion Paint
- Coal Tar Black Paint or Tarstil (IS 290)

(c) For Railway Steel Girder Bridges, Specifications indicated in **Annexure 12.1** shall be followed.

12.3.2.3 The specifications described in para 12.1 shall hold good in so far as they are applicable.

12.3.3 Painting on old surface: The surface which has been painted earlier shall be considered to be old surface.

12.3.3.1. Preparation of surface

(a) **Wood work :** If the old paint is sound and firm and its removal is considered unnecessary, the surface shall be rubbed down with pumice stone after it has been cleaned of all smoke and grease by washing with lime and rinsing with water and drying. All dust and loose paint shall be completely removed. The surface shall then be washed with soap and water.

If the old painted surface is blistered or flaked badly old paint shall be completely removed as described in para 12.22 and such removal shall be paid for separately. Holes and cracks if any shall be stopped with glazier's putty or wood putty conforming to IS: 419. Further the painting itself shall be treated as on new surface and paid for, accordingly.

(b) **Iron and Steel Work :** If the old paint is sound and firm and its removal is considered unnecessary, it shall be rubbed with wire brushes and any loosened paint taken off. All dust shall then be thoroughly wiped away. The surface shall then be wiped finally with mineral turpentine to remove grease and perspiration of hand marks etc. and then allowed to dry.

If the old painted surface is in bad condition and blistered and flaked, the old paint shall be completely removed and the surface prepared, as described in para 12.22. Such removal shall be paid for separately. The painting including the priming coat shall be treated as on new work and paid for accordingly.

(c) **Plastered surface :** It shall be as specified for wood work. If before painting, any portion of the wall shows signs of dampness, the causes shall be investigated and the damp surface shall be properly

treated. Such treatment shall be paid for separately. A thin coat of white lead if so required shall be applied on the wet or patchy portion of the surface before painting is undertaken and this shall be paid extra.

12.3.3.2 Application : The specifications described in para 12.1.4 shall hold good as far as applicable. The number of coats to be given shall be as stipulated in the description of the item.

12.3.3.3 The specifications described in 12.1 shall hold good in so far as they are applicable.

12.4 PAINTING READY MIXED PAINT OVER G.S. SHEETS

12.4.1 General : Ready mixed paint, suitable for painting over G.S. sheets, of approved brand and manufacture and of the required shade shall be used. New or weathered G.S. sheets shall be painted with a priming coat of one coat of red oxide zinc chromate paint or as specified. Primer shall be applied before fixing sheets in place.

12.4.2 Preparation of Surface

12.4.2.1 Painting New Surface : The painting of new G.S. sheets shall not usually be done till the sheets have weathered for about a year. When new sheets are to be painted before they have weathered they shall be treated with a mordant solution prepared by mixing 38 gm of copper acetate in a litre of soft water or 13 gm hydrochloric acid in a solution of 13 gm each of copper chloride, copper nitrate and ammonium chloride dissolved in a litre of soft water. This quantity of solution is sufficient for about 235 to 280 sqm of area and is applied for ensuring proper adhesion of paint. The painting with the mordant solution will be paid for separately.

Before painting on new or weathered G.S. sheets, rust patches shall be completely cleaned with coarse emery paper and brush. All grease marks shall also be removed and the surface washed and dried and rusted surface shall be touched with ready mixed paint of red lead.

12.4.2.2 Painting on Old Surface : If the old paint is firm and sound, it shall be cleaned of grease, smoke etc. The surface shall then be rubbed down with sand paper and dusted. Rusty patches shall be cleaned up and touched with red lead.

If the old paint is blistered and flaked, it shall be completely removed as described in 12.22. Such removal shall be paid for

separately and painting shall be treated as on new work.

12.4.3 Application : The number of coats to be applied shall be as in the description of item. In the case of C.G.S. sheets, the crowns of the corrugations shall be painted first and when these get dried the general coat shall be given to ensure uniform finish over the entire surface without the crowns showing signs of thinning. Special attention shall be paid to rivets, bolt heads and welds. If the existing primer appears to be of a poor quality or of inadequate thickness or if there are signs of rusting beneath the paint at numerous places, the whole surface shall be cleaned and reprimed. The second or additional coats shall be applied when the previous coat has dried.

12.4.4 Other Specifications : The specifications described in para 12.1 shall hold good so far as they are applicable.

12.5 PAINTING CAST IRON RAIN WATER, SOIL, WASTE AND VENT PIPES AND FITTINGS

12.5.1 General: The primer shall be prepared at site or shall be of approved brand and manufacture as specified in the item. Paint shall be anti-corrosive bitumastic paint, aluminium paint or other type of paint as specified in the description of the item.

12.5.2 Painting New Surface

12.5.2.1 Preparation of Surface : The surface shall be prepared for priming coat as described in para 12.2.2.2.

12.5.2.2 Application: The number of coats of painting over the priming coat shall be as stipulated in the description of the item. The application of paint over priming coat shall be carried out as specified in para 12.3.

12.5.2.3 Measurements: Measurements will be taken over the finished line of pipe including specials etc. in running metre, correct to a cm. Pipes of different diameters of bore shall be measured and paid for separately. Specials and fittings such as holder bat clamps, plugs etc. will not be measured separately.

12.5.2.4 Rate : The rate shall include the cost of all materials and labour involved in all the operations described above, including painting of all specials and fittings.

12.5.2.5 Specifications described in para 12.1 shall hold good as far as they are applicable.

12.5.3 Painting on old Surface

12.5.3.1 The surface shall be prepared as specified in para 12.3.2.1 (b).

12.5.3.2 The specifications for application shall be as described in para 12.1.4.

12.5.3.3 Measurements, rate and other details shall be as specified in para 12.5.2.

12.6 PAINTING WITH WOOD PRESERVATIVE

12.6.1 General: Oil type wood preservative of specified quality and approved make, conforming to IS : 218 shall be used. Generally, it shall be creosote oil type I or anthracene oil.

12.6.2 Painting on New Surface

12.6.2.1 Preparation of surface : Painting shall be done only when the surface is perfectly dry to permit of good absorption. All dirt, dust or other foreign matter shall be removed from the surface to be painted. All roughness shall be sand papered and cleaned.

12.6.2.2 Application: The preservative shall be applied liberally with a stout brush and not daubed with rags or cotton waste. It shall be applied with a pencil brush at the joints of the wood work. The first coat shall be allowed at least 24 hours to soak in before the second (the final) coat is applied. The second coat shall be applied in the same manner as the first coat. The excess of preservative which does not soak into the wood shall be wiped off with a clean dry piece of cloth.

12.6.2.3 The specifications described in para 12.1 shall hold good in so far as they are applicable.

12.6.3 Painting on old surface : The work shall be done in the same manner as on new surface except that only one coat shall be done.

12.7 COAL TARRING

12.7.1 General : Coal tar of approved manufacture conforming to IS : 290 shall be used. The tar, to every litre of which 200 gm of unslaked lime has been added, shall be heated till it begins to boil. It must then be taken off the fire and kerosene oil added to it slowly at the rate of one part of kerosene oil to six or more parts by volume and stirred thoroughly. The addition of lime is for preventing the tar from running.

12.7.2 Coal Tarring New Surface

12.7.2.1. Preparation of surface : This shall be done as specified in para 12.2.2 except that sand papering is not necessary. Where

iron work is to be painted it shall be freed from scales and rust before painting.

12.7.2.2. Application : The mixture shall be applied as hot as possible with a brush. The second coat shall be applied only after the first coat has thoroughly dried up. Where possible, the article to be tarred, shall be dipped in the hot mixture for better results. The quantity of tar to be used for the first or second coat shall be not less than 0.16 and 0.12 litre per sqm respectively. Thinning with kerosene oil shall be suitably done to ensure this.

12.7.2.3 The specifications described in 12.1 shall hold good in all other respects, so far as they are applicable.

12.7.3 Coal Tarring old Surface :

The work shall be done in the same manner as specified in para 12.7.2 except that only one coat using 0.12 litre per sqm. area shall be done.

12.7.4 Precautions : Coal tar and bitumen compounds, though not normally considered dangerous, can become so when heated in drums, either due to local boiling of the material at the point of heating or due to the liberation of inflammable gases which catch fire and cause an explosion. Care shall, therefore, be taken to ensure that heating is gradual and spread over a wide area. If due to solidification, material in closed drums is to be heated, the fire shall be kept well away from the open screw cap holes.

12.8 SPRAY PAINTING WITH FLAT WALL PAINT ON NEW SURFACE

12.8.1 General : (a) The work shall include a priming coat of 'Distempering Primer' or 'Cement Primer' as specified in the description of the item. Flat wall paint shall normally be applied on walls 12 months after their completion, in which case Distemper primer will suffice. If the walls are to be painted earlier, the primer coat shall consist of cement primer.

(b) Materials : The primer and the flat wall paint shall be of approved brand and manufacture and of the required shade.

12.8.2 Surface Preparation : The surface shall be prepared as described in Chapter 11.

12.8.3 Application

12.8.3.1 Primer Coat : The specified primer shall be painted or sprayed over the surface in an even and uniform layer.

12.8.3.2 Painting Coats : When the surface is dry, the spray painting with the wall paint

in uniform and even layers will be done to the required number of coats. Each coat shall be allowed to dry overnight and lightly rubbed with very fine grade of sand paper and loose particles brushed off before the next coat is sprayed.

Spraying should be done only when dry condition prevails. During spraying the spray gun shall be held perpendicular to the surface to be coated and shall be passed over the surface in a uniform sweeping motion. Different air pressures and fan adjustment shall be tried so as to obtain the best application. The Air pressure shall not be kept too high as otherwise the paint will fog up and will be wasted

At the end of the job, the spray gun shall be cleaned thoroughly so as to be free from dirt. Incorrect adjustments shall be set right, as otherwise they will result in variable spray patterns, runs, sags and uneven coats.

If after the final coat of wall paints, the surface obtained is not upto the mark, further one or more coats as required shall be given after rubbing down the surface and dusting off all loose particles to obtain a smooth and even finish.

If the primer or wall paint gets thickened during the application, it shall be thinned suitably with the thinner recommended by the manufacturer.

Adequate ventilation shall be provided to disperse spray fumes. Fitments and floor shall be protected from the spray

12.8.4 Other Specifications : The specifications described in Para 12.1 shall hold good for all other details as far as applicable.

12.9 SPRAY PAINTING WITH FLAT PAINT ON OLD SURFACE

12.9.1 General : (a) Where the old paint is in sound condition, renewal shall be carried out as described below, otherwise the old paint shall be completely stripped and spray painting shall be carried out as over new work. Such removal shall be paid for separately.

(b) Materials : The flat wall paint shall be of approved brand and manufacture and of required shade.

12.9.2. Preparation of Surface : The surface shall be washed to remove dust and dirt. A mild detergent solution like soap water shall be used for washing and the surface shall also be rubbed down lightly with abrasive paper when dry. Any patches

appearing on the surface shall first be touched up with a coat of paint. These shall be allowed to dry and then rubbed down lightly.

12.9.3. Application : The paint shall then be applied with spraying machine in uniform and even layer. A second coat shall be applied if considered necessary by the Engineer but only after the first coat is completely dry and hard.

Spraying should be done only when dry condition prevails. During spraying the spray gun shall be held perpendicular to the surface to be coated and shall be passed over the surface in uniform sweeping motion. Different air, pressures and fan adjustment shall be tried so as to obtain the best application. The Air pressure shall not be kept too high as otherwise the paint will fog up and will be wasted. At the end of the job, the spray gun shall be cleaned thoroughly so as to be free from dirt. Incorrect adjustments shall be set right, as otherwise they result in variable spray patterns, runs, sags and uneven coats

12.9.4 Other Specification : The specifications described in Para 12.1 shall hold good for all other details, as far as they are

12.10 WALL PAINTING WITH PLASTIC EMULSION PAINT

12.10.1 General : (a) The plastic emulsion paint is not suitable for application on external, wood and iron surface, and surfaces which are liable to heavy condensation. These paints are to be used on internal surfaces except wooden and steel.

(b) Materials : Plastic emulsion paint as per IS : 5411 of approved brand and manufacture and of the required shade shall be used.

12.10.2 Painting on new surface

12.10.2.1 Preparation : The wall surface shall be prepared as specified in para 12.1.3.

12.10.2.2 Application : The number of coats shall be as stipulated in the item. The paint will be applied in the usual manner with brush, spray or roller. The paint dries by evaporation of the water content and as soon as the water has evaporated the film gets hard and the next coat can be applied. The time of drying varies from 1 hour on absorbent surfaces to 2 to 3 hours on non-absorbent surfaces.

The thinning of emulsion is to be done with water and not with turpentine. Thinning with water will be particularly required for the under coat which is applied on the absorbent surface. The quantity of water to be added shall be as per manufacturer's instructions.

The surface on finishing shall present a flat velvety smooth finish. If necessary, more coats shall be applied till the surface presents a uniform appearance.

12.10.2.3 Precautions

(a) Old brushes if they are to be used with emulsion paint, should be completely dried of turpentine or oil paints by washing in warm soap water. Brushes should be quickly washed in water immediately after use and kept immersed in water during break periods to prevent the paint from hardening on the brush

b) In the preparation of wall for plastic emulsion no oil base putties shall be used in filling cracks, holes etc

(c) Splashes on floors etc. shall be cleaned out without delay as they will be difficult to remove after hardening.

(d) Washing of surfaces treated with emulsion paints shall not be done within 3 to 4 weeks of application.

12.10.2.4 Other details shall be as specified in para 12.1 as far as they are applicable.

12.10.3 Painting on old surface

12.10.3.1. Preparation of surface : This shall be done, generally as specified in 12.3.3.1 (c) except that the surface before application of paint shall be flattened well to get the proper flat velvety finish after painting.

12.10.3.2 Application : The number of coats to be applied shall be as in description of item. The application shall be as specified in para 12.10.2.2 except that thinning with water shall not normally be required.

12.10.3.3 Other details shall be as specified in para 12.1 as far as applicable.

12.11 PAINTING WITH ENAMEL PAINT

12.11.1 General : Enamel Paint (conforming to IS: 2933) of approved brand and manufacture and of the required colour shall be used. For the under coat, the paint of same quality but of shade to suit that of the top coat shall be used.

12.11.2. Preparation of Surface etc. : Preparation of surface and application shall

be as specified under para 12.3 for painting on new surfaces or old surfaces, as the case may be.

12.11.3 Other Specifications : Other details shall be as specified in para 12.1 as far as applicable.

12.12 PAINTING WITH SYNTHETIC ENAMEL PAINT

12.12.1 General: Synthetic enamel paint (conforming to IS:2932) of approved brand and manufacture and of the required colour shall be used for the top coat and an undercoat of ordinary paint of shade to match the top coat as recommended by the same manufacturer as far the top coat shall be used.

12.12.2 Painting on New Surface

12.12.2.1 Preparation of surface shall be as specified in para 12.3.2.1 (a) or (b) as the case may be.

12.12.2.2 Application : The number of coats including the undercoat shall be as stipulated in the item.

(a) Under Coat : One coat of the specified ordinary paint of shade suited to the shade of the top coat, shall be applied and allowed to dry overnight. It shall be rubbed next day with the finest grade of wet abrasive paper to ensure a smooth and even surface, free from brush marks and all loose particles dusted off.

(b) Top Coat : Top coats of synthetic enamel paint of desired shade shall be applied after the undercoat is thoroughly dry. Additional finishing coats shall be applied if found necessary to ensure properly uniform glossy surface.

12.12.2.3. Other details shall be as specified in para 12.1 as far as they are applicable.

12.12.3 Painting on Old Surface

12.12.3.1. Preparation of Surface : Where the existing paint is firm and sound it shall be cleaned of grease, smoke etc. and rubbed with sand paper to remove all loose particles dusted off. All patches and cracks shall then be treated with stopping and filler prepared with the specified paint. The surface shall again be rubbed and made smooth and uniform.

If the old paint is blistered and flaked it will be necessary to completely remove the same as described in para 12.22. Such removal shall be paid for separately and the painting shall be treated as on new surface.

12.12.3.2 Painting : The number of coats as stipulated in the item shall be applied with

synthetic enamel paint. Each coat shall be allowed to dry and rubbed down smooth with very fine wet abrasive paper, to get an even glossy surface. If however, the surface is not satisfactory, additional coats as required shall be applied to get correct finish.

12.12.3.3 Other details shall be as specified in para 12.1 as far as they are applicable.

12.13 PAINTING WITH ALUMINIUM PAINT

12.13.1 General : Aluminium paint shall conform to IS:2339 and of approved brand and manufacture. The paint generally comes in compact dual container with the paste and the medium separately. The two shall be mixed together to proper consistency before use.

12.13.2 Preparation of Surface

12.13.2.1 Steel Work (New Surfaces) : All rust and scales shall be removed by scraping or brushing with steel wire brushes and then smoothened with sand paper. The surface shall be thoroughly cleaned of dust.

12.13.2.2 C.G.S. Sheets (New Surfaces) : The preparation of surface shall be as specified in 12.4.2.1.

12.13.2.3 Steel work or C.G.S. sheets (Old Surfaces) : The specifications shall be as described in para 12.4.2.2.

12.13.3 Application : The number of coats to be applied shall be as given in the item. Each coat shall be allowed to dry for 24 hours and lightly rubbed down with fine grade sand paper and dusted off before the next coat is applied. The finished surface shall present an even and uniform appearance.

As aluminium paste is likely to settle in the container, care shall be taken to frequently stir the paint during use. Also the paint shall be applied and laid off quickly, as surface is otherwise not easily finished.

12.13.4 Other Specifications : Other details shall be as specified in para 12.1 as far as they are applicable.

12.14 PAINTING WITH ACID PROOF PAINT

12.14.1 General : Acid proof paint of approved brand and manufacture and of the required shade shall be used.

12.14.2 Preparation of Surface : Preparation of surface and application shall be as specified under 12.3 for new/old surface as the case may be.

12.14.3 Other Specifications : Other details shall, be as specified in para 12.1 as far as they are applicable.

12.15 PAINTING WITH ANTI-CORROSIVE BITUMASTIC PAINT

12.15.1 General : Ready mixed paint conforming to IS 158 shall be of approved brand and manufacture. It shall be black, lead free, acid- alkali- heat- water resistant.

12.15.2 Preparation of Surface etc : Preparation of surface and application shall be as specified in para 12.3 for painting on new or old surfaces as the case may be.

The drying time between consecutive coats however, shall be not less than 3 hours.

12.15.3. Other Specifications : Other details shall be as specified in para 12.1 as far as applicable.

12.16. FLOOR PAINTING

12.16.1 General : Floor paint of approved brand and manufacture and of the required colour shall be used.

12.16.2. Preparation of Surface : All dirt, grease shall be removed from the floor by wiping with rags, soaked in turpentine and scraping where necessary and then washing with warm water containing caustic soda or washing soda in solution. The floor should then be rinsed thoroughly with water and dried. Cracks and holes shall then filled with specified filler as recommended by manufacturer and rubbed smooth.

It should be noted that the painting with floor paints shall not be done over concrete surfaces less than two years old. Old surface shall be prepared as specified in para 12.3.3.1(c).

12.16.3. Application : The number of coats as in description of the item shall be applied. Each coat shall be allowed to dry for not less than 24 hours before the next coat is applied. The flooring should not be brought into use for a week after final coat so that the painted surface can thoroughly harden.

12.16.4. Measurements : Measurements shall be as per actual length and breadth being measured correct to a cm. The details given under para 12.1.6 shall hold good as far as applicable.

12.16.5. Other Specifications : Other details shall be as specified in para 12.1 as far as applicable.

12.17. VARNISHING

12.17.1 General : (a) Ordinary copal varnish or superior quality spray varnish shall be used. The work includes sizing of transparent wood filler.

(b) Materials : Varnish (conforming to IS:347) for the finishing and undercoats shall be of the approved manufacturer.

12.17.2 Varnishing on new Surfaces

12.17.2.1. Preparation of surface : New wood work to be varnished shall have been finished smooth with a carpenter's plane. Knots shall be cut to a slight depth. Cracks and holes shall be cleaned of dust. The knots, cracks etc. shall then be filled in with wood putty made as follows:

On a piece of wood say 20 x 15 cm face and on the side where cross grains appear, a small quantity of glue size shall be poured and the surface scraped with the edge of a fine carpenter's chisel. Very fine wood powder shall be mixed with the glue and the stiff paste thus formed shall be used for the filing.

The fillings when dry shall be rubbed down with a carpenter's file and then the entire surface shall be rubbed down perfectly smooth with medium grained and fine sand paper and wiped with dry clean cloth so that it presents uniform appearance. In no case shall sand paper be rubbed across the grains, as in this case even the finest marks will be visible when the varnishing is applied.

12.17.2.2. Sizing or Transparent Wood Filler Coat : The surface shall then be treated with either glue sizing or with transparent wood filler coat as stipulated in the description of item.

(a) Sizing : When sizing is stipulated, an application of thin clean size shall be applied hot on the surface. When dry, the surface shall be rubbed down smooth with sand paper and cleaned. It shall then be given another application of glue size nearly cold. The sized wood work shall again be rubbed down smoothly with fine sand paper and cleaned. The surface shall be perfectly dry and all dust shall be removed not only from the surface but also from the edges and joints before varnishing is commenced. If the wood work is to be stained, the staining colour shall be mixed with the second coat of the size which must be applied evenly and quickly keeping the colour on the flow.

Any joining up with work already dry will show badly. The object of application of the glue size is to seal the pores in wood to prevent absorption of the oil in the varnish.

Treating oily wood: If the wood work is of an oily nature, a little 'multani mitti' and ochre shall be added to the first coat of size as otherwise varnish will not dry readily. Nothing extra shall be paid for this.

Glue sizing is inadvisable on floors, table tops and other horizontal surfaces likely to carry wet household utensils which are likely to disturb the size coatings and thus expose bare wood. Where glue sizing is omitted to be done, the rate for the work shall be suitably reduced.

(b) Transparent Wood Filler Coat : Where instead of glue sizing, transparent wood filler application is stipulated in the item, then the surface prepared as described in 12.17.2.1 shall be given as application of the filler with brush or rag in such a way that the filler fills up all the pores and indentations and levels up the surface. It shall be allowed to dry for 24 hours. Then it shall be cut and rubbed with emery paper so that the surface of the wood is laid bare, with the filler only in the pores and crevices of the wood.

12.17.2.3 Application of Varnish : The number of coats to be applied shall be as stipulated in the description of the item.

The undercoat shall be with a flattening varnish. This dries hard and brittle and when cut and rubbed down to produce a smooth surface enhances the gloss of the finishing varnish. The top coat shall be given with stipulated brand of finishing varnish.

The varnish shall be applied liberally with a full brush and spread evenly with short light strokes to avoid frothing. If the work is vertical the varnish shall be crossed and recrossed and then laid off, latter being finished on the upstrokes so that varnish, as it sets, flows down and eliminates brush marks. The above process will constitute one coat. If the surface is horizontal, varnish shall be worked in every direction, with light quick strokes and finish in one definite direction so that it will set without showing brush marks. In handling and applying varnish care should be taken to avoid forming froth or air bubbles. Brushes and containers shall be kept scrupulously clean.

Rubbing down and flattening the surface shall be done after each coat except the final coat, with fine sand paper. The work shall be allowed to dry away from draughts and damp air. The finished surface shall then present a uniform appearance and fine glossy surface free from streaks, blister etc. Any varnish left over in the small container shall not be poured back into the stock tin, as it will render the latter turnout unfit for use. Special

fine haired varnishing brushes shall be used and not ordinary paint brushes. Brushes shall be well worn and perfectly clean. Other details shall be as specified in 12.1 as far as they are applicable.

12.17.3 Varnishing on old Surface

12.17.3.1 Preparation of Surface : If the old varnished surface is firm and sound it shall be cleaned of grease and dirt with turpentine and then rubbed with wet sand paper until the surface is clean and smooth. It shall be dried and wiped clean with a soft cloth. Knots, holes and cracks shall be stopped as specified in para 12.17.2.1 The entire surface shall then be rubbed down smooth with sand paper and wiped clean.

If the old varnished surface is peeled or cracked then it will be necessary to remove the entire varnish as described in para 12.22 and such removal shall be paid for separately outside the rate for varnishing. Further the varnishing itself will have to be done like new work and will be paid for as such.

12.17.3.2. Application : The specification shall be same as described in para 12.17.2.3 as far as applicable except that the coats to be applied will be with the stipulated quality of varnish for finishing coat.

12.17.3.3 Other details shall be as specified in para 12.1 as far as they are applicable.

12.18 FRENCH SPIRIT POLISHING

12.18.1 General:- Pure shellac conforming to IS: 16 varying from pale orange to lemon yellow colour, free from resin or dirt shall be dissolved in methylated spirit at the rate of 140 gm of shellac to 1 litre of spirit. Suitable pigment shall be added to get the required shade. Ready made polish conforming to IS: 348 can also be used.

12.18.2 Polishing New Surface

12.18.2.1. Preparation of Surface : The surface shall be cleaned. All unevenness shall be rubbed down smooth with sand paper and well dusted. Knots if visible shall be covered with a preparation of red lead and glue size laid on while hot. Holes and indentations on the surface shall be stopped with glazier's putty. The surface shall then be given a coat of wood filler made by mixing whiting (ground chalk) in methylated spirit at the rate of 1.5 Kg of whiting per litre of spirit. The surface shall again be rubbed down perfectly smooth with glass paper and wiped clean.

12.18.2.2. Application : The number of coats of polish to be applied shall be as described in the item.

A pad of woolen cloth covered by a fine cloth shall be used to apply the polish. The pad shall be moistened with the polish and rubbed hard on the Wood, in a series of overlapping circles applying the mixture sparingly but uniformly over the entire area to give an even level surface. A trace of linseed oil on the face of the pad facilitates this operation. The surface shall be allowed to dry and the remaining coats applied in the same way. To finish off, the pad shall be covered with a fresh piece of clean fine cotton cloth slightly damped with methylated spirit and rubbed lightly and quickly with circular motions. The finished surface shall have a uniform texture and high gloss.

12.18.2.3. Measurements, Rate and other details shall be as specified in para 12.1 as far as they are applicable.

12.18.3 Polishing Old Surface

12.18.3.1. Preparation of Surface : If the old polished surface is not much soiled, it shall be cleaned of grease and dirt by rubbing with turpentine and then rubbed with fine sand paper.

If the old polished surface is much soiled, then it will be necessary to remove the entire polish as described in para 12.22 and such removal shall be paid for separately outside the rate of polishing. Further the polishing itself will have to be done like new work and will be paid for as such.

12.18.3.2. Application : The specifications shall be same as described in para 12.18.2.2 as far as applicable.

12.18.3.3. Measurements, Rate and other details shall be as specified in para 12.1 as far as they are applicable.

12.19. OILING WITH LINSEED OIL

12.19.1 General : Raw linseed oil shall be lightly viscous but clear and of yellowish colour with light brown tinge. Its specific gravity at a temperature of 30°C shall be between 0.923 and 0.928. The oil shall be mellow and sweet to the taste with very little smell. Oil shall be clear and free from adulterants, sediment, suspended and other foreign matter. Linseed oil which is turbid or thick, with acid and bitter taste and rancid odour and which remains sticky for a considerable time shall be rejected. The oil shall conform in all respects to IS : 75. The oil shall be of approved brand and manufacture.

12.19.2 Oiling New Surface

12.19.2.1. Preparation of Surface : This shall be done as described in Para 12.17.2.1 except that no sizing will be done on the prepared surface.

12.19.2.2. Application : The number of coats to be applied shall be as stipulated in the description of item. The oil shall be applied freely with brushes (no rags) and spread evenly and smooth until no more oil is absorbed. Each subsequent coat shall be applied after the previous coat is thoroughly dried and in any case not before 24 hours of application of first coat. Work after completion shall not be patchy and sticky to the touch and shall present a uniform appearance.

12.19.2.3. Other details shall be as specified in para 12.1 as far as they are applicable.

12.19.3. Oiling on old Surface

12.19.3.1. Preparation of Surface : The wood work shall be cleaned of all smoke and grease by sand papering or by washing with lime and water. The surface shall then be washed with soap and water and completely dried.

12.19.3.2. The specification for application shall be as described in para 12.19.2.2.

12.19.3.3. Other details shall be as specified in para 12.1 as far as they are applicable.

12.20. BEES WAXING OR POLISHING WITH READY MADE WAX POLISH

12.20.1 General : The polishing shall be done with bees waxing prepared locally or with ready made wax polish of approved brand and manufacture, as stipulated in the description of item. Where bees waxing is to be prepared locally, the following specifications for the same shall apply.

Pure bees wax free from paraffin or stearine adulterants shall be used. Its specific gravity shall be 0.965 to 0.969 and melting point shall be 63 degree C. The polish shall be prepared from a mixture of bees wax, linseed oil, turpentine and varnish in the ratio of 2:1.5:1:0.5 by weight.

The bees wax and boiled linseed oil shall be heated over a slow fire. When the wax is completely dissolved the mixture shall be cooled till it is just warm and turpentine and varnish added to it in the required proportions and the entire mixture shall be well stirred.

12.20.2. Waxing New Surface

12.20.2.1. Preparation of Surface : Preparation of surface shall be as described in para 12.17.2.1 with the exception that knotting, holes and cracks shall be stopped with a mixture of fine saw dust formed of the wood being treated, beaten up with sufficient bees wax to give it cohesion.

12.20.2.2. Application : The polish shall be applied evenly with a clean soft pad of cotton cloth in such a way that the surface is completely and fully covered. The surface is then rubbed continuously for half an hour.

When the surface is quite dry, a second coat shall be applied in the same manner and rubbed continuously for one hour or until the surface is dry. The final coat shall then be applied and rubbed for two hours (more if necessary) until the surface has assumed a uniform gloss and is dry, showing no sign of stickiness. The final polish depends largely on the amount of rubbing which should be continuous and with uniform pressure with frequent changes in the direction.

12.20.2.3. Other details shall be as specified in para 12.1 as far as they are applicable.

12.20.3. Waxing Old Surfaces

12.20.3.1. Preparation of Surface : The wood work shall be cleaned of all smoke and grease by washing with lime water. The surface shall then be washed with soap and completely dried. Then it shall be prepared smooth as specified in Para 12.17.3.1.

12.20.3.2. Application : The polish shall be applied in the manner specified in Para 12.20.2.2. In this case one or two coats shall be applied as necessary to get uniform gloss, instead of three coats in the case of new work.

12.20.3.3. Other details shall be as specified in para 12.1 as far as they are applicable.

12.21. LETTERING WITH PAINT

12.21.1 General : Black Japan paint (conforming to 15:341) or ready mixed paint as ordered by the Engineer shall be used. The paint shall be of approved brand and manufacture. Ordinary ready mixed paint shall be of the shade required by the Engineer.

12.21.2. Lettering on New Surface

12.21.2.1. Application : The letters and figures shall be to the heights and width as ordered by the Engineer. These shall be stenciled or drawn in pencil and got approved before painting. They shall be of uniform size and finished neatly. The edges shall be straight or in pleasant smooth

curves. The thickness of the lettering shall be as approved by the Engineer. Lettering shall be vertical or slanting as required.

Two or more coats of paint shall be applied till uniform colour and glossy finish are obtained.

12.21.2.2. Measurements : Measurements shall be taken in terms of letter cm (the measurement relate to the vertical height of the lettering). The letter heights shall be measured correct to a cm. Dots, dashes, punctuations and other similar marks or lines shall not be measured for payment.

In Devanagari Script Dots & Matras occurring with the letters shall not be measured. Half letter shall be measured as full letter. The height of letters shall be measured excluding the Matras projecting above the head line and matras below the letters.

12.21.2.3. Rate : Rate shall include the cost of all labour and materials involved in the operations described above. The rate per cm height of letter shall hold good irrespective of the width of the letters or figures or the thickness of the lettering. The same rate will apply irrespective of whether black Japan or ready mixed paint of any shade as required is used.

12.21.3. Relettering on Old Surface

12.21.3.1. Painting shall be done over the existing letters and shall accurately follow their lines and curves. One or more coat of paints shall be applied till uniform colour and glossy finish is obtained.

12.21.3.2. Measurements and Rate shall be as specified under para 12.21.2.

12.22 REMOVING OLD PAINT

12.22.1. With Patent Paint Remover

12.22.1.1. Patent paint removers shall consist of volatile organic liquids thickened with waxes and other ingredients to retard the evaporation of the liquid and to enable a substantial layer of remover to be applied to the surface. The paint remover shall be of a brand and manufacture approved by the Engineer. It shall be free from alkaline matter and non-caustic so that it can be handled by workmen without injury. It shall be of non inflammable quality as far as possible.

12.22.1.2. Application: Paint remover shall be used where burning off with blow lamp is not suitable. The paint remover shall be applied liberally with a brush and allowed to remain on the surface for a period depending on the particular brand of remover used and

on the thickness of the paint coating to be removed. When the paint film lifts and wrinkles under the action of the remover it shall be stripped with a sharp instrument. If the film is not thoroughly removed a second coat of remover may be applied if necessary over such patches and then the film thoroughly scrapped.

After the surface has been stripped, it shall be washed down with mineral turpentine to remove all traces of paraffin wax, which forms one of the ingredients of patent paint remover and which if left in place will prevent the paint from drying. The cleaned surface shall be suitably prepared for application of paint or other finish.

12.22.1.3. Precautions : Where the paint remover used is of the inflammable type, suitable precaution against risk of fire shall be taken. Neighbouring painted surfaces which are not to be treated should be properly protected from contact with paint remover.

12.22.1.4. Preparation of Surface : The surface shall then be prepared as described in para 12.2.2.

12.22.1.5. Measurements: Specification under para 12.1.6 shall hold good.

12.22.1.6. Rate: Rate shall include the cost of all labour and materials involved in all operations described above.

12.22.1.7. Other details shall be as specified para 12.1 as far as possible.

12.22.2. With Caustic Soda Solution

12.22.2.1. Application : Caustic soda dissolved with 48 times its volume of water shall be applied to the old paint with a brush and when the paint film lifts and wrinkles it shall be thoroughly scrapped of in the same way as described in para 12.22.1.2. After the surface has been stripped thoroughly, it shall be rinsed with several changes of clean water to remove all traces of, alkali, which if allowed to remain are liable to spoil the new paint applied over it. A little acetic acid or vinegar added to the final change of rinsing water helps to neutralize any remaining alkali.

12.22.2.2. Precautions : Caustic soda as its name implies is a corrosive liquid and care should be taken to see that no liquid spills over the skin or clothing.

12.22.2.3. Preparation of Surface, Measurements, Rate and other details shall be as specified under 12.22.1

12.22.3. With Blow Lamp

12.22.3.1. The paint shall be removed either with a blow lamp or with an airacetylene equipment. The flame shall be allowed to play upon the paint just enough to soften it without charring either the paint or the background. The softened paint shall then be removed with a stripping knife following the flame as it is moved up the surface. Burning off shall begin at the bottom of the vertical surface and shall proceed upwards.

12.22.3.2. Precautions : Removal with blow lamp shall not be done on narrow or carved under cut surfaces or where there is risk of damage to neighbouring materials such as panes in glazed windows.

12.22.3.3. Preparation of surface, Measurements, Rate and other details shall be as described under Para 12.22.1. Neighbouring painted surfaces which are not to be treated should be properly protected from contact with paint remover.

ANNEXURE 12.1

EXTRACTS FROM BIS HAND BOOK ON BUILDING CONSTRUCTION PRACTICES

Schedules for Finishing New Woodwork – Interior

SL	Final Finish Required	Primer (one or Two coats as required)	Undercoat	First Finishing Coat	Second Finishing Coat
i)	Enamel	IS 102: 1962 OR IS 3536:1966 OR IS 3585:1966	IS 133:1993	IS 133: 1993	IS 133:1993
ii)	Oil Gloss	IS 102: 1962 OR IS 3536: 1966 OR IS 3585:1966	IS 3536: 1966	IS 3537: 1966	IS 3537:1966
iii)	Flat	IS 102:1962 OR IS 3536:1966 OR IS 3585:1966	IS 133:1993 OR IS 3539:1966 OR	IS 137:1965 OR IS 3537:1966	IS 137:1965 OR IS 3537:1966
iv)	Varnish	--	IS 524:1983 OR IS 525:1968	IS 337:1975 OR IS 524:1983 OR IS 525:1968	IS 337:1975 OR IS 524:1983 OR IS 525:1968
v)	Grained Work	--	Merging type glaze or stains	Merging type glaze or stains	IS 337:1975 OR IS 524:1983 OR IS 525:1968

1. For finishes (i) and (ii) fillers conforming to IS 110: 1983 may be applied after the prime coat as required.
2. French polish, when used, shall conform to IS 348:1968.

Schedules for Finishing New Woodwork – Exterior

SL	Final Finish Required	Primer (one or Two coats as required)	Undercoat	First Finishing Coat	Second Finishing Coat
(1)	(2)	(3)	(4)	(5)	(6)
i)	Enamel	IS 102: 1962 OR IS 3536:1966 OR IS 3585:1966	IS 2932:1993 OR IS 2933:1975	IS 2932:1993 OR IS 2933:1975	IS 2932:1993 OR IS 2933:1975
ii)	Oil Gloss	IS 102: 1962 OR IS 3536: 1966 OR IS 3585:1966	IS 3536: 1966	IS 3531:1983 (Alkyd) OR IS 117:1964 OR IS 124 (Part 3):1979 OR IS 127:1962 OR IS 128:1962	IS 3531:1983 (Alkyd) OR IS 117:1964 OR IS 124 (Part 3):1979 OR IS 127:1962 OR IS 128:1962
iii)	Flat	----- Proprietary materials to be used -----			
iv)	Varnish	--	IS 524:1983 OR IS 525:2968	IS 524:1983	IS 524:1983
v)	Grained Work	--	Merging type glaze or stains (see Annex B)	IS 524:1983	IS 524:1983

NOTE : For finishes (I), (ii) and (iii), fillers conforming to IS 110:1983 may be applied after prime coat as required.

Painting Schedules for Ferrous Surface (FOR INTERIORS)

SL	Final Finish Required	Primer	Undercoat	Finishing Coat	Number and Thickness of Coating
i)	Full gloss (enamel gloss)	IS 102:1962 (see Note) IS 207:1964	IS 133:1993 (i) (B) IS 2933:1975 (I) (B,S)	IS 133: 1933 (B) ⁽¹⁾ IS 2933:1975(B,S) ⁽¹⁾	For optimum results, two coats of primer, one under coat, and two finishing coats are recommended. The total film thickness shall be not less than 100 microns.
ii)	Oil gloss	Same as for (I)	IS 133:1993 (B) OR IS144:1950 (S)		Same as for (I)
iii)	Enggshell gloss	IS 102:1962 (see Note)	IS 137:1965	--	Same as for (i)
iv)	Flat	IS 102:1962 (see Note)	IS 137:1965	IS 137:1965	Same as for (I)
v)	Metallic finishes	Same as for (i)	--	IS 2339: 1963 (B) IS 1339:1963(S) OR Bituminous aluminium paints	One coat of primer and two finishing coats; if bituminous aluminium paint is used, three coats will be necessary
vi)	Bitumen	Same as for (i)	--	IS 158:1981	Three coats of bitumen shall be used.

Painting Schedules for Ferrous Surface (FOR EXTERIORS)

SL	Final Finish Required	Primer	Undercoat	Finishing Coat	Number and Thickness of Coating
vii)	Full gloss	IS 102:1962 (see Note)	IS 2933:1975 ¹)	IS 2933:1975 ¹)	For optimum results, two coats of primer, one undercoat and two finishing coats are recommended. The total film thickness shall not be less than 100 micron.
viii)	Oil gloss	Same as for (vii)	--	IS 117:1964 OR IS 128:1962	Same as for (vii)
ix)	Eggshell gloss	--	--	--	--
x)	Flat	IS 102:1962 (see Note)	--	--	
xi)	Metallic finishes	Same as for (vii)	--	IS 2339:1963 OR Bituminous aluminium paint	One coat of primer and two finishing coats; if bituminous aluminium paint is used, three coats will be necessary.

NOTE :

1. Paint primer conforming to IS 102:1962 may be used only where special precautions for drying of the primer coat are taken and where satisfactory drying condition is ensured before application of further coats.
2. Each of these Indian Standard cover both undercoating and finishing paints, and paints appropriate for the function shall be used.
3. (B) is brushing & (S) is spraying.

Chapter 13

Water Supply

13.0. TERMINOLOGY

Airgap : The unobstructed vertical distance through the free atmosphere between the lowest opening from any pipe or fitting supplying water to a tank or other device and the flood level rim of the receptacle in a water supply system.

Air Valve : A valve that releases air from a pipe line automatically without loss of water, or introduces air into a pipe line automatically if the internal pressure becomes less than that of the atmosphere.

Available Head : The head of water available at the point of consideration due to main's pressure or overhead tank or any other source of pressure.

Back flow : The flow of water into the distributing pipes of water system from any source or sources other than its intended source.

Back siphonage : The flowing back of used, contaminated or polluted water from a plumbing fitting or vessel into a water supply system due to a lowering of pressure in such system.

Ball cock : A faucet opened or closed by the fall or rise of a ball pens in the direction of normal flow and closes with reversal of flow. (Refer Fig. 13.2)

Collar : A pipe fitting in the form of a sleeve for jointing the spigot ends of two pipes in the same alignment.

Coupling : A pipe fitting with inside threads only, used for connecting two pieces of pipe.

Cross : A pipe fitting used for connecting four pipes at right angles (Refer Fig. 13.1).

Elbow : A pipe fitting for providing a sharp change of direction in a pipe line (Refer Figure 13.1).

Ferrule : A pipe fitting for connecting a service pipe to a water main (Refer Fig. 13.1).

Fitting : Anything fitted or fixed in connection with the supply, measurement, control, distribution, utilization or disposal of water.

Fire Hydrant : A device connected to a water main and provided with necessary valve and outlets, to which a fire hose may be attached for discharging water at a high rate for the purpose of extinguishing fires, washing down streets, or flushing out the

water main (Refer Fig. 13.1)

Flange : A projecting flat rim on the end of a valve, pipe etc. (Ref. Fig.13.1)

Flanged Pipe : A pipe provided with flanges so that the ends can be joined together by means of bolts (Refer Fig. 13.1)

Float Valve : A valve in which the closure to an opening such as a plug or gate, is actuated by a float to control the flow into a tank.

Sluice Valve (Gate Valve) : A valve in which the flow of water is cut off by means of a circular disc., fitting against machine-smoothed faces, at right angles to the direction of flow. The disc is raised or lowered by means of a threaded stem connected to the handle of the valve, the opening in the valve is usually as large as the full bore of the pipe (Refer Fig.13.2).

Nipple : A tubular pipe fitting usually threaded on both ends and less than 300 mm long used for connecting pipes or fittings (Refer Fig.13.1).

Offset : A combination of elbows or bends which brings one section of the pipe out of line but into a line parallel with the other section in a piping system.

Reflux valve : A non return valve used in a pipe line at a rising gradient to prevent water that is ascending the gradient from flowing back in the event of a burst lower down (Refer Fig.13.2).

Socket : The female-part of the spigot and socket joint (Refer Fig.13.1).

Spigot : The male part of a spigot and socket (Refer Fig.13.1)

Stop Cock : A control valve fixed at the end of communication pipe which controls the supply in the water main (Refer Fig.13.2).

Storage tank : A tank or a cistern for storage of water which is connected to the water main by means of a supply pipe.

Service or supply pipe : Pipe through which supply is drawn from water mains.

Union : A pipe fitting used for joining the ends of two pipes neither of which can be turned (Refer Fig.13.1).

Valve : A device used for controlling the flow of water in a pipe line.

13.1 GENERAL REQUIREMENTS

i) For details reference may be made to IS 2065 Code of Practice for Water supply in buildings.

ii) Bureau of Indian Standards Hand Book on Water Supply and Drainage with special emphasis on plumbing SP35 (S&T) may also be referred to for details.)

13.1.1 Contractor's Responsibility

Any damage caused to the building, or to electric, sanitary, water supply or other installations therein either due to negligence on the part of the Contractor, or due to actual requirements of the work, shall be made good and the building or the installations shall be restored to its original condition by the contractor. Nothing extra shall be paid for it, except where otherwise specified.

13.1.2. Execution of work: All water supply installation work shall be carried out through licensed plumbers only.

13.1.3. Inter connection of lines:

(a) It is most important to ensure that wholesome water supply provided for drinking and culinary purposes, is in no way liable to contamination from less satisfactory water. There shall, therefore be no cross connection whatsoever between a pipe fitting for conveying or containing wholesome water and a pipe or fitting for conveying or containing impure water or water liable to contamination or of uncertain quality of water which has been used for any purpose. The provision of reflux or non-return valves or closed and sealed valves shall not be construed a permissible substitute for complete absence of cross-connection.

(b) Where a supply of wholesome water is required as an alternative or standby to supply of less satisfactory water or is required to be mixed with the latter, it shall be delivered only into a cistern, and by a pipe or fitting discharging into the air gap at a height above the top edge of the cistern equal to twice its nominal bore,, and in no case less than 15 cm.

13.1.4. Precautions in laying :

(a) No piping shall be laid or fixed so as to pass into, through or adjoining any sewer, scour outlet or drain or any manhole connected therewith nor through any ashpit or manure-pit or any material of such nature that would be likely to cause undue deterioration of the pipe.

(b) Where the laying of any pipe through fouled soil or pervious material is unavoidable, the piping shall be properly protected from contact with such soil or material by being carried through an exterior

cast iron tube or by some other suitable means. Any piping or fitting laid or fixed, which does not comply with the above requirements shall be removed and relaid in conformity with the above requirements.

13.1.5 Pipe work design.

(a) The design of the pipe work shall be such that there is no possibility of backflow towards the source of supply from any cistern or appliance whether by siphon age or otherwise, and reflux or non-return valves shall not be relied upon to prevent such backflow.

(b) All pipe work shall be so designed, laid or fixed, and maintained as to be and to remain completely watertight, thereby avoiding waste of water, damage to property and the risk of contamination of the water conveyed.

(c) In designing and planning the layout of the pipe work, due attention shall be given to the maximum rate of discharge, required economy in labour and materials, protection against damage and corrosion, protection from frost, if required, and to avoidance of airlocks, noise transmission and unsightly arrangement.

(d) To reduce frictional losses, piping shall be as smooth as possible inside. Methods of jointing shall be such as to avoid internal roughness and projection of the joints, whether of the jointing materials or otherwise.

(e) Change in diameter and in direction shall preferably be gradual rather than abrupt to avoid undue loss of head. No bend or curve in piping shall be made so as to materially diminish or alter the cross-section.

13.1.6 Underground piping: Underground piping shall be laid at such a depth that it is unlikely to be damaged by frost or traffic loads and vibrations. It shall not be laid in ground liable to subsidence, but where such ground cannot be avoided; special precautions shall be taken to avoid damage to the piping. Where piping has to be laid across recently disturbed ground, the ground shall be thoroughly consolidated so as to provide a continuous and even support.

13.1.7 Service pipes :

(a) Where the service pipe is of diameter less than 50 mm, the stop valves shall be of the screwdown type and shall have loose washer plates to act as non-return valves. Other stop valves in the-service line may be of the gate type.

(b) In flats and tenements supplied by a common service pipe a stop tap shall be fixed to control the branch serving each

separately occupied part. In large buildings a sufficient number of stop valves shall be fixed on branch pipes, and to control groups of ball valves and draw off taps, so as to minimize interruption of the supply during repairs. All such stop valves shall be fixed in accessible positions and properly protected from being tampered with. They may be of the gate type to minimise loss of head by friction.

(c) Water for drinking or for culinary purposes should as far as possible be on branch pipes connected directly to the service pipe.

(d) Pumps shall not be allowed on the service pipe as they cause a drop of pressure on the suction side thereby affecting the supply to the adjoining properties. In cases where pumping is required, a properly protected storage tank of adequate capacity shall be provided to feed the pump.

(e) Service pipes shall be so designed and constructed as to avoid air-locks, so that all piping and fittings above ground can be completely emptied of water to facilitate repairs. There shall be draining taps or draw-off taps (not underground) at the lowest points, from which the piping shall rise continuously to draw-off taps, ball valves, cisterns, or vents (where provided at the high points).

(f) Service pipes shall be designed so as to reduce the production and transmission of noise as much as possible. Appliances which create noise shall be installed as far distant as possible from the living rooms of the house. High velocity of water in piping and fittings shall be avoided.

Piping shall be confined, as far as possible, to rooms where appliances are fixed. It should have easy bends, and where quietness is particularly desired, holder bats or clamps shall be insulated from the piping by suitable pads.

(g) The rising pipe to the storage cistern if any or any feed cistern shall be taken as directly as possible to the cistern and shall be fixed away from windows or ventilators.

(h) No service pipe shall be connected to any water closet or urinal. All such supplies shall be from flushing cisterns which shall be supplied from storage tank.

(i) No service or supply pipe shall be connected directly to any hot-water system or to any apparatus used for heating other than through a feed cistern thereof.

13.1.8 Facility for inspection :

(a) All pipe work shall be planned so that the piping is accessible for inspection, replacement and repair. To avoid its being unsightly, it is usually possible to arrange it in or adjacent to cupboards, recesses, etc. provided there is sufficient space to work on the piping with the usual tools.

Piping shall not be buried in walls or solid floors. Where unavoidable, piping may be buried for short distances provided that adequate protection is given against damage and that no joints are buried. If piping is laid in ducts or chases, these shall be roomy enough to facilitate repairs and shall be so constructed as to prevent the entry of vermin. To facilitate removal of pipe casing, floor boards covering piping shall be fixed with screws or bolts.

(b) When it is necessary for a pipe to pass through a wall or floor, a sleeve shall be fixed therein for reception of the pipe and to allow freedom for expansion and contraction and other movement. Piping laid in wood floors shall, where possible, be parallel with the joists.

13.1.9 Storage tanks : Where storage tanks are provided to meet overall requirements of water, connection of service pipe with any distributing pipe shall not be permitted except one direct connection for culinary or drinking requirements.

13.1.10 Miscellaneous:

a) Conformity with bye-laws and rules : All water supply installations shall comply with the bye-laws and rules and regulations laid down by the Local Bodies or State Governments from time to time.

b) Conveyance and Distribution of Water : All pipe work shall be so designed, laid or fixed, and maintained as to be and to remain completely water tight, thereby avoiding waste of water, damage to the property and the risk of contamination of the water conveyed.

c) Pipes for Unfiltered water : For unfiltered water supply, the minimum size of GI pipes used shall be 25mm diameter.

13.2 MATERIALS, FITTINGS, SPECIALS, APPLIANCES ETC :

The standard size of brass or gun metal fittings shall be designated by the nominal bore of the pipe outlet to which the fittings are attached. A sample of each kind of fittings shall be got approved from the Engineer and all supplies made according to the approved samples.

All cast fittings shall be sound and free from laps, blow holes and pittings. Both internal and external surfaces shall be clean, smooth and free from sand etc. Burning, plugging, stopping or patching of the casting shall not be permissible. The bodies, bonnets, spindles and other parts shall be truly machined so that when assembled the parts shall be axial, parallel and cylindrical with surfaces smoothly finished. The area of water way of the fittings shall not be less than area of the nominal bore, chromium plating wherever specified shall be of 0.3 micron conforming to IS:4827. The chromium shall never be deposited on brass unless a heavy coating of nickel is interposed. In the case of iron, a thick coat of

copper shall first be applied, then one of nickel and finally the chromium. In finish and appearance the plated articles when inspected shall be free from plating defects such as blisters, pits roughness and unplated areas and shall not be stained or dis-coloured. Before fitting is plated, the washer plate shall be removed from the fittings and the gland packing shall be protected from the plating solution.

13.2.1 Ball Valve (Brass) (Ref. Fig. 13.1)

The ball valve shall be of Brass or Gunmetal as specified conforming to IS:1703. The ball valve shall be following two classes detailed in Table 13.1.

TABLE 13.1

	Nominal size of ball valve					
	15 mm	20 mm	25 mm	32 mm	40 mm	50 mm
Diameter of spherical float (mm) High pressure (HP)	127	152	203	229	254	305
Low pressure (LP)	114	127	178	203	203	254
Minimum weight of ball valve including Back nut, body and piston (gms)	283	446	823	1149	1589	1852

a) **High pressure** : Indicated by the abbreviation 'HP' for use on mains having pressure of 1.75 kg/sq.cm. or above. These shall remain closed at a test pressure of 10.5 kg/sq.cm.

b) **Low pressure**: Indicated by the abbreviation 'LP' for use on mains having a pressure upto 1.75 kg/sq.cm. These shall remain closed at a test pressure of 3.5 kg/sq. cm.

The ball valves shall be of following nominal sizes 15 mm, 20 mm, 25 mm, 32 mm, 40 mm, and 50 mm. The nominal size shall correspond with the nominal bore of the inlet shanks. Polyethelene floats shall conform to IS : 9762 which covers floats suitable for float valves of nominal sizes 15 mm to 50 mm.

13.2.2. Bib cock and Stop cock (Refer Figure 13.2) :

Brass : A bib cock (bib tap) is a draw off tap with a horizontal inlet and free outlet and a stop cock (stop tap) is a valve with a suitable

means of connections for insertion in a pipe line for controlling or stopping the flow. They shall be of specified size and shall be of screw down type and shall conform to IS : 781. The closing device shall work by means of disc carrying a renewable non-metallic washer which shuts against water pressure on a seating at right angles to the axis of the threaded spindle which operates it. The handle shall be either crutch or butterfly type securely fixed to the spindle. Valve shall be of the loose leather seated pattern. The cocks (taps) shall open in anti-clock wise direction.

The bib cock and stop cock shall be polished bright. The minimum finished weights of bib tap • (cock) and stop tap (cock) shall be as specified in Table 13.2.

In case these are required to be nickel plated, the plating shall be of the first quality with a good thick deposit of silvery whiteness capable of taking high polish which will not easily tarnish or scale.

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TABLE 13.2

Size (mm)	Minimum finished weight	
	Bib tap (Kg.)	Stop tap (Kg.)
15	0.40	0.40
20	0.75	0.75

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Plastic : Plastic Bib Taps and stop Valves (Rising Specials) for cold water services should conform to IS:9763. Nominal sizes covered by IS:9763 are 15mm and 20 mm.

13.2.3. Ferrules (Ref. Fig. 13.1) :

(a) The ferrules for connection with C.I. main shall generally conform to IS : 2692. It shall be of non ferrous materials with a C.I. bell mouth cover and shall be of nominal bore as specified. The ferrule shall be fitted with a screw and plug or valve capable of completely shutting off the water supply to the communication pipe, if and when required.

(b) As extracted from IS:2692, the scope, definition and nominal sizes of Ferrules are as under:

(i) **Scope** : Ferrules are commonly used in taking out branch lines from water mains and also in stopping supply to branch lines where desired. Different types of ferrules are available to suit specific purposes.

(ii) **Definition** : A draw-off appliance with a vertical inlet for screwing on to water main and a horizontal outlet, and closed by means of a washer plate carrying a renewable washer which shuts against the water pressure on a seating at right-angles to the axis of the threaded plug which operates it.

(iii) **Nominal sizes:**

Ferrules shall be of the following nominal sizes: 15, 20, 25, 32, 40 and 50 mm. The nominal sizes of the ferrule shall be designated by the nominal bore of the inlet connection.

13.2.4. Fire Hydrants (Ref. Fig. 13.1) : The hydrants shall be of spindle type with 65 mm outlet combined with sluice valve, unless

otherwise specified. The hydrant shall conform to IS : 909 and shall consist of the following components :

- One sluice valve class 1 type, conforming to IS : 780 "Sluice valve for water works purposes 50 mm to 300 mm size".
- A duck foot bend,
- A 65 mm male coupling instantaneous pattern; and
- Cast iron cap permanently secured to the duck foot bend by means of a chain. Where the fire service requirement of coupling differs from the above, the requisite coupling shall be provided at no extra cost.

The body and cover shall be of good quality cast iron, spindle of bronze and the nut and the valve seat of leaded tin bronze. The bodies, spindle and other parts shall be truly machined with surface smoothly finished.

13.2.5. Full Way Valve Brass (SLUICE VALVE) (Ref. Fig. 13.2) : Full way valve is a valve with suitable means of connection for insertion in a pipe line for controlling or stopping the flow. The valve shall be of brass fitted with a cast iron wheel and shall be of gate valve type conforming to IS : 780 opening full way and of the size as specified.

The valves shall be of best quality as approved by the Engineer and shall approximately have the weights specified in **Table 13.3** with a tolerance of 5%.

13.2.6. Full Way Valve with Wheel - Gun Metal (Ref. Fig. 13.2) : These shall be of the gun metal fitted with wheel and shall be of gate valve type opening full way and of the size as specified. These shall generally conform to IS : 778 and their weights shall be as specified in **Table 13.3**.

TABLE 13.3

Mm	Flanged ends (Kg.)	Screwed ends (Kg.)
15	1.021	0.567
20	1.503	0.680
25	2.495	1.077
32	3.232	1.559
40	4.082	2.268

50	6.691	3.232
65	10.149	6.804
80	13.381	8.845

13.2.7. Sluice Valves-Brass/Gun Metal (Ref. Fig.13.2) : The sluice valves are used in a pipe line for controlling or stopping flow of water. These shall be of specified size and class and shall be of inside non-raising screw type upto 300 mm size and raising or non-raising screw type above 300 mm with either double flange or double socket ends and cap or hand wheel. These shall in all respects comply with the Indian Standard Specification IS: 780 for valves upto and including 300 mm size and IS:2906 for valves above 300 mm size. Class I sluice valves are used for maximum working pressure of 10 Kg/ sq.cm (100 metre head) and class II sluice valve for 15 Kg/sq.cm (150 metre head).

The body, domes covers, wedge gate and stuffing box shall be of good quality cast iron, the spindle of bronze and the nut and valve seats of leaded tin bronze. The bodies, spindles and other parts shall be truly machined with surface smoothly finished. The area of the water way of the fittings shall be not less than the area equal to the nominal bore of the pipe. The valve shall be marked with an arrow to show the direction of turn for closing of the valve.

13.2.8. Surface Box (Ref.Fig. 13.3 & 13.4) :

For details IS 3950 Specification for surface

boxes for sluice valves may be referred to. This shall be of cast iron, well made and free from casting and other defects. All sharp edges shall be removed and finished smooth. The shape and dimensions for surface boxes for stop cocks, sluice valves, fire hydrants, water meters etc. shall be as specified in **Fig. 13.3 & 13.4**.

The C.I. surface boxes shall be coated with a black bitumenous composition except in case of fire hydrants where the cover of the surface box shall be painted with two coats of rust resisting bright luminous yellow paint for clear visibility during night;

13.2.9. Non-return valve or check Valve-Brass (Ref.Fig.13.2):

For details refer to IS 5312 - Specifications for Swing check Type Reflex (Non return) Valves for Water works. A non-return valve permits water to flow in one direction only and is provided on the ascending part of the main to check return flow. The non -return valve shall be of brass and shall be of horizontal or vertical flow type as specified.

The valve shall be of quality approved by the Engineer and shall have the weights specified in **Table 13.4** with a tolerance of 5 percent.

TABLE 13.4

Diamters mm	Horizontal type Kg.	Vertical type Kg.
15	0.30	0.25
20	0.55	0.25
25	0.90	0.75
32	1.25	0.90
40	1.70	1.20
50	2.90	1.45
65	5.25	2.15
80	7.70	4.10

13.2.10. Non-Return valve or Check valve - Gun Metal (Ref. Fig. 13.2) : Specification described in para 13.2.9 shall apply except that non-return valve shall be of gun metal

and shall generally conform to IS : 778.

13.2.11. Pipes and Specials – General :

Pipes and specials may be of any of the following types as specified :

- a) Asbestos cement pressure pipes - IS:1592
- b) Cast iron centrifugally cast (spun) - IS:1536
- c) Galvanised steel - IS:1239 & IS:4736
- d) Plastic unplasticised rigid PVC IS 4984 & IS 4985
- e) Polythene / aluminium / polythene composite pressure pipes for hot and cold water supplies as per IS 15450:2004 (PL-AL-PE Pipes)
- f) Centrifugally cast (Spun) ductile iron pipes pressure pipes for water, gas and sewage as per IS : 8329:1994.

In choosing the material for piping and fittings, account shall be taken of the

character of the water to be conveyed through it, the nature of the ground in which the pipes are to be laid and the relative economics.

13.2.12. Pipes-Cast Iron Centrifugally Cast (Spun):

13.2.12.1. The spun iron pipes shall conform to IS:1536. The spun iron pipes, shall be of cast iron casted centrifugally and vary in diameters from 80 mm to 750 mm. These shall be of class LA, class A and class B, as specified. These pipes shall be used for water pressures upto half the Hydrostatic test pressure as detailed in **Table 13.7**. Tolerances on specials shall be as given in **Annexure-13.1**.

TABLE 13.7

Types of pipes	Test pressure of Kg/Sq.cm		
	Class LA	Class A	Class B
Spigot and socket pipe in all diameters	12	18	24
Flanged pipes upto 600 mm dia		18	24

13.2.12.2. Specials : The specials shall conform to IS: 1538. The Hydrostatic test pressure of each class shall be as detailed in **Table 13.8**. Tolerances on specials dimension shall be as given in **Annexure-13.2**.

TABLE-13.8

Nominal – Diameter	Test pressure in Kg/Sq.cm (metre head)	
	Fitting without branches or with branches not greater than half the principal diameter	Fitting with branches greater than half the principal diameter
Upto and including 300 mm	25 (250)	25 (250)
Over 300 mm and upto and including 600 mm	20 (200)	20 (200)
Over 600 mm and upto and including 1500 mm	15 (150)	10 (100)

13.2.13. Pipes-Galvanised Iron :

13.2.13.1. The pipes (tubes) shall be galvanised mild steel hot finished seamless (IFS) or welded (ERW) HRIW or HFW screwed and socketed conforming to the requirements of IS: 1239 Part-I for medium grade. They shall be of the diameter (nominal bore) specified in the description of the item, the sockets shall be designated by the respective nominal bores of the pipes for which they are intended.

13.2.13.2. Galvanising shall conform to IS:4736 The zinc coating shall be uniformly adherant, reasonably smooth and free from such imperfections as flux, ash and dross-inclusions, bare patches, black spots, pimples, lumping runs, rust stains, bulky white deposits and blisters. The pipes and sockets shall be cleanly finished, well galvanised in and out and free from cracks, surface flaws laminations and other defects. All screw threads shall be clean and well

cut. The ends shall be cut cleanly, and square with the axis of the tube.

13.2.13.3. The dimensions and weights of pipes and sockets and tolerances shall be as prescribed in **Annexure 13.3**.

13.2.13.4. All screwed tubes and sockets shall have fine threads conforming to the requirements of IS:554. Screwed tubes shall have taper threads while the sockets shall have parallel threads.

13.2.13.5. All tubes shall withstand a test pressure of 50 Kg/sq.cm without showing defects of any kind.

13.2.13.6. Fittings : The fittings shall be of mild steel tubular or wrought steel fittings conforming to IS:1239 (Part-II) or as specified. The fittings shall be designated by the respective nominal bores of the pipes for which they are intended.

13.2.14. Pipes-Plastic

13.2.14.1. The plastic pipes commercially available in the country are that of (i) low-density polyethylene (LDPE) (ii) High-density polyethylene HDPE, and (iii) Rigid (unplasticised) polyvinylchloride (UPVC). These pipes are corrosion resistant and light in weight, and have been found suitable for cold water services. Plastic materials perform on their own merits, and each of these plastic pipes has its own limitations and advantages for a particular application under conditions of use. Relevant Indian standard specifications have been laid down for these pipes.

13.2.14.2. Low Density Polyethylene to IS:3076 is flexible, it is now well established that this material is used for pipes with diameter upto 63 mm, generally recommended for use in long runs e.g. for point to point conveyance of water, because of its flexibility, and fact that LDPE pipes require closer spacing of clips for horizontal and vertical runs, their use has not been found practical for installation of internal water supply system.

13.2.14.3. High Density Polyethylene is rather tougher as compared to low-density polyethylene. Pipes upto 1600 mm diameter have been produced out of this material. In India however, HDPE pipes are available from 16 mm to 400 mm dia. Use of these pipes in small diameters for internal water supplies has not found ready acceptance because of practical problems like on-site jointing, and taking out of various connections in plumbing. Their use in larger diameters for conveyance of water/ effluents and in long runs from point to point has been

found very suitable and has been readily accepted by the Public Health Engineering and similar departments, in the country.

13.2.14.4. Polyethylene pipes are normally available in black colour. These are resistant to most chemicals, except nitric acid, and very strong acids, fats, and oils and certain solvents particularly chlorinated ones. There is a phenomenon called environmental stress cracking which means that if polyethylene is stressed at normal temperatures and comes into contact with certain materials then it will crack and eventually fail. The materials include detergents, organic acids, esters, aldehydes, ketone, amides, nitrocompounds, and alcohols (but not beer). The HDPE is worse than LDPE in this respect.

13.2.14.5. Rigid (Unplasticized) PVC Pipes are widely accepted for applications such as cold water services internal/external water supplies systems, water mains, rain water system, soil waste piping system, and underground (sewage pipes) drainage piping system. Rigid PVC is three times as rigid as polyethylene. It is also much stronger and will withstand much higher pressure for a given wall thickness. Joints can. easily be made in rigid PVC pipes by solvent welding, and a whole range of injection moulded matching fittings and specials are available for these pipes. Rigid PVC pipes are normally available in the shades of White/cream. Light to dark grey, Black

In general, rigid PVC is resistant to most inorganic acids, alkalies and salts, as well as many organic chemicals. It is quite resistant to most effluents, salt water and plating solutions, corrosive fumes, soils and the like which lead to its applications over a wide field. The material is also perfectly safe with potable water, whether hard or soft, and in the former case it tends to retard the formation of scale. Those materials which do attack it include concentrated oxidizing acids, esters, ketones, aromatic and chlorinated hydrocarbons, organonitro compounds, organo-amino compounds, lacquer solvents and acetic anhydride.

The pipes shall be reasonably round and shall be supplied in straight lengths with socketed ends. The internal and external surfaces of pipes shall be smooth & clean, free from grooving and other defects. The end shall be cleanly cut and square with the axis of the pipe. The pipe shall be designated by external diameter and shall

conform to IS : 4985 (Revised) in all respects. The dimensions and tolerances of rigid PVC pipes shall be as in **Annexure-13.4.**

13.2.14.6. Fittings : Fittings used shall be of the same make as that of PVC pipes, injection moulded or made in cast iron and shall conform to Indian standard wherever available.

13.2.14.7 Polythene / aluminium / polythene composite pressure pipes for hot and cold water supplies as per IS 15450:2004 (PE-AL-PE Pipes)

(Some important para of the above IS code are reproduced below for information and guidance.

3. PIPE DESIGNATION

PE-AL-PE composite pipes are designated by nominal inside and outside diameters. The concept of dimension ratio is not relevant to PE-AL-PE pipe and are not used to relate pressure rating with total wall thickness.

4. MATERIALS

4.1 The amterial from which PE-AL-PE pipe is manufactured shall comprise of polyethylene plastic and aluminium strip.

4.2 Polyethylene

Polyethylene compounds used for the manufacture of these pipes shall conform to IS 7328 as follows:

- a) PEEWA 45T006 for black pipes and
- b) PEELA 45T006 for coloured pipes

4.3 UV Stabilizer

The percentage of UV stabilizer used shall not be more than 0.5 percent by mass of finished resin. Raw material supplier to provide a certificate in this regard.

4.4 Aluminium

The material shall have the following properties and shall be tested as per IS 737:

- a) Minimum elongation : 20 percent
- b) Ultimate tensile strength : 100 Mpa

The aluminium strip shall have nominal thickness as specified in Table 1. Tolerances on all thickness for all sizes shall be +0.02 – 0.00 mm.

4.5 Rework Material

No rework material shall be used in the manufacture of pipe IS 15450 : 2004

Table 1 : Aluminium Thickness and Tolerances for PE-AL-PE Pipe (Clause 4.4)

SL	Nominal Pipe size mm	Nominal Aluminium Thickness mm
I	0.912	0.20
Ii	1.014	0.20
Iii	1.216	0.20
Iv	1.620	0.25
V	2.025	0.25
Vi	2.532	0.30
Vii	3.240	0.30
Viii	4.050	0.30

5. PRESSURE RATING

The PE-AL-PE composite pipe meeting the requirement so f this specification shall be pressure rated for maximum water pressures of 1.38 MPa at 230C and 1.10 MPa at 600C (see Annex A).

6. NOMINAL DIAMETERS

The nominal outside diameter of pipes are 12, 14, 16, 20, 25, 32, 40 and 50 mm. Respective nominal inside diameters are

9,10,12,16,20,25,32 and 40 mm.

7. COLOUR

Pipe manufactured from compound grade PEEWA45T006 having carbon black shall be black and made from compound grade PEELA45T006 shall be pigmented according to the requirement of the customer.

8. DIMENSIONS OF PIPE

8.1 Pipe diameter, out of roundness total wall thickness and thickness of outer PELayer

shall be as given in Table 2. The thickness of the outer layer of polyethylene, when tested as per Annex B, in the PE-AL-PE pipe shall have a minimum value as specified in Table 2, except for polyethylene material overlaying the weld, which shall have a minimum thickness of half that specified in Table 2. Tolerances of nominal OD shall be +.30mm/-.30mm up to and including 25 mm and +.50mm/-0.00mm for nominal OD 32 mm and above.

8.2 Method of Measurements

8.2.1 The outside diameter of pipe shall be taken as the average of two measurements taken at right angles. The wall thickness shall be measured by a dial vernier or ball ended micrometer. The resulting dimension shall be expressed to the nearest 0.1 mm.

8.2.2 Ovality shall be measured as the difference between maximum outside diameter and minimum outside diameter measured at the same cross section of pipe. For pipes to be coiled, the ovality shall be measured prior to coiling. For coiled pipes, however, re-rounding of pipes shall be carried out prior to the measurement of ovality.

8.3 Length of Straight Pipe

The pipe shall be supplied in straight lengths as agreed upon with the purchaser between 3 to 20 m.

8.4 Coiling

While coiling, the inside diameter of coils in mm, shall be not less than 20 times the

outside diameter of pipe.

9.0 VISUAL APPEARANCE

The internal and external surfaces of the pipe shall be smooth, clean and free from grooving and other defects. The ends shall be cleanly cut and shall be square with the axis of the pipes. Slight shallow longitudinal grooves or irregularities in the wall thickness shall be permissible provided that the wall thickness remains within the permissible limits.

RECOMMENDATORY INFORMATION for PL-AL-PL Pipes

A-1 STORAGE

A-1.1 Outside Storage

Pipe should be stored on a flat surface and supported in a manner that will prevent distortion.

A-2 CONNECTORS AND FITTINGS

A-2.1 PE-AL-PE pipes manufactured to this specification shall be capable of being jointed with suitable connectors or fittings provided that the connector or fitting alone or in assembly with PE-AL-PE pipe complies with the requirements as given in A-2.2 and A-2.3.

A-2.2 Internal Pressure Test

The fitting or connector, when assembled with PE-AL-PE pipe, shall not fail or weep at the specified duration as given in Table 9. The joint shall not have any leakage during the test.

Table 9 Test Pressure and Duration

(Clause A-2.2)

SL.No.	Pipe Size	Test Pressure	Duration
i)	1.014	36.0	1
ii)	1.216	31.3	1
iii)	1.620	26.7	1
iv)	2.025	26.7	1
v)	2.532	23.0	1
vi)	3240	22.3	1
vii)	4.050	20.4	1

A-2-3 Pull Out Test

A-2-3.1 Apparatus

The apparatus shall consist of one of the following:

- A tensile testing machine together with grips capable of subjecting the test assembly to a constant longitudinal forces; and
- A frame with means for suspending a test piece together with stirrup at the lower

end to hold sufficient weight(s) with which to apply the specified forces.

A-2.3.2 Test Assembly

The test assembly shall comprise a straight coupling or any other fitting which can join two pipe pieces assembled in accordance with the manufacturer's instructions with two pieces of pipe of the appropriate nominal size. Separate combinations shall be assembled for each type of pipe for which

fitting is designed. Each pipe shall be at least 100 mm in length.

A-2.3.3 Procedure:

Secure the test assembly in the apparatus and apply gradually over a period of 20s the appropriate force at ambient temperature as given in Table 10 as applicable. Hold the specimen in constant tension for the specified duration.

Table 10 : Test Pressure and Duration for Pull out Test
(Clause 1-2.3.3)

SL.No.	Pipe Size	Test Pressure	Duration
i)	1.014	620	1
ii)	1.216	740	1
iii)	1.620	1.068	1
iv)	2.025	1.640	1
v)	2.532	2.427	1
vi)	3240	3.694	1
vii)	4.050	5.463	1

13.2.14.8 - PPR Pipes & Fittings ;

1) SCOPE

The scope comprises of supply, installation, testing and commissioning of piping network for water supply (hot and cold water) for internal and external services.

The Contractor shall make all necessary application and arrangements for his work to be inspected by the Local Authorities, Consultants and Site personnel.

2) PIPING MATERIALS

The piping system shall consist of Polypropylene Random Copolymer Type 3 pipes and fittings conforming to DIN 8078. The sizes and makes are specified in the Schedule of Quantities.

For any internal works, the Polypropylene pipes and fittings shall be embedded in the wall chase or run on the floor/ ceiling unless otherwise specified. No unsighted exposed runs shall be permitted. Outside the building the piping shall be installed atleast 1.0 meter below the finished grade level.

3) Fusion Welded Polypropylene Pipes and fittings

The pipes shall be 3-Layered Polypropylene

Random Copolymer whereby the different layers of the pipes shall consist of :

- The inner-most layer of the pipe to be Anti-bacterial to prevent bacteria growth inside the pipe surface.
- The middle layer to be of plain PP-R which is neither in contact with Water and nor under direct effect of the atmospheric conditions.
- The outer-most layer to be of U.V. stabilized PP-R to prevent the pipe surface from sunlight under exposed atmospheric conditions.

The pipes should be conforming to the requirements of DIN 8078 April 1996 (PPR pipes General Quality requirements and Testing) and DIN 8077 December 1997 (PPR Pipe dimensions). The pipes should have smooth inner surface with Non - contracting diameters. The pipes shall be cleanly finished, free from cracks and other defects. The pipes shall be clean and well cut along ends after taking into consideration the desired length, using the Pipe scissors.

The fittings shall be as follows :-

- Plain fittings from sizes 16mm to 160mm

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(ii) Chrome Plated Brass Threaded fittings from sizes 16mm to 75mm.

(iii) Valves from sizes 20mm to 63mm.

a) The plain fittings shall be Polypropylene Random Copolymer and comply with all the requirements of the pipes. The size of fitting is specified in the schedule of quantities, corresponding to the size of the pipe. The plain fittings shall comprise of Socket, Elbow, Tee, Cross, Unions, Reducer socket, Reduction Tee, End Cap, Crossover, Omega, Threaded plug, and Wall Clamps in available sizes.

b) The Chrome Plated Brass threaded fittings shall be Chrome Plated Brass threaded piece molded inside Polypropylene Random copolymer fitting. The Plastic end shall comply with all the requirements of the pipes while the C.P. Brass end shall comply with BSP standards of Threading. The size of the C.P. Brass threaded fitting is specified in the schedule of quantities, corresponding to the pipe size. The Chrome plated Brass threaded fittings shall comprise of Socket, Elbow and Tee (Male & Female) in available sizes. These are the fittings for C.P. connections and for continuations from existing Galvanized Iron Pipes and fittings.

c) The valves shall be Polypropylene Random Copolymer Valves. The valves comprise of Gate Valve, Ball Valve, Concealed Stop Cock and Chrome Coated Valve in available sizes. The size and type of the Valve is specified in the Schedule of quantities.

The Valves sizes availability in Polypropylene Random Copolymer is as follows :

i) Gate Valve - 20 MM & 63 MM

ii) Ball Valve - 20 MM, 25 MM, 32 MM, 40 MM, 50 MM & 63 MM 75 MM 90 MM

iii) Concealed Stop Cock - 20 MM & 25 MM.

iv) Chrome Coated Valve - 20 MM & 25 MM.

However, the other Brass/ Bronze Valves can be connected to Polypropylene Random pipes using C.P. Brass threaded fittings of desired sizes.

4) Laying and Jointing of Polypropylene Random Pipes and Fittings ;

The Polypropylene Random Pipes and Fittings shall run in wall chase or ceiling or as specified. The installation of Polypropylene Random Copolymer pipes is similar to that of the metal pipes with the only difference in the Jointing procedure. The jointing of the Fusion welded PP-R pipes and fittings is done by means of a Welding Machine.

The quality of each installation system ultimately depends on the tightness, stability and lifetime of its connections. The homogeneous connection of PP-R pipes by fusion welding gives an absolutely safe pipe connection and guarantees utmost operational safety. It takes only a few seconds to make a connection by fusion welding process. After a couple of minutes, the welded joint cools down sufficiently and can be fully loaded. The pipe to the desired length is cut using the Pipe Scissors. The proper heating piece is taken and mounted on the welding machine. The welding device is switched on – Control lamp and switch lamp will lit. When ready, control lamp gets off, which means that welding temperature of 260 Degrees +/- 10 Degrees Celcius has been reached. The Pipe end and the fitting to be welded is heated on the welding machine. Before heating the fitting and the pipe, the dirty welding tools, pipe and fitting is cleaned with a cloth. When heated up (with heating time as per the Table shown below), the pipe and the fitting is removed from the welding machine and the two pieces connected together by applying a little pressure without twisting. The joint is allowed to cool down for a few seconds. The welding process is that safe because the properly heated parts of Polypropylene creates a homogeneous connection.

Guidelines for Welding PP-R Pipes and fittings (DVS guideline 2207, Part 11)

Outer diameter of pipe (MM)	Heating Time (Seconds)	Cooling Period (Minutes)
16	5	2
20	5	2
25	7	2
32	8	4

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40	12	4
50	18	4
63	24	6
75	30	8
90	30	8
110	45	10
160	60	12

The same procedure shall be adapted for exposed as well as concealed fittings. The Crossovers may be used wherever the overlapping of the PP-R pipes is required. The fixing shall be done by means of Wall Support Clamps keeping the pipes about 1.5 cm clear of the wall where to be laid on the surface. Where it is specified to conceal the pipes, chasing may be adopted. For pipes fixed in the shafts, ducts etc. there should be sufficient space to work on the pipes with the usual tools. Where directed by the owner's site representative/ Architect, pipe sleeves shall be fixed at a place the pipe is passing, through a wall or floor for reception of the pipe and allow freedom for expansion and contraction and other movements. Fixed supports prevent any movement of the pipe by fixing it at some points. Fittings are used in creating the fixed points. Fixed supports must not be installed at bending parts and

the direction changes must be done in the pipe itself. In between the fixed supports some arrangements must be done to compensate any potential elongation or shrinkage in the pipe length.

Expansion or shrinkage compensation arrangements can be installed in buildings very easily. For making one expansion loop, four elbows will be enough. For straight pipes having length more than 5 meters, to compensate the expansion an expansion piece must be used.

When necessary Polypropylene Random pipes can be bend by heating, but the pipes should not be put on flame. Heating should be done by hot air blowing device. To bend the pipes, they should be heated upto 140 Degree Celcius. Advised minimum radius for bending are shown in the under table :-

PIPE DIAMETER (d)	BEND RADIUS, MINIMUM (R= 8x d)
20	160
25	200
32	256
40	320
50	400
63	500
75	600
90	720
110	880
160	1280

All pipe work shall be carried out in a proper workman like manner, causing minimum disturbance to the existing services, buildings, roads and structure. The entire piping work shall be organised in consultation with other agencies work, so that all works can be carried out in one stretch.

PP-R pipes can be used in mixed installations and repair works. The pipes running parallel, should be separated by putting insulation parts to prevent sound reflection. To prevent noise, under or above ground installations the pipes should not contact to each other.

Cut-outs in the floor slab for installing the various pipes are indicated in the drawings. The Contractor should carefully examine the cut-outs provided and clearly point out wherever the cut-outs shown in the drawings, do not meet with the requirements.

All pipes shall be accurately cut to the required lengths and then cleaned with a clean cloth before fusion welding. Open ends of the pipes where the C.P. Brass threaded fittings are welded for C.P. connections at the later stage should be closed by means of Plugs to avoid the entrance of foreign matter.

Automatic air valves shall be provided at all

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high points in the piping system for venting. Automatic air valves shall also be provided on hot water risers. Discharge from the air valves shall be piped to the nearest drain or sump. All pipes shall be pitched towards the drain points.

Pressure gauges and Thermometers shall be provided as per the approved drawings and included in the Bill of quantities. Care should be taken to prevent these during Pressure testing.

5) INSTALLATION OF WATER METER AND VALVES

PP-R lines shall be cut to the required lengths at the position where the meter and Valves are required to be fixed. Suitable C.P. Brass threaded fittings shall be attached to the pipes. The meter and Valves shall be fixed in a position by means of connecting pipes, jam nut and socket etc. The Stop cock shall be fixed near the inlet of the water meter. The paper disc inserted in the ripples of the meter shall be removed. And the meter shall be installed exactly horizontally or vertically in the flow line in the direction shown by the arrow cast on the body of the meter. Care shall be taken to not to disturb the factory seal of the meter. Wherever the meter shall be fixed to a newly fitted pipeline, the pipeline shall have to be completely washed before fitting the meter.

6) TESTING

The Contractor shall inform in advance of any test so that Architect can witness tests if he so wishes. All water supply system shall be tested to Hydrostatic pressure test of atleast one and a half (1.5) times maximum working pressure but not less than 10 Kgs/Sqcm for a period of not less than 8 hours.

The pressure test is performed in 3 steps being preliminary test, main test and final test. For the preliminary test a pressure which is 1.5 times higher than the possible working pressure is applied and this is repeated two times in 30 minutes with intervals of 10 minutes. After a test period of 30 minutes, the test pressure must not be dropped more than 0.6 bar and no leak must occur. Main test follows the preliminary test. Test time is two hours, in doing so the test pressure taken from the preliminary test must not have fallen more than 0.2 bar. After completion of these tests, the final test comes which has to be done under a test pressure of 10 bar and 5 bar in the interval of 15 minutes. Between the respective test courses, pressure has to be removed.

All leaks and defects in joints revealed during the testing shall be rectified and got approved at site by retest. Piping required subsequent to the above pressure test shall be retested in the same manner. A record of Pressure test has to prepared and signed by the Client/ Architect and Contractor with statement of place and date.

7) DISINFECTION OF PIPING SYSTEM AND STORAGE TANKS :

Before commissioning the water supply system, the contractor shall arrange to disinfect the entire system. The water storage tanks and pipes shall first be filled with water and thoroughly flushed out. The storage tanks shall then be filled with water again and disinfecting chemicals (chlorine) are added gradually at the time of tanks being filled to ensure thorough mixing. Sufficient chemical shall be used to give water a dose of 50 ppm of water.

For any other chemical used, the proportions shall be specified by the manufacturer. When the storage tank is full, the supply shall be stopped and all the taps on the distributing pipes are opened successively. Each tap shall be closed when the water discharged begins to smell of chlorine. The storage tank and pipe shall then remain charged atleast for three hours. Finally the tank and pipes shall be thoroughly flushed out before any water is used for domestic purpose.

STERILIZATION OF MAIN

After the pipework has been tested and approved, but before it is coupled, it shall be sterilized with a solution of chloride of lime.

8) MEASUREMENTS

The length above ground shall be measured in running meter correct to a cm for the finished work, which shall include PP-R pipe and fittings including Plain fittings and Chrome Plated Brass Threaded fittings. Deductions for the length of valves shall be made. Rate quoted shall be inclusive of all fittings, clamps, Plugs, Chase cutting and making good the same and all items mentioned in the specifications and Bill of Quantities.

All PP-R pipes below ground shall be measured per linear meters (to the nearest cm) and shall be inclusive of all fittings including Plain fittings and Chrome Plated Brass Threaded fittings. Deductions for the length of valves shall be made. Rates quoted shall be inclusive of all fittings, clamps, excavation, back filling and disposal of

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surplus earth, cutting holes and making good all items mentioned in the Bill of Quantities.

9) SHIFTING OF EXCAVATED SURPLUS MATERIAL

Contractor shall make his own arrangement to shift the surplus excavated material within the site limits as directed by Owner's site representative at his own cost within time limit.

DUCTILE IRON FITTINGS FOR PRESSURE PIPES FOR WATER, GAS AND SEWAGE — As Per IS 9523 :2000

(Some important Para of the above IS code are reproduced below for information and guidance.

3. TERMINOLOGY

For the purposes of this standard, the following definitions shall apply:

3.1 Ductile Iron — Type of iron used for pipes, fittings and accessories in which graphite is present primarily in spheroidal form as per IS 8329:1994

3.2 Pipe — Casting of uniform bore, straight in axis, having either socket, spigot or flanged ends, except for flanged sockets, flanged spigots and collars which are classified as fittings.

3.3 Fitting — Casting other than a pipe, which allows pipeline deviation, change of direction or bore. In addition flanged sockets, flanged spigots and collars are also classified as fittings.

3.4 Accessory — Any item other than a pipe or fitting which is used in a pipeline, such as;

— glands and bolts for mechanical flexible joints;

— glands, bolts and locking rings or segments for restrained joints.

NOTE : Valves and hydrants of all types are not covered by the term accessory.

3.5 Flange — Flat circular end of fittings, extending perpendicular to its axis, with bolt holes equally spaced on a circle.

NOTE: A flange may be fixed (for example, integrally cast threaded on or welded on) or adjustable; An adjustable flange comprises of a ring in one or several parts bolted together, which bears on an end joint hub and can be freely rotated around the fittings axis before joining.);

3.6 Collar, Coupling — Connecting piece used to join together the spigots of mat pipes or fittings.

3.7.1 Spigot — Male end of fittings.

3.8 Socket — Female end of fittings to make the joint with spigot of an adjacent component.

3.9 Gasket — Sealing component of a joint.

3.10 Joint — Connection between the ends of fittings in which a gasket is used to effect a seal.

3.10 Flexible Joint: Joint which provides significant angular deflection and movement parallel and / or perpendicular to the fittings axis.

3.11 Push-on Flexible Joint — A flexible joint in which an elastomeric gasket is located in the socket and the joint assembly is effected by entering the spigot through the gasket into the socket.

3.12 Mechanical Flexible Joint — Flexible joint in which sealing is obtained by applying pressure to the gasket by mechanical means, for example, a gland.

3.13 Restrained Joint — Joint wherein a device is provided to prevent separation of the assembled joint.

3.14 Flanged Joint — Joint between two flanged ends.

3.15 Nominal Size (DN) — Numerical designation of size which is common to all components in a piping system. It is a convenient round number for reference purposes and is only loosely related to manufacturing dimensions.

3.16 Nominal Pressure (PN) — A numerical designation expressed by a number which is used for reference purposes. All compo of the same nominal size DN designated by the same PN number have compatible mating dimensions.

3.17 Batch — Quantity of castings from which a certain number of samples may be taken for testing purposes during manufacture.

3.18 3.19 Length — Effective length of a fitting, as shown on the drawings of 11.2

3.19 3.20 Ovality — Out of roundness of a fittings section it is equal to $100 (a_1 - A_2) / (A_1 + A_2)$ where a_1 is the maximum axis and A_2 the minimum axis of the fittings cross section.

3.20 Deviation in Length — Amount by which the design length may differ from the standardized length of a fittings.

Note : Fittings are designed to a length taking into account standard length plus or minus the deviation; they are manufactured to this length plus or minus the tolerances

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given in Table 14.

SECTION 1 GENERAL REQUIREMENTS

4. — MANUFACTURE AND REPAIR

4.1 — The metal used for the manufacture of casting shall conform to the appropriate grade as specified in IS 1865, in commensurate with the requirements as laid down in this standard. It shall be prepared at the discretion of the manufacturer in a cupola, or an active mixer or other suitable furnace.

4.2 — The castings shall be stripped with all precautions necessary to avoid warping or shrinkage defects, detrimental to their good quality. The castings shall be sound and free from surface or other defects.

4.3 — Casting showing small imperfections which result from the method of manufacture and which do not affect its final use shall not be rejected on that account alone.

4.4 — Minor defects may be rectified with the approval of the purchaser. Repairing of defects by welding, plugging off leaks by caulking or by application of epoxy putty may not be done without previously securing the approval of the purchaser. Repairs are to be carried out according to a written procedure included in the manufacturer's quality assurance system. Any dressing to remove imperfections, shall not reduce the thickness of the casting below the specified thickness.

4.5 — The castings shall be such that they could be cut, drilled or machined. In case of dispute the castings may be accepted provided that the hardness measured on the external un machined surface does not exceed 250 HBS.

4.6 — Where castings are required to withstand pressure higher than those specified in this standard, the casting may be strengthened by means of increased wall thickness, if necessary, at the expense of the internal diameter or by suitable ribbing or as may be mutually agreed between the manufacturer and the purchaser, to suit the pressure specified by the purchaser.

5. — THICKNESS

The thickness 'e' of fittings is calculated as a function of the nominal diameter 'DN' by using the formula given below with the following values for K:

$$e = K (0.5 + 0.01 \text{ DN})$$

Where K = 14, e = 7 + 0.014 DN

Where K = 12, e = 6 + 0.012 DN

For 'DN 80' the thickness of the fitting has

been limited to minimum of 7 mm, so that, taking the tolerances into account, the thickness of the fittings is always at least equal to that of the pipes of the same nominal diameter. Threaded on welded on) or adjustable; an flange comprises of a ring, in one or several parts bolted together, which bears on an end joint hub and can be freely rotated around the fittings axis before jointing.

5 — JOINTS

5.1 — In the case of push on joints for sizes 'DN 600' and above the sockets may be with or without centering rings.

5.2 — Design of the socket and rubber gaskets are no within the scope of this standard.

5.3 — If agreed between the manufacturer and the purchaser, the fittings can be made with plain end also, for jointing with the help of a collar/coupling provided that the overall length of the fitting remains the same. The length of the spigot necessary for jointing shall not be less than the length of the socket of the jointing pipe.

5.4 — In case of push on joints the spigot end of fitting, if any, shall be suitably chamfered to facilitate smooth entry of spigot in the socket of the pipes or fittings fitted with rubber gasket.

5.5 — In case of flange and mechanical joint casting the flange shall be at right angle to the axis of the joint. The bolt holes shall be either cored or drilled.

5.6 — The centre of bolt holes circle shall be concentric with the bore circle and shall be located off the centre line, unless otherwise specified by the purchaser. Where there are two or more flanges, the bolt holes shall be correctly aligned between them.

5.7 — The flanges shall be plain faced or with raised boss as given in Tables 4,5,6 and 7 over the contact surface with a tool mark finishing having a pitch of 1 ± 0.3 mm; serrations may be spiral or concentric.

5.8 — For high pressure mains, requiring working pressure greater than 2.4 MPa, suitable flexible joint may be preferred where the joint is restrained against axial movement.

5.9 — Push on joint fittings are normally not used for sizes above DN 1600.

7. — RUBBER GASKETS

The material of rubber gaskets for use with mechanical joints and push on joints shall conform to IS 5382. Unless otherwise agreed

between the manufacturer and the purchaser, dimensions of the rubber gasket shall be as per manufacturer's own design.

10. HYDROSTATIC TEST

For hydrostatic test, the fittings shall be kept under pressure for 10 seconds. They shall withstand the pressure test without showing

any sing of leakage, sweating or other defect of any king. The test shall be conducted before the application of surface coating.

10.1 The fittings shall withstand the hydrostatic pressure given in Table 2

Table 2 Hydrostatic Test Pressure for Castings

Nominal Diameter	Hydrostatic Test Pressure At works (MPa)
Upto and including 300	2.5
Over 300 and up to and including 600	1.6
Over 600 and up to and including 2000	1.0

NOTE : The work hydrostatic test pressure is less for fittings than for pipes specified in the relevant Indian Standard for pipes because the shape of the fittings makes it difficult to provide sufficient restraint to high internal pressure during the test.

10.2 When fittings are required for higher test pressures, the test pressures are subject to agreement between the purchaser and the manufacturer (see 4.6).

11. SIZES

The standard nominal sizes `DN; of the fittings covered in this standard are as follows:

80, 100, 125, 150, 200, 250, 300, 350, 400, 450, 500, 600, 700, 750, 800, 900, 1000, 1100, 1200, 1400, 1600, 1800 and 2000 mm.

NOTE : Nominal size is a number used to classify fittings/joints/casting and corresponds approximately to their internal diameter.

11.1 Dimensional and other requirements for sockets/spigot to push on joints; mechanical joints and flanges shall conform to the requirements specified in Tables 3,4,5,6 and 7 under Section 2 as relevant.

11.2 Dimensional and other requirements for fittings for specified DN shall conform to the values as given in the Table 15 to 31 under Section 3.

13. COATING

13.1 Fittings and accessories shall be normally delivered internally and externally coated.

13.1.1 External Coatings

By agreement between the manufacturer and the purchase, any one of the following coatings may be applied depending upon the external condition of use:

Metalic Zinc with finishing layer as included in Annex;

Zinc rich paint with finishing layer, as included in Annex A;

Bituminous paint : as included in Annex C; and External sleeving : Annex D.

13.1.2 Internal Linings

By agreement between the manufacturer and the purchaser, the following lining may be applied depending on the internal conditions of use:

Portland cement (with or without additives) mortar, as included in Annex B;

Blast furnace slag cement mortar as included in Annex B;

High alumina (calcium aluminate) cement mortar as included in Annex B;

Cement mortar with seal coat : as included in Annex B; and Bituminous paint as included in Annex C.

13.2 Unless otherwise between the purchaser and the manufacturer, the external coating and the internal lining when applied shall confirm to the requirements specified in this standard (including Annex). Additional requirements other than those specified may be agreed between the purchaser and the manufacturer.

14. QUALITY ASSURANCE

14.1 General

The manufacturer shall be able to demonstrate the conformity of the product to the requirements contained in this tandard by controlling the manufacturing process and carrying out the various tests as specified in this standard.

14.2 Quality Assurance System

The manufacturer shall control the quality of the product during manufacturing process by a system of process control in order to comply with the technical requirements

contained in this standard wherever possible statistical sampling techniques should be used to control the process so that the product is produced within the specified limits.

15. MARKING

15.1 Each fittings shall have as cast, stamped or indelibly painted on it, the following appropriate marks.

- Indication of the source of manufacture;
- The nominal diameter
- The last two digits of the year of manufacture;
- PN rating of flanges when applicable, and
- Any other mark required by the purchaser.

15.1.1 Marking may be done on the barrel of castings or on the outside of the sockets.

ANNEX B (Clause 13.1.2)

CEMENT MORTAR LINING

B-1 MATERIALS

B-1.1 Cement

The cement used for the lining shall conform to the existing standards on cement.

The type of cement to be used is to be mutually decided between the purchaser and the manufacturer. Normal recommendation are:-

(i) Portland cement (as per IS 269 or IS 455) mortar lining perform rather well and have an expected life of approximately 50 years in soft water with moderate amount of aggressive CO₂ and when pH is within 6 to 9. Longer service life can be obtained by increasing the mortar lining thickness.

(ii) Where cement mortar lining may be exposed to sulphate attack, ordinary Portland cement should be replaced by sulphate resisting Portland cement (as per IS 12330 or IS 6909). The sulphate concentration limit for sulphate resisting Portland cement is approximately 3000 mg/l; the same as ballast furnace slag cement which naturally possess a good resistance to sulphate attack. For sea water transmission ballast furnace slag cement which has C3 A content below 3 percent can be used.

(iii) High Alumina cement (as per IS 6452) mortar lining is suitable for continuous use of pH between 4 and 12 and no severe damage occur after occasional exposure to pH 3 to 4 to 12 to 13.

(iv) The recommended types of cements used for lining are as given in Table 32.

Table 32 Recommended Types of Cements Used for Lining

Water Characteristics	Portland Cement	Sulphate Resisting	High
		Cements (Including	Alumina
		Blast Furnace Slag	Cement
Minimum value of pH	6	5.5	4
Maximum content			
(mg/l of Aggressive CO ₂)	7	15	no limit
Sulphates (SO ₄)	400	3000	no limit
Magnesium (MG++)	100	500	no limit
Ammonium (NH ₄ +))	30	30	no limit

B-1.2 Sand

The sand used shall have a controlled granulometric distribution from fine to coarser elements; it shall be clean and shall be composed of inert, hard, strong and stable granular particles.

The fine fraction comprising particles passing through a sieve of aperture size 0.125mm shall not be more than 10 percent by mass.

The fraction comprising grains up to a maximum diameter equal to one third of the

normal thickness of the mortar lining shall not be less than 50 percent by mass.

The coarsest fraction (comprising particles which do not pass through a sieve of the aperture size closest to half the normal thickness of the mortar lining) shall not exceed 5 percent by mass

B-1.4 Mortar

The mortar of the lining shall be composed of cement, sand and water.

Additives, which shall be specified, may be used provided that they do not prejudice the quality of the coating and that of the transported water.

The mortar shall be thoroughly mixed and shall have a consistency which results in a dense and homogeneous lining.

The mortar shall contain by mass at least one part of cement to 3.5 parts of sand.

B-2 CONDITION OF THE INTERIOR SURFACE OF THE FITTINGS BEFORE APPLICATION OF THE LINING

All foreign bodies, loose scale or any other material which could be detrimental to good contact between the metal and the lining shall be removed from the surface to which the lining is to be applied.

The inner surface of fittings shall also be free of any metal projections likely to protrude beyond 50 percent the thickness of the lining.

B-3 APPLICATION OF THE LINING

The mortar will be works applied by a suitable process. Smoothing with a trowel is permitted. The layer of mortar should be free of any cavity or visible air bulges and care shall be taken to ensure maximum density at all points.

After the lining is applied it shall be cured at temperatures greater than 40°C. Any loss of water from the mortar by evaporation shall be sufficiently slow so that hardening is not impeded.

B-4 REPAIR OF LINING

Repairs to damaged or defective areas are allowable. The damaged mortar shall first be removed from these areas. Then the defective part shall be repaired by using, for example, a trowel with fresh mortar so that a

continuous lining having a constraint thickness is again obtained.

For the repair operation, the mortar shall have a suitable consistency, if necessary, additives may be included to obtain good adhesion against the side of the existing undamaged mortar.

B-5 THICKNESS OF THE LINING

The nominal thickness of the lining and its negative tolerance and maximum crack width/radial displacement are given in Table 33.

At the fittings ends, the lining may be reduced to values below the minimum thickness. The length of the chamber shall be as small as possible but, in any case, shall be less than 50 mm.

B-6 DETERMINATION OF LINING THICKNESS

The thickness of the lining is checked on the freshly centrifuged mortar by the insertion of a steel pin, or on the hardened mortar by means of a non-destructive method of measurement.

The thickness of the lining shall be measured at both ends of the fittings in at least one section perpendicular to the fittings axis.

B-7 SURFACE CONDITION OF THE HARDENED LINING

The surface of the cement mortar lining shall be uniformly smooth. Only isolated grains of sand are allowed to appear on the surface of the lining.

The lining shall be such that it cannot be dislodged with pressure of hand and shall be free from corrugations or ridges that could reduce the thickness of the lining to less than the minimum value at one point, as specified in the Table 33.

**Table 33 Thickness of Lining
(Clauses B-5 and B-7)**

All dimensions in millimetres

DN	Thickness		Maximum Crack Width and Radial displacement
	Nominal value	Tolerance	
080 to 300	3.0	1.5	0.8
350 to 600	5.0	2.0	1.0
700 to 1200	6.0	2.5	1.2
1400 to 2000	9.0	3.0	1.5

NOTE: Fittings ends may have a chamfer of maximum length 50mm.

On contraction of the lining, the formation of cracks cannot be avoided. These cracks,

together with other isolated cracks which may result from manufacturer or may develop during transportation, are acceptable up to a width given in the above.

B-8 SEAL COAT

B-8.1 General

When specified the cement lining shall be given a seal coat of bituminous material or any other epoxy based material compatible with Cement Mortar Lining. Other seal coat materials may be used, but they shall be agreed on at the time of purchase and shall be specified on the purchase order.

The purpose of seal coat is to minimize lime leaching of the cement mortar as well as to restrict the unwanted rise in pH value of the transmitted water.

When the pipes are to be used for conveying potable water the inside coating shall not contain any constituent soluble in such water or any ingredient which could impart any taste or whatsoever to the potable water after sterilization and suitable washing of the mains.

ANNEX C

(CLAUSES 13.1.1 AND 13.1.2)

BITUMINOUS COATING

C-1 General 65

Unless otherwise agreed between the purchaser and the manufacturer, fittings shall be coated externally and internally with the same material. (Bituminous coatings are either hot applied or cold applied).

C-2 GENERAL CHARACTERISTICS

C-2.1 Coating shall not be applied to any fittings unless its surfaces are clean, dry and free from rust.

C-2.2 Unless otherwise agreed between the purchaser and the manufacturer all fittings shall be coated externally and internally with the same material. The method of coating shall be as per usual practice of the manufacturers. The coating materials shall set rapidly with good adherence and shall not scale off. The mean thickness of the coating shall be not less than 70 µm and the local minimum thickness shall be not less than 50 µm.

C-2.3 Where the coating material has a tar or similar base, it shall be smooth and tenacious and hard enough not to flow when

exposed to a temperature of 650°C but not so brittle at a temperature of 00°C as to chip off when scribed with a penknife.

C-2.4 When the pipes are to be used for conveying potable water the inside coating shall not contain any constituent soluble in such water or any ingredient which could impart any taste or whatsoever to the potable water after sterilization and suitable washing of the mains.

C-2.5 Pipes with or without sockets and flanges which are imperfectly coated or where the coating does not set or conform to the required quality, the coating shall be removed and the pipes/flanges recoated.

13.2.15. Shower Rose Brass : The shower rose shall be of chromium plated brass of specified diameter. It shall have uniform perforations. The inlet size shall be 15 mm or 20 mm as required.

13.2.16. Water Meter (Domestic Type)

For details IS:779 water meters (Domestic type may be referred to)

13.2.16.1. Water meters shall be selected according to flow to be measured and not necessarily to suit a certain size of main. The following points shall govern the selection of meters :

- The maximum flow shall not exceed the nominal capacity of the meter.
- The continuous flow shall be not greater than the continuous running capacity rating.
- The minimum flow to be measured shall be within minimum starting flows.

13.2.16.2. Inferential water meter has the same accuracy as the semi-positive type at higher flows; it passes unfiltered water better than a semi-positive meter and is lower in cost.

13.2.16.3. Special care is necessary in selecting the most suitable meter where large rates of flow may exist for short periods. The normal working flow shall be well within the continuous running capacity specified in IS:779, as high rates of flow over short period may cause excessive wear if the meter chosen is too small for the duty.

13.2.16.4. Owing to the fine clearances in the working parts of meters, they are not suitable for measuring water containing sand or similar foreign matter, and in such cases a filter or dirt box of adequate effective area shall be fitted on the upstream side of the meter. See **Fig. 13.2**. It shall be noted that the normal strainer fitted inside a meter is not a filter and does not prevent the entry of small particles, such as sand.

13.2.16.5. Water meters and their parts, especially parts coming in continuous contact with water shall be made of materials resistant to corrosion and shall be non-toxic. Use of dissimilar metals in contact under water shall be avoided as far as possible in order to minimise electrolytic corrosion.

13.2.16.6. Body : The body of water meter shall be made either from Type A or Type B materials as specified below :

Type A : The body of water meters shall be made from bronze, brass or any other corrosion resistant material e.g. Grey iron castings, blackheart malleable iron, pherodial graphite iron casting.

Type B : The body of the water meters shall be made form suitable plastics which shall have following qualities:

- i) It shall not affect the potability of water.
- ii) Elongation, 15 percent, Min. on a specimen of length 150 mm.
- iii) Water absorption on immersion for 24 hours should not exceed 0.6 percent by weight.
- iv) It shall be capable of withstanding temperature upto 55° C without undergoing deformation or softening and becoming unsatisfactory in performance.

13.2.16.7. Registration Box : Registration box of water meters of Type A shall be made from bronze, brass, aluminium alloy or suitable plastics. Registration box of water meters of Type B shall be made from suitable plastics or aluminium alloys. The registration box of dry dial water meters shall be provided with one or two escape holes for minimising the accumulation of condensed water.

13.2.16.8. Cap : Cap of water meters of Type A shall be made from brass, bronze, aluminium alloy or suitable plastics. The cap of water meters of Type B shall be made of plastics or aluminium alloy. Where the cap and registration box are integral, the

materials-for cap may be the same as used for registration box. The cap shall be so designed and fixed to the registration box as to avoid entry of water and dirt. The transparent window which covers the dial shall be inserted from the inside into the cap. The protective lid shall be secured by a robust hinge or other suitable method of robust construction.

13.2.16.9. Locking arrangement : Provision shall also be made to lock the lid. The provision shall be such that the lock is conveniently operated from the top. Where the provision is designed for use in conjunction with padlocks, the hole provided for padlocks shall be of a diameter not less than 4 mm.

13.2.16.10. Wiper : Where so required for dry-type water meters the transparent window covering the dial shall be provided with a wiper on the inner side for wiping off condensed water.

13.2.16.11. Connecting Arrangements : The meter casing shall be fitted in the pipe line by means of two conical or cylindrical nipples or tail pieces with connecting nuts which shall be provided with each meter. The nipples of water meters of Type A shall be made of the same materials as specified for body. Nipples of water meters of Type B shall be made of the same materials as specified for the body where they are integral with the body of the water meters; where they are separate, they shall be made of malleable iron, galvanized steel or suitable plastics. The nuts shall be of the same material as used for nipples. The internal diameter of the nipple where it connects the pipe line shall be equal to that corresponding to the nominal size of the meter. The threads on the connection shall conform to IS:554. The minimum length of the threads shall be as given in **Table 13.9**. Screws & studs shall be of brass or other corrosion resistant material.

TABLE 13.9
MINIMUM LENGTH OF THREAD ON CONNECTIONS (mm)

Nominal size of meter	Minimum length of thread
15	13
20	16
25	19
40	21
50	25

13.2.16.12. Strainers : Water meters shall be provided with strainers. Strainers shall be of a material which is not susceptible to electrolytic corrosion. They shall be of plastics or other corrosion-resistant materials for both Type A and Type B meters. They shall be rigid, easy to remove and clean, and shall be fitted on the inlet side of the water meter. It shall be possible to remove and clean the strainer in such a way as not to permit disturbing the registration box or

tampering with it. The strainer shall have a total area of holes not less than twice the area of the nominal inlet bore of the pipe to which the meter is connected. However, in the case of meters provided with internal strainer involving opening of the registration box for cleaning, an additional external strainer shall be fitted on the inlet side satisfying the above requirements. Overall dimension of water meters shall be as specified in **Table. 13.10**.

TABLE 13.10
OVERALL DIMENSIONS OF WATER METERS

Nominal size of Meter	Overall length including nipples	Overall width. (Max.)	Overall height (Max.)	Nominal flow rate KL/ Hour
1	2	3	4	5
15	250	130	180	1.5
20	290	130	180	2.5
25	380	140	200	3.5
40	430	230	250	10
50	470	250	300	15

All dimensions are in mm. Tolerance on the overall length shall be ± 5 mm.

13.2.16.13. Capacity on Short Period Rating or Nominal Capacity : The nominal capacity of the water meters shall be as

specified in **Table 13.11**. The meters shall be capable of giving minimum discharges as stated in the Table without the head loss exceeding 10 m within the meters.

TABLE 13.11
NOMINAL CAPACITY OF WATER METERS

Nominal size of meter (mm)	Discharge per hour	
	Semi positive Type (liters)	Inferential Type (liters)
15	2000	2500
20	3400	3500
25	5500	5500
40	10000	16000
50	15000	23000

13.2.17. Yarn (Spun) : Spun yarn shall be of clean hemp and of good quality. It shall be soaked in hot coal tar or bitumen and cooled before use.

13.3 LAYING AND JOINTING OF PIPES AND FITTINGS – GENERAL

13.3.1. Unloading

13.3.1.1. The pipes shall be unloaded where they are required.

13.3.1.2. Except where mechanical handling facilities are available, pipes weighing upto 60 kg shall be handled by two persons by hand passing. Heavier pipes shall be unloaded from the lorry or wagon by holding them in loops, formed with ropes and sliding over planks set not steeper than 45 degree. The planks shall be sufficiently rigid and two ropes shall always be used to roll the pipes down the planks. The ropes should be tied on the side opposite the unloading. Only one pipe shall be unloaded at a time.

13.3.1.3. Under no circumstances shall the pipes be thrown down from the carriers or be dragged or rolled along hard surfaces.

13.3.1.4. The pipes shall be checked for any visible damage (such as broken edges, cracking or spalling of pipe) while unloading and shall be sorted out for reclamation. Any pipe which shows sufficient damage to preclude it from being used shall be discarded.

13.3.2. Storing

13.3.2.1. The pipes and specials shall be handled with sufficient care to avoid damage to them. These shall be lined up on one side of the alignment of the trench, socket facing upgrade when line runs uphill and upstream when line runs on level ground.

13.3.2.2. Each stack shall contain pipes of same class and size, consignment or batch number and particulars of suppliers, wherever possible, shall be marked on the stack.

13.3.2.3. Storage shall be done on firm, level and clean ground. Wedges shall be provided at the bottom layer to keep the stack stable.

13.3.3. Cutting

13.3.3.1. Cutting of pipes, may be necessary when pipes are to be laid in lengths shorter than the lengths supplied, such as while replacing accessories like tees, bends, etc. at fixed position in the pipe lines.

13.3.3.2. A line shall be marked around the pipe with a chalk piece at the point where it is to be cut. The line shall be so marked that the cut is truly at right angle to the longitudinal axis of the pipe. The pipe shall be rigidly held on two parallel rafters nailed to cross beams, taking care that the portion to be cut does not overhang and the cut mark is between the two rafters. The pipe shall be neatly cut at the chalk mark with carpenter's saw or hacksaw having a long blade, by slowly rotating the pipe around its longitudinal axis so as to have the uncut portion on top for cutting. Cutting of the pipe at the overhang should, as far as

possible, be avoided, as an overhanging end is liable to tear off due to its weight before the cutting is complete.

13.3.4. Trenches

13.3.4.1. The trenches shall be so dug that the pipes may be laid to the required alignment and at required depth. Excavation shall proceed to within about 7.5 cms of the finished formation level. The final 7.5cm is to be trimmed and removed as a separate operation immediately prior to the laying of the pipe or their foundations.

13.3.4.2. Cover shall be measured from top of pipe to the surface of the ground.

13.3.4.3. The bed of the trench, if in soft or made up earth, shall be well watered and rammed before laying the pipes and the depressions, if any, shall be properly filled with earth and consolidated in 20 cm layers.

13.3.4.4. If the trench bottom is extremely hard or rocky or of loose stony soil, the trench shall be excavated at least 150 mm below the trench grade. Rocks, stone or other hard substances from the bottom of the trench shall be removed and the trench brought back to the required grade by filling with selected fine earth or sand (or fine moorum if fine soil or sand is not available locally) and compacted so as to provide a smooth bedding for the pipe. Where excavation requires blasting operation, it shall be ensured that no pipes have been stacked in the vicinity and completed pipe line in the vicinity has already been covered before starting of blasting operations; this is necessary to prevent damage to the exposed pipes in the vicinity by falling stones as a result of blasting.

13.3.4.5. After the excavation of the trench is completed, hollows shall be cut at the required position to receive the socket of the pipes and these hollows shall be of sufficient depth to ensure that the barrels of the pipes shall rest throughout their entire length on the solid ground and that sufficient spaces left for jointing the underside of the pipe joint. These socket holes shall be refilled with sand after jointing the pipe.

13.3.4.6. Roots of trees within a distance of about 0.5 metre from the side of the pipe line shall be removed or killed.

13.3.4.7. The excavated materials shall not be placed within 1 metre or half of the depth of the trench, whichever is greater, from the edge of the trench. The materials excavated shall be separated and stacked so that in refilling they may be relaid and compacted in the same order to the satisfaction of the

Engineer.

13.3.4.8. The trench shall be kept free from water. Shoring and timbering shall be provided wherever required. Excavation below water table shall be done after dewatering the trenches.

13.3.4.9. Where the pipe line or drain crosses an existing road, the road crossing shall be excavated half at a time, the 2nd half being commenced after the pipes have been laid in the first half and the trench refilled. Necessary safety measures for traffic as directed shall be adopted. All pipes, water mains cables, etc. met within the course of excavation shall be carefully protected and supported. Care shall be taken not to disturb the electrical and communication cable met with during course of excavation, removal of which, if necessary, shall be arranged by the Engineer.

13.3.5. Laying

13.3.5.1. The pipes shall be lowered into the trench by means of suitable pulley blocks, shear legs, chains, ropes etc. In no case the pipes shall be rolled and dropped into the trench. One end of each rope may be tied to a wooden or steel peg driven into the ground and the other end held by men which when slowly released will lower the pipe into the trench. After lowering, the pipes shall be arranged so that the spigot of one pipe is carefully centered into the socket of the next pipe, and pushed to the full distance that it can go. The pipe line shall be laid to the levels required. Specials shall also be laid in their proper position as stated above.

13.3.5.2. Where so directed, the pipes and specials may be laid on masonry or concrete pillars. The pipe laid on the level ground, shall be laid with socket facing the direction of flow of water.

13.3.5.3. The pipes shall rest continuously on the bottom of the trench. The pipes shall not rest on lumps of earth or on the joints. Four metre long wooden templates may be used to check the level of the bed. Clearance of approximately 100 mm in depth and width equal to length of the collar plus 30mm on both sides shall be provided at the joint which shall be refilled from sides after the joint is made.

13.3.5.4. In unstable soils, such as soft soils and dry lumpy soils it shall be checked whether the soils can support the pipelines and if required suitable special foundation shall be provided.

13.3.5.5. Some clayey soils (for example

black cotton soil) are drastically affected by extremes of saturation and dryness. In changing from saturated to a dry condition, these soils are subjected to extraordinary shrinkage which is usually seen in the form of wide and deep cracks in the earth surface and may result in damages to under ground structures, including pipe materials. The clay forms a tight gripping bond with the pipe, subjecting it to excessive stresses as the clay shrinks. It is recommended that in such cases an envelope of a minimum 100 mm of tamped sand shall be made around the pipe line to avoid any bonding.

13.3.5.6. In places where rock is encountered, cushion of fine earth or sand shall be provided for a depth of 150 mm by excavating extra depth of the trench, if necessary, and the pipes laid over the cushion. Where the gradient of the bed slopes is more than 30 degree it may be necessary to anchor a few pipes against sliding downwards (Ref. Fig. 13.5).

13.3.6. Thrust Blocks (Ref. Fig. 13.5)

13.3.6.1. Thrust blocks are required to transfer the resulting Hydrostatic thrust from the fitting of pipe on to a larger load bearing soil section.

13.3.6.2. Thrust blocks shall be installed wherever there is a change in the direction/size of the pipe line or the pressure line diagram, or when the pipe line ends at a dead end. If necessary, thrust blocks may be constructed at valves also.

13.3.6.3. Thrust blocks shall be constructed taking into account the pipe size, water pressure, type of fitting, gravity component when laid on slopes and the type of soil. The locations of thrust blocks for various types fittings is given in Fig. 13.5.

13.3.6.4. When a fitting is used to make a vertical bend, it shall be anchored to a concrete thrust block designed to have enough weight to resist the upward and outward thrust. Similarly at joints, deflected in vertical plane, it shall be ensured that the weight of the pipe, the water in the pipe and the weight of the soil over the pipe provide resistance to upward movement. If it is not enough, ballast or concrete shall be placed around the pipe in sufficient weight to counteract the thrust.

13.3.6.5. When the line is under pressure there is an outward thrust at each coupling. Good soil, properly tamped is usually sufficient to hold pipe from side movement. However, if soft soil conditions are encountered, it may be necessary to provide

side thrust blocks or other means of anchoring. In such cases only pipe on each side of the deflected coupling shall be anchored without restricting the coupling.

13.3.6.6. Pipes on slopes need be anchored only when there is a possibility of the back fill around the pipe sloping down the hill and carrying the pipe with it. Generally for slopes upto 30 degree good well drained soil carefully tamped in layers of 100 mm under and over the pipe, right upto the top of trench will not require anchoring.

13.3.6.7. For steeper slopes, one out of every three pipes shall be held by straps fastened to vertical supports anchored in concrete.

13.3.7. Back Filling and Tamping

13.3.7.1. Back filling shall follow pipe installation as closely as possible to protect pipe from falling boulders, eliminating possibility of lifting of the pipe due to flooding of open trench and shifting pipe out of line by caved in soil.

13.3.7.2. The soil under the pipe and coupling shall be solidly tamped to provide firm and continuous support for the pipe line. Tamping shall be done either by tamping bars or by using water to consolidate the back fill materials.

13.3.7.3. The initial back fill material used shall be free of large stones and dry lumps. In stony areas the material for initial back fill can be shaved from the sides of the trenches. In bogs and marshes, the excavated material is usually little more than vegetable matter and this should not be used for bedding purposes. In such cases, gravel or crushed stone shall be hauled in.

13.3.7.4. The initial back fill shall be placed evenly in a layer about 100 mm thick. This shall be properly consolidated and this shall be continued till there is a cushion of at least 300 mm of cover over the pipe.

13.3.7.5. If it is desired to observe the joint or coupling during the testing of mains they shall be left exposed. Sufficient back fill shall be placed on the pipe to resist the movement due to pressure while testing.

13.3.7.6. Balance of the back fill need not be so carefully selected as the initial material. However, care shall be taken to avoid back filling with large stones which might damage the pipe when spaded into the trench.

13.3.7.7. Pipes in trenches on a slope shall require extra attention to make certain that the newly placed back fill will not become a blind drain in effect because until back fill

becomes completely consolidated there is a tendency for ground or surface water to move along this looser soil resulting in a loss of support to the pipe. In such cases, the back fill shall be tamped with extra care and the tamping continued in 100 mm layers right upto the ground level.

13.3.8. Hydrostatic Tests (Ref.Fig. 13.6):
(Note: Annexure-13.5 may be seen for details)

13.3.8.1. After a new pipe or any valved section thereof has been laid, jointed and back filled, it shall be subjected to the following two tests :

a) Pressure test at a pressure of at least double the maximum working pressure- pipe and joints shall be absolutely water tight under the test

b) Leakage test (to be conducted after the satisfactory completion of the pressure test) at a pressure to be specified by the authority for a duration of two hours.

13.3.8.2. Hydrostatic Tests : The portions of the line shall be tested by subjecting to pressure test as the laying progresses before the entire line is completed. In this way any error of workmanship will be found immediately and can be corrected at a minimum cost. Usually the length of the section to be tested shall not exceed 500 m.

13.3.8.3. Where any section of a main is provided with concrete thrust blocks or anchorages, the pressure test shall not be made until at least five days have elapsed after the concrete is cast. If rapid hardening cement has been used in these blocks or anchorages, test shall not be made until atleast two days have elapsed.

13.3.8.4. Prior to testing, enough back fill as described in para 13.3.7 shall be placed over the pipe line to resist upward thrust. All thrust blocks forming part of the finished line shall have been sufficiently cured and no temporary bracing shall be used.

13.3.8.5. The open end of the section shall be sealed temporarily with an end cap having an outlet which can serve as an air relief vent or for filling the line, as may be required. The blind face of the end cap shall be properly braced during testing by screw jacks and wooden planks or steel plate as shown in Fig. 13.6.

13.3.8.6. The section of the line to be tested shall be filled with water manually or by a low pressure pump. Air shall be vented from all high spots in the pipe line before making the pressure strength test because entrapped air gets compressed and causes difficulty in

raising the required pressure for the pressure strength test.

13.3.8.7. The test pressure shall be gradually raised at the rate of approximately one Kg./sq. cm./min. The duration of the test period if not specified shall be sufficient to make a careful check on the pipe line section.

13.4 Special Cast Iron Fittings and Accessories

13.4.1. Normally when pipe line is laid, a certain number of cast iron fittings such as tees, bends, reducers, etc. and special fittings such as air or sluice valves are required.

13.4.2. Laying of Fittings: All cast iron fittings shall be plain ended to suit the class and diameter of pipe manufactured. Cast iron fittings are jointed by cast iron detachable joints only. Cast iron specials having flanges are jointed in the pipe line with cast iron flange adapters having one end flanged and the other plain ended.

13.4.3. Anchorages : It shall particularly be noted that the cast iron joints do not hold pipe ends within firmly. During working or test pressure, there will be the tendency for the pipe ends or specials ends to slip out of the joint, more so in case of blank end cap used for closure of pipe line and in case of degree bends and tees. In order to keep them firmly in the pipe line, anchoring of

these specials is necessary against the direction of thrust.

The anchorage shall consist of either concrete cast-in-situ or masonry built in cement mortar. The anchors shall be extended to the firm soil of the trench side. The shape of the anchors will depend on the kind of specials used. They shall be spread to the full width of trench and carried vertically by the side and over the special to about 15 cm. The bearing area on sides of the trench shall be proportional to the thrust and to the bearing capacity of the sides of the trench. (Refer Fig. 13.5).

13.4.4 Hydrostatic Tests

13.4.5.1. The pipes shall be tested as specified in IS:5913 in the factory and hence the purpose of field testing is to check the quality of workmanship and also to check whether the pipes have been damaged in transit. As such, the test pressure shall be kept as 1.5 times the actual operating pressure unless a higher test pressure is specified. However, it may be noted that the test pressure during the field test shall not exceed the values given in Table 13.12.

13.4.5.2. Asbestos cement pipes always absorb a certain amount of water. Therefore, after the line is filled, it shall be allowed to stand for 24 hours before pressure testing and the line shall be again filled.

TABLE 13.12
TEST PRESSURE FOR PIPES

Class of pipe	Maximum field test pressure kgf./sq.cm
5	3.75
10	7.50
15	11.25
20	15.00
25	18.75

13.4.6. Measurements

13.4.6.1. The net length of pipes as laid or fixed shall be measured in the running metres correct to a cm. Specials shall be excluded and enumerated and paid for separately. The portion of the pipe within the collar at the joints, shall not be included in the length of pipe work.

13.4.6.2. Excavation, refilling, shoring and timbering in trenches, masonry or concrete pillars and thrust blocks, wherever required, shall be measured and paid for separately,

under relevant items of work.

13.4.6.3. The joints shall be enumerated and paid for separately.

13.4.7. Rates : The rate shall include the cost of materials.-and labour involved in all the operations described above except for the items measured/ enumerated separately under para 13.4.6.1, 13.4.6.2 and 13.4.6.3 which shall be paid for separately.

13.5. LAYING AND JOINTING OF CAST IRON PIPES AND FITTINGS (EXTERNAL

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For details IS:12288 Code of practice for use and laying of Ductile Iron pipes may be referred to Specifications described in para 13.3 shall apply, as far as applicable.

13.5.1. Trenches:

13.5.1.1. The gradient is to be set out by means of boning rods and the required depth to be excavated at any point of the trench shall be as directed by the Engineer. The depth of the trench shall not be less than 1 metre measured from the top of the pipe to the surface of the ground under roads and not less than 0.75 metre elsewhere.

13.5.1.2. The width of the trench shall be the nominal diameter of the pipe plus 40 cm but it shall not be less than 55 cm in case of all kinds of soils excluding rock and not less than 1 metre in case of rock.

13.5.2. Laying : Any deviation either in plan or elevation less than 11.25 degrees shall be effected by laying the straight pipes around a

flat curve of such radius that minimum thickness of lead at the face of the socket shall not be reduced below 6 mm or the opening between spigot and socket increased beyond 12 mm at any joint. A deviation of about 2.25 degree can be effected at each joint in this way. At the end of each day's work the last pipe laid shall have its open ends securely closed with a wooden plug to prevent entry of water, soil, rats and any other foreign matter into the pipe.

13.5.3. Lead Caulked joints with Pig Lead

13.5.3.1. This type of lead caulking is generally done in providing joints in gas, water and sewer lines wherever it is practicable to use cast lead caulking, but not in case of wet conditions.

13.5.3.2. The approximate depth and weights of pig lead for various diameters of C.I. pipes and specials shall be as given in **Table 13.13**.

TABLE 13.13
LEAD FOR DIFFERENT SIZES OF PIPES

Nominal size of pipe (mm)	Lead per joint (Kg.)	Depth of lead joint (mm)
80	1.8	45
100	2.2	45
125	2.6	45
150	3.4	50
200	5.0	50
250	6.1	50
300	7.2	55
350	8.4	55
400	9.5	55
450	14.0	55
500	15.0	60
600	19.0	60
700	22.0	60
750	25.0	60

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Note :

1. The quantity of lead given in the Table are on average basis and a variation of 10 percent is permissible.
2. Before pipes are jointed on large scale, three or four sample joints shall be made and the average consumption of lead per joint shall be got approved by the Engineer.

3. Only required quantity of spun yarn shall be put so as to give the specified depth of lead in the joint.

13.5.4. Lead Caulked joints with Lead Wool Yarn

13.5.4.1. This type of lead caulking is generally done when it is inconvenient or dangerous to use molten lead for joints, for

example in cases such as inverted joints or in wet trenches or in exceptional cases. In such cases the joints shall be made with lead wool or yarn. Caulking with lead wool, or yarn shall however be not carried out without the prior permission of Engineer.

13.5.4.2. The approximate weights and depths of lead wool or lead yarn required for each joint of various dia. of C.I. pipes and specials shall be as given in **Table 13.14**. Just sufficient quantity of spun yarn shall be put so as to give specified depth of

lead wool.

13.5.4.3. Jointing : The spun yarn shall first be inserted and caulked into the socket as described under jointing with pig lead. Lead wool or yarn shall then be introduced in the joint in strings not less than 6 mm thick and the caulking shall be repeated with each turn of lead wool or yarn. The whole of the lead wool or yarn shall be compressed into a dense mass. The joint shall then be finally finished flush with face of the socket.

TABLE 13.14

Diameter of pipe (mm)	Weight of lead wool or lead yarn (kg)	Depth of lead wool or lead yarn (mm)
80	0.80	19
100	0.90	19
125	1.25	20
150	1.60	23
200	2.05	23
250	2.95	25
300	3.50	25
350	4.65	29
400	5.70	31
450	6.70	32
500	8.30	33
600	10.00	35
700	11.80	36
750	13.60	38
800	15.40	40
900	16.80	40

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Note : An allowance of five per cent variation in the specified weights and depths is permissible.

13.5.4.4 Pig Lead : Pig lead shall be of uniform quality, clean and free from foreign materials. It shall be of uniform softness and capable of being easily caulked or driven. It shall conform to IS : 782 for caulking lead in all respects.

13.5.4.5 Lead Wool : Lead wool shall conform to IS : 782 in all respects. Lead wool shall consist of fine strands or plated ribbons of lead. The cross-section of the individual strands shall be flat. The dimensions in the sectional- plane shall not be less than 0.13 mm and not more than 0.90 mm and the rope shall be supplied in minimum lengths of two metres and the maximum length in any

one package shall be such that the package does not weigh more than 50 Kg.

13.5.5. Flanged joints:

13.5.5.1. Cast iron pipes may be jointed by means of flanges cast on. The jointing material used between flanges of pipes shall be compressed fiber board or rubber of thickness between 1.5 mm to 3 mm. The fiber board shall be impregnated with chemically neutral mineral oil and shall have a smooth and hard surface. Its weight per sqm shall be not less than 112 gm/mm thickness.

13.5.5.2. Each bolt should be tightened a little at a time taking care to tighten diametrically opposite bolts alternatively. The practice of fully tightening the bolts one after another shall not be allowed.

13.5.5.3. Several proprietary flexible joints are available for jointing cast iron pipes and these may be used with the specific approval of the authority. However, they shall be used strictly in accordance with the manufacturer's instructions.

13.5.5.4. For joints in small diameter cast iron piping, copper-alloy screwed unions or ferrules shall be used, and for large dia. the joints shall be made by flanged connecting pieces.

13.5.6. Hydrostatic Test : The procedure for testing for leakage under pressure shall be as described in **Annexure 13.5** which are to be read in addition to para 13.3.8. The joints of pipes and specials have to be repaired till the leakage in the portion under test is within the specified limit indicated in **Annexure 13.5**.

13.5.7. Measurements

13.5.7.1. The net length of pipes as laid or fixed, shall be measured in the running metres correct to a cm. Specials shall be excluded and enumerated and paid for separately. The portion of the pipe within the collar at the joints shall not be included in the

length of pipe work.

13.5.7.2. Excavation, refilling, shoring and timbering in trenches masonry or concrete pillars and thrust blocks, wherever required, shall be measured and paid for separately, under relevant items of work.

13.5.7.3. Lead caulked joints shall be measured and paid for separately.

13.5.8. Rate : The rate shall include the cost of materials and labour involved in all the operations described above except for the items measured/ enumerated separately under paras 13.5.7.1, 13.5.7.2, 13.5.7.3 which shall be paid for separately.

13.6. LAYING AND JOINTING OF G.I. PIPES (EXTERNAL WORK)

13.6.0 The specifications described in para 13.3 shall apply, as far as applicable.

13.6.1. Trenches : The galvanised iron pipes and fittings shall be laid in trenches. The widths and depths of the trenches for different diameters of the pipes shall be as in **Table 13.15**.

TABLE 13.15

Dia of pipe (mm)	Minimum Width of trench (cm)	Minimum Depth of trench (cm)
15 to 50	30	60
65 to 100	45	75

At joints the trench width shall be widened where necessary. The work of excavation and refilling shall be done true to line and gradient in accordance with general specifications for earth work in trenches. When excavation is done in rock, it shall be cut deep enough to permit the pipes to be laid on a cushion of sand minimum 7.5 cm deep.

13.6.2. Cutting and Threading : Where the pipes have to be out or rethreaded, the ends shall be carefully filed out so that no obstruction to bore is offered. The end of the pipes shall then be carefully threaded conforming to the requirements of IS: 554 with pipe dies and taps in such a manner as will not result in slackness of joints when the two pieces are screwed together. The taps and dies shall be used only for straightening screw threads which have become bent or damaged and shall not be used for turning of the threads so as to make them slack, as the

later procedure may not result in a water tight joint. The screw threads of pipes and fittings shall be protected from damage until they are fitted.

13.6.3. Jointing : The pipes shall be cleaned and cleared of all foreign matter before being laid. In jointing the pipes, the inside of the socket and the screwed end of the pipes shall be oiled and rubbed over with white lead and a few turns of spun yarn wrapped round the screwed end of the pipe. The end shall then be screwed in the socket, Tee etc. with the pipe wrench. Care shall be taken that all pipes and fittings are properly jointed so as to make the joints completely water tight and pipes are kept at all times free from dust and dirt during fixing. Burr from the joint shall be removed after screwing. After laying, the open ends of the pipes shall be temporarily plugged to prevent access of water, soil or any other foreign matter.

13.6.4. Thrust Blocks (Refer Fig. 13.5) : In

case of bigger diameter pipes where the pressure is very high, thrust blocks of cement concrete 1:2:4 (1 cement: 2 coarse sand: 4 graded stone aggregate of 20 mm nominal size) of adequate size and shape shall be provided on all bends to transmit the Hydrostatic thrust to the ground, spreading it over a sufficient area, depending upon the type of soil met with.

13.6.5. Painting : The pipes shall be painted with two coats of anticorrosive bitumastic paint of approved quality.

13.6.6. Testing of joints : The pipes and fittings after they are laid and jointed shall be tested to Hydrostatic pressure of 6 Kg/sq. cm (60 meter). The pipes shall be slowly and carefully charged with water allowing all air to escape and avoiding all shock or water hammer. The draw off taps and stop cocks shall then be closed and specified Hydrostatic pressure shall be applied gradually. Pressure gauge must be accurate and preferably should have been recalibrated before the test. The test pump having been stopped, the test pressure should be maintained without loss for at least half an hour. The pipes and fittings shall be tested in sections as the work of laying proceeds, leaving the joints exposed for inspection during the testing. Pipes or fittings which are found leaking shall be replaced and joints found leaking shall be redone, without extra payment.

13.6.7. Trench Filling : The pipes shall be laid on a layer of 7.5 cm sand and filled upto 15 cm above the pipes. The remaining portion of the trench shall then be filled with excavated earth as described in para 13.3.7. The surplus earth shall be disposed off as directed.

13.6.8. Measurements : The lengths shall be measured in running metre correct to a cm for the finished work, which shall include G.I. Pipe and G.I. Fittings such as bends, tees, elbows, reducers, crosses, plugs, sockets, nipples and nuts, but exclude brass or gun metal taps (cocks), valves, unions, lead connection pipes and shower rose. All pipes and fittings shall be classified according to their diameters, method of jointing and fixing substance quality and finish. In case of fittings of an equal bore the pipe shall be described as including all cuttings and wastage. In case of fittings of unequal bore the largest bore shall be measured..

G.I. unions shall be paid separately in external work as paid in internal work in accordance with para 13.8.2. Digging and

refilling of trenches shall either be measured separately as specified in the appropriate clauses of excavation and earth work or clubbed with main item.

13.6.9. Rate : The rate shall included the cost of labour and materials involved in all the operations described above. The rate shall not include excavation in trenches, painting of pipes and sand filling all round the pipes, unless otherwise specified.

13.7. LAYING AND JOINTING UNPLASTICISED P.V.C. PIPES (EXTERNAL WORK)

Note: For details IS:7634 Code of Practice for Plastic pipes work for Potable Water supplies Part III Laying and Jointing of U PVC Pipes may be referred to)

13.7.1. Handling and Storage : Unplasticized P.V.C. pipes are light in weight material. Reasonable care shall be taken in handling and storage of these to prevent damages. On no account the pipes shall be dragged along the ground. Pipes shall be given adequate support at all times. They shall not be stacked in large piles, especially under warm temperature conditions as the bottom pipes may distort, thus giving rise to difficulty in pipe alignment and jointing.

For temporary storage in the field, where racks are not provided care shall be taken that the ground is level and free from loose stones. Pipes stored thus shall not exceed three layers and shall be so stacked as to prevent movement. The pipes shall preferably be stored under shade.

For satisfactory service performance of plastic pipes under conditions of use, the following points must be kept in view while undertaking installation of plastic piping system :

- a) The plastic materials are 'thermoplastic' in nature, and must not be used in contact with hot surfaces or hot water;
- b) They must be supported at regular intervals for above ground installation
- c) Allowance must be made, during installation for their expansion, particularly by using loose clips/clamp
- d) A range of specials, and matching fittings must be identified and their manufacturers/suppliers listed.

Rigid P.V.C. pipes upto 600 mm dia have been produced. However, in India these are available from 16 mm to 315 mm. In these specifications only the use of rigid (unplasticised) P.V.C. pipes for cold -water supplies is covered.

13.7.2. Trenches : The trench bottom shall be carefully examined for the presence of hard objects such as flints, rock projections or tree roots etc. Pipes shall be bedded in sand or soft soil free from rock and gravel. Back fill 15 cm above the pipe shall also be of fine sand or soft soil. Pipes shall not be painted. The width of trench shall be not less than outside dia meter of pipe plus 30 cm in case of gravel soils. Pipes shall be laid at least 90 cms below the ground level, measured from surface of the ground to the top of the pipe.

13.7.3. Jointing :

13.7.3.1. Solvent welded joints. (Fig. 13.8) : Non heat application Method :

In this method, instead of forming a socket on one pipe an injection moulded socket fitting or coupler is used, with a provision to take in the pipes at both ends. The solvent cements are applied on the surfaces to be jointed and the joint is made at ambient temperature. Injection moulded fittings only shall be used in preference to fabricated fittings. Only solvent recommended by the manufacturers of the pipes shall be used and full load on the joints applied only after 24 hours. The pipe shall be cut perpendicular to the axis of the pipe length with a metal cutting saw or an ordinary hand saw with small teeth. Pipe ends have to be beveled slightly with a beveling tool (Reamer) at an angle of about 30 degrees. The total length of insertion socket (injection moulded socket or coupler) shall be marked on the pipe and checked how far the pipe end could be inserted into the fitting socket. Attempt shall be made to push the pipe to the marked distance and if not possible it shall at least be pushed for 2/3 of this distance

Dust, oil, water, grease etc. shall be wiped cut with a dry cloth from the surface. Further the grease should be thoroughly removed with a suitable solvent, such as methylene chloride or as an alternative the outside surface of the pipe and the inside of the fitting may be roughened with emery paper.

Generous coatings of solvent cement shall be evenly applied on the insides of the fitting around the circumference for the full length of insertion and on the outside of the pipe end upto the marked line with non synthetic brush of suitable dimension. The pipe shall be pushed into the fitting socket and held for 1 or 2 minutes as otherwise the pipe may come out of the fitting due to the slippery quality of solvent cement and the tapering inside bore of the fitting. The surplus cement on the pipe surfaces shall be wiped out. If

the solvent cement has dried up too much or the tapering of the socket is too steep, jointing will not be proper and pipe will come out of the fitting.

In summer months joints shall be made preferably early in the morning or in the evening when it is cooler., This will prevent joint from pulling apart when the pipe cools off at night. Heat application method for jointing shall not be allowed.

13.7.3.2. Flanged Joints : For jointing P.V.C. pipes particularly of larger sizes to valves and vessels and larger size metal pipes where the tensile strength is required, the joint is made by the compression of a gasket or ring seal set in the face of C.I. flange. Flanges solvent welded to the P.V.C. pipes shall be supplied by the manufacturers.

13.7.3.3. Rubber Ring joints : Rubber ring joints can provide a water tight seal but do not resist pull. As such these may be used only as repairs collar and for jointing pipes larger than 110 mm. Such joints may be provided on pipes which are buried in the ground and supported throughout on a bedding so that they are not subject to movement and longitudinal pull. The material of rubber ring shall conform to IS: 5382. Where aggressive soils are met with, synthetic rubbers perform better for jointing. The ring shall be housed in a groove formed in plastic or metallic housing. The rubber is compressed and makes a seal between the pipe and the housing. The ring shape and the method of compressing the ring vary considerably in different types of joints. Most joints often require the application of lubricating paste which shall be procured from the manufacturer of P.V.C. pipes. Rubber rings shall be supplied by the manufacturers.

The rubber ring joints can be either of (i) With spigot and socket or (ii) With separate collar pieces having two rubber rings, one at either end.

13.7.4. Crossing Road or Drain (Ref. Fig. 13.9) : Where the pipe line crosses a road or a drain, it shall be through C.I. or R.C.C. pipe.

13.7.5. Supports for Valve and Hydrant : Valve and hydrant tees shall be-supported as shown in **Figure 13.10** so that the torque applied in operating a valve is not transmitted to the pipe line.

13.7.6. Inspection and Testing : Solvent welded pipe shall not be pressure tested until at least 24 hours after the last solvent

cemented joint has been done.

All control valves shall be positioned open for the duration of the test and open end closed with water tight fittings. The testing pressure on completion of the work shall not be less than one and a half times the working pressure of the pipes.

Pressure shall be applied either by hand pump or power driven pump. Pressure gauges shall be correctly positioned and closely observed to ensure that at no time the test pressure is exceeded. The system shall be slowly and carefully filled with water to avoid surge pressure or water hammer. Air vents shall be open at all high points so that air may be expelled from the system during filling.

When the system has been fully charged with water and air displaced from the line, air vent shall be closed and the line initially inspected for seepage at joints and firmness of supports under load. Pressure may then be applied until the required test pressure is reached.

Without any additional requirement of make-up water the test pressure should not fall more than 0.2 kg./sq.cm. at the end of one hour test duration.

13.7.7. Measurements : The length shall be measured in running metre correct to a cm for the finished work which shall include P.V.C. fittings such as bends, tees, elbows, reducer, crosses, plugs, sockets, nipples and nuts, but exclude, taps, valves, etc. All pipes and fittings shall be classified according to their outside diameters and pressure ratings. Fittings of unequal outside diameter shall be measured alongwith the larger diameter pipe.

13.7.8. Rate : The rate shall include the cost of labour and material in all the operation described above except excavation in trenches, sand filling all round the pipes, metal pipe used for encasing P.V.C. pipe and anchor blocks, unless otherwise specified.

13.8. LAYING AND JOINTING G.I. PIPES (INTERNAL WORK)

13.8.1. General: For internal work the galvanised iron pipes and fittings shall run on the surface of the walls or ceiling (not in

chase) unless otherwise specified. The fixing shall be done by means of standard pattern holder bat clamps, keeping the pipes about 1.5 cm clear of the wall. When it is found necessary to conceal the pipes, chasing may be adopted or pipes fixed in the ducts or recess etc., provided there is sufficient space to work on the pipes with the usual tools. The pipes shall not ordinarily be buried in walls or solid floors. Where unavoidable, pipes may be buried for short distances provided, adequate protection is given against damage and where so required joints are not buried. Where directed by the Engineer, a M.S. tube sleeve shall be fixed at a place the pipe is passing through a wall or floor for reception of the pipe and to allow freedom for expansion and contraction and other movements. In case the pipe is embedded in walls or floors it should be painted with anticorrosive bitumastic paint of approved quality. The pipe shall not come in contact with lime mortar or lime concrete as the pipe is affected by time. Under the floors the pipes shall be laid in layer of sand filling as done under concrete. floors.

All pipes and fittings shall be fixed truly vertical and horizontal unless unavoidable. The pipes shall be fixed to walls with standard pattern holder bat clamps of required shape and size so as to fit tightly on the pipes when tightened with screwed bolts. These clamps shall be embedded in brick work in cement mortar 1:3 (1 cement: 3 coarse sand), and shall be spaced at regular intervals in straight lengths as shown in **Table 13.16**.

The clamps shall be fixed at shorter lengths near the fittings as directed by the Engineer .

For G.I. pipes 15 mm diameter, the holes in the walls and floors shall be made by drilling with chisel or jumper and not by dismantling the brick work or concrete. However, for bigger dimension pipes the holes shall be carefully made of the smallest size as directed by the Engineer. After fixing the pipes the holes shall be made good with cement mortar 1:3 (1 cement: 3 coarse sand) and properly finished to match the adjacent surface.

TABLE 13.16

Dia. of Pipe mm	Max Horizontal length M	Max Vertical length M
15	2.0	2.5

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20	2.5	3.0
25	2.5	3.0
32	2.5	3.0
40	3.0	3.5
50	3.0	3.5
65	3.5	5.0
80	3.5	5.0

Unions will be provided to facilitate connections, additions and alterations as well as for maintenance and for change of pipes. The locations where unions are to be provided will be decided with prior written approval of the Engineer.

13.8.2. Measurements : The lengths shall be measured in running metre correct to a cm for the finished work, which shall include G.I. pipe and G.I. fittings such as bends, tees elbows, reducers, crosses, plugs, sockets, nipples and nuts, but exclude brass or gun metal taps (cocks), valves, unions, lead connection pipes and shower rose. All pipes and fittings shall be classified according to their diameters, method of jointing and fixing substance, quality and finish. In case of fittings of an equal bore the pipe shall be described as including all cuttings and waste. In case of fittings of unequal bore, the largest bore shall be measured. Pipes laid in trenches (or without supports) and pipes fixed to walls, ceilings, etc. with supports shall be measured separately.

13.8.3. Rate : The rate shall include the cost of labour and material involved in all the operations described above. The rate shall include the cost of cutting holes in walls and floors and making good the same. This shall not however, include concealed pipe work in

which case cutting of chase and making good shall be paid separately. It shall not include painting of pipes and providing sleeves, unless specified otherwise. It will also not include union which shall be paid for separately.

13.9. LAYING AND JOINTING P.V.C. PIPES (INTERNAL WORK)

13.9.1. Clamping : The pipes shall be laid and clamped to wooden plugs fixed above the surface of the wall, as shown in Fig. 13.11. Alternatively plastic clamps of suitable designs, wherever available, shall be preferred. Provision shall be made for the effect of thermal movement by not gripping the pipe at supports between the anchors for suspended pipes. The supports shall allow the repeated longitudinal temperature movement to take place without abrasion. Line or point contact with the pipe shall be avoided. Heavy components such as metal valves shall be individually supported.

13.9.2. Supports : P.V.C. pipes require supports at close interval. Recommended support spacings for plasticised P.V.C. pipes are given in Table 13.17. This spacing may be increased by 50% for vertical runs support.

TABLE 13.17

Pipe Din. (MM)	Max Support spacing (MM)
20	700
25	750
32	825
40	975
50	975

It is essential that P.V.C pipes shall be aligned properly before fixing them on the wooden plugs with clamps. Even if the

wooden plugs are fixed using a plumb line, P.V.C. pipe shall also be checked for its alignment before clamping. The pipe line

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will be wavy if the clamps are not fixed keeping the pipe plumb.

13.9.3. Connection to a Water Tap : Connection to the water tap shall be made by means of a G.I. adopter as shown in the Fig. 13.11. G.I. adopter shall preferably be supplied by the same manufacturer as that of P.V.C. pipe. In any threaded coupling between P.V.C. and G.I. is preferable that P.V.C. is fitted inside the G.I. fitting. If however greater projection is desired, same shall be achieved by joining a short piece of a G.I. pipe (Nipple) as shown in Fig. 13.11.

13.9.4. Connection to a shower Rose : Shower rose connection shall be of G.I. pipes as shown in Fig. 13.11.

13.9.5. Connection from Masonry/Concrete Water Tank : Solvent cement shall be coated on the section of the pipe to be embedded in concrete. Fine dry sand and cement mixture shall be sprinkled uniformly around the pipe. This shall give a rough surface which can be safely embedded in concrete, water proofing cement shall be used to close the gap properly.

13.9.6. Measurements : The length shall be measured in running metre correct to a cm for the finished work which shall include P.V.C. fittings such as bends, tees, elbows, reducer, crosses plugs, sockets, nipples and nuts, but exclude, taps, valves, etc. All pipes and fittings shall be classified according to their outside diameters and pressure ratings. Fittings of unequal outside diameter shall be measured along with the larger diameter pipe.

13.9.7. Rate : The rate shall include the cost of labour and material in all the operations described above, except metal pipe used for encasing P.V.C. pipe and anchor blocks, unless otherwise specified.

13.10. MAKING CONNECTION OF G.I. DISTRIBUTION BRANCH WITH G.I. MAIN

13.10.1. Preliminary Work : A pit of suitable dimensions shall be dug at the point where the connection is to be made with the main and earth removed upto 15 cm below the main. The flow of water in the water main shall also be disconnected by closing the sluice or wheel valves on the mains.

13.10.2. Making Connection : For cutting and jointing paras 13.6.2 and 13.6.3 shall apply. The G.I. main shall first be cut. Water if any collected in the pit shall be bailed out and, ends of the G.I. pipes threaded. The

connection of distribution pipe shall then be made after fixing G.I. tee of the required size to the G.I. main and fittings such as jam nut, G.I. socket connecting piece etc.

13.10.3. Testing of Joints : After laying and jointing, the pipes and fittings shall be inspected under working condition of pressure and flow. Any joint found leaking shall be redone and all leaking pipes removed and replaced without extra payment.

The pipes & fittings after they are laid shall be tested to Hydrostatic pressure of 6 kg./sq.cm. (60 m). The pipes shall be slowly and carefully charged with water allowing all air to escape and avoiding all shock of water hammer. The draw of taps and stop cocks shall than be closed and specified Hydrostatic pressure shall be applied gradually. Pressure gauge must be accurate and preferably should have been recalibrated before the test. The test pump having been stopped, the test pressure should be maintained without loss for at least half an hour. The pipes and fittings shall be tested in sections as the work of laying proceeds, leaving the joints exposed for inspection during the testing.

13.10.4. Finishing: The portion of the pipe in the pit shall be painted with bitumastic paint and encased with sand 15 cm around. The pit shall be filled with earth in level with the original ground surface watered, rammed and the area dressed.

13.10.5. Measurements : The work of making connections-shall be enumerated.

13.10.6. Rate : The rate shall include the cost of labour and materials involved in all the operations described above.

13.11. P.V.C. PIPES SERVICE CONNECTION (Ref. FIG. 13.9)

13.11.1. General: Either metal or P.V.C. saddles, as specified, shall be used for the off take of service connections from larger bore pipes (50 mm diameter and above). The saddle consists of two half round sections of metal or P.V.C. which are bolted together or held round the pipe by wedge grips. A seal is formed between the saddle and the pipe and the under surface of the upper section. The service connection is taken from a boss on the upper section.

Conventional equipment for tapping under pressure may be used with these service connections using a special cutter to pierce the pipe wall. Ferrules shall not be screwed directly into pipes without the introduction of

saddle piece. A typical illustration of a ferrule connection is shown in Fig. 13.9.

13.11.2. Measurements : Connections shall be enumerated.

13.11.3. Rate : The rate shall include the cost of labour and materials involved in all the operations described above.

13.12. P.V.C. PIPE-REPAIRS :

13.12.1. General: While temporary or emergency repairs may be made to the damaged pipes, permanent repairs should be made by replacement of the damaged section. In case of damage by external blows, the extent of the damage may be greater on the inner-surface.

Some times, pipes are damaged accidentally due to trenching operation in street repairs, Shell split or chipout occurs in the wall of the pipe. A short piece of pipe of sufficient length to cover the damaged portion of the pipe is cut. The sleeve is cut longitudinally and heated sufficiently to soften it so that it may be slipped over the damaged pipe.

13.12.2. Measurements : Repairs shall be enumerated.

13.12.3. Rate : Rate shall include the cost of all materials and labour involved in all the operations described above.

13.13. FIXING BRASS AND GUN METAL WATER FITTINGS:

13.13.1.General: The fitting shall be fully examined and cleared of all foreign matter before being fixed. The fitting shall be fitted in the pipe line in a workman like manner. The joints between fittings and pipes shall be leak-proof when tested to a pressure of 17.5 kg/sq.cm. The defective fittings and joints shall be replaced or redone.

13.13.2. Measurements : Fittings shall be enumerated.

13.13.3. Rate : The rate shall include cost of all the materials and labour involved in all the operation described above.

13.14. FIXING FERRULES:

13.14.1.General: For fixing ferrule the empty main shall be drilled and tapped at 45 degree to the vertical and the ferrule screwed in. The ferrule must be so fitted that no portion of the shank shall be left projecting within the main into which it is fitted.

13.14.2. Measurements : Ferrule shall be enumerated.

13.14.3. Rate : The rate shall include the cost of all materials and labour involved in fixing the ferrule.

13.15. INSTALLATION OF FIRE HYDRANT:

13.15.1. General : The hydrant shall be fully examined and cleared of all foreign matter before being fixed. The fixing shall be done on the water main which shall be of minimum 80 mm dia. The flanged end of the hydrant shall be fixed to the flanged outlet of a tee in the water main by means of bolts, nuts and 3 mm rubber insertion or chemically treated compressed fibre board 1.5 mm minimum thickness and of weight not less than 0.183 gm. per sq.cm. This can also be fixed by means of flanged tail piece which may be connected to the water main by C.I. specials.

13.15.2. Measurements : Fire hydrant shall be enumerated.

13.15.3 Rate : The rate shall include the cost of materials and labour involved in all the operations described above against relevant item of work.

13.16. INSTALLATION OF SLUICE VALVE :

13.16.1. General: The valve shall be fully examined and cleared of all foreign matter before being fixed. The fixing of the valve shall be done by means of bolts, nuts and 3 mm rubber insertions or chemically treated compressed fibre board 1.5 mm minimum thickness and of weight not less than 0.183 gm./sq.cm. with the flanges of spigot and the socketed tail pieces drilled to the same specification in case of S&S pipes and with flanges in case of flanged pipes, the tailpieces shall conform to IS: 1938. These shall be jointed to the pipe line by means of lead caulked joints.

13.16.2. Measurements: Sluice valve shall be enumerated.

13.16.3 Rate: The rate shall include the cost materials and labour involved in all. the operations described above.

13.17. INSTALLATION OF WATER METER AND STOP COCK (REFER FIG. 13.2)

13.17.0. For details IS:2401 Code of Practice for selection, installation and maintenance of domestic water meters may be referred to.

13.17.1. General: The G.I. line shall be cut

to the required length at the position where the meter and stop cock are required to be fixed. The ends at the pipe shall then be threaded. The meter and stop cock shall be fixed in position by means of connecting pipes, G.I. jam nut and socket etc. The paper disc inserted in the nipples of the meter shall be removed and the meter installed exactly horizontal or vertical in the flow line in the direction shown by the arrow cast on the body of the meter.

Care shall be taken that the factory seal of the meter is not disturbed. Wherever the meter shall be fixed to a newly fitted pipe line, the pipe line shall have to be completely washed before fitting the meter. For this purpose a piece of pipe equal to the length of the meter shall be fitted in the proposed position of the meter in the new pipe line. The water shall be allowed to flow completely to wash the pipe line and then the meter installed as described above by replacing the connecting piece.

13.17.2. Testing of Joints: Testing of joints shall be done as described in para 13.3.8.

13.17.3. Measurements: The work of fixing meters and stop cocks shall be counted in numbers separately according to the diameters.

13.17.4. Rate: The rate shall include the cost of labour and materials involved in all the operations described above excluding the cost of stop cock and water meter.

13.18. FIXING SURFACE BOX (REFER FIG.13.3 & 13.4):

13.17.1. General: The C.I. surface box shall be fixed on the top of masonry chamber in plain or reinforced cement concrete 1:2:4 (1 cement: 2 coarse sand: 4 graded stone aggregate 20 mm nominal size) as the case may be.

13.18.2. Measurements: Masonry chambers shall be enumerated under the relevant items.

13.18.3. Rate : The rate shall include the cost of materials and labour involved in all the operations described above, except the excavation in saturated soil, soft or decomposed and hard rock if met with. The difference of cost, between ordinary soil and saturated soil or soft or decomposed or hard rock as the case may be, shall be paid for separately

13.19. CONSTRUCTING R.C.C. POST FOR HYDRANT (REFER FIG. 13.10):

13.19.1. General: The R.C.C. post for a hydrant shall be of the size 25 x 25 cm at the bottom and 15 x 15 cm at the top. A pipe of specified size shall be provided during casting in the centre of the post. The post shall be of 170 cm height, out of which 60 cm shall be kept below ground level.

13.19.2. Earth Work : The excavated earth shall be disposed off as directed by the Engineer .

13.19.3. Reinforced Cement Concrete Work : The post shall be made of cement concrete 1:2:4 (1 cement: 2 coarse sand: 4 graded stone aggregate 12.5 mm nominal size) and reinforced with 4 Nos. 10 mm dia. bars at corners. 6 Nos. square stirrups of 6 mm diameter bars shall be provided for keeping the vertical reinforcement in position.

13.19.4. Finishing : The R.C.C. post shall be plastered with 6 mm thick cement plaster 1:4 (1 cement: 4 fine sand) on all the exposed surfaces and, upto a depth of 15 cm below ground level. The plastered surface shall be finished with a floating coat of neat cement.

13.19.5. Measurements: The R.C.C. posts shall be enumerated.

13.19.6. Rate: The rate shall include the cost of labour and materials required for all the operations described above including providing and embedding of the pipe in the post.

13.20. CONSTRUCTING MASONRY PILLAR FOR HYDRANT (Refer FIG. 13.10):

13.20.1. General: The section of the pillar shall be one and half brick square or one brick square, as specified. The height of the pillar above ground shall be 110 cm.

13.20.2. Earth Work : The excavated earth shall be disposed off as directed by the Engineer

13.20.3. Concrete Work : Foundation concrete shall consist of 15mm thick cement concrete 1:5:10 (1 cement: 5 fine sand: 10 graded stone aggregate 40 mm nominal size) or as specified.

13.20.4. Brick Work : The masonry shall be with bricks of class designation 75 in cement mortar, 1:4 (1 cement: 4 fine sand). The brick masonry shall be kept upto-a height of 100 cm above ground level. The hydrant pipe shall pass through the post or shall be fixed to pillar with G.I. holder bat

clamps as directed by the Engineer.

13.20.5. Finishing : The pillar masonry shall be plastered with 12 mm cement plaster 1:4 (1 cement: 4 coarse sand) finished with a floating coat of neat cement. The top of the masonry pillar shall have 10 cm thick cement concrete 1:2:4 (1 cement: 2 coarse sand: 4 graded stone aggregate 12.5 mm nominal size) coping with edges rounded off. The concrete of the coping shall be rendered smooth with neat cement.

13.20.6. Measurements: Hydrant pillars shall be enumerated.

13.20.7. Rate:: The rate shall include the cost of labour and materials required for all the operations described above except providing and fixing of pipe which shall be paid separately.

13.21. CONSTRUCTING MASONRY PLATFORM FOR STAND POST (Refer FIG.13.10):

13.21.1. General: The internal dimension of the platform shall be 120 x 120 cm or 90 x 90 cm as specified.

13.21.2. Earth Work : Earth work shall be done true to dimensions as shown in the drawing. The excavated earth shall be disposed off as directed by the Engineer .

13.21.3. Concrete Work : Foundation for the platform shall consist of 10 cm thick cement concrete 1:5:10 (1 cement : 5 fine sand : 10 graded stone aggregate 40 mm nominal size) or as specified.

13.21.4. Kerbing: The kerbing for the platform shall be of half brick thick with bricks of class designation 75 in cement mortar 1:4 (1 cement : 4 fine sand). The kerb shall be plastered on top and sides with 12 mm thick cement plaster 1:4 (1 cement : 4 coarse sand) finished with a floating coat of neat cement. The junctions and corners of the kerbing and the floor shall be rounded off.

13.21.5. Flooring: Flooring shall consist of 40mm thick cement concrete 1:2:4 (1 cement: 2 coarse sand: 4 graded stone aggregate 20 mm nominal size) which shall be finished with a floating coat of neat cement. The floor shall be given proper slopes as directed by the Engineer.

13.21.6. Measurements: Platforms for stand posts shall be enumerated.

13.21.7. Rate: The rate shall include the cost of labour and materials for all the operations described above.

13.22. POLYETHYLENE WATER

STORAGE TANKS:

13.22.0. For details IS:12701 "Rotational Moulded Polyethylene Water Storage Tanks" may be referred to.

13.22.1. Material : Polyethylene used for manufacture of tanks and manhole lids may be high density (HDPE), low density (LDPE) or linear low density (LLDPE) and shall conform to IS: 10146. Polyethylene shall be compounded with carbon black so as to make it resistant to ultra violet rays from the sun. The percentage of carbon black content in polyethylene shall be 2.5 ± 0.5 percent and it shall be uniformly distributed. The materials used for the manufacture of tank, manhole lid and fittings shall be such that they neither contaminate the water nor impart any taste, colour, odour or toxicity to water.

13.22.2. Manufacture and Finish : The tanks shall be manufactured by rotational moulding process. Each tank and the manhole lid shall be single piece having arrangement for fixing and locking the manhole lid with the tanks. Excess material at the mould parting line and near the top rim shall be neatly cut and finished. The internal and external surface of the tanks shall be smooth, clean and free from hidden internal defects like air bubbles, pit and metallic or other foreign material inclusion. Capacity of the tank, minimum weight of the empty tank (without manhole lid) and the manufacture brand name shall be embossed on the top surface of the tank near manhole.

13.22.3. Shape, Size and Capacity: The tank shall be cylindrical vertical with closed top having a manhole. Diameter and height of the tank of various capacities shall be as per manufacturer's specifications and a tolerance of ± 3 percent shall be permitted on these dimensions. Capacity of the tank shall be upto the bottom of the inlet location. Capacity of the tank shall be specified and extra capacity if any, shall be ignored.

13.22.4. Weight and Wall Thickness : Minimum weight of the empty tank (exclusive of manhole lid fittings) and the minimum wall thickness of top, bottom and sides shall be as specified in, **Table 13.19**. Wall thickness shall be checked beyond 150 mm of the edge where the direction of the plane of tank surface changes.

13.22.5. Installation and Fittings : The flat base of the tank shall be fully supported over its whole bottom area on a durable rigid flat and level platform sufficiently

strong to stand without deflection, the weight of the tank when fully filled with water. Depending upon the capacity and location tanks may be suitably anchored as per the directions of the Engineer. For inlet, outlet and other connections fully threaded GI, HDPE or PVC connections with hexagonal check nuts and washers on either side of the tank wall shall be provided. Holes for threaded connections shall be drilled and not punched. Pipes entering or leaving the tank shall be provided with unions and suitably supported on a firm base to avoid damage to the tank walls.

13.22.6. Manhole lid : The lid shall rest

evenly and fit over the rim of the manhole so as to prevent the ingress of any foreign matter into the tank. The lid shall be provided with suitable arrangement for locking it with the tank.

13.22.7. Local Bye laws: The tank and its components shall conform to the local bye-laws for prevention of mosquito menace.

13.22.8. Measurements : Dimensions shall be measured to the nearest cm. and weight of the empty tank shall be recorded to the nearest 100g. Capacity of the tank as defined in para 13.23.3 shall be calculated to the nearest litre.

TABLE 13.19

S.No	Capacity litres	Minimum Wall thickness mm	Minimum Weight of empty tank (Kg.)
1	2	3	4
1	200	4.4	7.8
2	300	4.4	9.0
3	400	5.5	15.0
4	500	6.0	18.0
5	700	6.6	23.5
6	1000	7.0	33.0
7	1250	7.0	40.0
8	1500	7.0	47.0
9	1700	7.0	54.0
10	2000	8.2	64.0
11	2500	8.2	81.0
12	3000	8.8	96.0
13	4000	10.4	138.0
14	5000	10.7	191.0
15	6000	10.7	209.0
16	7500	10.7	250.0
17	10000	11.5	363.0
18	15000	11.5	550.0
19	20000	13.2	814.0

13.22.9. Rate : The rate shall include the cost of the tank, manhole lid, carriage and delivery at the place specified. Hoisting, installation, fittings, platform and anchoring shall be payable separately.

13.23. R.C.C. STORAGE TANKS:

13.23.1. General: These tanks shall be cast

in situ, circular/ rectangular in shape and 270 and 540 litres capacity. These shall be as per approved drawing.

13.23.2. Concrete Mix: The mix of R.C.C. shall be 1:1.5:3 for walls and bottom slab and 1:2:4 for top slab. The specification for R.C.C. shall be as per Chapter 4. The top slab shall have the cover of 2 mm thick M.S. sheet 35 mm x 35 mm size having frame of

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angle iron 20 x 20 x 5 mm size. The detailed specifications shall be as per steel work in Chapter 8.

13.24. FIXING R.C.C. OR P.V.C. STORAGE TANK

13.24.1. Location : Tank shall be located nearest to the fittings for which water is to be supplied. It should not be visible as far as possible from the main road and compound of the buildings. The overflow pipe shall discharge at a convenient and visible point so that it does not damage the building and does not prove a nuisance, should the tank go out of order.

13.24.2. Hoisting : The hoisting of tanks into position, as directed by the Engineer, shall be carried so that no part of the tank or of structure is damaged in the operation. The tank shall be installed in position truly level. The supports for the tanks shall be provided as ordered and shall be measured and paid for separately.

13.24.3. Measurements : Water storage tanks shall be counted in numbers for the complete job.

13.24.4. Rate : The rate shall include the cost of materials and labour involved in all the operations described above except the cost of external painting, providing and fixing stop cock and supports for storage tank for which separate payment shall be made under respective items of work.

13.25. TUBE WELLS WITH HAND PUMPS

13.25.1. Casing Pipe : The casing pipe shall be of M.S. or W.I. of 100 mm dia. and strong enough to stand hammering and vibrations to which it is subject.

13.25.2. Filter and Brass Strainer : The filter shall consist of a G.I. pipe of the required diameter with 15 mm diameter holes covered with brass strainer both inside and outside. It shall have a driving point rivetted or welded to it.

13.25.3. Hand Pump : This shall be of approved quality. It shall be complete with necessary bolts and nuts for joining to the masonry or concrete base.

13.26 DUCTILE IRON FITTINGS FOR PRESSURE PIPES FOR WATER, GAS AND SEWAGE As Per IS 9523 : 2000 - Some important paras of the above IS code are reproduced below for information and guidance (Para numbers are as per IS code)

For the purposes of this standard, the following definitions shall apply.

3.1 Ductile Iron – Type of iron used for pipes, fittings and accessories in which graphite is present primarily in spheroidal form as per IS8329:1994

3.2 Pipe – Casting of uniform bore, straight in axis, having either socket, spigot or flanged ends, except for flanged sockets, flanged spigots and collars which are classified as fittings.

3.3 Fitting – Casting other than a pipe, which allows pipeline deviation, change of direction or bore. In addition flanged sockets, flanged-spigots and collars are also classified as fittings.

3.4 Accessory – Any item other than a pipe or fitting which is used in a pipeline, such as :-

- glands and bolts for mechanical flexible joints;
- glands, bolts and locking rings or segments for restrained joints.

NOTE : Valves and hydrants of all types are not covered by the term accessory.

3-63.5 Flange – Flat circular end of fittings, extending perpendicular to its axis, with bolt holes equally spaced on a circle.

NOTE : A flange may be fixed (for example, integrally cast threaded on or welded on) or adjustable; An adjustable flange comprises of a ring in one or several parts bolted together, which bears on an end joint hub and can be freely rotated around the fittings axis before joining.),

3.6 Collar, Coupling – Connecting piece used to join together the spigots of mat pipes or fittings.

3.7.1 Spigot – Male end of fittings.

3.8 Socket – Female end of fittings to make the joint with spigot of an adjacent component.

3.9 Gasket – Sealing component of a joint.

3-213.10 Joint – Connection between the ends of fittings in which a gasket is used to effect a seal.

3-223.11 Flexible Joint: Joint which provides significant angular deflection and movement parallel and / or perpendicular to the fittings axis.

3-233.12 Push-on Flexible Joint – A flexible joint in which an elastomeric gasket is located in the socket and the joint assembly is effected by entering the spigot through the gasket into the socket.

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3. TERMINOLOGY

3-243.13 Mechanical Flexible Joint – Flexible joint in which sealing is obtained by applying pressure to the gasket by mechanical means, for example, a gland.

3-253.14 Restrained Joint – Joint wherein a device is provided to prevent separation of the assembled joint.

3-263.15 Flanged Joint – Joint between two flanged ends.

3-273.16 Nominal Size (DN) – Numerical designation of size which is common to all components in a piping system. It is a convenient round number for reference purposes and is only loosely related to manufacturing dimensions.

3-283.17 Nominal Pressure (PN) – A numerical designation expressed by a number which is used for reference purposes. All compo of the same nominal size DN designated by the same PN number have compatible mating dimensions.

3-293.18 Batch – Quantity of castings from which a certain number of samples may be taken for testing purposes during manufacture.

3-303.19 3.19 Length – Effective length of a fitting, as shown on the drawings of 11.2

3-313.20 3.20 Ovality – Out of roundness of a fittings section it is equal to $100 (a_1 - A_2) / (A_1 + A_2)$ where a_1 is the maximum axis and A_2 the minimum axis of the fittings cross section.

3-323.21 Deviation in Length – Amount by which the design length may differ from the standardized length of a fittings.

Note :-Fittings are designed to a length taking into account standarad length plus or minus the deviation; they are manufactured to this length plus or minus the tolerances given in Table-14.

4. MANUFACTURE AND REPAIR

4.1 The metal used for the manufacture of casting shall conform to the appropriate grade as specified in IS 1865, in commensurate with the requirements as laid down in this standard. It shall be prepared at the discretion of the manufacturer in a cupola, or an active mixer or other suitable furnace.

4.2 The castings shall be stripped with all precautions necessary to avoid warping or shrinkage defects, detrimental to their good quality. The castings shall be sound and free from surface or other defects.

4.3 Casting showing small imperfections

which result from the method of manufacture and which do not affect its final use shall not be rejected on that account alone.

4.4 Minor defects may be rectified with the approval of the purchaser. Repairing of defects by welding, plugging off leaks by caulking or by application of epoxy putty may not be done without previously securing the approval of the purchaser. Repairs are to be carried out according to a written procedure included in the manufacturer's quality assurance system. Any dressing to remove imperfections, shall not reduce the thickness of the casting below the specified thickness.

4.5 The castings shall be such that they could be cut, drilled or machined. In case of dispute the castings may be accepted provided that the hardness measured on the external un-machined surface does not exceed 250 HBS.

4.6 Where castings are required to withstand pressure higher than those specified in this standard, the casting may be strengthened by means of increased wall thickness, if necessary, at the expense of the internal diameter or by suitable ribbing or as may be mutually agreed between the manufacturer and the purchaser, to suit the pressure specified by the purchaser.

5. THICKNESS

The thickness 'e' of fittings is calculated as a function of the nominal diameter 'DN' by using the formula, given below with the following values for K:

$$e = K (0.5 + .001 DN)$$

Where $K = 14$, $e = 7 + 0.014 DN$

Where $K = 12$, $e = 6 + 0.012 DN$

For 'DN 80' the thickness of the fitting has been limited to minimum of 7 mm, so that, taking the tolerances into account, the thickness of the fittings is always at least equal to that of the pipes of the same nominal diameter. Threaded-on welded-on) or adjustable; an flange comprises of a ring, in one or several parts bolted together, which bears on an end joint hub and can be freely rotated around the fittings axis before jointing.

6.5 JOINTS

6-15.1 In the case of push-on-joints for sizes 'DN 600' and above the sockets may be with or without centering rings.

6-25.2 Design of the socket and rubber gaskets are no within the scope of this standard.

6-35.3 If agreed between the manufacturer and the purchaser, the fittings can be made

with plain end also, for jointing with the help of a collar/coupling provided that the overall length of the fitting remains the same. The length of the spigot necessary for jointing shall not be less than the length of the socket of the jointing pipe.

6-45.4 In case of push-on-joints the spigot end of fitting, if any, shall be suitably chamfered to facilitate smooth entry of spigot in the socket of the pipes or fittings fitted with rubber gasket.

6-55.5 In case of flange and mechanical joint casting the flange shall be at right angle to the axis of the joint. The bolt holes shall be either cored or drilled.

6-65.6 The centre of bolt holes circle shall be concentric with the bore circle and shall be located off the centre line, unless otherwise specified by the purchaser. Where there are two or more flanges, the bolt holes shall be correctly aligned between them.

6-75.7 The flanges shall be plain faced or with raised boss as given in Tables 4, 5, 6 and 7 over the contact surface with a tool mark finishing having a pitch of 1 ± 0.3 mm, serrations may be spiral or concentric.

6-85.8 For high pressure mains, requiring working pressure greater than 2.4 MPa, suitable flexible joint may be preferred where the joint is restrained against axial movement.

6-95.9 Push-on-joint fittings are normally not used for sizes above DN 1600.

7. RUBBER GASKETS

The material of rubber gaskets for use with mechanical joints and push-on-joints shall conform to IS 5382. Unless otherwise agreed between the manufacturer and the purchaser, dimensions of the rubber gasket shall be as per manufacturer's own design.

10. HYDROSTATIC TEST

For hydrostatic test, the fittings shall be kept under pressure for 10 seconds. They shall withstand the pressure test without showing any sing of leakage, sweating or other defect of any kind. The test shall be conducted before the application of surface coating.

10-310.1 The fittings shall withstand the hydrostatic pressure given in Table 2

Table 2 Hydrostatic Test Pressure for Castings

Nominal Diameter	Hydrostatic Test Pressure At works, MPa
Upto and including 300	2.5
Over 300 and up to and including 600	1.6
Over 600 and up to and including 2000	1.0

NOTE : The work hydrostatic test pressure is less for fittings than for pipes specified in the relevant Indian Standard for pipes because the shape of the fittings makes it difficult to provide sufficient restraint to high internal pressure during the test.

10-410.2 When fittings are required for higher test pressures, the test pressures are subject to agreement between the purchaser and the manufacturer (see 4.6).

11. SIZES

The standard nominal sizes `DN; of the fittings covered in this standard are as follows:

80, 100, 125, 150, 200, 250, 300, 350, 400, 450, 500, 600, 700, 750, 800, 900, 1000, 1100, 1200, 1400, 1600, 1800 and 2000 mm.

NOTE: Nominal size is a number used to classify fittings/joints/casting and corresponds approximately to their internal diameter.

11.1 Dimensional and other requirements for sockets/spigot to push-on-joints, mechanical joints and flanges shall conform to the requirements specified in Tables 3,4,56 and 7 under Section 2 as relevant.

11.2 Dimensional and other requirements for fittings for specified DN shall conform to the values as given in the Table 15 to 31 under Section 3.

13. COATING

13.1 Fittings and accessories shall be normally delivered internally and externally coated.

13.1.1 External Coatings

By agreement between the manufacturer and the purchase, any one of the following coatings may be applied depending upon the external condition of use:

Metalic Zinc with finishing layer as included in Annex ;

Zinc rich paint with finishing layer, ~~as included in Annex A:~~

Bituminous paint : as included in Annex C;
and External sleeving : Annex D.

13.2.213.1.2 Internal Linings

By agreement between the manufacturer and the purchaser, the following lining may be applied depending on the internal conditions of use:

Portland cement (with or without additives) mortar, as included in Annex B;

Blast furnace slag cement mortar as included in Annex B;

High alumina (calcium aluminate) cement mortar as included in Annex B;

Cement mortar with seal coat : as included in Annex B; and Bituminous paint as included in Annex C.

13.313.2 Unless otherwise between the purchaser and the manufacturer, the external coating and the internal lining when applied shall confirm to the requirements specified in this standard (including Annex). Additional requirements other than those specified may be agreed between the purchaser and the manufacturer.

14. QUALITY ASSURANCE

14.314.1 General

The manufacturer shall be able to demonstrate the conformity of the product to the requirements contained in this standard by controlling the manufacturing process and carrying out the various tests as specified in this standard.

14.414.2 Quality Assurance System

The manufacturer shall control the quality of the product during manufacturing process by a system of process control in order to comply with the technical requirements contained in this standard wherever possible statistical sampling techniques should be used to control the process so that the product is produced within the specified limits.

15. MARKING

15.215.1 Each fittings shall have as cast, stamped or indelibly painted on it, the following appropriate marks.

a) Indication of the source of manufacture,

b) The nominal diameter

c) The last two digits of the year of manufacture,

d) PN rating of flanges when applicable, and

e) Any other mark required by the purchaser.

15.1.1 Marking may be done on the barrel of castings or on the outside of the sockets.

ANNEX B (Clause 13.1.2)

CEMENT MORTAR LINING

B-1 MATERIALS

B-1.1 Cement

The cement used for the lining shall conform to the existing standards on cement.

The type of cement to be used is to be mutually decided between the purchaser and the manufacture. Normal recommendation are :

(i) Portland cement (as per IS 269 or IS 455) mortar lining perform rather well and have an expected life of approximately 50 years in soft water with moderate amount of aggressive CO₂ and when pH is within 6 to 9. Longer service life can be obtained by increasing the mortar lining thickness.

(ii) Where cement mortar lining may be exposed to sulphate attack, ordinary Portland cement should be replaced by sulphate resisting Portland cement (as per IS 12330 or IS 6909). The sulphate concentration limit for sulphate resisting Portland cement is approximately 3000 mg/l, the same as ballast furnace slag cement which naturally possess a good resistance to sulphate attack. For sea water transmission ballast furnace slag cement which has C3 A content below 3 percent can be used.

(iii) High Alumina cement (as per IS 6452) mortar lining is suitable for continuous use of pH between 4 and 12 and no severe damage occur after occasional exposure to pH 3 to 4 to 12 to 13..

(iv) The recommended types of cements used for lining are as given in Table 32.

Table 32 Recommended Types of Cements Used for Lining

Water Characteristics	Portland Cement	Sulphate Resisting Cements (Including	High Alumina

		Blast Furnace Slag	Cement
Minimum value of pH	6	5.5	4
Maximum content _(mg/1 of			
Aggressive CO ₂	7	15	no limit
Sulphates (SO ₄)	400	3000	no limit
Magnesium (MG++)	100	500	no limit
Ammonium (NH ₄ +))	30	30	no limit

B-1.2 Sand

The sand used shall have a controlled granulometric distribution from fine to coarser elements; it shall be clean and shall be composed of inert, ahrd, strong and stable granular particles.

The fine fraction comprising particles passing through a sieve of aperture size 0, 125mm shall not be more than 10 percent by mass.

The fraction comprising grains up to a maximum diameter equal to one third of the normal thickness of the mortar lining shall not be less than 50 percent by mass.

The coarsest fraction (comprising particles which do not pass through a sieve of the aperture size closest to half the normal thickness of the mortar lining) shall not exceed 5 percent by mass

B-1.4 Mortar

The mortar of the lining shall be composed of cement, sand and water.

Additives, which shall be specified, may be used provided that they do not prejudice the quality of the coating and that of the transported water.

The mortar shall be thoroughly mixed and shall have a consistency which results in a dense and homogeneous lining.

The mortar shall contain by mass at least one part of cement to 3.5 parts of sand.

B-2 CONDITION OF THE INTERIOR SURFACE OF THE FITTINGS BEFORE APPLICATION OF THE LINING

All foreign bodies, loose scale or any other material which could be detrimental to good contract between the metal and the lining shall be removed from the surface to which the lining is to be applied.

The inner surface of fittings shall also be free of any metal projections likely to protrude beyond 50 percent the thickness of the lining.

B-3 APPLICATION OF THE LINING

The mortar will be works applied by a

suitable process. Smoothing with a trowel is permitted. The layer of morar should be free of any cavity or visible air bulles and care shall be taken to ensure maximum density at all points.

After the lining is applied it shall be cured at temperatures greater than 40C. Any loss of water from the mortar by evaporation shall be sufficiently slow so that hardening is not impeded.

B-4- REPAIR OF LINING

Repairs to damaged or defective areas are allowable. The damaged mortar shall first be removed from these areas. Then the defective part shall be repaired by using, for example, a trowel with fresh mortar so that a continuous lining having a constraint thickness is again obtained.

For the repair operation, the mortar shall have a suitable consistency, if necessary, additives may be included to obtain good adhesion against the side of the existing undamaged mortar.

B-5 THICKNESS OF THE LINING

The nominal thickness of the lining and its negative tolerance and maximum crack width/radial displacement are given in Table 33.

At the fittings ends, the lining may be reduced to values below the minimum thickness. The length of the chamber shall be as small as possible but, in any case, shall be less than 50 mm.

B-6 DETERMINATION OF LINING THICKNESS

The thickness of the lining is checked on the freshly centrifuged mortar by the insertion of a steel pin, or on the hardned mortar by means of a non destructive method of measurement.

The thickness of the lining shall be measured at both ends of the fittings in at least one section perpendicular to the fittings axis.

B-7 SURFACE CONDITION OF THE HARDENED LINING

The surface of the cement mortar lining shall

be uniformly smooth. Only isolated grains of sand are allowed to appear on the surface of the lining.

The lining shall be such that it cannot be dislodged with pressure of hand and shall be

free from corrugations or ridges that could reduce the thickness of the lining to less than the minimum value at one point, as specified in the Table 33.

Table 33 Thickness of Lining

(Clauses B-5 and B-7)

All dimensions in millimetres

DN	Thickness		
	Nominal value	Tolerance	Maximum Crack Width & Radial displacement
080 to 300	3.0	-1.5	0.8
350 to 600	5.0	- 2.0	1.0
700 to 1200	6.0	-2.5	1.2
1400 to 2000	9.0	-3.0	1.5

NOTE : Fittings ends may have a chamfer of maximum length 50mm.

On contraction of the lining, the formation of cracks cannot be avoided. These cracks, together with other isolated cracks which may result from manufacturer or may develop during transportation, are acceptable up to a width given in the above.

B-8 SEAL COAT

B-8.1 General

When specified the cement lining shall be given a seal coat of bituminous material or any other epoxy based material compatible with Cement Mortar Lining. Other seal coat materials may be used, but they shall be agreed on at the time of purchase and shall be specified on the purchase order.

The purpose of seal coat is to minimize lime leaching of the cement mortar as well as to restrict the unwanted rise in pH value of the transmitted water.

When the pipes are to be used for conveying potable water the inside coating shall not contain any constituent soluble in such water or any ingredient which could impart any taste or whatsoever to the potable water after sterilization and suitable washing of the mains.

purchaser and the manufacturer, fittings shall be coated extremely and internally with the same material. (Bituminous coatings are either hot applied or cold applied).

C-2 GENERAL CHARACTERISTICS

C-2.1 Coating shall not be applied to any fittings unless its surfaces are clean, dry and free from rust.

C-2.2 Unless otherwise agreed between the purchaser and the manufacturer all fittings shall be coated externally and internally with the same material. The method of coating shall be as per usual practice of the manufacturers. The coating materials shall set rapidly with good adherence and shall not scale off. The mean thickness of the coating shall be not less than 70 pm and the local minimum thickness shall be not less than 50 pm.

C2.3 Where the coating material has a tar or similar base, it shall be smooth and tenacious and hard enough not to flow when exposed to a temperature of 650 C but not so brittle at a temperature of 00C as to chip off when scribed with a penknife.

C-2.4 When the pipes are to be used for conveying potable water the inside coating shall not contain any constituent soluble in such water or any ingredient which could impart any taste or whatsoever to the potable water after sterilization and suitable washing of the mains.

C-2.5 Pipes with or without sockets and flanges which are imperfectly coated or where the coating does not set or conform to the required quality, the coating shall be removed and the pipes/flanges recoated.

ANNEX C

(CLAUSES 13.1.1 AND 13.1.2)

BITUMINOUS COATING

C-1 General

Unless otherwise agreed between the

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ANNEXURE 13.1

TOLERANCES FOR CAST IRON (CENTRIFUGALLY CAST) PIPES

Tolerance in Diameter Dimensions	Nominal diameter (DN)	Tolerance in mm
a) External diameter of barrel (DE)	All diameters.	$\pm (4.5 + 0.0015 \text{ DN})$
b) Internal diameter of socket (DI)	All diameters.	$\pm (3.0 \pm 0.001 \text{ DN})$
c) Depth of socket (P)	(1) Upto and including 600 mm (2) Over 600 mm and upto and including 1000 mm	± 5 ± 10

Note: (1) The jointing tolerances applicable to rubber joints (mechanical or push in joints) shall be as specified by their manufacturer and shall be within the tolerances specified above.

Tolerance on Thickness

Dimensions	Tolerance in mm
a) Wall thickness	$- (1 + 0.05 \text{ e})$
b) Flange thickness	$\pm (2 + 0.05 \text{ b})$

Where e = the thickness of the wall in millimeters and
 b = the thickness of the flange in millimeters.

Tolerance on Length

Type of Casting	Tolerance in mm
a) Socket and spigot, and plain ended pipes	± 25
b) Flanged pipes	± 10

ANNEXURE 13.2

TOLERANCES FOR SPECIALS OF CAST IRON PIPES

Tolerances in Diameter			
Dimension	Nature of joint	Nominal diameter (DN)	Tolerance in mm
External diameter of spigot (DE)	Lead joint	All diameters	$\pm 1/2 F$ or $\pm (4.5 + 0.0015 DN)$
Internal diameter of socket (DI)	Lead joint	diameters	$\pm 1/3 F$ or $\pm (3 + 0.001 DN)$
Depth of socket (P)	Lead joint	Upto and including 600 mm	± 5
		Over 600 mm upto and including 1000 mm.	± 10
		Over 1000 mm upto and including 1500 mm	± 15

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Tolerances on Thickness	
Dimension	Tolerance in mm
Wall thickness	$-(2 + 0.05 e)$
Flange thickness	$\pm (3 + 0.05 b)$
Where e = the standard thickness of the wall in millimeters, and b = the standard thickness of the flange in millimeters.	

Tolerance on Lengths		
Type of fitting	Nominal diameter	Tolerance in mm
Socket fittings and flange spigot pieces	Upto and including 450 mm	± 20
	Over 450 mm	$\pm 20 - 30$
Flanged fittings	All diameters	± 10

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ANNEXURE 13.3

PARTICULARS OF MEDIUM GRADE G.I. PIPES

Nominal Bore (mm)	Dimension of pipes			Weight of pipe	
	Outside diameter		Thickness	Plain end	Screwed end socket
	Max. (mm)	Min. (mm)	(mm)	Kg/m	Kg/m
6	10.6	9.8	2.0	0.404	0.407
8	14.0	13.2	2.3	0.641	0.645
10	17.5	16.7	2.3	0.839	0.845
15	21.8	21.0	2.6	1.21	1.22
20	27.3	26.5	2.6	1.56	1.57
25	34.2	33.3	3.2	2.41	2.43
32	42.9	42.0	3.2	3.10	3.13
40	48.8	47.9	3.2	3.56	3.60
50	60.8	59.7	3.6	5.03	5.10
65	76.6	75.3	3.6	6.42	6.54
80	89.5	88.0	4.0	8.36	8.53
100	115.0	113.1	4.5	12.2	12.50
125	140.8	138.5	4.8	15.90	16.40
150	166.5	163.9	4.8	18.90	19.50

Tolerance in Thickness and Weight.

A) Thickness		
1.	Butt welded medium tubes	+ not limited - 10 percent.
2.	Seamless tubes	+ not limited -12.5 per cent
B) Weight		
1.	Single tube (light series)	+ 10 percent - 8 percent
2.	Single tube (medium and heavy series)	± 10 percent
3.	For quantities per load of 10 tonnes, min (light series)	± 5 percent
4.	For quantities per load of 10 tonnes, min (medium and heavy series)	± 7.5 percent

ANNEXURE 13.4

UNPLASTICISED RIGID P.V.C PIPES

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A. For internal work

Outside dia. in mm	Tolerance on outside dia.	Wall thickness in mm for 10 Kgf/sq. cm. working pressure	
		Min.	Max.
20	+ 0.3	2.8	3.3
25	+ 0.3	2.9	3.4
32	+0.3	3.4	3.9
40	+ 0.3	3.6	4.2
50	+0.3	3.7	4.3

B. For External work

Outside diameter	Tolerance on outside dia	Wall thickness for working pressure							
		2.5 Kgf/sqcm		4 Kgf/sqcm		6 Kgf/sqcm		10 Kgf/sqcm	
		Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.
16	+0.3							1.1	1.5
20	+0.3							1.1	1.5
25	+0.3							1.4	1.8
32	+0.3							1.8	2.2
40	+0.3					1.4	1.8	2.2	2.7
50	+0.3			1.2	1.6	1.7	2.1	2.8	3.3
63	+0.3			1.5	1.9	2.2	2.7	3.5	4.1
75	+0.3			1.8	2.2	2.6	3.1	4.2	4.9
90	+0.3	1.3	1.7	2.1	2.6	3.1	3.7	5.0	5.7
110	+0.4	1.6	2.0	2.5	3.0	3.7	4.3	6.1	7.0
125	+0.4	1.8	2.2	2.9	3.4	4.3	5.0	6.9	7.7
140	+0.5	2.0	2.4	3.2	3.8	4.8	5.5	7.7	8.7
160	+0.5	2.3	2.8	3.7	4.3	5.4	6.2	8.8	9.9
180	+0.6	2.6	3.1	4.2	4.9	6.1	7.0	9.9	11.1
200	+0.6	2.9	3.4	4.6	5.3	6.8	7.7	11.0	12.3
225	+0.7	3.3	3.9	5.2	6.0	7.6	8.6	12.4	13.9
250	+0.8	3.6	4.2	5.7	6.5	8.5	9.6	13.8	15.4
280	+0.9	4.1	4.8	6.4	7.3	9.5	10.7	15.4	17.2
315	+1.0	4.6	5.3	7.2	8.2	10.7	12.0	17.3	19.3

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ANNEXURE 13.5

PROCEDURE FOR PRESSURE TEST

1. Each valved section of the pipe shall be slowly filled with water and all air shall be expelled from the pipe through hydrants and blowoffs. If these are not available at high places, necessary tapping may be made at points of highest elevation before the test is made and plugs inserted after the tests have been completed.

2 If the trench has been partially back-filled the specified pressure based on the elevation of the lowest point of the line or section under test and corrected to the elevation of the test gauge, shall be applied by means of a pump connected to the pipe in a manner satisfactory to the Engineer . The duration of the test shall not be less than 5 minutes.

3. Examination under Pressure : All exposed pipes, fittings, valves, hydrants and joints should be carefully examined during the open-trench test. When the joints are made with lead, all such joints showing visible leaks shall be recaulked until tight. When the joints are made with cement and show seepage or slight leakage, such joints shall be cut out and replaced as directed by the Engineer. Any cracked or defective pipes, fittings, valves or hydrants discovered in consequence of this pressure test shall be removed and replaced by sound material and the test shall be repeated until satisfactory to the Engineer.

4. If the trench has been back-filled to the

top, the section shall be first subjected to water pressure normal to the area and the exposed parts shall be carefully examined. If any defects are found, they shall be repaired and the pressure test repeated until no defects are found. The duration of the final pressure tests shall be at least one hour.

Procedure for Leakage Test

5. Leakage is defined as the quantity of water to be supplied into the newly laid pipe, or any valved section thereof, necessary to maintain the specified leakage test pressure after the pipe has been filled with water and the air expelled.

No pipe installation shall be accepted until the leakage is less than the number of cm³/h determined by the formula :

$$ql = \frac{ND \sqrt{P}}{3.3}$$

Where ql = the allowable leakage in cm³/h.

N = number of joints in the length of the pipe line.

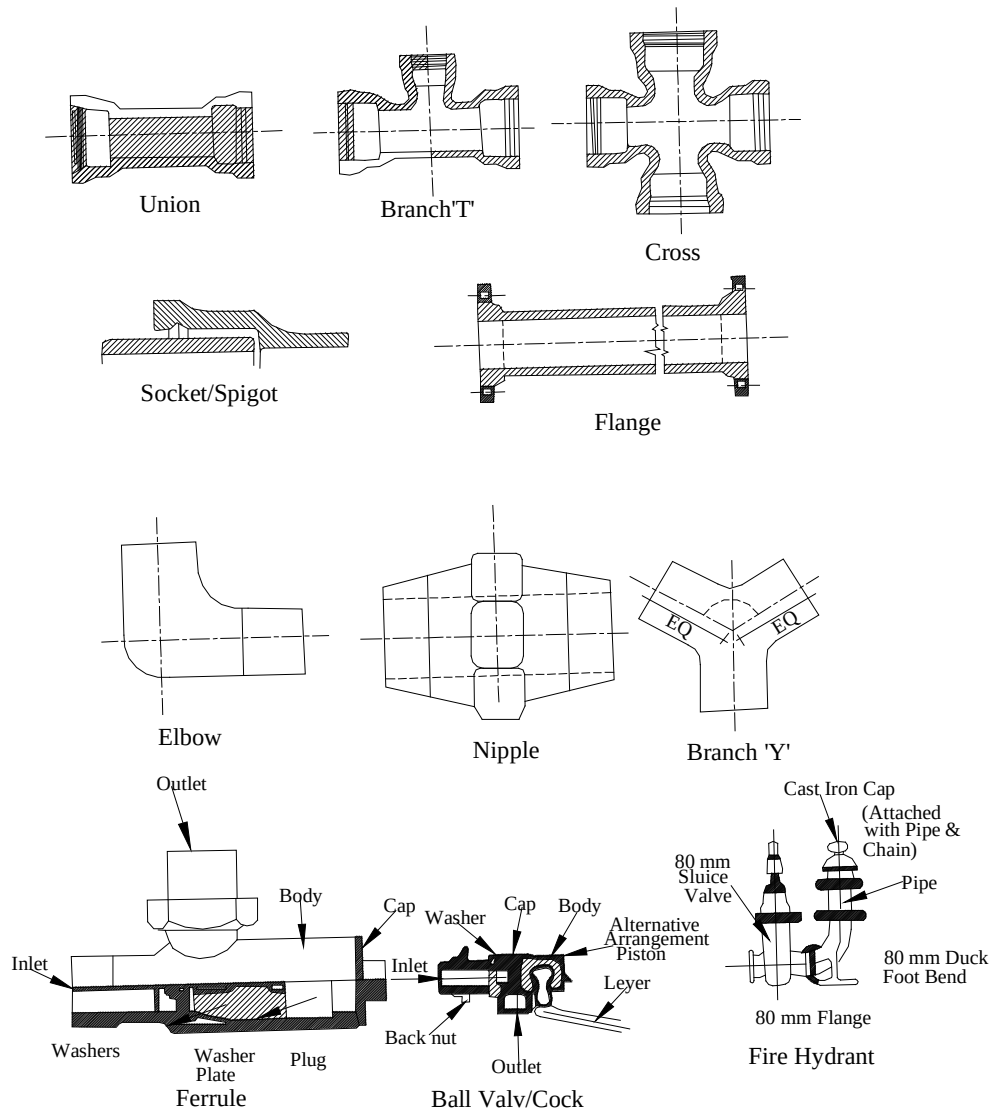
D = diameter in mm, and

P = the average test pressure during the leakage testing kg/cm².

6. Variation from Permissible Leakage : Should any test of pipe laid in position disclose leakage greater than that specified in para 5 the defective joints shall be repaired until the leakage is within the specified allowance.

FITTING & SPECIALS

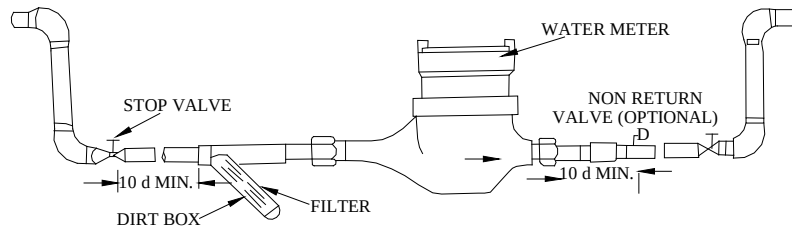
FIGURE 13.1



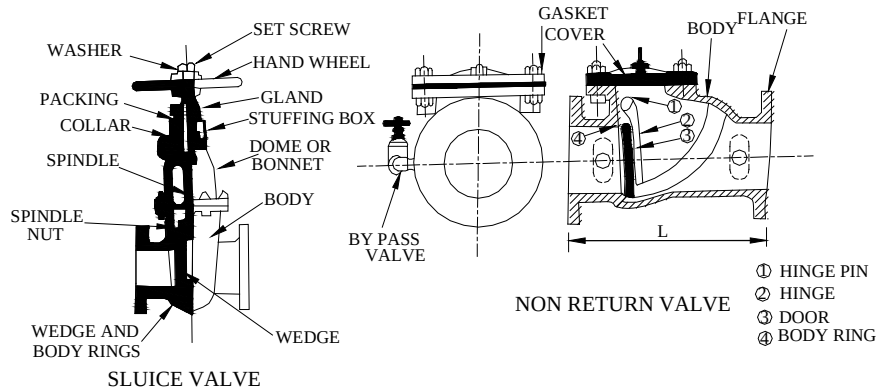
All dimensions are in mm
Drawings not to Scale

WATER SUPPLY COCKS, VALVES & METERS

FIGURE 13.2

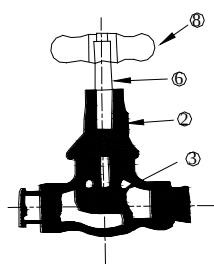


WATER METER ASSEMBLY

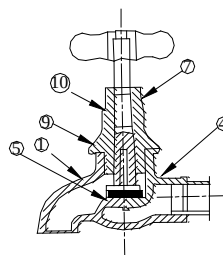


SLUICE VALVE

NON RETURN VALVE



STOP COCK



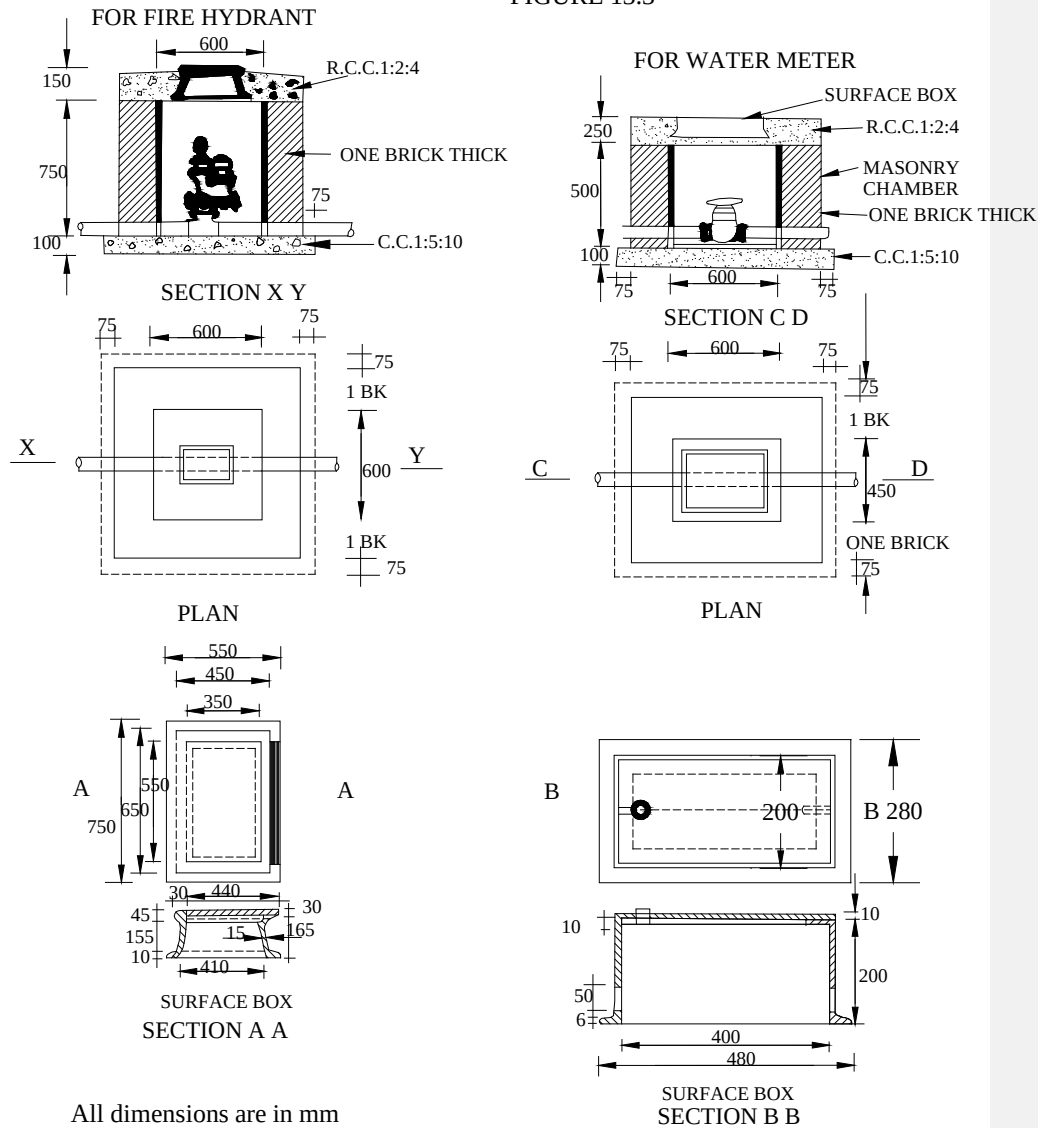
BIG COCK

- ① BODY ③ WASHER PLATE ⑤ NUT FOR WASHER
② BONNET ④ WASHER ⑥ SPINDLE ⑦ GLAND
⑧ HANDLE ⑨ BONNET JOINT WASHER ⑩ GLAND PACKING

All dimensions are in mm
Drawings not to Scale

MASONRY CHAMBERS & SURFACE BOXES FOR FIRE HYDRANTS AND WATER METERS

FIGURE 13.3

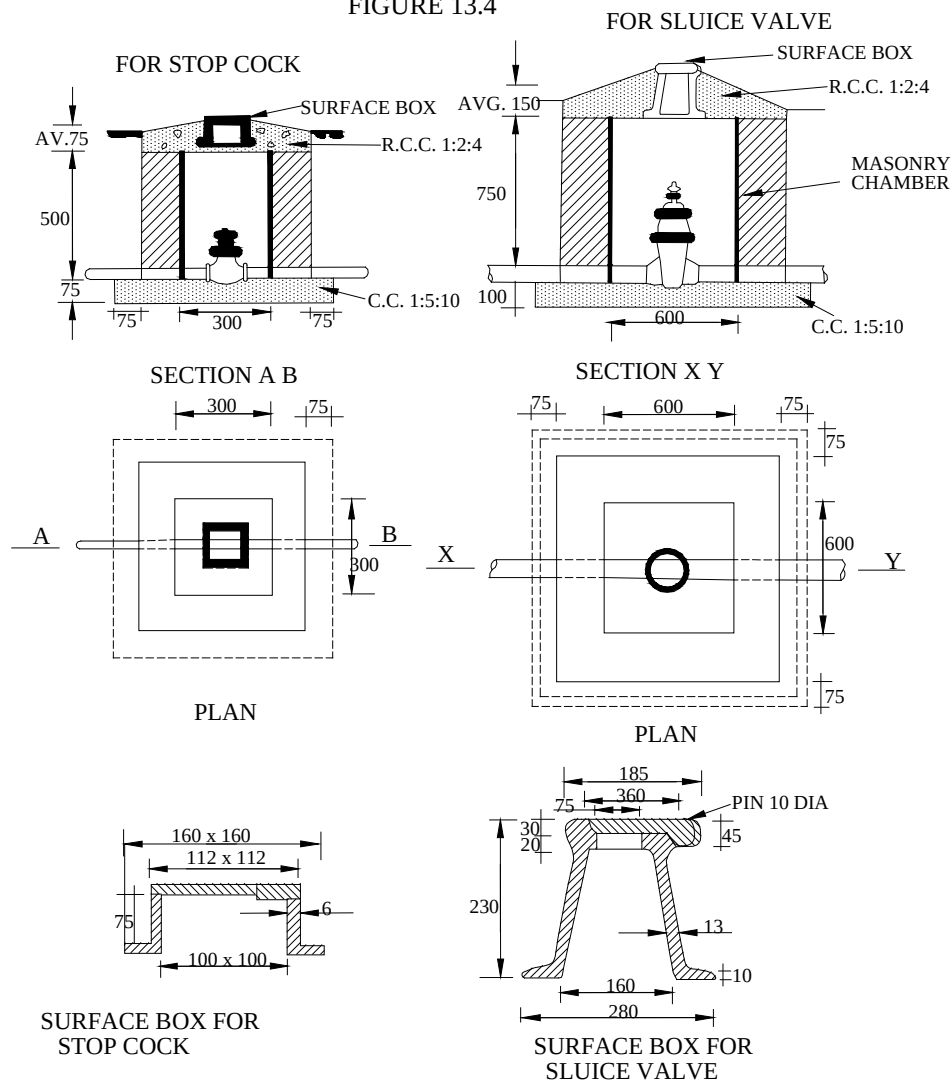


All dimensions are in mm
Drawings not to Scale

MASONRY CHAMBERS & SURFACE BOXES

(CONTD)

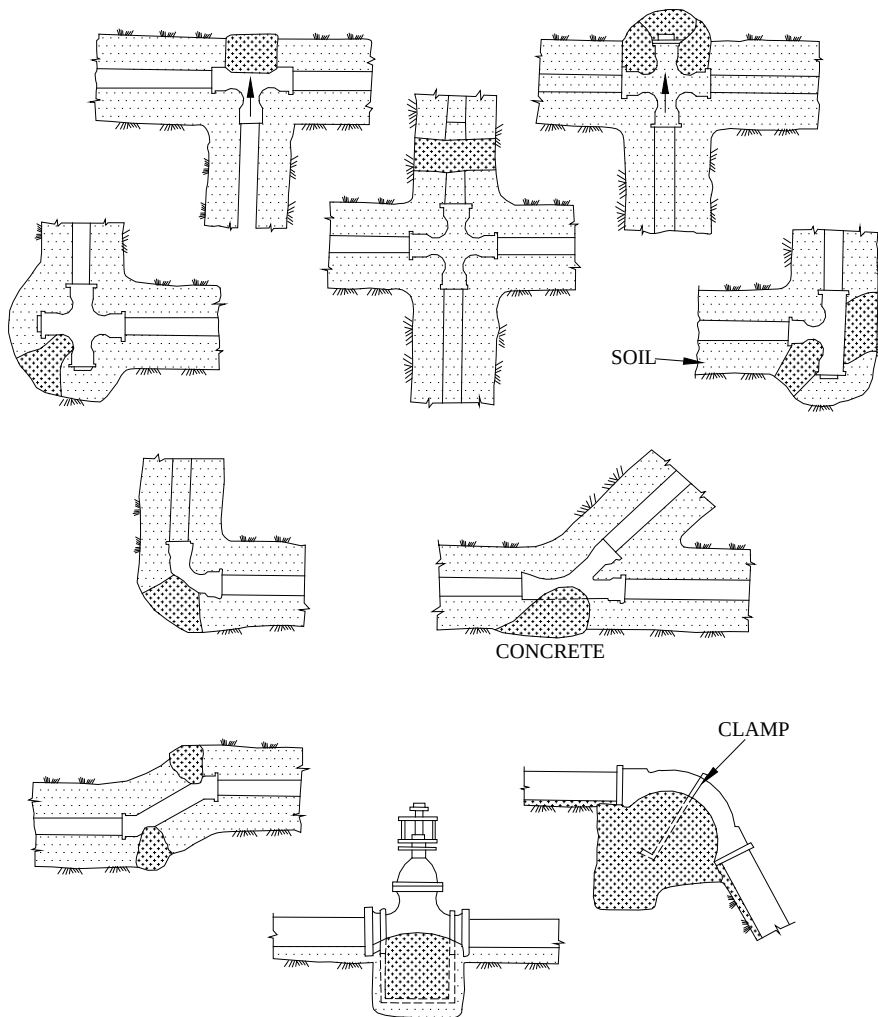
FIGURE 13.4



All dimensions are in mm
Drawings not to Scale

THRUST BLOCKS

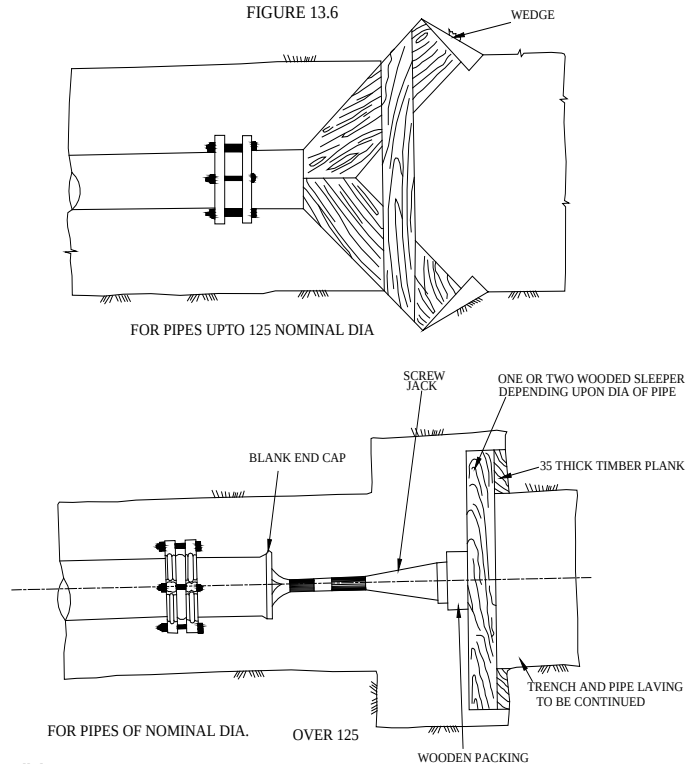
FIGURE 13.5



Drawings not to Scale

HYDROSTATIC TESTS
(END CLOSURE FOR PIPES)

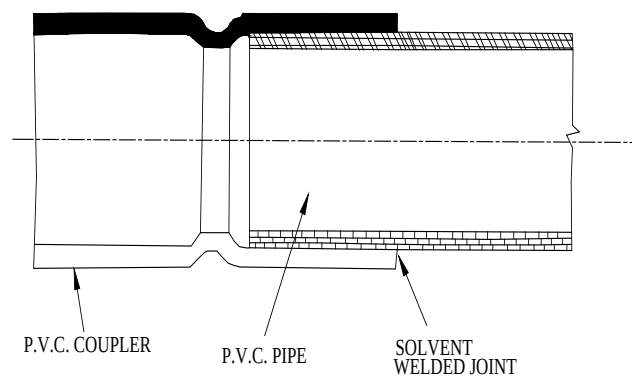
FIGURE 13.6



All dimensions are in mm
Drawings not to Scale

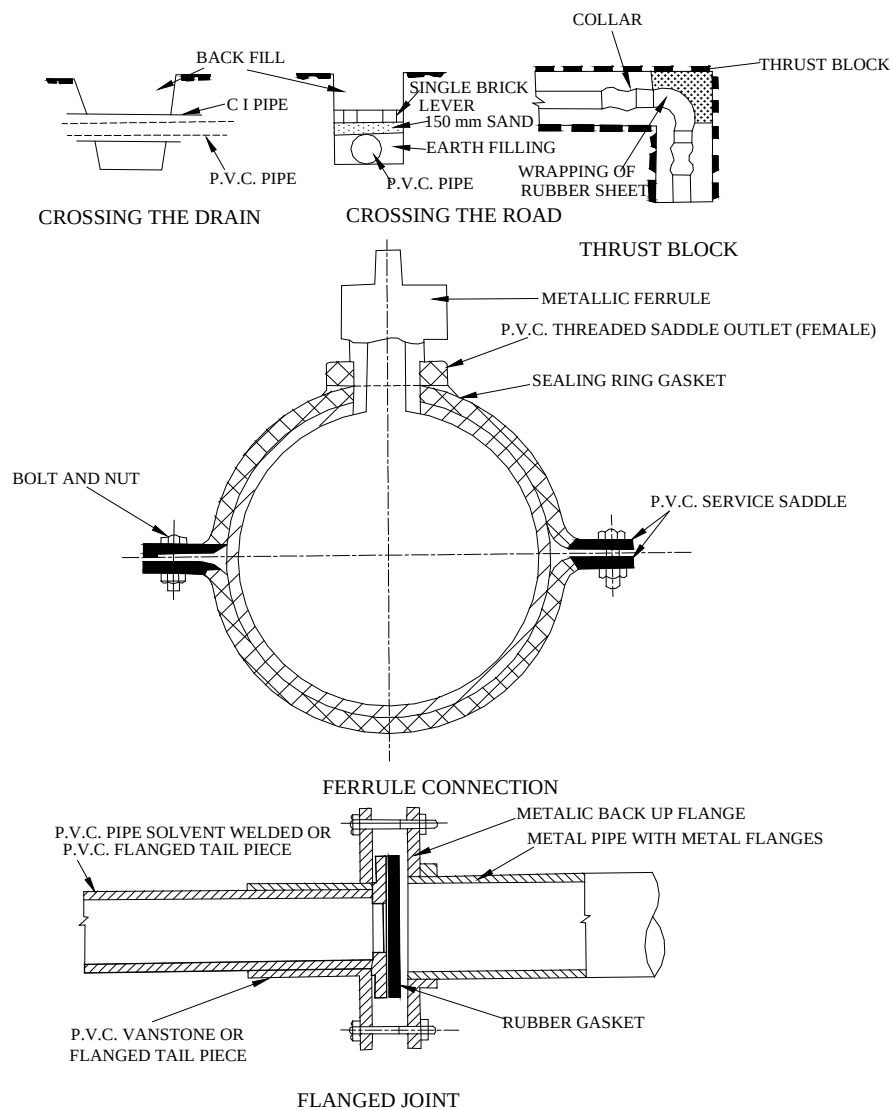
P.V.C.. SOLVENT WELDED JOINT

FIGURE 13.8



P.V.C.. PIPING

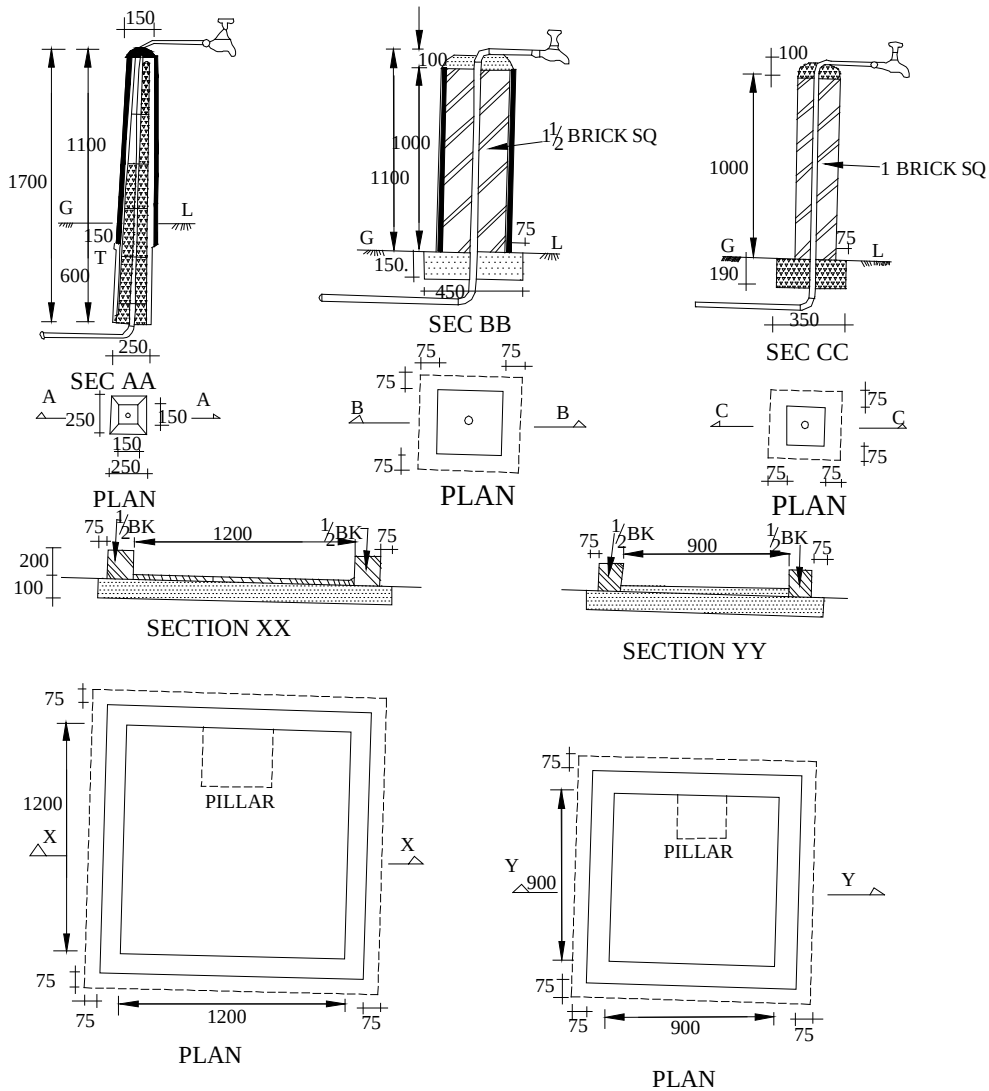
FIGURE 13.9



Drawings not to Scale

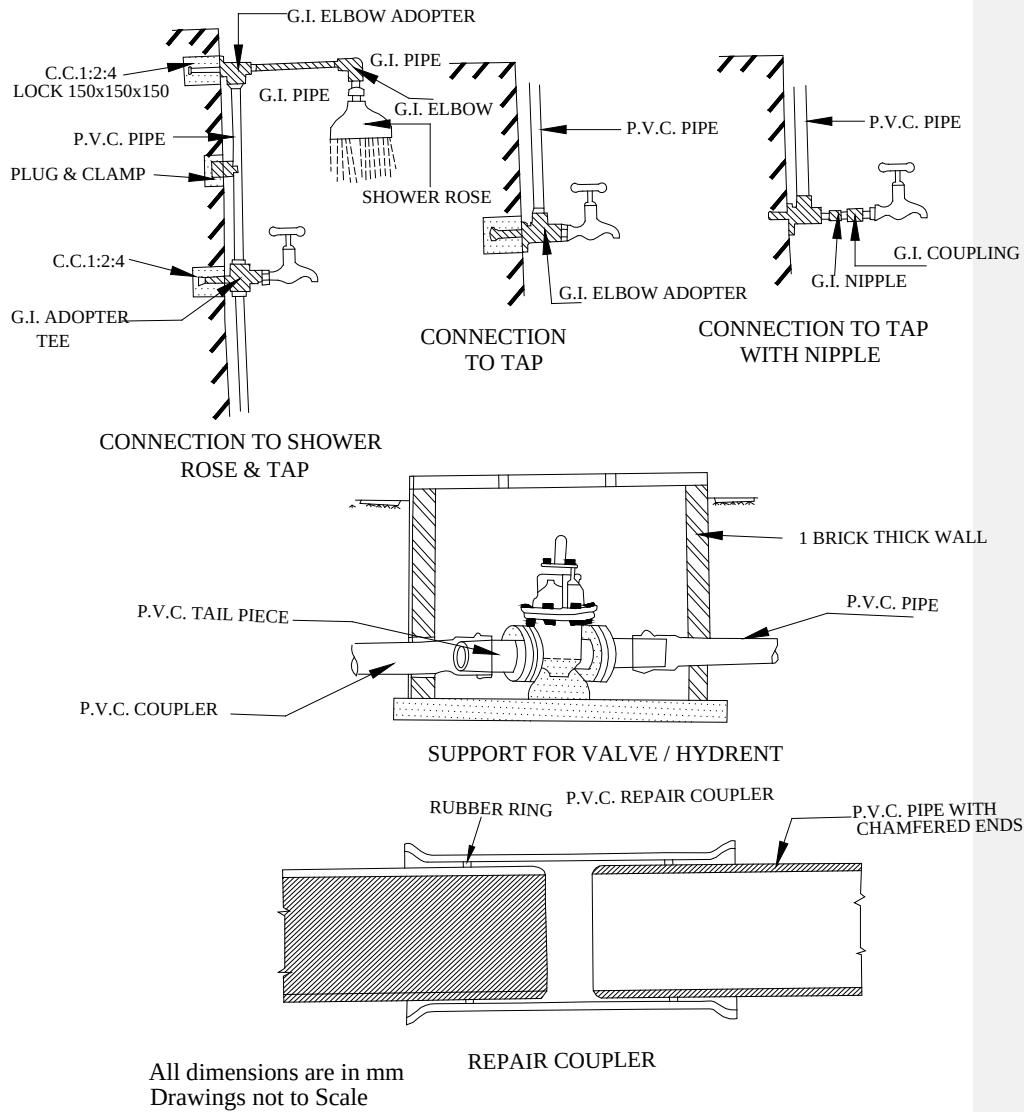
HYDRANT POSTS AND PLATFORMS

FIGURE 13.10



All dimensions are in mm
Drawings not to Scale

P.V.C. PIPING SPECIALS
FIGURE 13.11



Chapter 14

Drainage And Sewerage

14.0. TERMINOLOGY

Benching (Fig. 14.10) : The sloped floor of a manhole or an inspection chamber on both sides and above the top of the channel for the purpose of conforming the flow of sewage.

Channel : The open waterway through which sewage, storm water or other liquid waste flow at the invert of a manhole or an inspection chamber.

Cleaning Eye (Fig. 14.10) : An access opening having a removable cover to enable obstructions to be cleared by means of a drain rod.

Connections : The junction of a foul water drain, surface water drain with public sewer, cesspool, soakway or other water courses.

Curb, Kerb : The stone margin of a side walk.

Dispersion Trench : A trench in which open jointed pipes surrounded by coarse aggregate media and overlaid by fine aggregate, are laid. The effluent from septic tank gets dispersed through the open joints and is absorbed in the surrounding soil.

Depth of Manhole : The vertical distance from the top of the manhole to the outgoing invert of the main drain channel.

Drain : A line of pipes including all fittings and equipment, such as manholes traps, gullies and floor traps used for the drainage of a building, or a number of buildings or yards appurtenant to the buildings, within the same cartilage. Drain shall also include open channels used for conveying surface water.

Drainage : The removal of any liquid by a system constructed for the purpose.

Drop connection (Fig. 14.10) : A branch drain of which the last length of piping of the incoming drain, before connection to the sewer, is vertical.

Drop Manhole (Fig. 14.10) : A manhole incorporating a vertical drop for the purpose of connecting a sewer or drain at high level to one at lower level.

Effluents

a) **Tank effluent**: The supernatant liquid discharge from a septic tank.

b) **Filter effluent**: The liquid discharged from a biological filter.

Gully Chamber (Fig. 14.4) : The chamber built of masonry around a gully trap, for housing the same.

Gully Trap (Fig. 14.4) : A trap water seal provided in a drainage system in a suitable position to collect waste water from the scullery, kitchen sink, wash basins, baths and rain water pipes.

Haunching (Fig. 14.14) : Concrete bedding with additional concrete at the sides of the pipe.

Junction pipe : A pipe incorporating one or more branches.

Invert : The lowest point of the interior of a sewer or drain at any cross action.

Inspection Chamber : A water tight chamber constructed in any house drainage system which takes wastes from gully traps and disposes off to manhole with access for inspection and maintenance.

Interceptor Manhole (interceptor chamber) : A manhole incorporating an intercepting trap, and providing means of access thereto and equipped with a fresh air inlet on the upstream side of the trap.

Manhole (Manhole Chamber) : Any chamber constructed on a drain or sewer so as to provide access thereto for inspection testing or the clearance of obstruction.

Rest Bend (Duck Foot Bend) : A bend supported in a vertical position by a foot formed at its base.

Saddle : A purpose made fitting, so shaped as to fit over a hole cut in a sewer or drain, and used to form connections.

Soffit : The highest portion of the interior of a sewer or drain at any cross-section.

Soil waste: The discharge from water closets, urinals, slope sinks, stable or cowshed gullies and similar appliances.

Soil pipe: Which receives the discharges from soil fitments, such as water closets urinals, and slope sinks.

Sullage Waste Water: Spent water from baths, wash basins kitchen sinks, and similar appliances which does not contain human or animal excreta.

Sewer: A closed drain carrying night soil and other water borne waste.

Surface Water Drain : A drain conveying surface water including storm water.

Surface Water: The run off from precipitation, other water that flows over surface of the ground.

Sub Soil Water : Water occurring naturally below the surface of the ground.

Sludge : The settled solid matter in semi solid condition

Soak Pit (seepage pit soakway) (Fig. 14.17) : A pit through which effluent is allowed to seep or leach into the surrounding soil.

Septic Tank : A water tight single storeyed tank in which sewage is retained sufficiently long to permit sedimentation of suspended solids and partial digestion of settled sludge by anaerobic bacteria.

Scum : The greasy and other substances floating on the surface of sewage.

Vent Pipe : A pipe line installed to provide flow of air to or from a drainage system or to provide circulation of air within such system to protect trap seals from siphonage and back flow.

Waste Water : The discharge from wash basins, sinks and similar appliance, which does not contain human excreta.

14.1. GENERAL REQUIREMENTS - For Details IS 1742 -1988 Code of Practice for Building Drainage may be referred to. Extracts of some important clauses of this code are given at **ANNEXURE 14.1**.

14.1.1. Design of Drainage system: In designing a drainage system for building(s), the aim shall be to provide self cleansing conduits for the conveyance of soil, waste, surface or subsurface waters, and the removal of such wastes speedily and

efficiently to a sewer or other outlet, without risk of nuisance and hazard to health.

14.1.2. Gradient and discharge: The discharge of water through a domestic drain is intermittent and limited in quantity and therefore, small accumulations of solid matter are liable to form in the drains between the building and the public sewer. There is usually a gradual shifting of these deposits as discharges take place. Gradients shall be sufficient to prevent these temporary accumulations building up and blocking the drains.

14.1.3. Self cleaning velocity: Normally, the sewer shall be designed for discharging three times the dry weather flow flowing half-full with a minimum self cleansing velocity of 0.75 metre per second. The approximate gradients which give this velocity for the sizes of pipes likely to be used in building drainage, and the corresponding discharges when flowing half-full are given in **Table 14.1**. The sizes and slopes shall conform to Local Municipal Bye Laws.

14.1.4. Minimum velocity of flow: In cases, where it is practically not possible to conform to the minimum gradients, a flatter gradient may be used but the minimum velocity in such cases shall on no account be less than 0.61 metres per second.

14.1.5. Maximum velocity of flow: On the other hand, it is undesirable to employ gradients giving velocity of flow greater than 2.4 metres per second. Where it is unavoidable, cast iron pipes shall be used. The approximate gradients which give a velocity of 2.4 metres per second for the various sizes of pipes and the corresponding discharge when flowing half-full are given in **Table 14.1**.

TABLE 14.1
GRADIENTS FOR SEWERS

Diameter <i>mm</i>	Minimum Gradient		Maximum Gradient	
	<i>Gradients</i>	<i>Discharge cum/Min.</i>	<i>Gradients</i>	<i>Discharge cum/Min.</i>
100	1 in 57	0.18	1 in 5.6	0.59
150	1 in 100	0.42	1 in 9.7	1.32
200	1 in 145	0.73	1 in 14	2.4
230	1 in 175	0.93	1 in 17	2.98
250	1 in 195	1.10	1 in 19	3.60
300	1 in 250	1.70	1 in 24.5	5.30

14.1.6 Design of pipes: Subject to the minimum size of 100mm, the sizes of pipes, shall be decided in relation to the estimated quantity of flow and the available gradient.

14.1.7 Cast Iron Soil pipes, waste pipes and vent pipes

14.1.7.0 Material: All cast iron soil, waste and vent pipes shall conform to the relevant IS Specification in force. The pipes as well as specials shall have spigot and socket ends with bends on spigot ends. They shall be of heavy grade and distinguished from light cast iron rain water pipes by their larger thickness and weight. All C.I. pipes and specials used shall be coated with an approved anti-corrosive treatment at the factory itself.

14.1.7.1 Soil pipes: The minimum internal diameter for soil pipes shall not be less than 100mm. Soil pipes shall be situated outside the building or in a suitably designed open shaft. The work of the soil pipe shall be carried down truly vertical, but where unavoidable, they may be laid at an inclination of not less than $22\frac{1}{2}^{\circ}$ to Horizontal. Soil pipes below ground shall

be cast iron. Above ground asbestos cement soil pipes may also be used in exceptional case.

14.1.7.2 Vent pipes: The soil or waste pipe above the highest inlet connection shall be continued upwards either to the full diameter or to a reduced diameter of not less than 80mm for water closets, and 50 mm for other fixtures to serve as a ventilating pipe. The vent pipe shall be carried to a height of at least 60 cm above the outer covering of roof (near the cover) of the building. In the case of flat roof with access provided the height shall be at least 120 cm above the parapet, and 2 meters above the roof level. The top of the pipe shall also not be less than 2 metres above the head of any window within a horizontal distance of 3 metres from it. The top of the vent pipe shall be fitted with a hard cast iron / GI or copper wire dome.

14.1.7.3 Waste pipes: The main outside waste stacks from wash basins, sinks, baths, floor traps, etc shall be as indicated below :

Type of fitting	No. connected to the waste stack	Minimum dia. of waste stack
Wash basin	One	4 cm lead or 2 in (5 cm) H.C.I
Do	More than one	2 in (5 cm) H.C.I.
Baths or sinks	Any number	Do
Floor traps	Do	3 in (7.5 cm) H.C.I

Waste Pipes shall be fixed and jointed in the same manner as soil pipes. Branch waste pipes from fittings to the main waste stack shall ordinarily be of lead and these shall be connected to the fittings through an efficient syphon trap.

14.1.7.4 Antisiphon pipes: Where more than one water closet or sink discharge with the same soil pipe, the traps of such fittings shall be ventilated from a point not less than 7.5cm or more than 30 cm from their highest part and on the side nearest to the soil pipe by providing Anti-syphon pipes. These Antisiphon pipes shall be lead pipes or cast iron pipes of not less than 50mm internal diameter. The antisiphon pipe may either be connected with a separate vent pipe and continued upwards to terminate in a wire dome as for vent pipes, or be connected to the main vent pipe itself through a 45° branch not less than 1.2 meters above the topmost inlet connection in the soil or waste pipe.

14.1.7.5 Discharge: All soil pipes, after passing vertically below ground level shall be led by an easy bend into the adjoining home service manhole if provided or be connected direct to a sewer pipe. No soil pipe shall discharge into a gully trap or open drain. All waste pipes shall discharge into open gully traps, provided with square C.I. gratings. A waste pipe shall not be connected directly to a manhole or soil pipe or sewer.

14.1.7.6 Access Door: On waste traps, soil pipe junctions and bends, wherever clogging of pipes is likely to occur, access door shall be provided to facilitate cleaning. Doors shall be provided with 3 mm rubber insertion packing. When closed and bolted they shall be watertight.

14.1.7.7 Rain Water Drain Pipe: If a separate underground drainage system is provided for surface water rainwater down pipes shall discharge in the open air over untrapped gullies. Otherwise they shall

discharge in the open air into surface drains.

14.1.7.8 Traps: All traps shall be set perfectly true and level. No fixture shall have more than one trap. The trapped waste from a fixture shall not connect with the inlet or house side of the trap of an adjoining fixture. The size of trap is as follows :

Water closets	80 - 100 mm
Slop sinks	80 mm
Kitchen sinks	50 mm
Wash tubes	50 mm
Urinals	50 mm
Wash basins & pantry sinks	40mm

14.1.7.9 Tests: All soil, waste pipes, laid above ground, shall be subjected to a smoke test, at the expense of the contractor, after fixing in position preferably with the use of a smoke machine. Smoke shall be pumped in from the lower end and all joints and traps carefully examined for any leakage of smoke. In case of pipes laid below ground, they shall be subject to a static head of water of 60 cm above the crown at the top most point following the same method as for glazed earthenware pipes.

14.1.8 Asbestos cement, soil, waste & vent pipes

14.1.8.1 The specification shall be the same as per cast iron pipes vide para 14.1.7 above except the material and the manner of fixing them shall be as for rain

water pipes of asbestos cement. The use of AC pipes should be restricted as far as possible since these are liable to crack and are damaged easily.

14.1.8.2 Asbestos cement building pipes shall not be used for soil or waste pipes to be laid below ground level.

14.1.9 Glazed Half round Earthen ware pipes

14.1.9.1 These pipes shall correspond to IS 771 (1962). The diameter referred to shall be the inside diameter.

14.1.9.2 These pipes shall be laid over the bed of a lime concrete or cement concrete as specified. The joints of the pipes shall be made up of cement mortar 1:2 and cured well.

14.1.10 Fixing of soil waste and vent pipes

14.1.10.1 a) The pipes shall be fixed to the wall of the building at intervals as laid down in Table below. Except where eared pipes are employed this fixing shall be done by means of holderbat clamps of approved pattern. A holderbat clamp is a bracket made in two halves so as to securely grip the pipe being held therein. Alternately the holder bats may contain a bracket for fixing the same to the wall and this bracket shall be fastened to the wall by wrought iron nails, which shall be driven into wooden plugs into the walls at the points required and held clear of the wall by wooden blocks or bobbins.

MAXIMUM SPACING OF PIPE FIXINGS

Item	Material of pipe	Dia of pipe	Max. spacing of pipe fixing	
			vertical Runs	horizontal Runs
1	Cast Iron *	All sizes	3.00 m	1.50 m
2	Cement Asbestos *	All sizes	3.00 m	1.50 m
3.	Wrought iron or Mild steel	20 mm	2.75 m	2.10 m
		25 mm	3.00 m	2.40 m
		32 mm to 50 mm	3.65 m	3.00 m
		65 mm to 80 mm	4.55 m	3.65 m

* Note: One fixing must be provided for each fittings.

b) The eared pipes shall be fastened to the wall in a similar way.

c) The clearance between the surface of the pipe and the surface of the wall should not be less than 32 mm.

d) All fixing shall be carefully aligned and spaced so as to support the runs of pipe in

correct straight alignment. All soil pipe shall be carried up above the roof and shall have HCI terminal guard.

14.1.10.2 Connection between main pipe and branch pipe shall be made by using proper branches and bends with access doors for cleaning.

14.1.10.3 a) Joints: Both cement asbestos and cast iron soil and ventilating pipes shall

have joints made with gasket of tarred yarn caulked to a depth of 25 millimetres. The joint shall then be filled with molten lead / lead wool which shall be caulked after cooling so as to make a secure water tight joint.

b) For cement asbestos pipes if approved by the Engineer a layer of approved bituminous compound may be used in place of the caulked lead joint.

c) The caulked lead or the bituminous compound shall be followed by fittings with neat cement mortar which shall be brought up to the edge of the socket and neatly trowelled off around the joint.

14.1.10.4 The lead shall be rendered thoroughly fluid and each joint filled in one pouring. Before caulking, the projecting lead shall be removed by flat chisels and then the joint caulked round with proper caulking tools and a hammer of 1 kg. Being well set up, the joint is to be left flush, neat and even with socket. The caulked lead shall be followed by filling with neat cement mortar which shall be brought up to the edge of the socket and neatly trowelled off around the joint.

14.2. MATERIALS

14.2.1. Flushing Tank (Refer Fig. 14.1)

14.2.1.1. C.I. Cover : C.I. Cover shall be of 560 mm dia and shall be medium duty or heavy duty depending upon the locations of the tank. It shall conform in all respects to IS: 1726 (Part IV and Part II) respectively. Weight of cover and frame shall conform to IS: 1726.

14.2.1.2. Syphon shall be automatic syphon made of cast iron with trapped outlet for flushing. The syphon for flushing a sewer line shall be as 65 mm, 80 mm or 100 mm dia as specified.

14.2.2. Manholes – Covers and Foot rests

14.2.2.1. C.I. Covers : The covers and frames shall conform to IS: 1726 and shall be generally of the following grades and types. The basic performance requirement of manhole covers and frames are given in **Table 14.2**. The use of Cast Iron covers

should be restricted to the minimum and only at places where chances of theft are negligible. Normally precast RCC covers should be used if possible.

a) Heavy duty: These shall be denoted by the letters HD circular solid type for use under heavy vehicular traffic condition and shall conform to IS : 1726 (Part-II).

b) Medium duty: These shall be denoted by the letters MD circular or rectangular solid type for use under light traffic condition such as foot paths, carriage drives and cycle tracks. These shall conform to IS: 1726 (Part IV&V).

c) Light duty: These shall be denoted by the letter LD of rectangular size for use in domestic premises or where they are not subjected to wheeled traffic loads. These shall conform to IS: 1726 (PartVI)-Square types shall conform to IS: 1726 (Part-VII). The covers and frames shall be cleanly cast and they shall be free from air and sand holes and from cold shuts. They shall be neatly dressed and carefully trimmed. All castings shall be free from voids whether due to shrinkage, gas inclusion or other causes. Covers shall have a raised chequered design on the top surface to provide an adequate non-slip grip.

The cover shall be capable of easy opening and closing and it shall be fitted in the frame in workmanship like manner. The cover shall be gas tight and water tight. The covers used in manholes in sewer lines shall invariably bear the word, 'SEWER' on the top and those used for storm water drains shall bear the word 'STORM'. These markings shall be done during casting of the covers. The sizes of covers specified shall be taken as the clear internal dimensions of the frame. The approximate weights of the various types of manhole covers and frames shall be as per IS: 1726.

Covers and frames shall be coated with a black bituminous composition. The coating shall be smooth and tenacious. It shall not flow when exposed to a temperature of 63 degree centigrade and shall not be brittle as to chip off at temperature of 0 degree centigrade.

Table 14.2

BASIC AND PERFORMANCE REQUIREMENTS OF MANHOLE COVERS & FRAMES

Grade Designation	Type/shape of cover	Clear opening of frame mm	Frame		Test Load Tonnes
			Depth fd mm	Seating S mm	
LD-2.5	Rectangular	450x600	35	50	2.5
	Square	450x450	30	50	
		400x400	30	50	
	Circular	370(dia)	45	40	
		350(dia)	45	40	
MD-10	Circular	450(dia)	60	40	10
		480(dia)	70	40	
		500(dia)	80	50	
	Rectangular	450x600	80	50	
HD-20	Circular	500 (dia)	100	50	20
		560(dia)	110	60	
		600(dia)	110	75	
	Lamphole cover	350(dia)	130	25*	
	Square	560x560	110	75	
	Rectangular (scraper manhole)	450x900	100	60	
EHD-35	Circular	560(dia)	130	60	35
		600 (dia)	140	75	
	Square	560x560	130	60	
	Rectangular (scraper manhole)	600x900	120	70	

Note: The depth and seating in the frame for the respective test loads may vary depending upon the design of the frame (inside) and the corresponding matching cover.

* This seating at 25mm is in case of tapered designs of the frame (inside) as also the matching cover.

14.2.2.2. Precast concrete manhole covers & frames

Precast reinforced cement concrete manhole covers intended for use in sewerage and water works shall generally conform to IS: 12592 (Part 1 & 2). Detailed specifications are as under. In case the ready made covers are procured from approved manufacturer test certificate should be submitted by the agency before use at site.

14.2.2.2.1. Grades: Types & Uses

Manhole covers and frames shall be of the following four grades and types :

Grades	Grade	Type/shape of cover
	Designation	
Light Duty	LD - 2.5	Rectangular, Square, circular
Medium Duty	MD - 10	Rectangular, Circular
Heavy Duty	HD - 20	Circular-Square, Rectangular, (Scraper Manhole)
Extra Heavy Duty	EHD - 35	Circular, Square, Rectangular, (Scraper Manhole)

14.2.2.2.2. The different grades and types of manhole covers may be used as follows :

a) LD-2.5 Rectangular, Square or Circular types:- These are suitable for use within residential and institutional complexes/ areas with pedestrian but occasional LMV traffic. These covers may also be used for Inspection chambers.

b) MD-10- These are suitable for use in service lanes/roads, car parking areas etc.

c) MD-20- Suitable for use in institutional/ commercial areas/carriage ways with heavy duty vehicular traffic like buses, trucks, etc.

d) EHD-35- Circular, square, or rectangular (scraper manhole) types - These are suitable for use on carriage way in

commercial industrial/port areas/near warehouses/ godowns/Goods shed where frequent loading and unloading of trucks/trailers are common, with slow to fast moving vehicular traffic of the types having wheel loads upto 11.5 tonnes, irrespective of the location of the manhole chambers.

14.2.2.2.3. Materials

Cement : Cement used for the manufacture of precast concrete manhole covers shall be portland cement conforming to IS : 269 or 1489 (part 1 & 2) or IS : 8041 or IS : 8043 - or IS : 8112 or IS : 155.

Aggregates : The aggregates used shall be clean and free from deleterious matter and shall conform to the requirements of IS : 383. The aggregates shall be well graded and the nominal maximum size of coarse aggregate shall not exceed 20 mm.

Concrete : The mix proportions of concrete shall be determined by the manufacturer and shall be such as will produce a dense concrete without voids, honey combing etc. The minimum cement content in the concrete shall be 360 kg/m³ with a maximum water cement ratio of 0.45. Concrete weaker than grade M30 (design mix) shall not be used. Compaction of concrete shall be done by machine vibration.

Reinforcement

a) The reinforcement steel shall conform to IS : 226 or IS : 432 (Part I) or IS : 832

(part 2) or IS : 1566 or IS : 1786 as specified.

Reinforcement shall be clean and free from loose mill scale, loose rust, and mud, oil, grease or any other coating which may reduce or destroy the bond between the concrete and steel. A light film of rust may not be regarded as harmful but steel shall not be visibly pitted by rust.

b) **Fibres steel**: In addition to the main steel bar reinforcement, steel fibres of appropriate types and forms may also be used as secondary reinforcement (minimum upto 0.5% by volume of concrete). The diameter/equivalent diameter of steel fibres shall not be greater than 0.75mm. The aspect ratio of the fibres (ratio of length of fibre to its dia / equivalent dia) shall be in the range of 50-80.

c) **Plastics** : Plastics fibres of polypropylene fibrillated film of suitable type and form (0.25% by weight of cement) may also be used as reinforcement in line of steel reinforcement.

14.2.2.2.4. Shapes and Dimensions

Shapes : The shapes of precast concrete manhole covers shall be square, rectangular or circular as specified.

Dimensions : Dimensions of precast concrete manhole covers shall be as given in **Table 14.3**, the minimum clearance at top between the frame and cover shall be 5 mm

TABLE 14.3

SL	Description	Heavy/Extra Heavy duty HD/EHD	Medium duty MD	Light duty LD
1.	Clear opening matching the top opening of manhole	560mm dia or 600mm dia or square or 560mm	450mm dia 480mm dia 500mm dia or square	600x450mm (rectangular) 450mm dia or 350mm dia or square
2.	Precast slab with integral frame (D/T)	900mm dia x 180mm or square corners cut/1000mm dia x200mm or square corner cut	800mm dia x 130mm/800mm dia x150mm	850mmx700mmx100mm/625mm diax100mm or 575 mm dia x100 mm or square
3.	Thickness of cover depth of frame (T1)	100mm or 110/120mm	70/80mm	50mm
4.	Matching manhole cover (B)	685/660mm or 735/710mm dia or square	585mm dia or 645 mm dia or square	685x535mm/515mm dia or square 435mm dia or square
5.	Edge protection of covers/lifting facility	Precast manhole covers are designed and provided with MS rims of 2.5mm thickness welded around with provision of two lifting hooks welded at appropriate locations.		

6.	Chequered pattern on operative surface	The MS rims along with the edges of precast manhole covers and their operative surface are suitably coated/finished using corrosion resistant paint.
7.	Marking on the covers	Precast manhole covers/precast slabs are suitably marked on the operative surface with the following letters, unless specified otherwise. Name of the department/Sewer or SWD/Grade/Date of MFR/Trade Name etc.
8.	Performance requirements Test Load	When tested for ultimate braking load using 300mm dia block as per the method described in IS 12592 (Part I) manhole covers shall be within the following range. Light-duty 2.5 tonnes (LD 2.5) Heavy duty – 20 tonnes (HD-20) Medium duty- 10 tonnes (MD-10) Extra heavy duty 35 tonnes (EHD-35)

14.2.2.2.5. Lifting Device : The minimum diameter of mild steel rod used as lifting device shall be 10 mm for light and 12 mm for medium duty covers and 16 mm for heavy and extra heavy duty covers. The lifting device shall be protected from corrosion by not galvanising or epoxy coating or any other suitable.

14.2.2.2.6. Finishing & Coating : To prevent any possible damage from corrosion of steel the underside of the covers shall be treated with anticorrosive paint. The top surface of the covers shall be given a chequered finish.

In order to protect the edges of the covers from possible damage at the time of lifting and handling it is necessary that the manhole covers shall be cast with a protective mild steel sheet of minimum 2.5

mm thickness around the periphery of the covers. Exposed surface of mild steel sheet shall be given suitable treatment with anticorrosive paint or coating.

14.2.2.2.7. Physical Requirements

a) **General :** All units shall be sound and free from cracks and other defects which interface with the proper placing of the unit or impair the strength or performance of the units. Minor chipping at the edge/surface resulting from the customary methods of handling during delivery shall not be deemed for rejecting.

b) **Load Test :** The breaking load of individual units when tested in accordance with the method described in IS: 12592 shall be not less than the values specified in **Table 14.4.**

TABLE 14.4

Grade of cover	Type	Load in Tonnes	Diameter of Blocks in mm
EHD-35	Circular, square or rectangular	35	300
HD-20	Circular, square or rectangular	20	300
MD-10	Circular or rectangular	10	300
LD-2.5	Rectangular, square or circular	2.5	300

14.2.2.2.8. Fixing : The frames of manhole shall be firmly embedded to correct alignment and level in RCC slab or plain concrete as the case may be on the top of masonry which shall be paid as extra unless specified otherwise.

14.2.2.2.9. Measurements : The manhole covers shall be enumerated under relevant items.

14.2.2.2.10. Rates : The rate shall include the cost of materials and labour involved in all the operation described above except fixing of frames and covers which shall be paid as extra unless specified otherwise in the item.

14.2.2.3. Foot Rests : Foot rests shall be of 20 mm M.S. square or round bars as specified.

14.2.3. Pipes and Specials

14.2.3.1. Cast iron (centrifugally cast) pipes and specials shall conform to the specifications described in 13.2.12.

14.2.3.2. Cement Concrete Pipes (with and without Reinforcement)

For details of different classes of pipes **Table 14.5** below may be referred to. The pipes shall be with or without reinforcement as required and shall be of, the specified class. These shall conform to IS: 458. The reinforced cement concrete pipes shall be

manufactured by centrifugal (or spun) process while un-reinforced cement concrete pipes by spun or pressure process. All pipes shall be true to shape, straight, perfectly sound and free from cracks and flaws. The external and internal surface of the pipes shall be smooth and hard. The pipes shall be free from defects resulting from imperfect grading of the aggregate mixing or moulding.

Concrete used for the manufacture of unreinforced and reinforced concrete pipes and collars shall not be leaner than 1:2:4 (1 cement: 2 coarse sand: 4 graded stone

aggregate). The maximum size of aggregate should not exceed one third of the thickness of the pipe or 20 mm whichever is smaller. The reinforcement in the reinforced concrete pipes shall extend throughout the length of the pipe. The circumferential and longitudinal reinforcements shall be adequate to withstand the specified hydrostatic pressure and further bending stresses due to the weight of water when running full across a span equal to the length of pipe plus three times its own weight.

TABLE 14.5 CONCRETE PIPES

Class	Description	Test pressure (Hydrostatic)	Conditions where normally used
NP1	Un-reinforced concrete non pressure pipes	0.7 kg/sq.cm (7 meter head)	For drainage and irrigation use, above ground or in shallow trenches
NP2	Reinforced concrete light duty, non-pressure pipes	0.7 kg/sq.cm (7 meter head)	For drainage and irrigation use, for culverts carrying light traffic.
NP3	Reinforced concrete, medium-duty non-pressure pipes	0.7 kg/sq.cm (7 meter head)	For drainage and irrigation use for culverts, carrying heavy traffic
NP4	Reinforced concrete, heavy duty non-pressure pipes	0.7 kg/sq.cm (7 meter head)	For drainage and irrigation use for culverts carrying very heavy traffic, such as railway loading.
P1	Reinforced concrete pressure pipes	2.0 kg/sq.cm (20 metre head)	For use on gravity mains, the design pressure not exceeding two-third of the test pressure
P2	Reinforced concrete pressure pipes	4.0 kg/sq.cm (40 metre head)	For use on pumping mains, the design pressure not exceeding half of the test pressure.
P3	Reinforced concrete pressure pipes	6.0 kg/sq.cm (60 metre head)	-do-

The dimensional requirements of concrete pipes are given in **Annexure 14.2**. The minimum cover for reinforcement of spun pipes and for all other pipes shall be as given in **Table 14.6**.

TABLE 14.6

Pipe thickness	Cover for	
	Spun pipes mm	Other than spun pipe mm
Less than 30mm	9	12
30mm to 75mm	12	16
75mm and over	18	18

14.2.4. Road Gully Grating (Fig 14.2 and 14.3)

14.2.4.1. Horizontal Gully Grating : The casting of the grating and frames shall be the same as that of manhole covers described in 14.2.2.1. The gully grating cover shall be hinged to the frame to facilitate its opening for cleaning and repairs. A typical grating is shown in **Fig. 14.2 & 14.3** The weight of grating shown in Figure shall be minimum 75 Kg. In case of R.C.C. horizontal gully grating it shall be in cement

concrete 1:1:2 (1 cement: 1 coarse sand: 2 graded stone aggregate 20 mm nominal size) as shown in **Fig. 14.2**

14.2.4.2. Vertical Gully Grating : The chamber shall be of brick masonry, 12mm dia, round bar shall be fixed in cement concrete block at the bottom. The bars at the top shall be welded or riveted to Mild Steel flat 40x6 mm as shown in **Fig. 14.3**

14.2.4.3. Horizontal and vertical Gully Grating : The details of typical road gully chamber of brick masonry with horizontal

and vertical grating shall be as given in **Fig. 14.3**

14.2.5. Stone Ware Pipes and Fittings : All pipes with spigot and socket ends and fittings shall conform to IS: 651. These shall be sound, free from visible defects such as fire cracks or hair cracks. The glaze of the

pipes shall be free from crazing. The pipes shall give a sharp clear tone when struck with a light hammer. There shall be no broken blisters. The thickness of pipes shall be as given in the **Table 14.7**

TABLE 14.7
STONEWARE PIPES

Internal diameter mm	Thickness of the barrel and socket mm
100	12
150	16
200	17
230	19
250	20
300	25
350	30
400	35
450	38

The length of pipes shall be 60, 75, 90 cm exclusive of the internal depth of the socket. The pipes shall be handled with sufficient care to avoid damage to them.

14.2.6. S.W. Gully Trap (Fig. 14.4) : Gully traps shall conform to IS: 651. These shall be sound, free from visible defects such as fire cracks, or hair cracks. The glaze of the traps shall be free from crazing. They shall give a sharp clear tone when struck with light hammer. There shall be no broken blisters.

Each gully trap shall have one C.I. grating of square size corresponding to the dimensions of inlet of gully trap. It will also have a water tight C.I. cover with frame inside dimensions 300 x 300 mm the cover weighing not less than 4.50 Kg and the frame not less than 2.70 Kg. The grating, cover and frame shall be of sound and good casting and shall have truly square machined seating faces.

14.3. CONSTRUCTING FLUSHING TANK (FIG. 14.1)

For details, refer to IS 4111-1986 Code of Practice for ancillary structure to sewage system Part 2 Flushing tanks. Where it is not practicable to obtain gradients in the sewers, steep enough to give a self cleansing velocity of not less than 75 cm per second, it is necessary to provide flushing water tanks at suitable points in a sewer line to help the flow of sewage. For pipes under 600-mm dia the quantity of flushing water should be sufficient to fill the sewer at least half bore over the whole length of sewer to be flushed or from one flush point to the next. The head at which the flush is discharged should give an initial velocity much higher than the self cleansing velocity so as to ensure that solids already deposited will be removed. The approximate quantity of flushing water per flush over a length of 75 m to 90 m is given in **Table 14.8**.

TABLE 14.8
WATER REQUIRED PER FLUSH

Diameter of pipe mm	Quantity of water litres
250	1400 to 1700
350	1700 to 2700
400	2700 to 3600
450	3600 to 4500

14.4. CONSTRUCTION OF MANHOLES (FIG. 14.5 to 14.10)

14.4.0. General: At every change of alignment, gradient or diameter of a drain, there shall be a manhole or inspection

chamber. Bends and junctions in the drains shall be grouped together in manhole as far as possible. The maximum distance between manholes shall be 30 m. IS 4111-1986 Codes of Practice for ancillary structures in sewage system Part 1 may be referred to for further details.

Manholes of different types and sizes as specified shall be constructed in the sewer line at such places and to such levels and dimensions as shown in the drawings or as directed by the Engineer-in-charge. The size specified shall indicate the inside dimensions between brick faces of the manholes.

Where the diameter of the drain is increased, the crown of the pipe shall be fixed at the same level and necessary slope given in the invert of the manhole chamber. In exceptional cases and where unavoidable, the crown of the branch sewer may be fixed at lower level but in such cases the peak flow level of the two sewers shall be kept the same.

Sewers of unequal sectional area shall not be jointed at the same invert in a manhole. The invert of the smaller sewer at its junction with main shall be at least $\frac{2}{3}$ the diameter of the main above the invert of the main. The branch sewers shall deliver sewage in the manhole in the direction of main flow and the junction must be made with care so that flow in main is not impeded.

No drain from house fittings, e.g. gully trap or soil pipe, etc to manhole shall normally exceed a length of 6 m unless it is unavoidable.

Manholes 90 x 80 cm are generally constructed within compound for house drainage only and near the buildings for house drainage normally for depth of 1 m or less. Manholes 1.2 m x 90 cm are generally constructed for main drainage work for depths less than 1.5 m.

Manhole - 1.4 m x 90 cm are of the arched type and are generally constructed for main drainage works where depth is 1.50 m or more. The width of manholes shall be increased more than 90 cm on bends or junctions or pipes with diameter greater than 450 mm and that the benching width on either side of the channel is minimum 20 cm.

Manholes of circular type of 1.4 m internal diameter are generally constructed for main drainage works where depth is 2.45 m or more as an alternative to manholes of arch type. The diameter shall be increased suitably, for pipes with diameter greater than

450 mm in the same manner as in the case of rectangular manholes.

Before deciding size of manholes, Local Municipal Bye Laws shall be consulted. As a general guide some typical type designs of manholes generally followed have been shown in Fig. 14.6 to 14.9. When manholes are constructed on foot path, these shall be provided with cover of medium duty casting and when built within the width of the road under vehicular traffic, these shall be provided with cover of heavy duty casting.

14.4.1. Excavation : The excavation for manhole shall be true to dimensions and levels shown on the plans or as directed by the Engineer.

14.4.2. Bed concrete : The manhole shall be built on a bed of cement concrete 1:4:8 (1 cement: 4 coarse sand: 8 graded stone aggregate 40 mm nominal size) unless otherwise stipulated by local authorities. The thickness of the bed concrete shall be 20 cm for manholes up to 4.25 m depth and 30 cm for depths beyond 4.25 m unless otherwise specified or directed by the Engineer. In bad ground, special foundations as suitable shall be provided.

14.4.3. Brick Work : The brick work shall be with class 7.5 bricks in cement mortar 1:4 (1 cement: 4 coarse sand). The external joints of the brick masonry shall be finished smooth, and the joints of the pipes with the masonry shall be made perfectly leak proof. For arched type and circular manholes, brick masonry in arches and arching over the pipes shall be in cement mortar 1:3 (1 cement: 3 fine sand). In the case of manholes of circular type the excess shaft shall be corbelled inwardly on three sides at the top to reduce its size to the cover frame to be fitted.

The walls shall be built of one brick thickness for depths up to 4.25 m. Below a depth of 4.25 m in ordinary subsoil the wall thickness shall be increased to one and half brick and at 9.75 m below ground two brick thick walls shall be built.

14.4.4. Plaster and Pointing: The walls of the manholes shall be plastered inside with 12 mm thick cement plaster 1:3 (1 cement: 3 coarse sand) finished smooth. In the case of arched type manhole the walls of the manhole shall be plastered inside all around only upto the crown level, and flush pointed for the shaft with cement mortar 1:2 (1 cement: 2 fine sand). Where the saturated soil is met with, also the external surface of the walls of the manhole shall be plastered with 12 mm thick cement plaster 1:3 (1

cement: 3, coarse sand) finished smooth upto 30 cm above the highest sub-soil water level with the approval of the Engineer. The plaster shall further be water proofed with addition of approved water proofing compound in a quantity as per manufacturer's specifications. In case Local Authorities/Bye Laws specify richer specifications, the same shall be adopted.

For earth work excavation, bed concrete brick work, plaster and pointing, R.C.C. work

and refilling of earth, respective specifications shall be followed.

14.4.5. Benching : The channels and benching shall be done in cement concrete 1:2:4 (1 cement: 2 coarse sand: 4 graded stone aggregate 20 mm nominal size) and rendered smooth with neat cement. The depth of channels and benching shall be as given in **Table 14.9**.

TABLE 14.9

Sizes of drain mm	Top of channel at the centre above bed concrete cm	Depth of benching at side walls above bed concrete cm
100	15	20
150	20	30
200	25	35
250	30	40
300	35	45
350	40	50
400	45	55
450	50	60

14.4.6. Foot Rests (Fig. 14.10) : All manholes deeper than 0.8 m shall be provided with M.S. foot rests. These shall be embedded 20 cm deep in 20x20x10 cm blocks of cement concrete 1:2:4 (1 cement: 2 coarse sand 4 graded stone aggregate 20 mm nominal size). The concrete block with M.S. foot rest placed in its centre shall be cast in situ along with the masonry and surface finished with 12 mm thick cement plaster 1:3 (1 cement: 3 coarse sand) finished smooth.

Foot rests which shall be of 20x20 Sq. M.S. bars as shown in **Fig. 14.10** shall be fixed 40 cm apart vertically and staggered laterally and shall project 10 cm beyond the surface of the wall. The top foot rest shall be 45 cm below the manhole cover.

Foot rests shall be painted with coal tar, the portion embedded in the cement concrete block being painted with thick cement slurry before fixing.

14.4.7. Manhole covers and Frames : The frame of manhole shall be firmly embedded to correct alignment and levels in R.C.C. slab or plain concrete as the case may be on the top of the masonry. After completion of the work, manhole covers shall be sealed by means of thick grease.

14.4.8. Measurements : Manholes shall be enumerated under relevant items. The depth of the manhole shall be reckoned from the top level of C.I. cover to the invert level of channel. The depth shall be measured correct to a cm. The extra depth shall be measured and paid as extra over the specified depth.

14.4.9. Rate : The rate shall include the cost of materials and labour involved in all the operations described above but exclude the cost of (i) excavation, (ii) M.S. foot rests and (iii) 12 mm thick cement plaster with water proofing material applied at the external surface of the manhole if required. These items shall be paid for separately under relevant items of work:

Payment for extra depths of manholes shall be made separately under relevant items of work.

14.4.10 Reinforced Cement Concrete Man holes (Refer IS 4111- 1986 for further details)

14.4.10.1 Reinforced Cement Concrete Manholes : Where sewers are to be laid in high sub-soil water conditions, manholes may be constructed in reinforced cement concrete of Grade M 20 or 1:1 ½ : 3 mix (see

IS 456-1978). The manholes in this type of construction shall be preferably circular type.

14.4.10.2 Walls may be constructed of brick masonry above the sub-soil water level. A typical illustration of a reinforced cement concrete manhole with brick masonry above the sub-soil, water level is shown in **Figure 14.11**

14.4.11 **Safety Measures:** (Refer IS 4111-1986 for further details).

14.4.11.1 In deep manholes enlarged rest chambers should be made at about 6m intervals, each provided with a landing platform in the form of a grating incorporating a hinged trap-door immediately under the ladder.

14.4.11.2 All the manholes on sewers of 1m diameter and over should be provided with provision for fixing safety chains (galvanized wrought iron closelink, 6 or 10mm) for placing across the mouth of the sewer on the downstream side when men are at work; galvanized pipe handrail (nominal 38mm bore) should be provided on the edges of all benchings, platforms etc, to prevent possibility of a man falling into the sewer.

14.4.11.3 If ground conditions are such as to give rise to excessive risk of settlement and consequential damage to the manhole or sewer a concrete slab shall be provided at the top of the shaft to receive the cover frame. This should be independent of the shaft in order to avoid transmitting traffic shocks to the manhole. Any subsidence of the back filling on which the slab rests, shall be brought to the required road level without disturbing or damaging the pipe or the shaft.

14.4.11.4 No manhole shall be permitted inside a building or in any passage therein

14.4.11.5 In cascades and ramps, handrails and chains should be provided for the safety of workmen.

14.4.11.6 For further details IS 11972 -1987 "Code of Practice for Safety precautions to be taken where entering a sewage system" may be referred to.

14.5. CONSTRUCTING DROP CONNECTION (FIG. 14.10)

14.5.0. **General:-** In cases where branch pipe sewer enters the manhole of main pipe sewer at a higher level than the main sewer, a drop connection shall be provided. The work shall be carried out as per **Fig. 14.10** S.C.I. pipes and special conforming to IS: 1729 shall be of the same size as that of the branch pipe sewer.

For 150 and 250 mm main line, if the difference in level between the water line (peak flow level) and the invert level of the branch line is less than 60 cm, a drop connection may be provided with in the manhole by giving suitable ramp. If the difference in level is more than 60 cm, the drop shall be provided externally.

The main lines upto 350 mm dia, are designed for half depth of flow, from 350 mm to 900 mm for 2/3 depth of flow and beyond 900 mm for 3/4 depth of flow.

14.5.1. **Excavation :** The excavation shall be done for the drop connection at the place where the branch line meets the manhole the excavation shall be carried upto the bed concrete of the manhole and to the full width of the branch line.

14.5.2. **Laying :** At the end of branch sewer line S.C.I. cross shall be fixed to the line which shall be extended through the wall of the manhole by a horizontal piece of S.C.I. pipe to form an inspection or cleaning eye. The open end shall be provided with chain and lid. The S.C.I. drop pipe shall be connected to the cross at the top and to the S.C.I. bend at the bottom. The bend shall be extended through the wall of the manhole by a piece of C.I. pipe which shall discharge into the channel. Necessary channel shall be made with cement concrete 1:2:4 (1 cement: 2 coarse sand: 4 graded stone aggregate 20 mm nominal size) and finished smooth to connect the main channel. The joint between S.C.I. pipe and fittings shall be lead caulked as described in para 13.5.3. The joint between S.C.I. cross and S.W. branch line shall be made with cement mortar 1:1 (1 cement : 1 fine sand). The exposed portion of the drop connection shall be encased all around with minimum 15 cm thick concrete 1:3:6 (1 cement: 3 fine sand: 6 graded stone aggregate 40 mm nominal size) and cured. For encasing the concrete around the drop connection, the necessary centering and shuttering shall be provided. The holes made in the walls of the manhole shall be made good with brick work in cement mortar 1:4 (1 cement: 4 coarse sand) and plastered with cement mortar 1:3 (1 cement: 3 coarse sand) on the inside of the manhole wall. The excavated earth shall be back field in the trench in level with the original ground level.

14.5.3. **Measurements :** Drop connection shall be enumerated. The depths beyond 60 cm shall be measured in running metres correct to a cm under relevant items.

14.5.4. **Rate :** The rate shall include the cost of labour and materials involved in all the

operations described above but excluding the cost of excavations and refilling.

14.6. LAYING AND JOINTING CEMENT CONCRETE PIPES AND SPECIALS

14.6.0 **General:-** The pipes shall be as described in para 14.2.3.2

14.6.1. **Trenches :** Trenches shall be as described in para 13.3.4. Where the pipes are to be bedded directly on soil, the bed shall be suitably rounded to fit the lower part of the pipe, the cost for this operation being included in the rate for laying the pipe itself.

14.6.2. Laying

14.6.2.1. Loading, transporting and unloading of concrete pipes is to be done with care. Handling shall be such as to avoid impact. Gradual unloading by inclined plane or by chain pulley block is recommended. All pipe sections and connections shall be inspected carefully before being laid. Broken or defective pipes or connections shall not be used. Pipes shall be lowered into the trenches carefully. Mechanical appliances may be used. Pipes shall be laid true to line and grade as specified. Laying of pipes shall proceed upgrade of a slope.

14.6.2.2. If the pipes have spigot and socket joints, the socket ends shall face upstream. In the case of pipes with joints to be made with loose collars, the collars shall be slipped on before, the next pipe is laid. Adequate and proper expansion joints shall be provided where directed.

14.6.2.3. In case where foundation conditions are unusual such as in the proximity of trees or holes, under existing or proposed tracks manholes etc. the pipe shall be encased all-around in 15 cm thick cement concrete 1:3:6 (1 cement : 3 fine sand : 6 graded stone aggregate 40 mm nominal size) or compacted sand or gravel.

14.6.2.4. In cases where the natural foundation is inadequate the pipes shall be laid either in concrete cradle supported on proper foundations or on any other suitably designed structure. If a concrete cradle bedding is used the depth of concrete below the bottom of the pipe shall be at least 1/4th of the internal dia of the pipe subject to the min. of 10 cm and a maximum of 30 cm. The concrete shall extend up the sides of the pipe at least to a distance of 1/4th of the outside diameter of pipes 300 mm and over in dia. The pipe shall be laid in this concrete bedding before the concrete has set.- Pipes laid in trenches in earth shall be bedded evenly and firmly and as far up the haunches

of the pipe as to safely transmit the load expected from the backfill through the pipe to the bed. This shall be done either by excavating the bottom of the trench to fit the curve of the pipe or by compacting the earth under / around the curve of the pipe to form an even bed. Necessary provision shall be made for joints wherever required.

14.6.2.5. When the pipe is laid in a trench in rock hard clay, shale or other hard material the space below the pipe shall be excavated and replaced with an equalising bed of concrete, sand or compacted earth. In no place shall pipe be laid directly on such hard material.

14.6.2.6. The method of bedding and laying the pipes under different conditions are illustrated in **Fig. 14.12**

14.6.2.7. When the pipes are laid completely above the ground the foundations shall be made even and sufficiently compacted to support the pipe line without any material settlement. Alternatively the pipe line shall be supported on rigid foundations at intervals. Suitable arrangements shall be made to retain the pipe line in the proper alignment, such as by shaping the top of the supports to fit the lower part of the pipe. The distance between the supports shall in no case exceed the length of the pipe. The pipe shall be supported as far as possible close to the joints. In no case shall the joints come in the centre of the span. Care shall be taken to see that super imposed ' loads greater than the total load equivalent to the weight of the pipe when running full shall not be permitted.

Suitably designed anchor blocks at change of direction and grades for pressure lines shall be provided where required.

14.6.3. Jointing

14.6.3.0. Joints are generally of rigid type. Where specified flexible type joints may also be provided.

14.6.3.1. **Rigid Spigot and Socket Joint (Fig. 14.13) :** The spigot of each pipe shall be slipped home well into the socket of the pipe previously laid and adjusted in the correct position. The opening of the joint shall be filled with stiff mixture of cement mortar in the proportion of 1:2 (1 cement: 2 fine sand) which shall be rammed with caulking tool. After a day's work any extraneous material shall be removed from the inside of the pipe and the newly made joint shall be cured.

14.6.3.2. **Rigid Collar Joint (Fig. 14.13) :** The two adjoining pipes shall be butted against each other and adjusted in correct

position. The collar shall then be slipped over the joint, covering equally both the pipes. The annular space shall be filled with stiff mixture of cement mortar 1:2 (1 cement: 2 fine sand) which shall be rammed with caulking tool. After a day's work any extraneous materials shall be removed from the inside of the pipe and the newly made joint shall be cured.

14.6.3.3. Semi flexible spigot and socket Joint (Fig. 14.13) : The joint is composed of specially shaped spigot and socket ends on the concrete pipes. A rubber ring shall be placed on the spigot which shall be forced into the socket of the pipe previously laid. This compresses the rubber ring as it rolls into the annular space formed between the two surfaces of the spigot and the socket, stiff mixture of cement mortar 1:2 (1 cement: 2 fine sand) shall then be filled into the remaining annular space and rammed with a caulking tool. After day's work any extraneous materials shall be removed from the inside of the pipe and the newly made joint shall be cured.

14.6.3.4. Semi Flexible Collar Joint : This is made up of a loose collar which covers two specially shaped pipe ends as shown in the Fig. 14.13. Each end shall be fitted with a rubber ring which when compressed between the spigot and the collar, seal the joint. Stiff mixture of cement mortar 1:2 (1 cement: 2 fine sand), shall then be filled into the remaining annular space and rammed with a caulking tool. After day's work, any extraneous material shall be removed from the inside of the pipe and the newly made joint shall be cured.

14.6.3.5. Internal. Flush Joint (Fig. 14.13) : This joint is generally used for culvert pipe of 60 cm dia and over. The ends of the pipe are specially shaped to form a self centering joint with an internal jointing space 1 -3 cm wide the finished joint is flush with both inside and outside with the pipe wall as shown in Fig. 14.13. The jointing space is filled with cement mortar 1:2 (1 cement: 2 fine sand) mixed sufficiently dry to remain in position when forced with a trowel or rammer. After day's work, any extraneous material shall be removed from the inside of the pipe and the newly made joint shall be cured.

14.6.3.6. External Flush Joint : This joint is suitable for pipes which are too small for jointing from inside. This joint is composed of specially shaped pipe ends as shown in Fig. 14.13. Each end shall be butted against each other and adjusted in correct position. The jointing space shall then be filled with

cement mortar 1:2 (1 cement: 2 fine sand) sufficiently dry and finished off flush. Great care shall be taken to ensure that the projecting ends are not damaged as no repairs can be readily affected from inside the pipe.

14.6.3.7. In all pressure pipe lines the recess at the end of the pipe line shall be filled with jute braiding dipped in hot bitumen or other suitable approved compound. Pipes shall be so jointed that the bitumen ring of one pipe shall set into the recess of the next pipe. The ring shall be thoroughly compressed by jacking or by any other suitable method.

The number of pipes that shall be jacked together at a time shall depend on the diameter of the pipes and the bearing capacity of the soil, for small pipes upto 25 cm diameter, six pipes can be jacked together at a time.

The quantity of jute and bitumen in the ring shall be just sufficient to fill the recess in the pipe when pressed hard by jacking or by any other suitable method. Before and during jacking care shall be taken to see that there is no offset at the joint.

14.6.4. Testing : For pressure pipes, the completed pipeline shall be tested for pressure (Known as site test pressure) which shall not be less than the maximum pipeline operating pressure plus the calculated surge pressure, but in no case shall it exceed the hydrostatic test pressure. For non-pressure pipes the joints shall be tested as per procedure laid down under para 14.7.4.

14.6.5. Refilling of Trenches : The specification described in para 13.3.7 shall apply. In case where pipes are not bedded on concrete special care shall be taken in refilling, trenches to prevent the displacement and subsequent settlement at the surface resulting in uneven street surfaces and dangers to foundations etc. The backfilling materials shall be packed by hand under and around the pipe and rammed with a shovel and light tamper. This method of filling will be continued upto the top of pipe. The refilling shall rise evenly on both sides of the pipe continued upto 60 cm above the top of pipe so as not to disturb the pipe. No tamping shall be done within 15 cm of the top of pipe. The tamping shall become progressively heavier as the depth of the backfill increases.

14.6.6. Measurements : The lengths of pipes shall be measured in running metres nearest to a cm as laid or fixed, -from inside of one manhole to the inside of the other manhole. The length shall be taken along the

centre line of the pipes over all fittings such as bends, collars, junctions, etc. which shall not be measured separately.

Excavation, refilling, shoring and timbering in trenches, and cement concreting wherever required shall be measured separately under relevant items of work.

14.6.7. **Rate** : The rate shall include the cost of materials and labour involved in all the operations described above.

14.7. LAYING AND JOINTING STONE WARE PIPES

14.7.0. **General: For all sewers and drains, glazed stoneware pipes shall be used as far as possible in preference to other types of pipes.** These are suitable, particularly where acid effluents or acid sub-soil conditions are likely to be encountered. Stone ware pipes and specials shall conform to Grade A of the Indian Standards Specification No. IS: 651-1980. All pipes shall be new and perfectly sound, free from fire cracks and imperfections of glazing, cylindrical and straight. They shall be made of hard burnt stoneware and thoroughly salt-glazed inside and outside. They shall be got approved from the Engineer, before use. For details refer to IS 4127-1983 – Code of practice for laying glazed stone ware pipes.

14.7.1. Trenches

14.7.1.1. Specifications described in 14.6.1 shall apply, as far as possible.

14.7.1.2. The trench shall be so dug that the pipe can be laid to the required alignment and at the required depth. When the pipe line is under a roadway, a minimum cover of 90 cm is recommended for adoption, but it may be modified to suit local conditions. The trench shall be excavated only so far in advance of pipe laying as specified by the Engineer. The trench shall be so shored and drained that the workmen may work therein safely and efficiently. The discharge of the trench dewatering pumps shall be conveyed either to drainage channels or to natural drains.

14.7.1.3. The excavation shall be carried out with manual labour or with suitable mechanical equipment as approved by the Engineer.

14.7.1.4. Unless otherwise specified by the Engineer-in-charge, the width at bottom of trenches for different diameters of pipes laid at different depths shall be as given below:-

a) For all diameters, upto an average depth of 120 cm, width of trench in cm shall be equal to External diameter of pipe + 30 cm.

b) For all diameters for depths above 120 cm, width of trench in cm shall be equal to External diameter of pipe + 40 cm.

c) Notwithstanding (a) and (b) the total width of trench shall not be less than 75 cm for depths exceeding 90 cm.

The width of trench in the upper reaches shall be increased as directed by the Engineer.

14.7.2. Laying (Fig. 14.14)

14.7.2.1. All pipes shall be laid on a bed of cement concrete with thickness and mix as specified, projecting on each side of the pipe to the specified width of the trench. The pipes with their crown level at 1.20 m depth and less from ground shall be covered with 15 cm thick. Concrete above the crown of the pipe and sloped off to meet the outer edges of the concrete, to give a minimum thickness of 15 cm all around the pipe (**Fig. 14.14**). Pipes laid at a depth greater than 1.20 m at crown shall be concreted at the sides upto the level of the centre of the pipe and sloped off from the edges to meet the pipe tangentially (**Fig. 14.14**). Concreting shall be paid for separately, but nothing extra shall be paid for rounding or sloping of the concrete surface.

14.7.2.2. The pipe shall be carefully laid to the alignments, levels and gradients shown on the plans and sections. Great care shall be taken to prevent sand etc. from entering the pipes. The pipes between two manholes shall be laid truly in a straight line without vertical or horizontal undulation. All junctions and changes in directions and diameter shall be made inside manholes by means of curves/tapered channels formed in cement concrete finished smooth and benched on both sides. The pipes shall be laid with socket up the gradient. The body of the pipe shall for its entire length rest on an even bed of concrete and places shall be excavated in the concrete to receive the socket of the pipe. The pipes shall be laid socket up the gradient.

14.7.2.3. Where pipes are not bedded on concrete, the trench floor shall be left slightly high and carefully bottomed up as pipe laying proceeds, so that the pipe barrels rest on firm and undisturbed ground. If the excavation has been carried too low due to negligence by the contractor the desired levels shall be made up with concrete 1:5:10 (1 cement: 5 fine sand: 10 graded stone

aggregate 40 mm nominal size) for which no extra payment shall be made.

14.7.2.4. If the floor of the trench consists of rock or very hard ground that cannot easily be excavated to smooth surface the pipe shall be laid on a levelling course of concrete.

14.7.2.5. When S.W. pipes are used for storm water drainage, no concreting will normally be necessary. The cement mortar for jointing will be 1:3 (1 cement: 3 fine sand). Testing of joints will also not be done, and no recovery made on this account

14.7.3. Jointing

14.7.3.1. Tarred gasket of hemp yarn soaked in thick cement slurry shall first be placed round the spigot of each pipe and the spigot shall then be slipped home well into the socket of the pipe previously laid. The pipe shall then be adjusted and fixed in the correct position and the gasket caulked tightly home so as to fill not more than 1/4th of the total depth of the Socket or 1-3cm in depth.

14.7.3.2. The remainder of the socket shall be filled with stiff mixture of cement mortar in the proportion of 1:1 (1 cement: 1 fine sand). When the socket is filled, a fillet shall be formed round the joint with a trowel forming an angle of 45 degree with the barrel of the pipe.

14.7.3.3. After a day's work any extraneous material shall be removed from the inside of the pipe. The newly made joints shall be cured for at least seven days.

14.7.3.4. Mortar shall be mixed as required for immediate use and no mortar shall be beaten up and used after it has begun to set.

14.7.3.5 **Curing:-** Newly made joints shall be protected, until set, from the sun, drying winds, rain or frost. Sacking or other suitable materials, which shall be kept damp, may be used for the purpose. Cement mortar joints shall be cured for atleast 7 days.

14.7.4. Testing of joints.

14.7.4.1. Stoneware pipes used for sewers shall be subjected to a test pressure of 2.5 m head of water at the highest point of the section under test. The test shall be carried out by suitably plugging the lower end of the drain and the ends of the connection if any and filling the system with water. A knuckle bend shall be temporarily jointed in at the top end and a sufficient length of vertical pipe jointed to it so as to provide the required test head, or the top may be plugged with a connection to a hose ending in a funnel

which could be raised or lowered till the required head is obtained and fixed suitable for observation. The test will be for an hour or such longer period as may be decided upon by the Engineer. If the water level in the funnel during the test period does not fall more than 1 cm in a length of 175m of the sewer, the joint may be considered satisfactory.

14.7.4.2. If any leakage is visible, the defective part of the work shall be cut out and made good. A slight amount of sweating which is uniform may be overlooked, but excessive sweating from a particular pipe or joint shall be watched for and taken as indicating a defect to be made good.

14.7.4.3. Any joint found leaking or sweating, shall be rectified or embedded into 15 cm layer of cement concrete (1:2:4) 30 cm in length and the section retested.

14.7.5. Tests for straightness and Obstruction: These tests shall be carried out:-

a) by inserting at the high end of the sewer or drain, a smooth ball of a diameter 15mm less than the pipe bore. In the absence of obstruction, such as yarn or mortar projecting through the joints, the ball should roll down the invert of the pipe and emerge at the lower end; and

b) by means of a mirror at one end of the line and lamp at the other. If the pipe line is straight, the full circle of light can be observed. If the pipe line is not straight, this will be apparent. The mirror will also indicate obstructions in the barrel.

14.7.6. Refilling : In cases where pipes are not bedded on concrete special care shall be taken in refilling trenches to prevent the displacement and subsequent settlement at the surface resulting in uneven street surfaces and dangers to foundations etc. The backfilling materials shall be packed by hand under and around the pipe, and rammed with a shovel and light tamper. This method of filling will be continued upto the top of pipe. The refilling shall rise evenly on both sides of the pipe continued upto 60 cm above the top of pipe so as not to disturb the pipe. No tamping should be done within 15 cm of the top of pipe. Filling shall continue in layer not exceeding 15cm in thickness both layer being watered as well and well rammed)

14.7.7 Precautions

(a) All pipes, water mains, cables, etc met within the course of excavation shall be

carefully protected and supported by timbers and / or chains or rope slings. Care shall be taken not to disturb the electrical and communication cables, removal of which, if necessary, shall be arranged by the Engineer.

(b) The contractor shall be responsible for providing the requisite fencing, watchmen and red light during night to guard against any accident.

(c) To avoid clogging of drains, both ends shall be kept plugged until the construction of manholes is completed in every respect. On completion, care shall be taken that each plug is removed and the face of the drain made smooth.

14.7.8. Measurements : The lengths of pipes shall be measured in running metres nearest to a cm as laid or fixed, from inside of one manhole to the inside of the other manhole. The length shall be taken along the centre line of the pipes over all fittings such as bends, junctions, etc. which shall not be measured separately. Excavation, refilling, shoring and timbering in trenches, and cement concreting wherever required shall be measured separately under relevant items of work.

14.7.9. Rate : The rate shall include the cost of materials and labour involved in all the operations described above excluding the cost of Excavation, refilling, shoring, timbering in trenches and concrete which shall be paid for separately.

14.8. FIXING S.W. GULLY TRAP (FIG. 14.15A TO 14.15D)

14.8.1. Excavation : The excavation for gully traps shall be done true to dimensions and levels as indicated on plans or as directed by the Engineer.

14.8.2. Fixing : The gully traps shall be fixed on cement concrete foundation 70 cm square and not less than 10 cm thick. The mix for the concrete will be 1:5:10 (1 cement: 5 fine sand: 10 graded stone aggregate 40 mm nominal size). The jointing of gully outlet to the branch drain shall be done similar to jointing of S.W. pipes described in para 14.7.3.

14.8.3. Brick Masonry Chamber : (Fig. 14.15 A and C) After fixing and testing gully and branch drain, a brick masonry chamber 300 x 300 mm (inside) in brick work of specified class in cement mortar 1:6 (1 cement: 6 fine sand) shall be built with a half brick thick brick work round the gully trap from the top of the bed concrete upto ground level. The space between the chamber walls

and the trap shall be filled in with cement concrete 1:5:10 (1 cement: 5 fine sand: 10 graded stone aggregate 40 mm nominal size). The upper portion of the chamber i.e. above the top level of the trap shall be plastered inside with cement mortar 1:3 (1 cement: 3 coarse sand), finished with a floating coat of neat cement. The corners and bottom of the chamber shall be rounded off so as to slope towards the grating.

C.I. cover with frame 300 x 300 mm (inside) shall then be fixed on the top of the brick masonry with cement concrete 1:2:4 (1 cement: 2 coarse sand: 4 graded stone aggregate 20 mm nominal size) and rendered smooth. The finished top of cover shall be left about 4 cm above the adjoining ground level so as to exclude the surface water from entering the gully trap.

14.8.4 : Random rubble stone masonry chamber: Instead of brick masonry chamber as shown in **Figure 14.15A** for 10 cm S.W. Gully Trap and **Figure 14.15C** for 15cm S.W. Gully trap. Random Rubble Stone Masonry can also be used where convenient. They are shown in **Figure 14.15B** for 10cm S.W. Gully trap and **Fig. 14.15D** for 15cm S.W. Gully Trap.

14.8.5. Measurements : The work shall be enumerated. Excavation shall be measured separately under relevant item of earth work.

14.8.6. Rate : The rate shall include the cost of materials and labour involved in all the operations described above, except earthwork which shall be paid for separately.

14.9. CONSTRUCTING ROAD GULLY CHAMBER WITH GRATING

14.9.1. Road Gully chamber with Horizontal Grating (Fig. 14.2 & 14.3) : The chamber shall be of brick masonry of specified class and shall have a C.I. grating with frame fixed in 15 cm thick cement concrete 1:2:4 (1 cement: 2 coarse sand: 4 graded stone aggregate 20 mm nominal size) at the top. The size of the chamber shall be taken as the clear internal dimensions of the C.I. frame. The chamber shall have a connection pipe, the length of which in metre between the road gully chamber and the manhole of the drain shall not be less than one by forty (1 /40) times the nominal diameter of pipe in mm (i.e. for 150 mm connection pipe, length shall not be less than 3.7 m and for 250 mm connection pipe length shall not be less than 6.25 m). The chamber shall be built at the location fixed by the Engineer-in-Charge. Generally

the spacing of the chambers shall be 18 to 36 m depending upon the grading of the road channel and the area of the drainage. R.C.C. gully grating shall be fixed in cement mortar 1:2 (1 cement: 2 coarse sand) as shown in **Fig. 14.2**. For details refer to IS 7740-1985 –Code of practice for Construction and Maintenance of Road Gullies.

14.9.2. Road Gully Chamber with Vertical Grating (Fig. 14.3) : The chamber shall be of brick masonry 12 mm dia round bar shall be fixed in cement concrete block at the bottom. The bars at the top shall be welded or riveted to M.S. flat 40 x 6 mm as shown in **Fig. 14.3**. The specifications shall be same as described in para 14.10.1.

14.9.3. Road Gully Chamber with Horizontal and Vertical Grating : The details of typical road gully chamber of brick masonry shall be same as shown in **Fig. 14.3**

14.9.4. Measurements Road gully chambers shall be enumerated.

14.9.5. Rate : The rate shall include the cost of materials and labour involved in all the operations described above except the cost of excavation and connection pipes.

14.10. CONSTRUCTING BRICK MASONRY GREASE TRAP (FIG. 14.17)

14.10.0. General: The internal size of the trap shall be 80 x 40 x 46 cm. The height shall be measured from the top of the floor to the top of the cover. 40 mm thick stone baffles / RCC precast slabs shall be fixed 50 mm deep in masonry with cement mortar 1:4 (1 cement: 4 fine sand), as shown in the **Fig. 14.17**. The connection of open surface, drain with a soak pit shall be invariably through a grease trap. It should be covered with stone slab / RCC precast slab.

14.10.1. Measurements : Grease traps shall be enumerated.

14.10.2. Rate : The rate shall include the cost of labour and materials required for all the operations described above.

14.11. CONSTRUCTION OF SEPTIC TANK - (FIG. 14.18)

14.11.0. General: In unsewered area, every house shall have arrangements for its sewage being treated in septic tank, effluent from which should be given secondary treatment either in a biological filter or on the land, or in a sub-surface disposal system.

For details IS 2470-1985 Code of Practice for installation of septic tank may be referred.

Surface and sub-soil water should be excluded from finding way into the septic tank. Waste water may be passed into the septic tank provided the tank and the means for effluent disposal are designed to cope up with this extra liquid. Depending on the location of the water table and the nature of the strata, the type of disposal for the effluent from the septic tank shall be decided.

14.11.1. Dimensions : Septic tanks shall have minimum width of 75 cm, minimum depth of one metre below water level and a minimum liquid capacity of the one cubic metre. Length of tanks shall be 2 to 4 times the width. Suitable sizes of septic tanks for use of 5, 10, 15, 20 and 50 persons based on certain assumptions are given in **Annexure 14.3**.

14.11.2. Cover and Frame : Every septic tank shall be provided with C.I. cover of adequate strength. The cover and frames shall be 500 mm dia. (M.D.) minimum or 610 mm x 455 mm (LD). The specification for frames and cover given in para 14.2.2 shall apply. As an alternate RCC slabs may be permitted in lieu of CI covers.

14.11.3. Ventilating Pipe : Every septic tank shall be provided with C.I. ventilating pipe of at least 50 mm diameter. The top of the pipe shall be provided with a suitable cage of mosquito proof wire mesh.

The ventilating pipe shall extend to a height which would cause no smell nuisance to any building in the area. Generally the ventilating pipe may extend to a height of about 2 m, when the septic tank is at least 15 m away from the nearest building and to a height of 2 m. above the top of the building when it is located closer than 15 metres. The ventilating pipe may also be connected to the normal soil ventilating system of the building where so desired.

14.11.4. Disposal of Sludge : The sludge from septic tanks may be delivered into covered pit or into a suitable vehicle for removal from the site. Spreading of sludge on the ground in the vicinity shall not be allowed.

14.11.5. Testing : Before the tank is commissioned for use, it shall be tested for water-tightness by filling it with water and allowing it to stand for 24 hours. It shall then be topped up, if necessary, and allowed to stand for a further period of 24 hours during

which time the fall in the level of the water shall not be more than 1.5 cm.

14.11.6. Commissioning of Septic Tank.

The tank shall be filled with water to its outlet level before the sewage is let into the tank. It shall, preferably, be seeded with small quantities of well digested sludge obtained from septic tanks or sludge digestion tanks. In the absence of digested sludge a small quantity of decaying organic matter, such as digested cow dung, may be introduced.

14.11.7. Sub-surface Absorption System :

The effluent from septic tank shall be disposed of by soak pit or dispersion trench depending on the position of the sub-soil water level, soil and sub-soil conditions and the size of the installation.

14.11.8. Measurements : All the relevant items may be paid separately under the relevant item as excavation, brick masonry, flooring, plaster, CC, pre cast RCC, CI cover, ventilation pipes, water proofing compound cowl etc,

14.11.9 Rate: Rate shall include cost of materials and labour involved in relevant items.

14.12. SOAK PIT – 2.5M DIA x 3 M DEEP (FIG. 14.19)

14.12.1. Construction : The earth excavation shall be carried out to the exact dimensions as shown in the figure. In the soak pit shall be constructed a honey-comb dry brick shaft 45x45 cm and 292.5 cm high. Round the shaft and within the radius of 60 cm shall be placed. well burnt brick bats. Brick ballast of, size from 50 to 80 mm nominal size shall be packed round the brick bats upto the radius of 90 cm. The remaining portion shall be filled with brick ballast of 40 mm nominal size. The construction of shaft and filling of the bats and the ballast shall progress simultaneously.

14.12.2. Cover and Drain : Over the filling shall be placed a single matting which shall be covered with minimum-layer of 7.5 cm earth. The shaft shall be covered with 7.5 cm thick stone or. R.C.C. slab, 11 cm wide and 15 cm deep brick edging with bricks of class designation 75 shall be provided round the pit. The connection of the open surface drain to the soak pit shall be made by means of 100 mm diameter S.W. pipe with open joints.

14.12.3. Measurements : Soak pit shall be enumerated if constructed as per SOR item otherwise various items may be paid separately under the relevant items.

14.12.4. Rate : Rate shall include the cost of labour and material involved in all the operations / separate different items described above.

14.13. DESLUDGING OF SEPTIC TANKS

Septic tanks shall be de-sludged periodically, the intervals of de-sludging, depending upon the design of the septic tanks and the capacity in relation to its users. De-sludging may be done when the sludge level reaches a predetermined level. A portion of the sludge may be left in the tank to seed the fresh deposits. De-sludging shall preferably be carried out by hydrostatic head or by using a portable pump. Manual handling of sludge shall be discouraged.

14.14. VENT SHAFT

14.14.1 Vent shaft Location : Vent shaft shall be provided at the starting point of the main sewer and at such points where the flow is distributed e.g. at falls, siphons etc. As far as possible, the location shall be at such a place where it receives sun rays for the maximum period of the day.

14.14.2 Design : Vent shaft shall be of S.C.I. pipe or of RCC manufactured by centrifugal spun process. RCC vent shaft shall be provided as per **Figure 14.21**.

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ANNEXURE 14.1**IS 1748:1988 – CODE OF PRACTICE FOR
BUILDING DRAINAGE – SOME
IMPORTANT CLAUSES****4.0 Design consideration**

4.1 Aim: In designing a drainage system for individual building (s), the aim shall be to provide a system of self-cleansing conduits for the conveyance of soil, waste, surface or sub-surface waters and for the removal of such wastes speedily and efficiently to a sewer or other outlet without risk of nuisance and hazard to health.

4.3.4 Additional requirements: The pipes shall be laid in straight lines as far as possible and with uniform gradients. Anything that is likely to cause irregularity of flow, such as, abrupt changes of directions shall be avoided. No bends and junctions whatsoever shall be permitted in sewers except for manholes and inspection chambers.

4.3.4.1 Where it is not possible to avoid a change of direction in the case of drains, access shall be provided through manholes and inspection chambers. Necessary terminal bends at junctions shall be 1/8 or preferably 1/16 bends.

4.3.4.2 All junctions shall be oblique and the contained angle shall not be more than 60 deg.

4.3.4.3 Drains may be laid under the buildings only when unavoidable and when it is not possible to obtain otherwise a sufficient fall in the drain.

4.3.4.4 Where it is necessary to lay a drain under a building or exposed locations within the building, the following conditions shall be observed:

- a. Pipes shall be of cast iron (see IS 1536-1976 and IS: 1537-1976)
- b. The drains shall be laid in a straight line and at a uniform gradient;
- c. Means of access in the form of manholes/inspection chambers shall be provided at each end, immediately outside the building.
- d. In case the pipe or any part of it is laid above the natural surface of the ground, it shall be laid on concrete supports the bottom of which goes at least 150mm below the ground surface.

e. It is desirable that drains should not be taken through a living room or kitchen and shall preferably be taken under a staircase room or a passage.

4.3.4.5 Surcharge of sewers (precautions): Where there is a risk of the sewer becoming surcharged under storm conditions all gullies and sanitary fittings shall be located above the level of maximum surcharge of the sewer. Where this is not practicable, an anti-flood valve shall be provided in the manhole nearest to the junction of the drain and sewer. Parts exposed to wear in anti-flood valves shall be of non-corrodable metal and easily accessible. The cross-sectional area of flow through the valve shall not be less than that of the pipe connected. In extreme cases, pumping may have to be considered.

4.3.4.6 The distance between inspection chamber and gully chamber shall not exceed 6 m.

4.7 CHOICE OF MATERIALS

4.7.1 Salt glazed stoneware Pipes: For all sewers and drains in all soils, except where supports are required as in made-up ground, glazed stoneware pipe shall be used as far as possible in preference to other type of pipes; they are particularly suitable where acid effluents or acid subsoil conditions are likely to be encountered. Salt glazed stoneware pipes shall conform to IS 651-1980 or IS:3006-1979.

4.7.2 Cement Concrete pipes: When properly ventilated, cement concrete pipes with spigot and socket or collar joints present as alternative to glazed stoneware sewers over 150mm diameter. These shall not be used to carry acid effluents or sewage under condition favourable for the production of hydrogen sulphide and shall not be laid in those sub-soils which are likely to affect adversely the quality or strength of concrete. Cement concrete pipes may be used for surface water drains in all diameters. These pipes shall conform to IS 458-1971. Where so desired the life of cement concrete pipe may be increased by lining inside of the pipe by suitable coatings like epoxy/polyester resin, etc

4.7.3 Cast Iron Pipes: Cast iron pipes (see IS : 1536-1976 and IS:1537-1976) shall be used in the following situations.

- (a) In bad or unstable ground where soil movement is expected.
- (b) In made-up or tipped ground
- (c) To provide for increased strength where a sewer is laid at insufficient depth,

where it is exposed or where it has to be carried on piers or above ground.

(d) Under buildings and where pipes are suspended in basements and like situations.

(e) In reaches where the velocity is more than 2.4m/sec and

(f) For crossings of water courses.

4.7.3.1 It shall be noted that cast iron pipes even when given as protective paints are liable to severe external corrosion in certain soils. Among such soils are

(a) Soils permeated by peaty waters and

(b) Soils in which the subsoil contains appreciable concentrations of sulphates. Local experiences shall be ascertained before cast iron pipes are used where corrosive soil conditions are suspected. Where so used, suitable measures for the protection of the pipes may be resorted to as an adequate safeguard.

4.7.4 **Asbestos cement pipes:** Asbestos cement pipes are commonly used for house drainage systems and they shall conform to the requirements specified in IS:1626 (Part I)-1980. They are not recommended for underground situations. However, asbestos cement pressure pipes conforming to the requirements specified in IS:1592-1980 may be used in underground situations also provided they are not subjected to heavy superimposed loads. These shall not be used to carry acid effluents or sewage under conditions favourable for the production of hydrogen sulphide and shall not be laid in those sub-soils which are likely to affect adversely the quality or strength of asbestos cement pipes. Where so desired, the life of asbestos cement pipes may be increased by lining inside of the pipe by suitable coatings like epoxy/polyester resins, etc

4.7.5 **Lead pipes:** Branch soil pipes from fittings to main soil pipes and branch waste pipes from fittings to main stack and branch antisiphonage pipes may be of lead and shall conform to IS :404 (Part I) 1977.

4.7.8 **PVC pipes:** Unplasticized PVC pipes may be used for drainage purposes; however, where hot water discharge is anticipated, the wall thickness should be at least 3mm irrespective of the size and flow load, UPVC pipe shall conform to IS 1985-1981.

Note: Where possible, high density polyethylene pipes (HDPE) and UPVC pipes may be used for drainage and sanitation purposes, depending upon suitability. HDPE pipes shall conform to IS 4984-1978.

4.8. **Drainage pipes:** Drainage pipes shall be kept clear of all other services. Provisions shall be made during the construction of the building for the entry of the drainage pipes. In most cases, this may be done conveniently by building sleeves or conduit pipes into or under the structure in appropriate positions. This will facilitate the installation and maintenance of the services.

4.8.1 Where soil and ventilating pipes are accommodated in ducts, access to cleaning eyes shall be provided. Any connection to a drain shall be through a gully with scaled cover to guard against ingress of sewer gas, vermin or backflow. Trenches and subway shall be ventilated, preferably to the open air.

4.8.2 All vertical soil, waste, ventilating and anti-siphonage pipes shall be covered on top with a copper or heavily galvanized iron wire dome or cast iron terminal guards. All cast iron pipes which are to be painted periodically shall be fixed suitably to the wall to give a minimum clearance of 50mm.

Note: Asbestos Cement cowls may be used in case asbestos cement pipes are used as soil pipe.

4.8.3 Drainage pipes shall be carried to a height above the buildings as specified for ventilating pipe (see IS 5329-1983).

5. CONSTRUCTIONS RELATING TO CONVEYANCE OF SANITARY WASTES

5.1 **Pipe Lines and jointing:** All soil pipes, waste pipes, ventilating pipes and all other pipes, when above ground, shall be gas tight. All sewers and drains laid below ground shall be water tight.

5.2 **Jointing Lead and Iron Pipes:** Where any lead waste pipe, ventilating pipe or trap is connected with an iron pipe or drain communicating with a sewer these shall be inserted between such lead waste pipe and such iron pipe or drain an ordinary thimble of copper or brass, which shall be connected to such lead waste pipe by means of a wiped joint. The thimble shall be connected with such cast iron pipe by means of a joint made with molten lead, properly caulked, a sufficient quantity lead being melted at a time to finish each joint at one pouring. (Note: For figure see IS 1742:1988)

5.3 **Jointing stoneware with Lead pipes:** Where any stoneware or semi-vitrified ware trap or pipe is connected with a lead soil pipe, waste pipe or trap communicating with a sewer, these shall be inserted between such stoneware or semi-vitrified ware trap or pipe and such lead soil pipe, waste pipe, or trap a socket of copper, cast brass or other

suitable alloy, which shall be connected with such stone-ware or semi-vitrified-ware trap or pipe by means of a joint made with mortar consisting of one part of cement and one part of coarse sand with the lead soil pipe, waste pipe or trap by means of wiped metallic joint. (Note:- For Figure see IS 1742:1988).

5.4 Jointing Cast Iron pipes with stoneware pipes: Where any cast iron soil pipe, waste pipe, ventilating pipe or trap is connected with a stone ware or semi-vitrified waste pipe or drain communicating with a sewer, the beaded spigot end of such cast iron soil pipe, waste pipe, ventilating pipe, or trap shall be inserted into a socket of such stoneware of semi-vitrified ware pipe or drain

and the joint made with mortar consisting of one part of cement and one part of clean coarse sand after placing a tarred gasket or hemp yam soaked in neat cement slurry round the joint and inserted in it by means of a caulking tool. (Note:- For Figure see IS 1742:1988).

5.4.1 Jointing stoneware with cast iron pipes: Where any water closet pan or earthenware trap connected to such pan is to be jointed with a cast iron soil pipe, the joint between the stoneware spigot and the cast iron socket shall always be of a flexible (non-rigid) nature. Such joint shall be made preferably with a mixture of bitumen and chopped asbestos fibre.(not dust.)

ANNEXURE 14.2

DIMENSIONAL REQUIREMENTS OF CONCRETE PIPES

A. CLASS NP-1 – UNREINFORCED NON-PRESSURE PIPES

Internal diameter of pipes mm	Barrel wall thickness mm	Collar Dimensions		
		Minimum Caulking mm	Minimum Thickness mm	Minimum Length mm
80	25	13	25	150
100	25	13	25	150
150	25	13	25	150
200	25	13	25	150
225	25	13	25	150
250	25	13	25	150
300	30	16	30	150
350	32	16	32	150
400	32	16	32	150
450	35	19	35	200

B. CLASS NP2- REINFORCED CONCRETE LIGHT DUTY, NON PRESSURE PIPES

Internal diameter of pipes Nominal mm	Barrel wall thickness mm	Collar Dimensions		
		Minimum Caulking mm	Minimum Thickness mm	Minimum Length mm
80	25	13	25	150
100	25	13	25	150
150	25	13	25	150
200	25	13	25	150
225	25	13	25	150
250	25	13	25	150
300	30	16	30	150
350	32	16	32	150
400	32	16	32	150

450	35	19	35	200
500	35	19	35	200
600	45	19	40	200
700	50	19	40	200
800	50	19	45	200
900	55	19	50	200
1000	60	19	55	200
1100	65	19	60	200
1200	70	19	65	200
1400	75	19	75	200
1600	80	19	80	200
1800	90	19	90	200
2000	100	19	100	200
2200	110	19	110	200

Note : 1. The effective length of barrel shall be 2m upto 250mm nominal diameter pipes and 2.5, 3.0, 3.5 or 4.0 m for pipes above 250mm

2. The actual internal diameter is to be declared by the manufacture and the

tolerance is to be applied on the declared diameter.

3. Minimum thickness and minimum length of collars shall be the same as that for the next higher size available in NP2 class pipes corresponding to the calculated.

C. CLASS NP3- REINFORCED CONCRETE, MEDIUM DUTY, NON PRESSURE PIPES

Internal diameter of pipes mm	Barrel Wall thickness mm
80	25
100	25
150	25
200	30
225	30
250	30
300	40
350	75
400	75
450	75
500	75
600	85
700	85
800	95
900	100
1000	115
1100	115
1200	120
1400	135
1600	140
1800	150
2000	170
2200	185
2400	200
2600	215

D. REINFORCED CONCRETE PRESSURE PIPES CLASS P1 TESTED TO TO 20M HEAD, CLASS P2 TESTED TO 40M HEAD AND CLASS P3 TESTED TO 60M HEAD

Internal diameter of pipes mm	Barrel Dimensions		
	Minimum Caulking mm	Minimum Thickness mm	Minimum Length mm
80	25	25	25
100	25	25	25
150	25	25	25
200	25	30	35
225	25	30	35
250	25	30	35
300	30	40	45
350	32	45	55
400	32	50	60
450	35	50	70
500	35	55	75
600	40	65	90
700	40	70	105
800	45	80	120
900	50	90	-
1000	55	100	-
1100	60	-	-
1200	65	-	-

Note: Collar dimensions will be same as operated for class NP2 pipe.

ANNEUXRE 14.3

RECOMMENDED SIZES OF SEPTIC TANKS

RECOMMENDED SIZES OF SEPTIC TANKS FOR 20 USERS

No. of users	Length m	Breadth m	Liquid depth (cleaning interval of	
			1 year m	2 year m
5	1.5	0.75	1.0	1.05
10	2.0	0.90	1.0	1.40
15	2.0	0.90	1.3	2.00
20	2.3	1.10	1.3	1.80

Note: 1. The capacities are recommended on the assumption that discharge from only WC will be treated in the septic tank.

2. A provision of 300mm should be made for free board

3. The sizes of septic tanks are based on certain assumptions, while choosing the size of septic tank exact calculation shall be made

RECOMMENDED SIZES OF SEPTIC TANKS FOR RESIDENTIAL COLONIES

No. of users	Length m	Breadth m	Liquid depth (cleaning interval of	
			1 year m	2 year m
50	5.0	2.0	1.0	1.24
100	7.5	2.65	1.0	1.24
150	10.0	3.0	1.0	1.24
200	12.0	3.3	1.0	1.24
300	15.0	4.0	1.0	1.24

1. A provision of 300mm should be made for free board

- The sizes of septic tanks are based on certain assumptions, while choosing the size of septic tank exact calculation shall be made
- For population over 100, the tank may be divided into independent parallel chambers for ease of maintenance and cleaning.

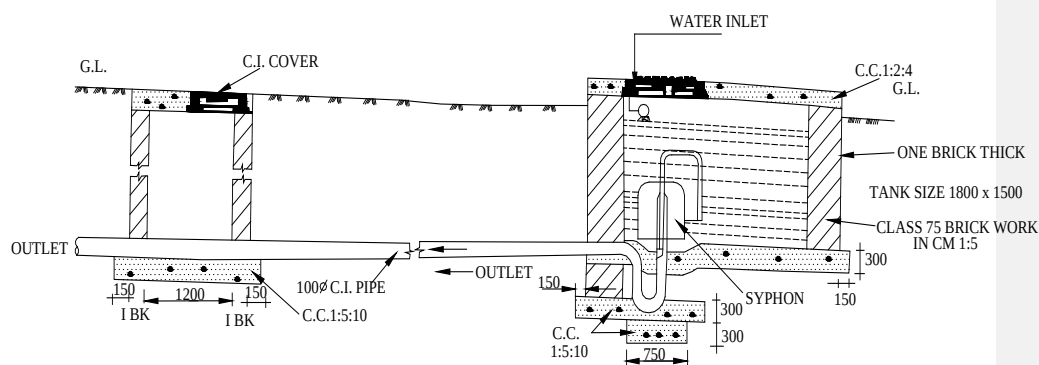
RECOMMENDED SIZES OF SEPTIC TANKS FOR HOSTEL AND BOARDING SCHOOLS

No. of users	Length m	Breadth m	Liquid depth (cleaning interval of	
			1 year m	2 year m
50	5.0	1.6	1.3	1.4
100	5.7	2.1	1.4	1.7
150	7.7	2.4	1.4	1.7
200	8.9	2.7	1.4	1.7
300	10.7	3.3	1.4	1.7

- A provision of 300mm should be made for free board
- The sizes of septic tanks are based on certain assumptions, while choosing the size of septic tank exact calculation shall be made
- For population over 100, the tank may be divided into independent parallel chambers for ease of maintenance and cleaning.

AUTOMATIC FLUSHING TANK

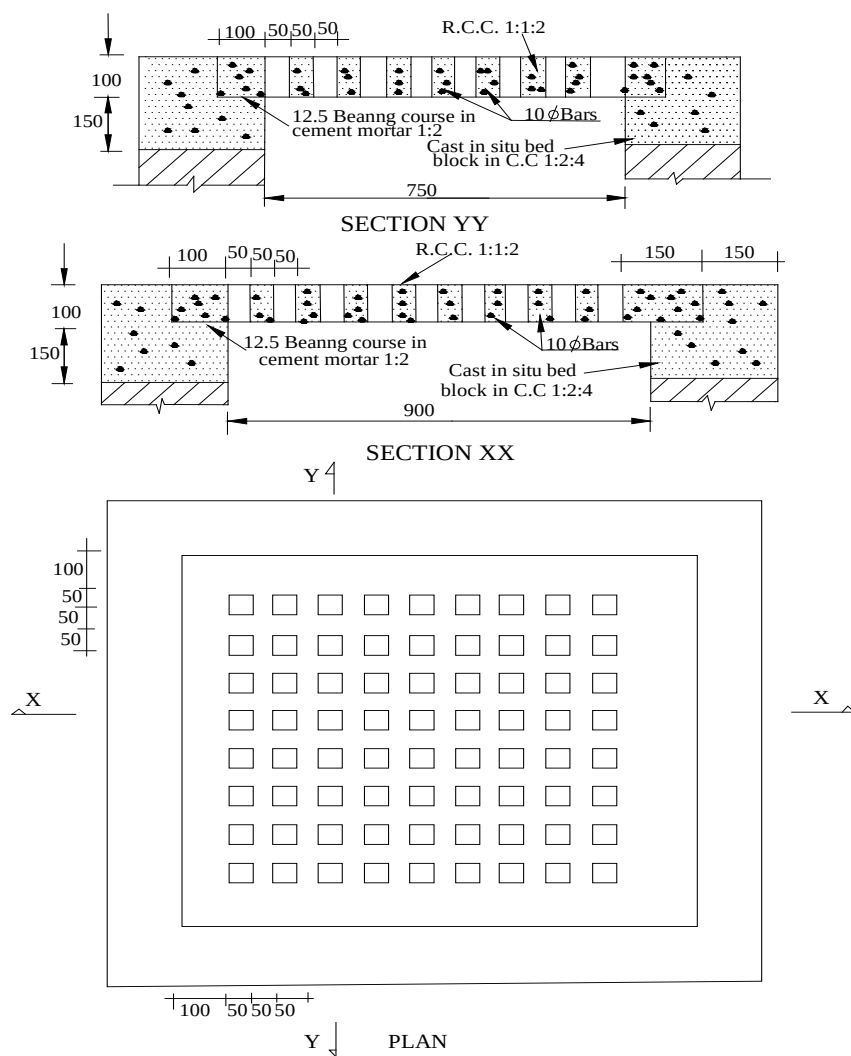
FIGURE 14.1



All dimensions are in mm
Drawings not to Scale

R.C.C. ROAD GRATING

FIGURE 14.2



CLEAR COVER OVER REINFORCEMENT SHALL BE 20 MM

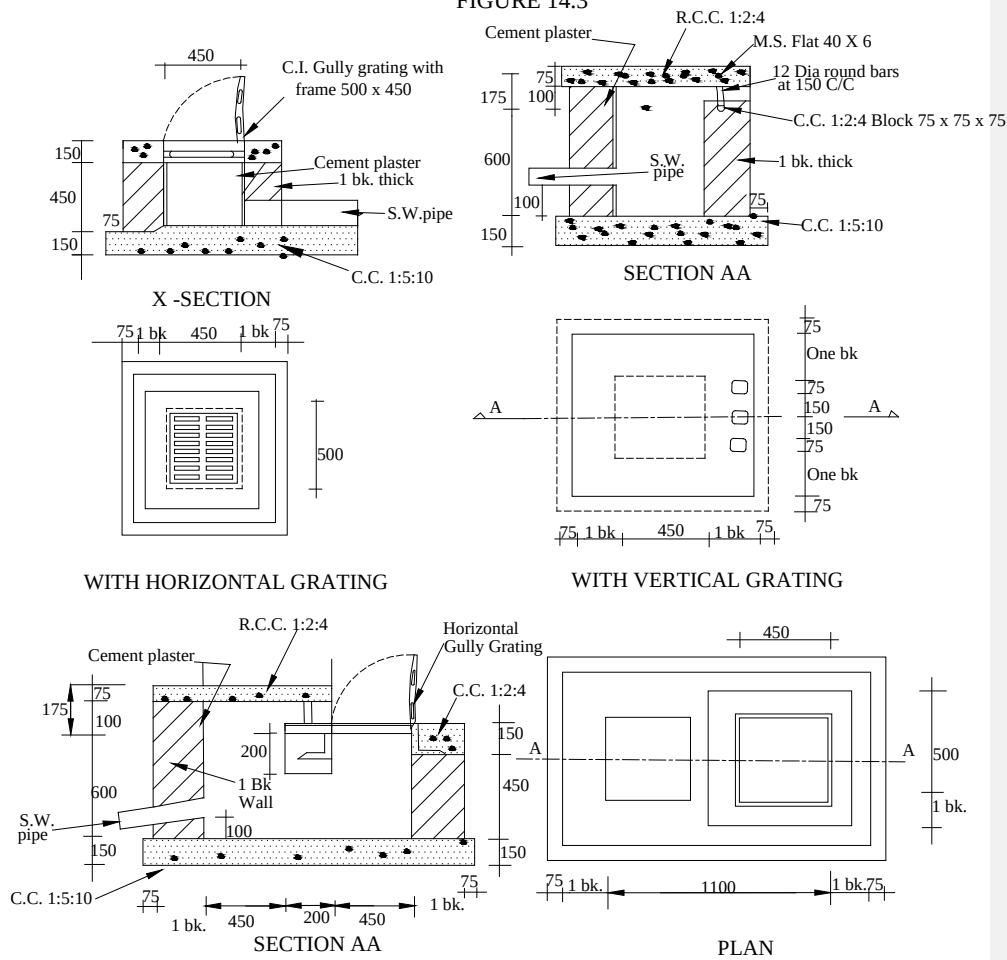
THE SLAB COVERS SHALL CAST IN R.C.C.. 1:1:2

THE R.C.C. COVER SHALL BE PROPERLY CURED

All dimensions are in mm
Drawings not to Scale

ROAD GULLY CHAMBER WITH HORIZONTAL GRATING

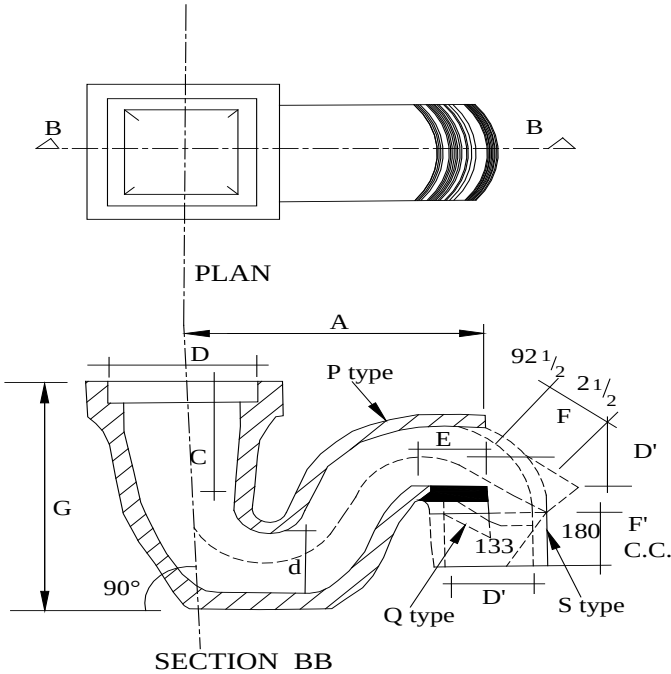
FIGURE 14.3



All dimensions are in mm
Drawings not to Scale

STONE WARE GULLY TRAP

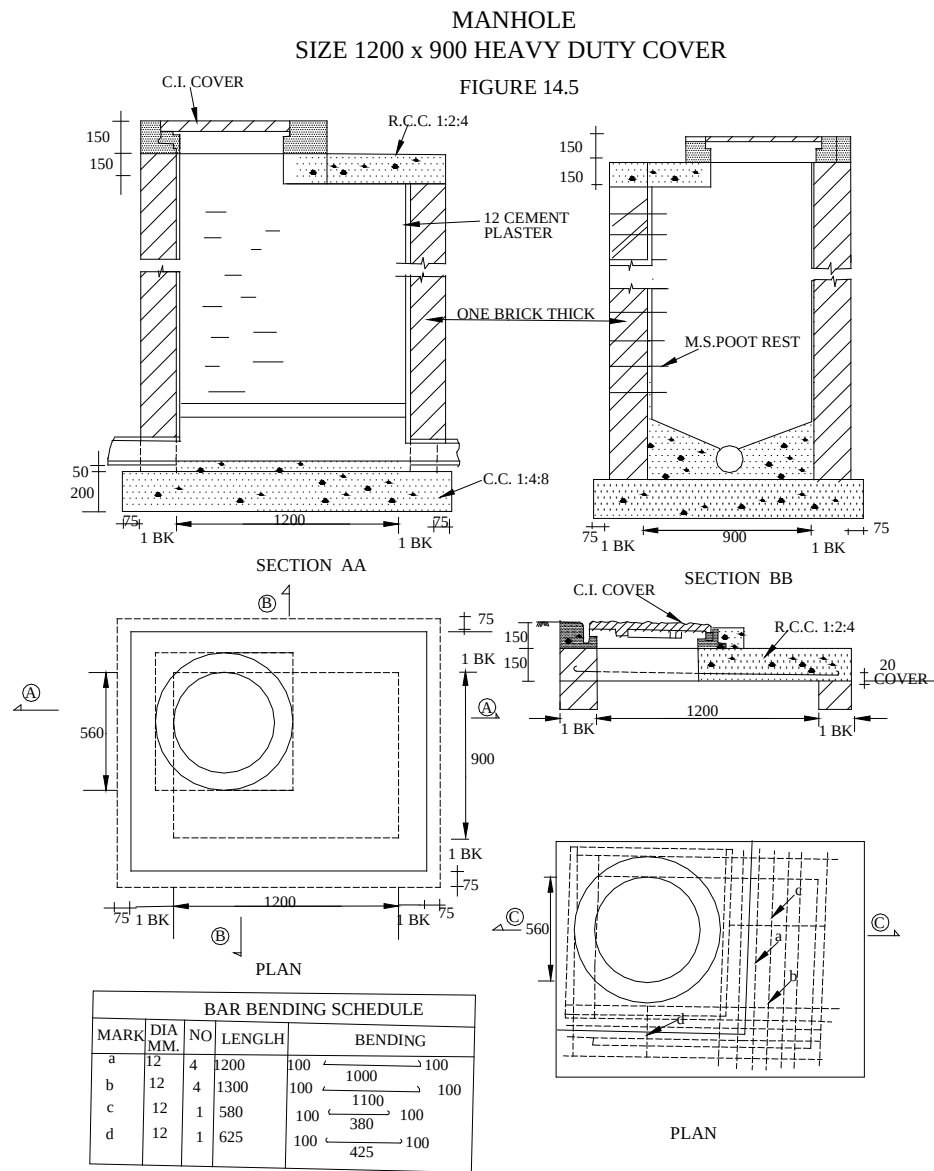
FIGURE 14.4



STONEWARE GULLY TRAP

Type	Size	A	C	d	D	D	E	F	F	G
P	100x100	305	175	100	100	100	65	-	-	330
P	125x100	265	165	75	125	100	60	-	-	345
P	150x100	330	165	100	150	100	75	-	-	346
P	180x100	320	200	75	180	100	65	-	-	380
P	180x150	405	270	140	180	150	75	-	-	520
Q	125x100	330	165	75	125	100	-	80	-	345
S	125x100	290	165	90	125	100	-	-	100	345
S	150x100	330	165	100	150	100	-	-	115	346
S	180x150	445	275	125	180	150	-	-	125	520

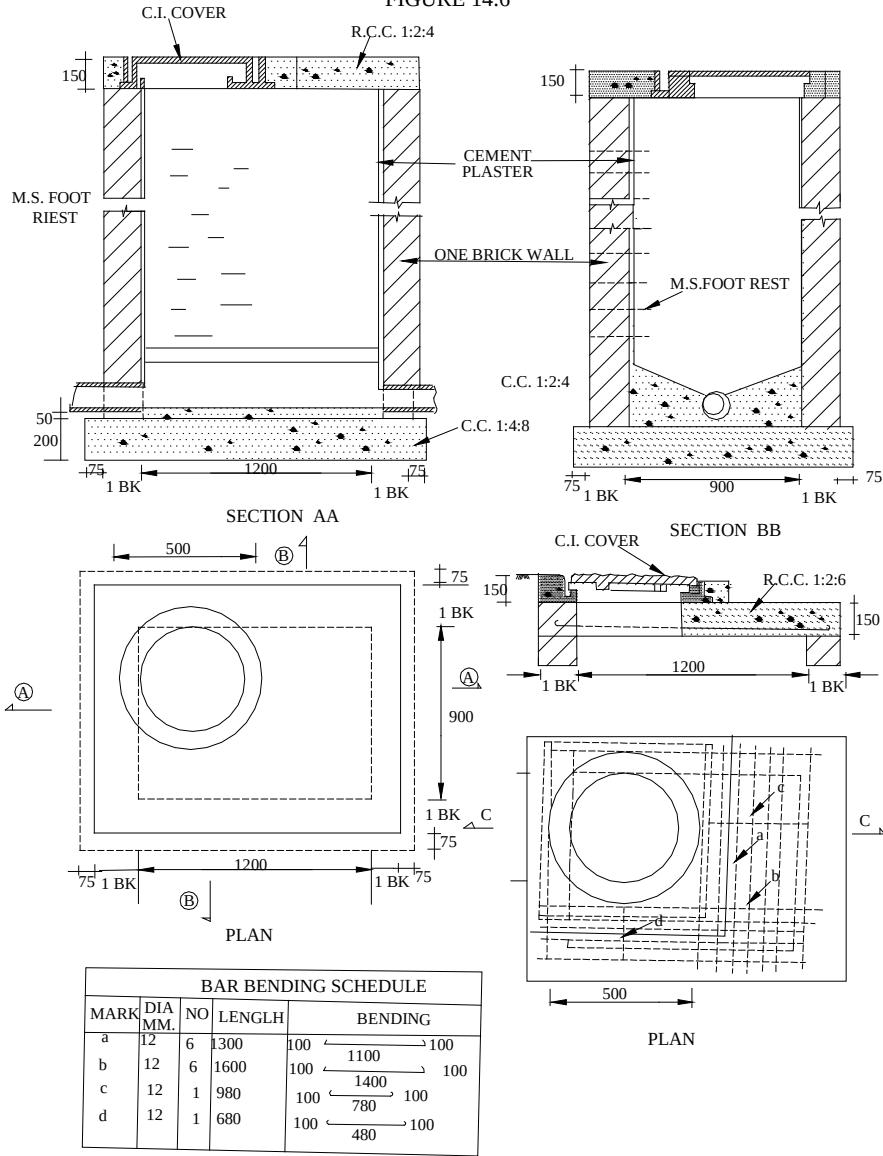
All dimensions are in mm
Drawings not to Scale



All dimensions are in mm
Drawings not to Scale

MANHOLE (CONTD.)
SIZE 1200 x 900 WITH MEDIUM DUTY COVER

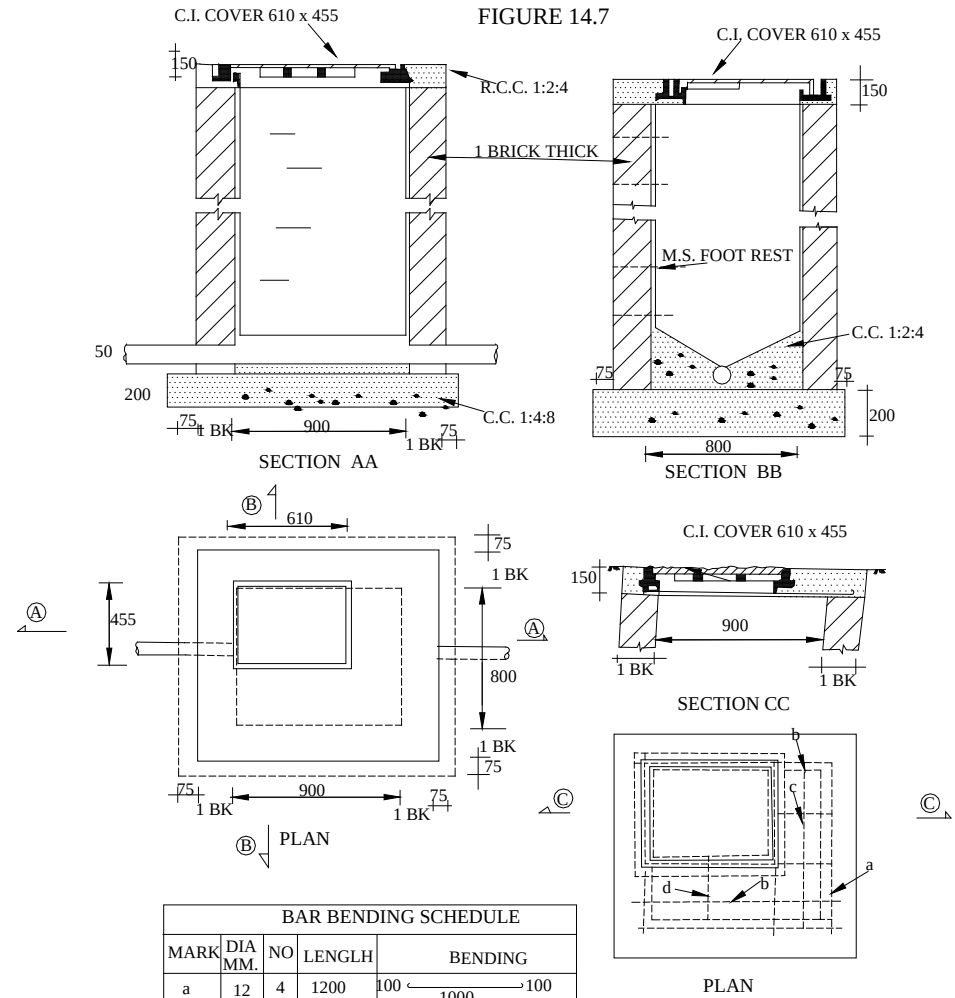
FIGURE 14.6



MANHOLE (CONTD)

SIZE 900 x 800 WITH LIGHT DUTY COVER

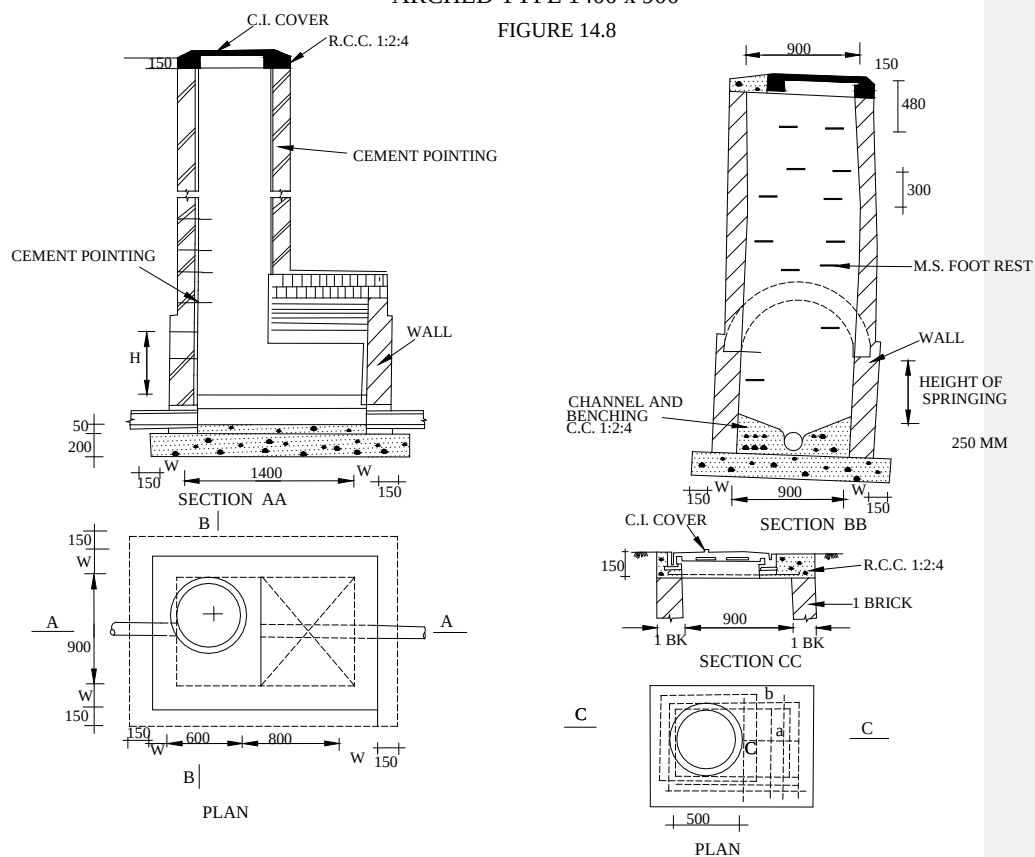
FIGURE 14.7



All dimensions are in mm
Drawings not to Scale

ARCHED TYPE 1400 x 900

FIGURE 14.8



DEPTH OF MANHOLE FROM TOP OF C.I. COVER	FROM TOP 4250 (W)	FROM 4250 TO 9750 FR- OM TOP (W)	BEYOND 9750 FROM TOP (W)	H	T
2450 to 4250	1 BK.	-	-	900	200
MORE THAN 4250 UP TO 9750	1 BK.	1½BK.	-	1800	300
MORE THAN 9750	1 BK.	1½BK.	2 BK.	1800	300

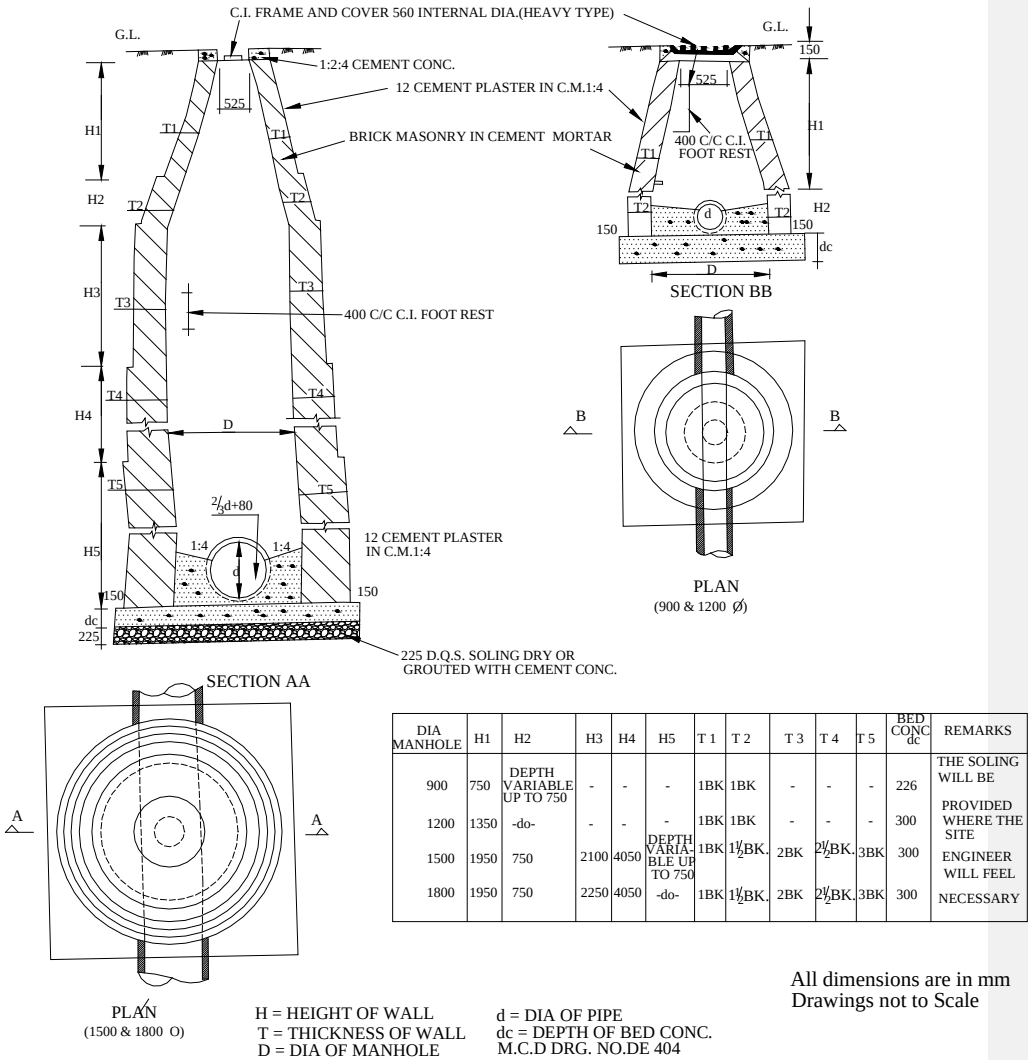
BAR BENDING SCHEDULE						
	MARK	DIA	NO	LENGTH	BENDING	
FOR MED- IUM DUTY	a	12	5	1000	100	$\overbrace{\hspace{1.5cm}}^{800}$ 100
	b	12	3	1300	100	$\overbrace{\hspace{1.5cm}}^{1100}$ 100
	c	12	1	880	100	$\overbrace{\hspace{1.5cm}}^{480}$ 100
FOR HEAVY DUTY	a	12	5	1000	100	$\overbrace{\hspace{1.5cm}}^{800}$ 100
	b	12	2	1300	100	$\overbrace{\hspace{1.5cm}}^{1100}$ 100
	c	12	1	620	100	$\overbrace{\hspace{1.5cm}}^{420}$ 100

W = WIDTH OF WALL.
H = HEIGHT OF SPRING OF ARCH ABOVE THE BENCHING LEVEL.
T = THICKNESS OF FOUNDATION CONCRETE

All dimensions are in mm
Drawings not to Scale

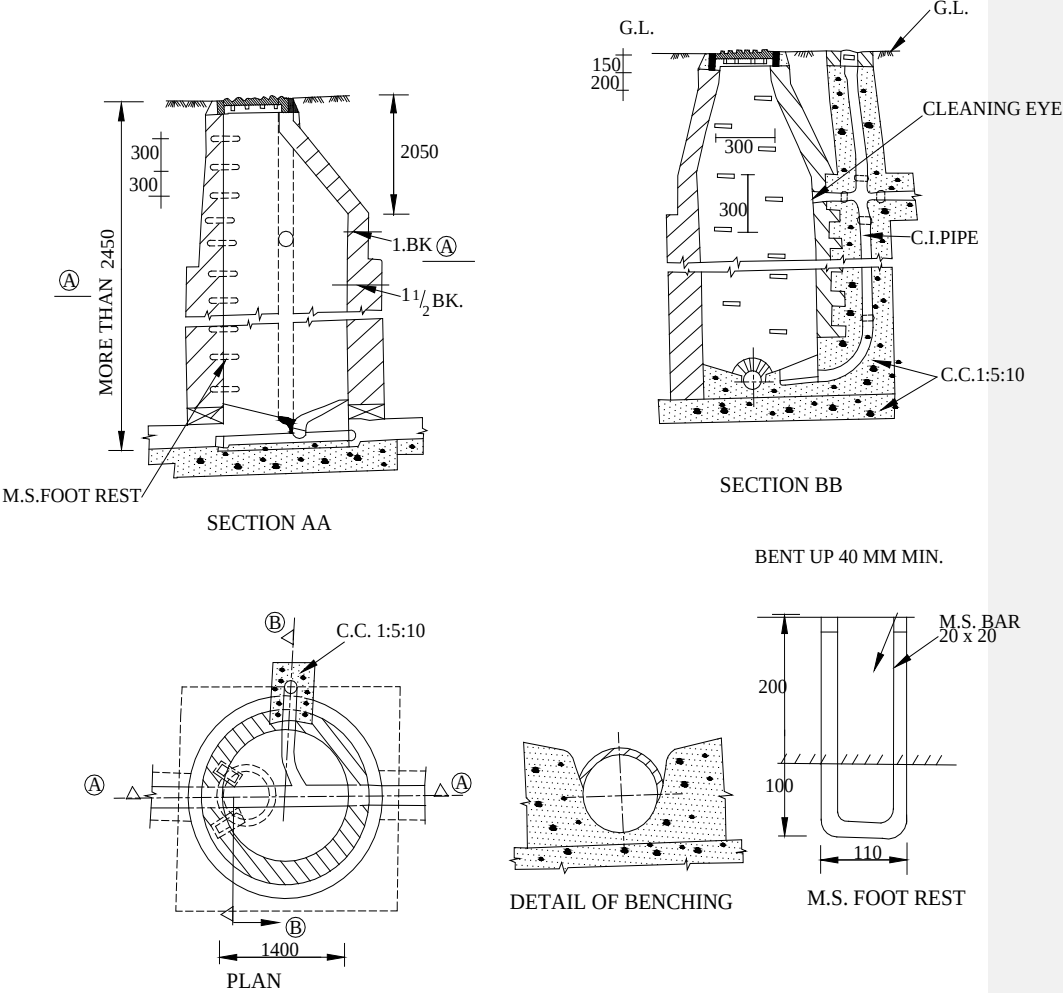
MANHOLE
(CIRCULAR TYPE 900x1800 MM DIA)

FIGURE 14.9



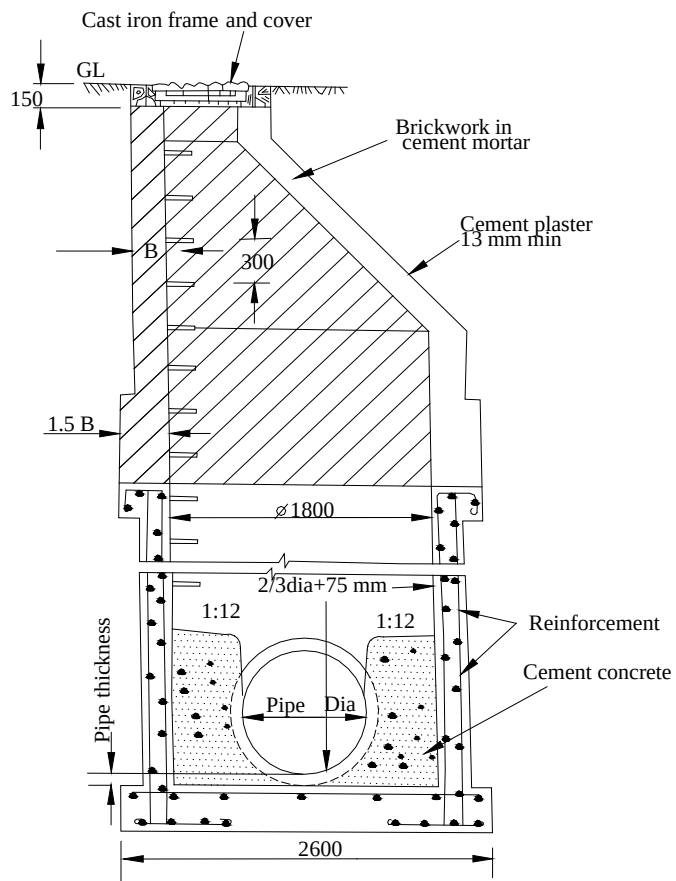
MANHOLE
(WITH DROP CONNECTIONS)

FIGURE 14.10



All dimensions are in mm
Drawings not to Scale

FIGURE 14.11
IS 4111-1986 Part 1

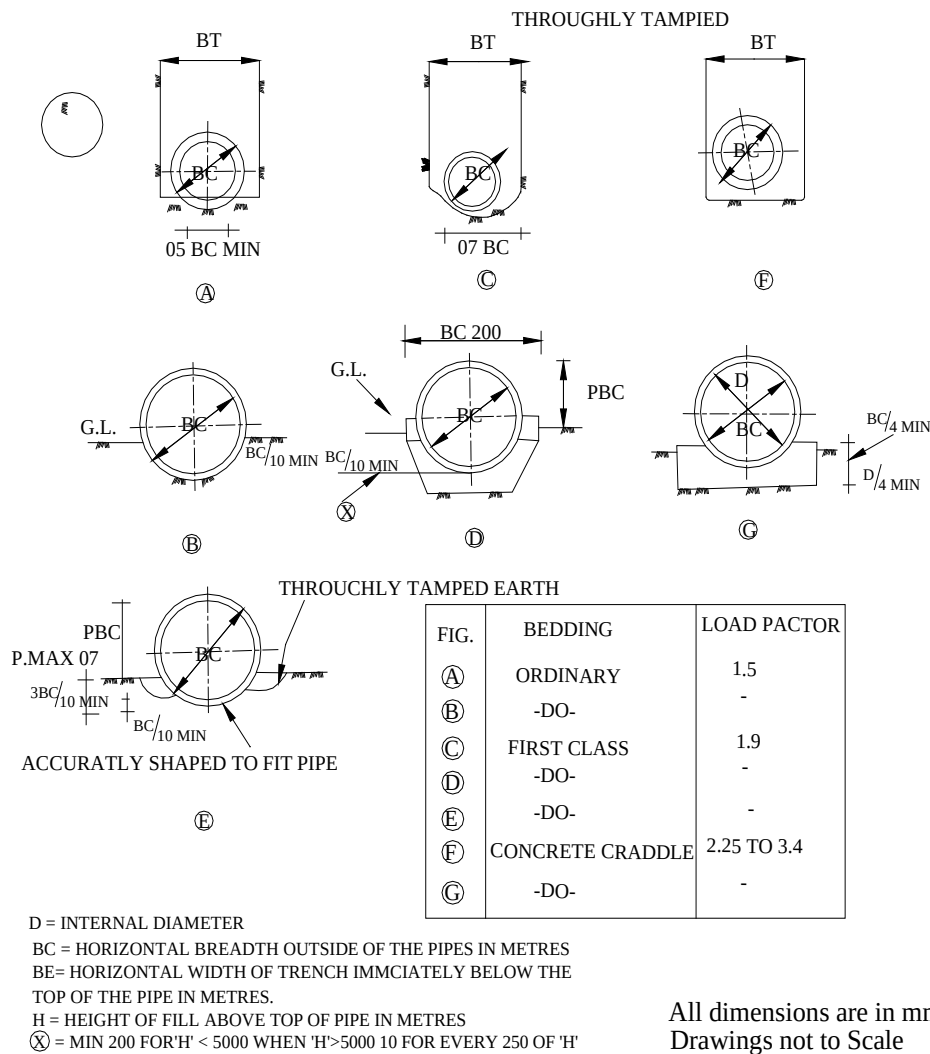


B - Thickness of Wall

All dimensions are in mm

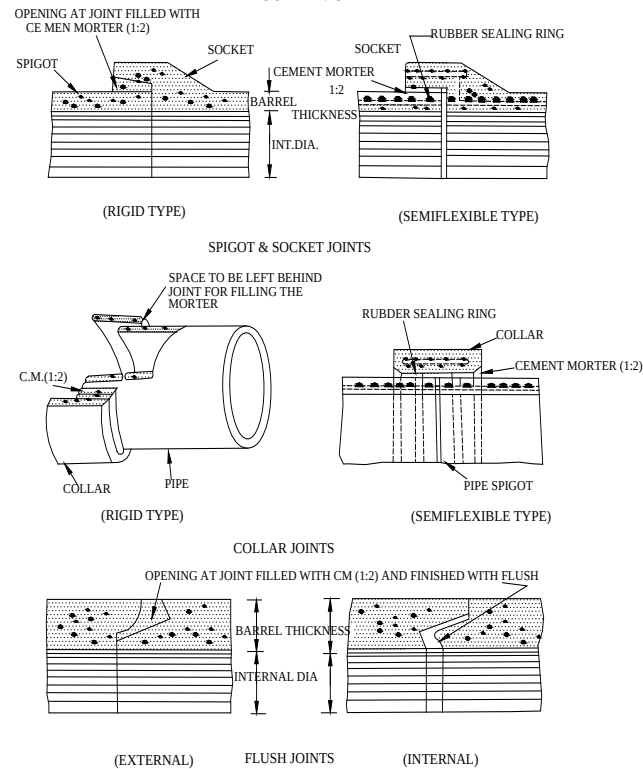
BEDDING OF PIPES

FIGURE 14.12



JOINTS OF CONCRETE PIPES

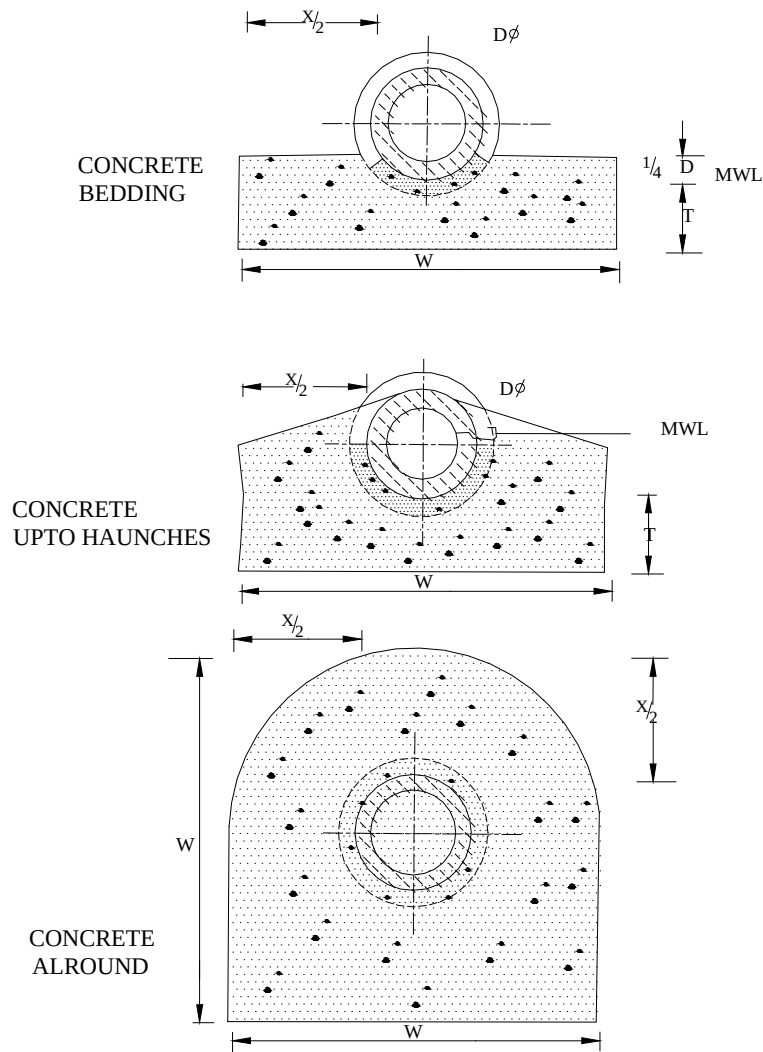
FIGURE 14.13



Drawings not to Scale

BEDDING/ENCASING STONE WARE PIPES

FIGURE 14.14



$W = D + X$, WHERE D IS THE EXTERNAL DIAMETER OF THE PIPE

$X = \{ 300 \text{ UPTO TRENCH DEPTH OF } 1200$

$\{ 400 \text{ TRENCH DEPTH MORE THAN } 1200$

$T = 100 \text{ FOR PIPES UNDER } 150, \frac{1}{4} \text{ TH INTERNAL}$
 $\text{DIA. SUBJECT TO A MIN. OF } 1500 \text{ AND MAX. } 300$
 $\text{FOR PIPES MORE THAN } 1500 \text{ DIA.}$

MWL = MAXIMUM WATER LEVEL.

All dimensions are in mm
 Drawings not to Scale

FIXING SW GULLY TRAP

10 cm S.W. GULLY TRAP WITH BRICK MASONRY CHAMBER

FIGURE 14.15A

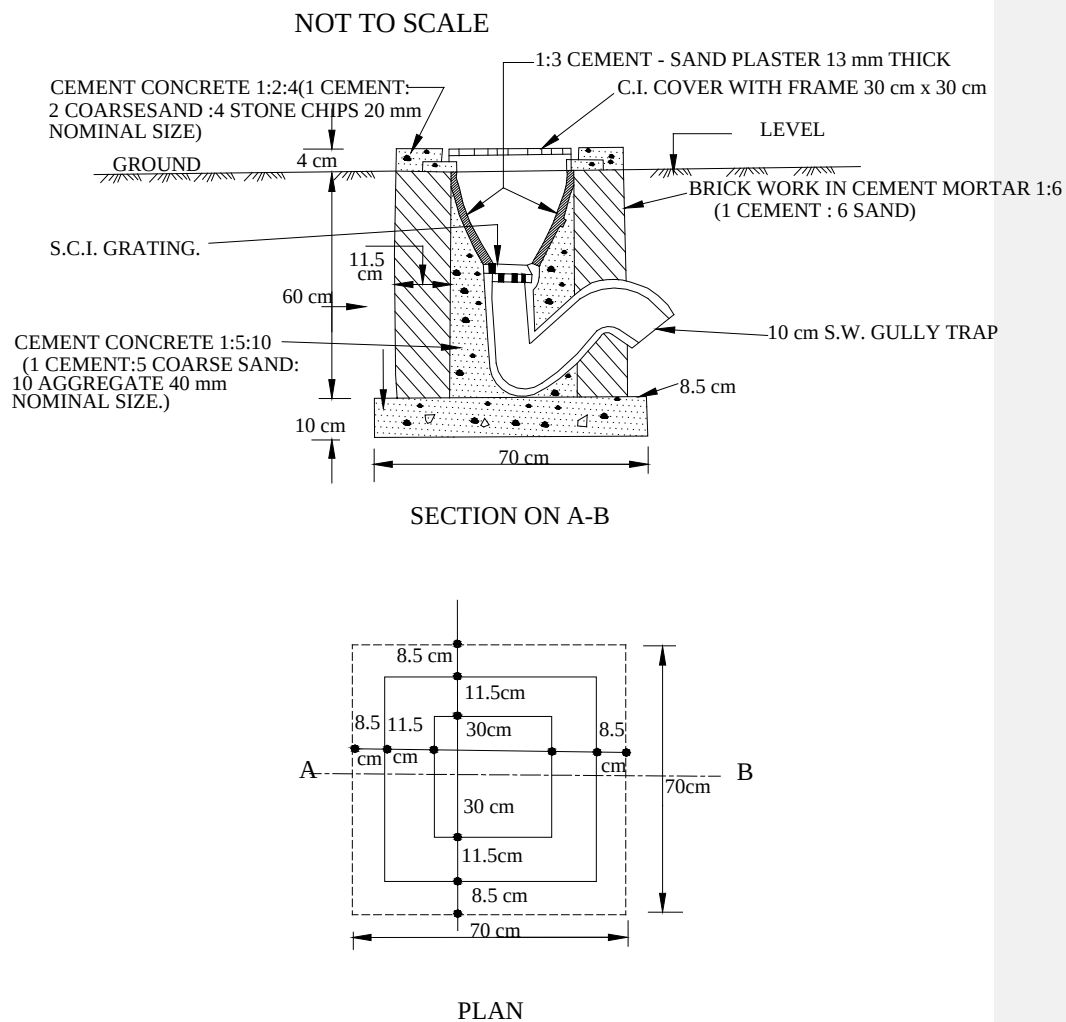
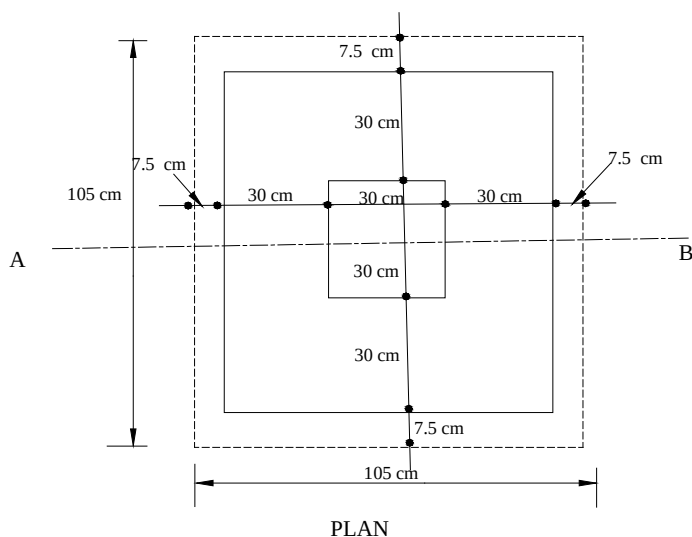


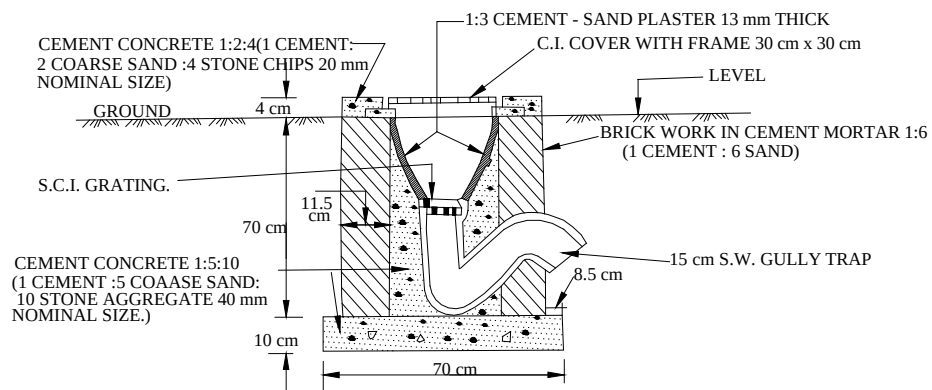
FIGURE 14.15 B



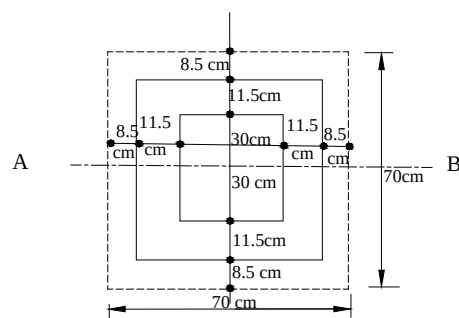
15 cm S.W. GULLY TRAP WITH
BRICK MASONRY CHAMBER

FIGURE 14.15 C

NOT TO SCALE

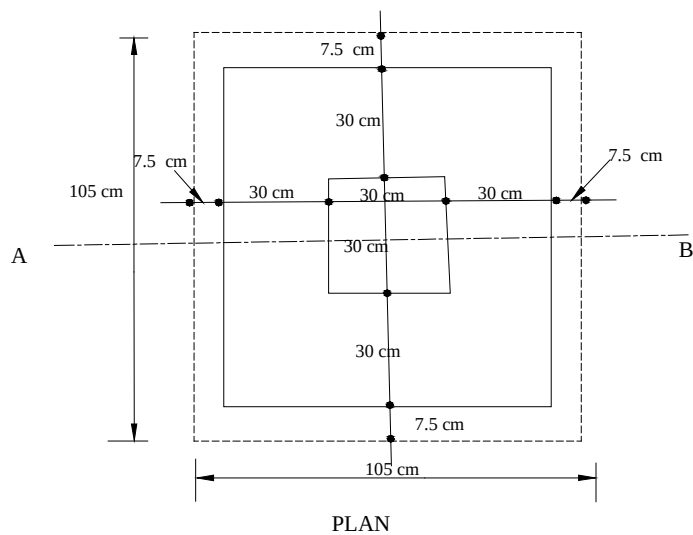


SECTION ON A-B



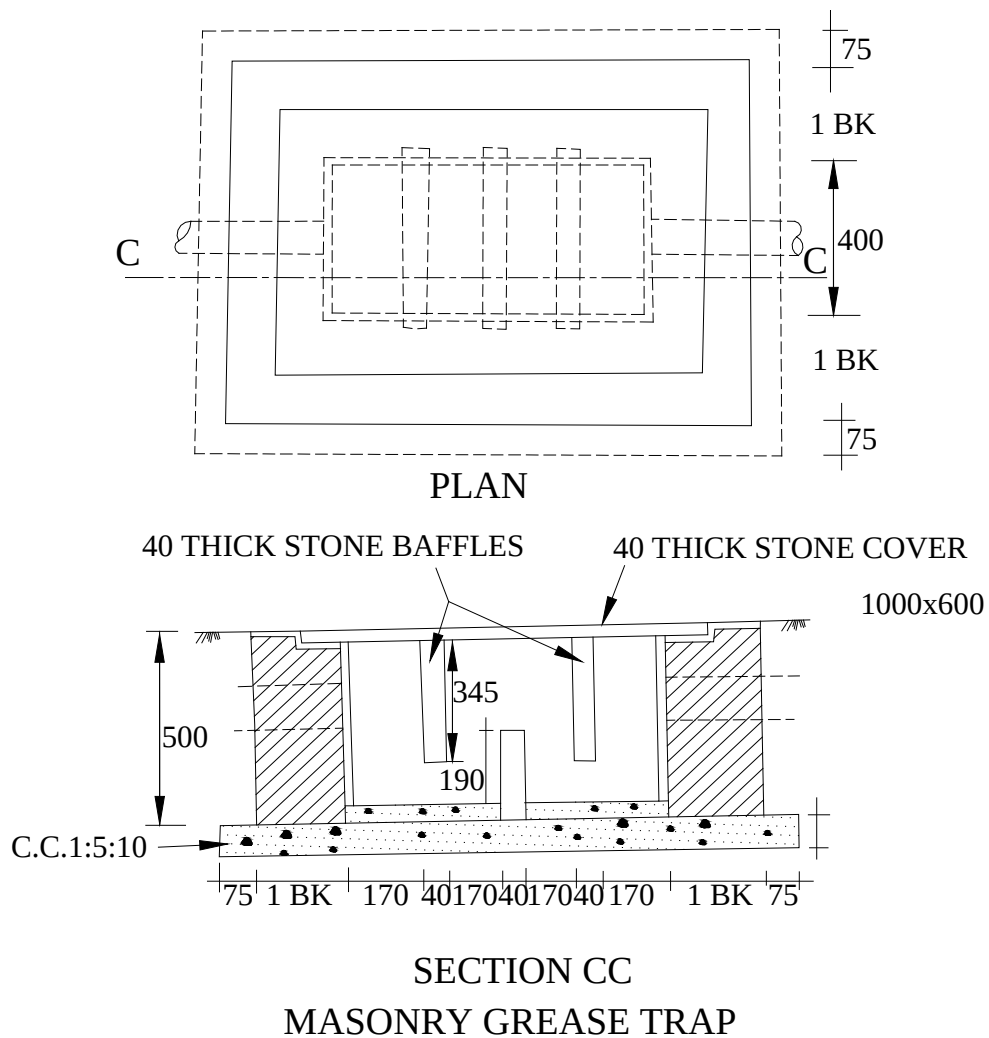
PLAN

FIGURE 14.15 D
NOT TO SCALE



GULLY GREASE TRAP

FIGURE 14.17



All dimensions are in mm
Drawings not to Scale

SEPTIC TANK

FIGURE 14.18

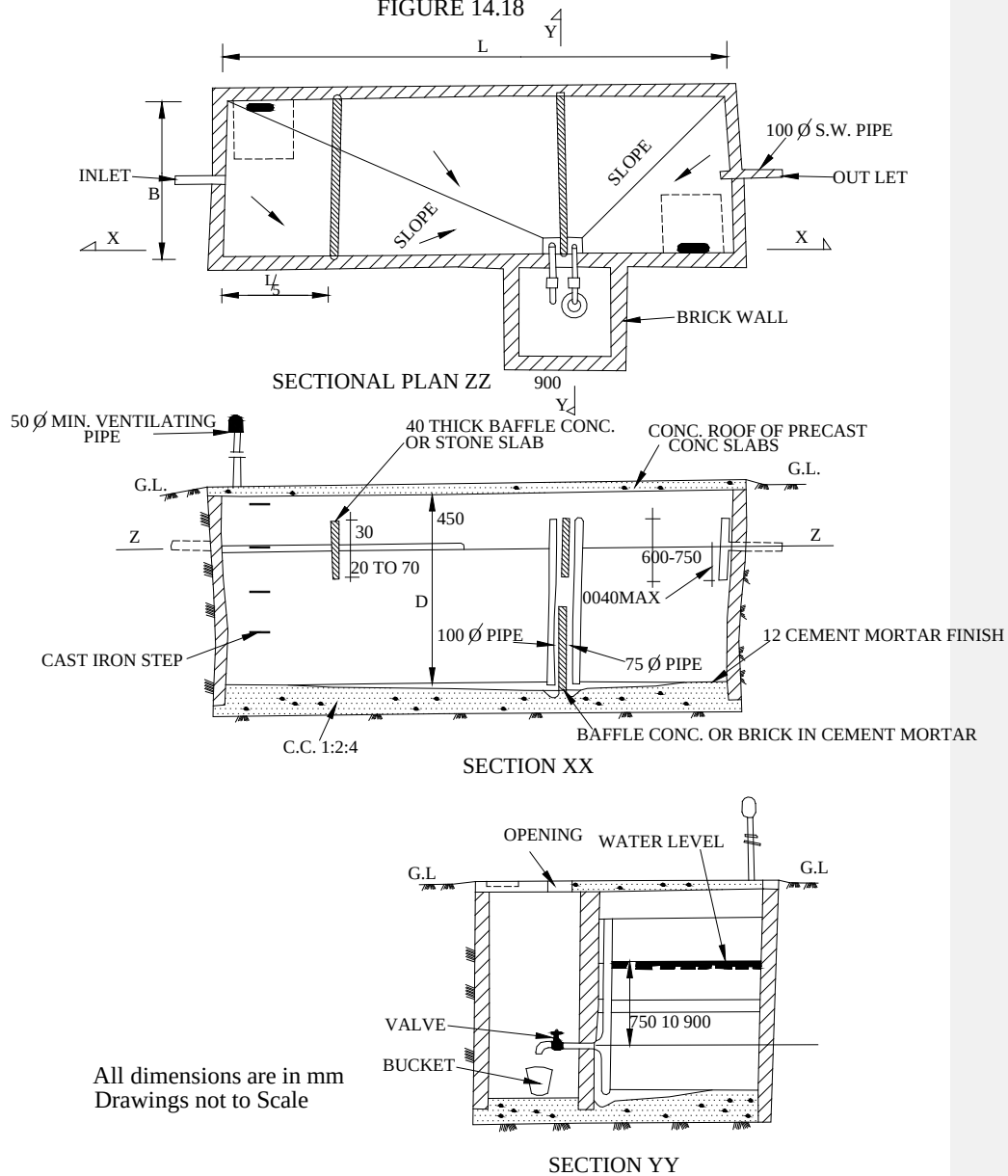
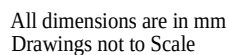
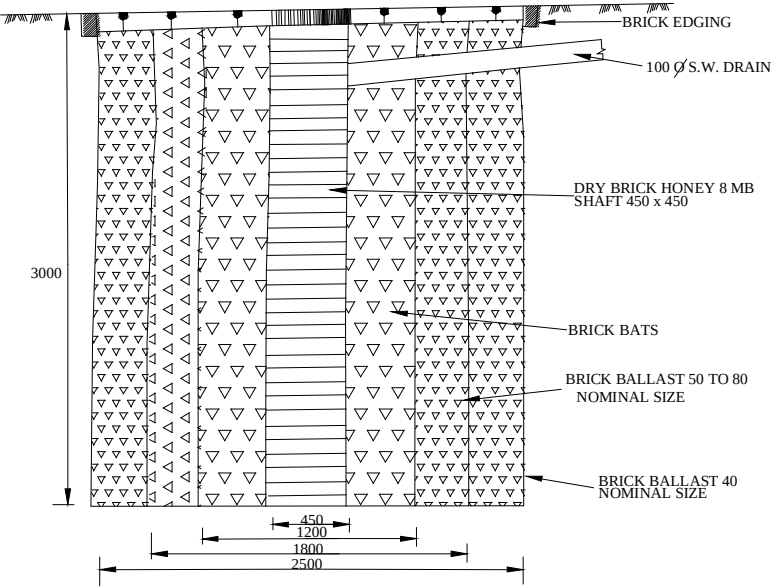


FIGURE 14.18

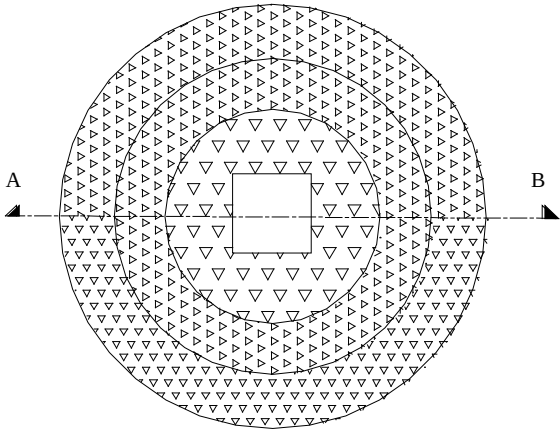


SOAK PIT
(2.5M DIA x 3.0 M DEEP)

FIGURE 14.19



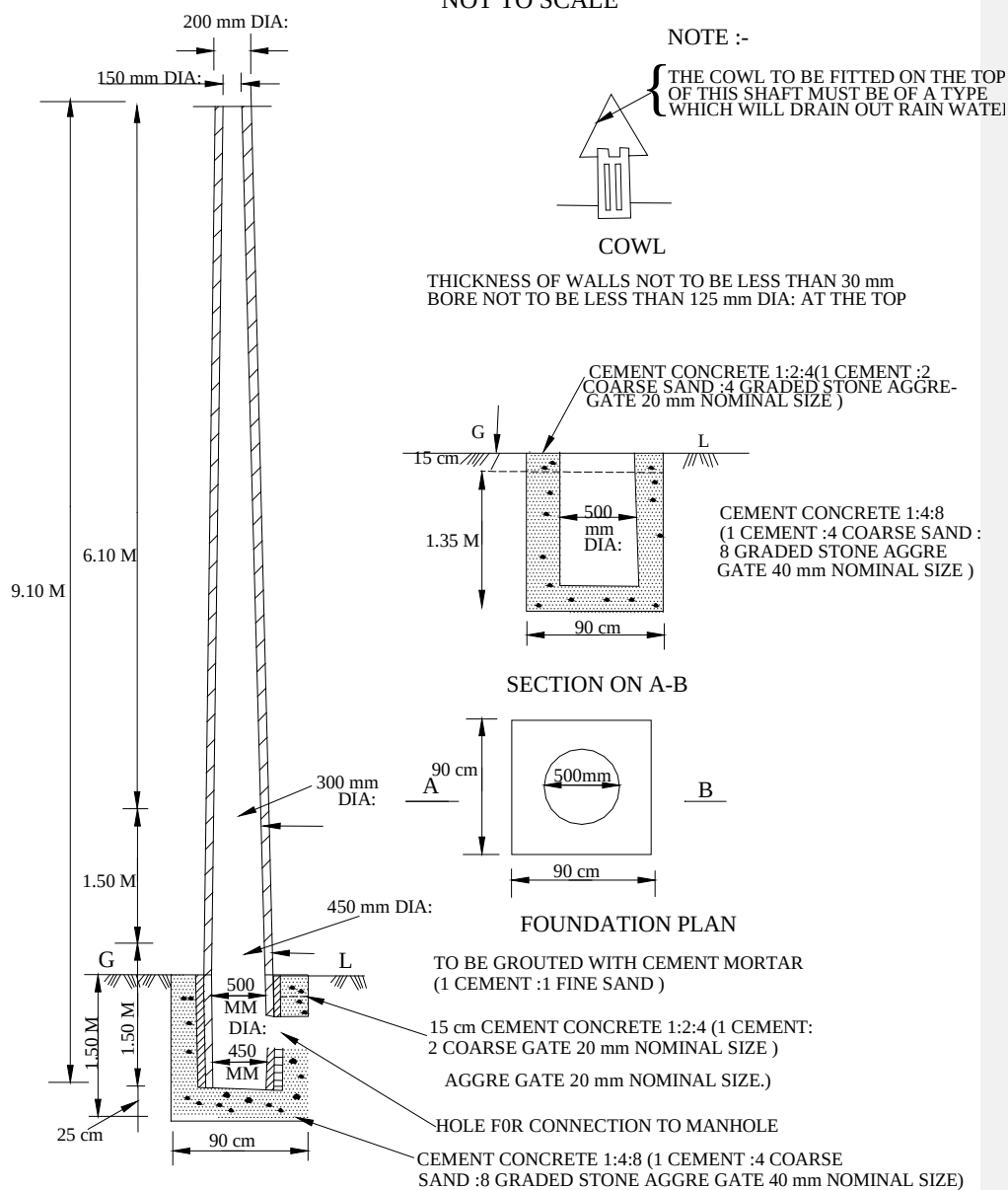
SECTION A B



PLAN

All dimensions are in mm
Drawings not to Scale

RCC VENT SHAFT

FIGURE 14.21
NOT TO SCALE

Chapter 15

Sanitary Installations

15. Terminology :

Antisiphon Pipe (Fig.15.1): A ventilating pipe connected to or close to the outlet side of a trap seal.

Automatic Flushing Cistern (Fig.15.3): A flushing cistern arranged to discharge its content by siphonage at regular intervals, determined by the rate at which water is fed into the cistern.

Ball Cock (Fig.15.3): A faucet opened or closed by the fall or rise of a ball floating in the surface of water.

Ball Valve (Fig.15.3): A simple non return valve consisting of a ball resting on a cylindrical seat within a fluid passageway.

Bell mouth (Fig.15.3): An expanded rounded entrance to a pipe or orifice.

Bend :Length of pipe bent or cast into an angle shape.

Bib Tap :A tap with a horizontal inlet and nozzle bent to discharge in a downward direction.

Blister :A raised portion of the surface protruding not more than one millimetre above the surface and not greater than 3 mm in its greatest dimension.

Box Union: A device for joining two threaded pipes.

Branch (Fig. 15.1):

(a) A special form of vitrified sewer and cast iron pipe used for making connections to a sewer or water main. The various types are called T, Y, T-Y, double Y, and V branches, according to their respective shapes.

(b) Any part of piping system other than a main.

Caulking:

(a) The process of driving, pouring or forcing lead, oakum, plastic or other material into a joint to make it leak proof.

(b) The material used in the caulking process.

Caulked Joint: A spigot and socket joint in which the jointing material is compacted by means of caulking tool and hammer.

Chase: A continuous recess in wall, floor or ceiling for the purpose of holding pipes and conduits.

Cistern (Fig.15.3): A fixed container for water in which the water is at atmospheric

pressure. The water is usually supplied through a ball valve.

Collar :A pipe fitting in the form of sleeve for jointing the spigot ends of two pipes in the same alignment.

Cowl (Fig.15.1): A hood on the top of a vent pipe or soil stack.

Craze or Crazing :Fine cracks in the glaze

Cross: A pipe fitting used for connecting four pipes at right angles.

Fittings: Coupling, flange, branch, bend, tee, elbow, union, waste with plug, P or S trap with vent, ferrule, stop tap, bib tap, pillar tap, ball valve, cistern, storage tank, baths, water closets, boiler geyser, pumping set with motor and accessories, metre, hydrant valve and any other article used in connection with water supply, drainage and sanitation.

Float Valve (Fig 15.3): A valve in which the closure to an opening such as plug or gate, is actuated by a float to control the flow into a tank.

Flush Bend: A bend located at the bottom of low level flushing cistern for the purpose of flushing pedestal type water closet and similar fixture.

Flushing cistern (Fig.15.3): A cistern provided with a device for rapidly discharging the contained water and used in connection with a sanitary appliance for the purpose of cleaning the appliance and carrying away its contents into a drain.

Gasket :A piece of compressible material used to make a joint between two flat surfaces.

Oakum: Hemp or old hemp rope soaked in oil to make it water proof.

One Pipe System (Fig. 15.1): In this a single soil waste pipe conveys both soil and waste directly to the building drain.

Pinhole: A hole in the body, less than 1.5 mm, in its maximum dimension.

Reducer: A pipe fitting with inside threads larger at end than at the other. All such fittings having more than one size are reducers because of the custom of stating the larger size first.

Single stack system (Fig. 15.1): This is the name given to a simplified one pipe system wherein all ventilation pipes are omitted. The

stack itself is made to cater (or provide) for all the vent requirements by restricting the flow into the stack to certain predetermined limits.

Sink (Fig.15.7): A shallow fixture, ordinarily with a flat bottom, that is usually used in kitchen or in connection with the preparation of food, laboratory purposes and for certain industrial processes.

Socket: The female part of spigot. and socket joint.

Soil Pipe: A pipe which conveys to drain the discharge from a water closet or urinals. In 'One pipe' and 'single stack' system, the soil pipe also conveys to a drain the discharges from bath, wash basins, sinks, and similar appliances.

Speck: Area of the finished surface with contrasting colour less than one millimetre maximum dimension.

Spigot: The male part of a spigot and socket joint.

Spigot and Socket Joint: Joint in which the end of the one pipe enters the enlarged end of the next pipe.

Stack: A main vertical discharge or ventilating pipe.

Trap: A fitting or device so designed and constructed as to provide, when properly vented, a liquid seal which will prevent the back passage of air without materially affecting the flow of sewage or waste water through it.

Two pipe system (Fig. 15.1). In this, the soil pipe conveys discharges from water closets, urinals, and similar soil appliances directly to the drainage system and the waste pipe conveys waste from ablutionary and culinary appliances to the drainage system directly or through a trapped gully where desired.

Union: A pipe fitting used for joining the ends of two pipes neither of which can be turned.

Valve: A device used for controlling the flow of liquid in a line of pipe.

Ventilating pipe (Vent pipe) The pipe which provides a safe outlet into the atmosphere for the foul gases in the drain or sewer.

Warpage Distortion of original shape during manufacturing process.

Water Seal The depth of water which should be removed from a fully charged trap before air can pass through the trap.

Waste Pipe : A pipe used to convey liquid waste not containing human excreta.

Waste Stack: A vertical pipe used to convey

liquid waste not containing human excreta.

15.1 APPLIANCES AND FITTINGS:

15.1.0. General:

(a) **Materials:** All sanitary appliances and their components shall be durable, impervious corrosion resisting, and have a smooth surface which can be easily cleaned. All materials shall conform to the relevant Indian Standards where they exist; otherwise they shall be of the best quality and workmanship. All sanitary appliances and fittings shall be got approved from the Engineer before use.

(b) **Conformity with byelaws and rules:** All sanitary installations shall comply with the bye-laws and rules regulations laid down by the Local Bodies or State Government from time to time. All sanitary installation work shall be carried out by experienced and licensed plumbers.

(c) **Fixing :** All appliances and sanitary accommodation shall be arranged to facilitate access for cleaning and repairing.

Soil, waste and ventilating branch connections with supporting brackets, shall be fitted before the erection of appliances is begun.

Care should be taken at all times, particularly after fixing, to protect appliances from damage. All orifices shall be temporarily plugged during the progress of work to prevent obstruction.

All damage done to floors, walls etc. during the course of sanitary installation work shall be restored to its original condition free of cost. Appliances shall be finally cleaned of all marks of cement, lime, oil, paint, etc. for which nothing extra shall be paid.

(d) **Traps :** Traps for sanitary fittings shall be of an approved type, made of H.C.I., stoneware or brass or of the same material as the appliance itself. Traps to soil fitments shall have a minimum water seal of 5 cm and traps to waste fitments (other than those leading into soil pipes) shall have a minimum water seal of 4 cm.

(e) **Joints :** (i) Between stoneware traps of sanitary fittings and cast iron soil pipes, jointing may be done as for stoneware pipes provided special C.I. sockets or brass thimbles are used to suit the girth of the trap outlet.

ii) Unless otherwise specified, the methods summarized below shall be followed for jointing of pipes of different materials, used in sanitary installations –

Materials of pipes	Method of jointing
Lead to Lead	Wiped solder joint
Iron to iron	Two rings of hemp yarn, caulked with cement mortar
Lead to Stoneware	Thimble or socket of brass with wiped solder joint to lead pipe and caulked cement mortar joint to stoneware pipe
Lead to cast iron	Brass thimble or socket as above, but final joint in socket of iron pipe with yarn and molten lead, properly caulked
Iron to stoneware	Hemp yarn and caulked cement mortar
Stoneware to iron	As described in sub-para (i) above
Lead to galvanized iron	Brass plumber's union, with wiped solder joint on lead pipe and connected to a nipple on the iron pipe, secured to the latter by a nut and lock nut

iii) Each connection between a G.I. water pipe and a sanitary fitting shall generally be with a lead pipe, properly jointed with plumber's brass unions to the fitting and to the G.I. Pipe. Where specially permitted, the connection may be given directly with the use of suitable GI pipes and specials, fitted up accurately. Alternately the connection may be made with the help of polyethylene pipe of suitable length fitted with coupling nuts at both ends. The coupling nuts are to be screwed to the metal fittings of the sanitary fittings and the GI pipes at the other end. Care shall be taken to see that there is no twisting of the polyethylene pipe which may block the flow of water.

(f) **Pipes:** Galvanized or black M.S. pipes shall not be used for soil, waste, vent or antisiphonage pipes. Stoneware pipes for soil and waste shall be used only below ground. A.C. building pipes for soil, waste, vent or antisiphonage shall not be laid below ground level.

(g) General reference

(i) For pipe system and parts refer **Figure 15.1**.

(ii) For details IS:5329-1943 (Code of Practice for Sanitary Pipe work above ground for buildings) may be referred to.

(iii) For guidance in Design IS:1172-1993 (Code of Basic requirement for water supply, drainage and sanitation) may be referred to.

(iv) For guidance on selection, installation and manufacture of sanitary appliances Code of Practice IS:2064-1993 may be referred to.

(v) Brief details of items covered by IS:5329-1983, IS:1172-1993 and IS:2064-1993 have been given in **Annexure 15.1**.

15.1.1 Isolation: In all sanitary installation works, unless otherwise ordered, one screw-down gun metal isolation stop cock shall be fitted on each water supply pipe leading to a

sanitary fitting, in addition to any tap forming part of the fitting, to enable the water supply being cut off when the fitting is to be repaired.

15.1.2 Vitreous sanitary appliances : All vitreous sanitary appliances (Vitreous China) shall conform to IS : 2556 (Part-I) general requirements.

The chromium plating shall conform to IS : 4827 and shall be of grade 2 (thickness 10 micron). The chromium plating shall never be deposited on brass unless a heavy coating of nickle is interposed. In case these are required to be nickle plated, the plating shall be of first quality with a good thick deposit of silvery whiteness capable of taking high polish which will not easily tarnish or scale. In finish and appearance the plated articles when inspected shall be free from plating defects such as blisters, pits, roughness and unplated areas and shall not be stained or discoloured. Before fitting is plated the washer plate shall be removed from the fitting. The gland packing shall be protected from the plating solution.

15.1.3. Flushing cisterns (Fig.15.3)

The flushing cisterns shall be automatic or manually operated, high level or low level as specified, for water closets and urinals. A high level cistern is intended to operate with minimum height of 125 cm and a low level cistern with a maximum height of 30 cm between the top of the pan and the under side of the cistern.

Cisterns shall be of cast iron, Vitreous China, (IS :774 for Flushing type and IS : 2326 for Automatic Flushing Cistern) and Plastic (IS:7231).

The thickness of the body including cover shall be not less than 5 mm & 6 mm for cast iron and vitreous China cisterns respectively. The body of the pressed steel cistern shall be of seamless or welded construction. The

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outlet of each syphon or stand pipe shall be securely connected to the cistern by means of lock nut. The cistern shall be free from manufacturing faults and other defects affecting their utility. All working parts shall be designed to operate smoothly and efficiently. Cistern shall be mosquito proof. A cistern shall be considered mosquito proof only if there is no clearance any where which would permit a 1.6 mm wire to pass through in the permanent position of the cistern i.e. in the flushing position or filling position.

The breadth of a low level cistern, from front to back shall be such that the cover or seat, or both, of water closet pan shall come to rest in a stable position when raised.

The cistern shall be supported on two cast iron brackets of size as approved by the Engineer and embedded in cement concrete 1:2:4 block 100x75x150 mm. The cast iron brackets shall conform to IS : 775. These shall be properly protected by suitable impervious paint. Alternatively the cisterns shall have two holes in the back side above the overflow level for screwing into the wall, supplemented by two cast iron wall supports. A 5 litres cistern, however, may be supported by larger brackets cast on the body of the cistern.

The cistern shall have a removable cover which shall fit closely on it and be secured against displacement. In designs where the operating mechanism is attached to the cover this may be made in two sections, but the section supporting the mechanism shall be securely bolted or screwed to the body. The outlet fitting of each cistern shall be securely connected to the cistern. The nominal internal diameter of cistern outlet shall be not less than 32 mm and 38 mm for high level and low level cisterns respectively. The length of the outlet of the cistern shall be 37 ± 2 mm.

Ball valve shall be of screwed type 15 mm in diameter and shall conform to IS 1703. The float shall be made of polyethylene as specified in IS 9762. (The design shall permit the cistern to fill in rapidly and close effectively when the level of water reaches the working water level.)

In the case of high level manually operated cistern, the level arm of the cistern shall have a suitable hole near the end through which a split ring or a (S) hook shall pass. A chain

shall be attached to the ring or the hook. The chain shall be of G.I. and strong enough to sustain a suddenly applied pull of 10 Kg or a dead load of 50 Kg without any apparent or permanent deformation of the shape of the ring. The chain shall terminate in suitable handle or 'Pull' which shall be of pottery, galvanised iron, non ferrous metal or a moulding in any heat resisting and non absorbent plastic. The finish shall be smooth and free from burrs. In case of low level flushing cisterns, the handle shall be of a chromium plated brass. The cast iron cisterns shall be painted with two coats of black bitumastic paint on the inside and two or more coats of paint of approved quality and shade on the outside.

In the case of manually operated cisterns the siphonic action of the flushing cistern shall be capable of being rapidly brought into action by the operating lever, but shall not self siphon or leak. When tested according to IS 774 the discharge rate shall be 10 ± 0.5 litre in 6 seconds and 5 ± 0.5 litre in 3 seconds for cisterns of capacities 10 litre and 5 litre respectively. The cisterns shall be so designed that there is not appreciable variation in the force of flush during the discharge of the required quantity of water. The cistern shall have a discharge capacity of 5 & 10 litres as specified. When required to give a full flush, they shall respectively discharge 5 litres and 10 litres with variation of ± 0.5 litres.

The flush pipe shall be of (a) medium quality galvanised iron having internal diameter of 32 ± 1 mm for high level cistern and 38 ± 1 mm for low level cistern. The flush pipe shall be of suitable length with bends etc. as required for fixing it with front or back inlet W.C. Pan. (b) Polyethylene pipes low density conforming to IS:3076 or high density conforming to IS:4984 (c) Unplasticized PVC pipes conforming to IS:4985. For high density polyethylene and unplasticized PVC pipes, the outside diameter of the pipes shall be 40 mm. When PVC plumbing pipes are used the outside diameter of the pipe shall be 40 mm for high level cisterns and 50 mm for low level cisterns.

In case of high level cistern the flush pipe shall be a vertical pipe 125 cm long and having a nominal internal dia 32 ± 1 mm (except plastic flush pipes) and in case of low level cistern 30 cm long and 38 ± 1 mm diameter (except plastic flush pipes).

Over flow pipe

(i) GI overflow pipe shall be of not less than 20 mm nominal bore and shall incorporate a non corrodible mosquito proof brass cover having 1.25 mm dia perforation, screwed in a manner which will permit it to be readily Cleaned or renewed when necessary. No provision shall be made whereby the overflow from the cistern shall discharge directly into the water closet or soil pipe without being detected.

(ii) The invert of the overflow pipe in the case of high level and low level cisterns shall be 19 mm minimum above the working water level. In case of overflow due to any reason water should drain out through the over flow pipe and not through the syphon pipe.

(iii) The plastic overflow pipes shall be manufactured from high density polyethylene conforming to IS : 4984 or unplasticized P.V.C. conforming to IS:4985.

Inlet and overflow holes The cistern shall be provided with inlet and overflow holes, situated one at each end which shall be capable of accommodating an overflow pipe of not less than 20 mm nominal bore and a 15 mm size ball valve. The holes shall be cleanly cast or drilled and the adjacent surfaces shall be smooth.

15.1.4. Draining board :

Draining board manufactured from stainless steel conforming to IS:13983 shall be provided.

Alternately Draining board made of Kota or similar Stone or Marble / granite Stone conforming to Specifications and as per directions of The Engineer, duly rubbed and polished without groove shall be provided. The draining board shall be provided with 15 mm thick back and side skirting. The size of the board measured from outside of skirting shall be 75x45x2.5 cm, 60x45x2.5 cm or as specified. The skirting measured from inside shall be 65 mm to 75 mm high with edges rounded off. The entire surface including bottom of the-board shall be finished smooth.

15.1.5. Foot rests (Fig. 15.4) :

Foot rests shall be of Vitreous China conforming to IS:2556 (Part-X). Foot rests which are rectangular shall meet the minimum requirements and dimensions shown in **Fig. 15.4** and may be of different designs where so specified. Foot rests of different shapes and sizes shall also be allowed subject to approval of the Engineer.

15.1.6. Glass Shelf :

Glass shelf shall consist of an assembly of glass shelf, with anodised aluminium angle frame to support the glass shelf. The shelf shall be of glass of best quality with edges rounded off, and shall be free from flaws specks or bubbles. The size of the shelf shall be 60x12 cm unless otherwise specified and thickness not less than 5.5 mm. The shelf shall have C.P. brass brackets which shall be fixed with C.P. brass screws to rawl plugs firmly embedded in the walls.

PVC shelf as per manufacturer's specifications and size as specified shall be provided.

15.1.7. Mirror :

The mirror shall be of superior sheet glass with edges rounded off or bevelled, as specified. It shall be free from flaws, specks or bubbles. The size of the mirror shall be 60x45 cm unless specified otherwise and its thickness shall not be less than 5.5 mm. It shall be uniformly silver plated at the back and shall be free from silvering defects. Silvering shall have a protective uniform covering of red lead paint. Where bevelled edge mirrors of 5.5 mm thickness are not available, fancy looking mirrors with PVC beading/border or aluminium beading or stainless steel beading/ border based on manufacture's specifications be provided nothing extra shall be paid on this account. Backing of mirrors, shall be provided with environmentally friendly material other than asbestos cement sheet.

15.1.8. M.S. Stays and Clamps (Fig. 15.5) :

The clamps shall be made from 1.5 mm thick M.S. flat of 32 mm width, bent to the required shape and size to fit tightly on the socket, when tightened with nuts & bolts. It shall be formed of two semicircular pieces with flanged ends on both sides with holes to fit in the screws, bolts and; nuts 40 mm long. The stay shall be minimum one metre long of 10 mm dia M.S. bar. One end of the stay shall be bent for embedding in the wall in cement concrete block of size 20x10x10 cm in 1:2:4 mix (1 cement : 2 coarse sand : 4 graded stone aggregate 20 mm nominal size). The concrete shall be finished to match with the surrounding surface.

15.1.9. Pillar Taps :

Pillar taps shall be chromium plated brass and shall conform to IS:1795. The nominal

sizes of the pillar tap shall be 15 mm or 20 mm as specified. The nominal size shall be designated by the nominal bore of the pipe

outlet to which the tap is to be fitted. Finished weights of 15 mm and 20 mm pillar taps shall be as prescribed in **TABLE 15.1**.

TABLE 15.1 - MINIMUM FINISHED WEIGHTS OF PILLAR TAPS

Particulars	Weights for	
	15 mm size gm	20 mm size gm
Body	255	505
Washer plate loose valve	15	28
Back nut	40	50
Tap	650	1175

Casting shall be sound and free from laps, blow hole and pitting. External and internal surfaces shall be clean, smooth and free from sand and be neatly dressed. The body, bonnet and other parts shall be machined true so that when assembled, the parts shall be axial, parallel and cylindrical with surfaces smoothly finished.

The area of waterway through the body shall not be less than the area of the circle of diameter equal to the bore of the seating of the tap. The seating of pillar tap shall be integral with the body and edges rounded to avoid cutting of washer. Pillar taps shall be nickel chromium plated and thickness of coating shall not be less than service grade No. 2 of IS:4827 and plating shall be capable of taking high polish which shall not easily tarnish or scale.

Every pillar tap, complete with its component parts shall withstand an internally applied hydraulic pressure of 20 Kg/sq. cm maintained for a period of 2 minutes during which period it shall neither leak nor sweat.

15.1.10. Sand Cast Iron or Centrifugally Cast (Spun) Iron Pipes and Fittings :

Sand cast iron spigot and socket soil, waste and ventilating pipes, fittings and accessories shall conform to IS: 1729. Centrifugally cast (Spun) iron spigot and socket soil, waste and ventilating pipes, fittings and accessories shall conform to IS:3989.

The fittings shall conform to the same I.S. specifications to which the pipe itself conforms in which they are connected.

The pipes shall have spigot and socket ends, with head on spigot end in case of sand cast iron pipes and without head on spigot end in case of cast iron (Spun) pipes. The pipes and fittings shall be true to shape, smooth and cylindrical, their inner and outer surface being as nearly as practicable concentric.

They shall be sound and shall be free from cracks, taps, pinholes and other imperfections and shall be neatly dressed and carefully fettled. All pipes and fittings shall ring clearly when struck with a light hand hammer.

The ends of pipes and fittings shall be reasonably square to their axis. The sand cast iron pipes shall be 1.5/1.8/2.0 metre in length including socket ends, cast iron (Spun) pipes shall be 1.5/1.75/2.0/2.5/3.0 metre in length excluding socket ends, unless shorter lengths are either specified or required at junctions etc. The pipe and fittings shall be supplied without ears, unless specified or directed otherwise.

All pipes and fittings shall be coated internally and externally with the same material at the factory, the fitting being preheated prior to total immersion in a bath containing a uniformly heated composition having a tar or other suitable base. The coating material shall have good adherence and shall not scale off. In all instances where the coating material has tar or similar base it shall be smooth and tenacious and hard enough not to flow when exposed to a temperature of 77 degree centigrade but not so brittle at a temperature of 0 degree centigrade as to chip off when scribed lightly with a pen knife.

The standard weights and thicknesses of pipes and their tolerances shall be as prescribed in ANNEXURE 15.3.

The thickness of fittings and their socket and spigot dimensions shall all conform to the thickness and dimensions specified for the corresponding sizes of straight pipes. The tolerance in weights & thicknesses shall be the same as for straight pipes.

The access door fittings shall be designed so as to avoid dead spaces in which filth may accumulate. Doors shall be provided with 3

mm rubber insertion packing and when closed and bolted, these shall be water tight.

Sand Cast Iron Floor Trap or Nahani Trap : Sand cast Iron Floor trap or Nahani trap shall be 'P' or 'S' type with minimum 50 mm seal. However, if the plumbing is in two pipe system and with a gully trap at the ground level the minimum water seal shall be 35 mm. The traps shall be of self cleansing design and shall have exit of same size as that of waste pipe-These shall conform to IS : 1729.

15.1.11. Plastic seat and covers for water closet (Fig. 15.6) :

The seat and cover shall be of thermosetting or thermoplastic conforming to IS:2548 Part I and 2 respectively or as specified. Unless and otherwise specified these shall be of closed pattern.

15.1.11.1. Thermosetting plastic used shall conform to grade 2 or 3 of IS : 1300 when it is phenolic or IS: 3389 when of urea formaldehyde.

Thermo plastic materials used may be of Polystyrene conforming to type 2 or 3 of IS : 2267 or of polypropylene, Appendix A of IS:2548. In public buildings where rough and heavy use of seats and covers are common, plastic seats shall be moulded out of thermosetting materials, phenolic or urea formaldehyde only and the under side of the seat shall be flat with solid moulding.

15.1.11.2. The hinging device shall be bronze or brass with nickel chromium plating conforming to IS : 2548 and the seat shall have not less than three rubber or plastic buffers unless otherwise specified. The cover shall be fitted with the same number of buffers as provided for the seat.

15.1.11.3. Seats shall have a smooth finish and shall be non absorptive and free from cracks and crevices. They shall be capable of being easily cleaned and shall not be adversely affected by common solvents or household cleanser.

15.1.11.4. Strength : The seats shall withstand without permanent distortions of the seat or hinge fittings and damage to any finish when a load of 1150 N for 30 minutes is applied in the manner prescribed in IS 2548.

15.1.12. Sinks (Fig. 15.7) :

15.1.12.0. Laboratory sinks shall be of White vitreous china with dimensions as specified conforming to IS : 2556 (Pt. V). Kitchen sinks shall be of white glazed fire clay confirming to IS : 771 (part-II) . The kitchen sink shall be of one piece construction with or without rim,

with or without overflow.

15.1.12.1. Wherever specified stainless steel kitchen sink of size as specified conforming to IS:13983 shall be provided.

15.1.12.2. Brackets for sinks shall be as shown in **Figure 15.8.**

15.1.13. Towel rails - The towel rail shall be of :

a) CP Brass with two CP brass brackets coated with nickel chromium plating of thickness not less than grade no.2 of IS : 4827.

b) Anodised aluminium fluted surface with two anodised aluminium brackets. The size of the rail shall be 75 cm x 20 mm dia or 60 cm x 20 mm dia, 1.25 mm thick as specified. The fixing screw shall be of C. P. brass.

15.1.14. Toilet paper holder : The toilet paper holder shall be of CP brass or vitreous china as specified and of size and design as approved by the Engineer. It shall be fixed in position by means of C.P. brass screws and rawl plugs embedded in the wall.

15.1.15. Urinals

15.1.15.1. Bowl type urinals (Fig. 15.9) : Urinal basins shall be of flat back or corner wall type lipped in front. These shall be of white vitreous china conforming to IS : 2556- (Part VI) Sec.I. The urinals shall of one piece construction. Each urinal shall be provided with not less than two fixing holes of minimum dia 6.5 mm on each side. Each urinal shall have an integral; flushing rim of suitable type and inlet or supply horn for connecting the flush pipe. The flushing rim and inlet shall be of the self draining type. It shall have a weep hole at the flushing inlet of the urinals.

At the bottom of the urinal an outlet horn for connecting to an outlet pipe shall be provided. The exterior of the outlet horn shall not be glazed and the surface shall be provided with grooves at right angles to the axis of the outlet to facilitate fixing to the outlet pipe. The inside surface of the urinal shall be uniform and smooth throughout to ensure efficient flushing. The bottom of pan shall have sufficient slope from the front towards the outlet such that there is efficient draining.

The following tolerances may be allowed on the dimensions :

- On dimension 50 mm and over ± 4 percent
- On dimensions less than 50 mm ± 2 mm
- On all angles ± 3 degree

15.1.15.2. Stall Urinals (Fig. 15.10) : The

stall urinal and its screens shall be of white glazed fire clay conforming to IS : 771 (Pt.3-Sec.2). The stall shall be 1140 mm high and 460 mm wide with 400 mm overall depth at the base. Where specified, screens which shall be 1200 mm high and 15 cm wide (overall) and projecting 50 cm after suitable embedment in the wall shall be provided as directed by the Engineer. In case of a range of two or more urinals, there shall be further division screens as shown in Fig. 15.10. The end screen shall also be suitably fixed as directed by the Engineer. The range shall have 15 cm deep standard pattern tread plates of fire clay or black granite as specified or otherwise directed by the Engineer. The inside surface of the stall and its screens shall be regular and smooth throughout to ensure efficient

15.1.15.3. Half stall urinals (Fig. 15.11) : They shall be of white vitreous China conforming to IS : 2556 (Part VI-Sec.2). They shall be of one piece construction with or without an integral flushing box rim and provided with slots or alternative fixing arrangement at the flat back end. They shall be provided with ridges where integral flushing rim is not provided in the sides of the interior of the bowl, to divert the water towards the front line of the urinal where integral flushing box rim is specified, water spreaders provided shall conform to IS : 2556 Part-VI Sec.6 (**Fig.15.12**). These shall be vitreous China of one piece construction with integral flush inlet.

The tolerance of ± 4 percent may be allowed on the dimensions specified.

15.1.15.4. Urinal Partition Slabs: Urinal Partition slabs shall be provided, as specified. IS:771 Part 3 Section 1 gives the specifications for glazed fire clay sanitary applications on slab urinals.

15.1.15.5. Squatting Plate Urinal (Fig. 15.13) : The plates shall be of white vitreous china conforming to IS : 2556 (Part-I) and IS : 2556 (Part-VI)/Section 3) with internal flushing rim with front or side inlet. Squatting Plate shall be of one piece construction. Each urinal shall have integral longitudinal flushing pipe of suitable type which may be connected to flush pipe. Following tolerances may be allowed on the dimensions :

- a) On dimension 50 mm and over ± 4 percent
 - b) On dimensions less than 50 mm ± 2 mm
- These shall be 100 mm dia white glazed vitreous

15.1.16. Wash Basins (Fig. 15.14, 15.15,

15.16, 15.17 & 15.18) :

Wash basins shall be of white vitreous china conforming to IS: 2556 (Part-I) and IS: 2556 (Part I). Wash basins either of flat back or angle back as specified shall be of one piece construction, including a combined overflow. All internal angles shall be designed so as to facilitate cleaning. Each basin shall have a rim on all sides, except sides in contact with the walls and shall have a skirting at the back. Basins shall be provided with single or double tap holes as specified. The tap holes shall be 28- mm square or 30 mm round or 25 mm round for pop up hole. A suitable tap hole button shall be supplied if one tap hole is not required in installation. Each basin shall have circular waste hole to which the interior of basin shall drain. The waste hole shall be either rebated or bevelled internally with dia meter of 65 mm at top. Each basin shall be provided with a nonferrous 32 mm waste fitting. Stud slots to receive the brackets on the underside of the wash basin shall be suitable for a bracket with stud not exceeding 13 mm diameter, 5 mm high and 305 mm from the back of basin to the centre of the stud. The stud slots shall be of depth sufficient to take 5 mm stud. Every basin shall have an integral soap holder recess or recesses, which shall fully drain into the bowl. A slot type of overflow having an area of not less than 5 sq. cm shall be provided and shall be so designed as to facilitate cleaning of the overflow.

Where oval shape or round shape wash basins are required to be fixed these shall be fixed preferably in RCC platform with available stone topping either fully sunk in stone top or top flush with the stone topping as directed by the Engineer.

The wash basins shall be one of the following patterns and sizes as specified (**Fig. 15.14**).

a) Flat back : 630 x 450 mm 550 x 400 mm 450 x 300 mm

b) Angle back : 600 x 400 mm 400 x 400 mm

White glazed pedestals for wash basins, where specified shall be provided. The quality of the glazing of the pedestal shall be exactly the same as that of the basin along with which it is to be installed. It shall be completely recessed at the back to accommodate supply and waste pipes and fittings. It shall be capable of supporting the basin rigidly and adequately and shall be so designed as to make the height from the floor to top of the rim of basin 75 to 80 cm as shown in Fig. 15.14,15.15,15.16,15.17 & 15.18. All the waste fittings shall be brass

chromium plated, or as specified. The following tolerances may be allowed on dimensions specified :

- a) On dimension 75 mm and over ± 4 percent
- b) On dimensions less than 75 mm ± 2 mm
- c) Diameter of the waste hole ± 3 mm

15.1.17. Waste fittings and CI Brackets for wash basins and sinks (Fig. 15.8):

The waste fittings shall be of nickel chromium plated brass, with thickness of plating not less than service grade 2 of IS : 4827 which is capable of receiving polish and will not easily scale off. The fitting of copper alloy shall conform in all respect to IS : 2963 and shall be sound, free from laps, blow holes and pittings and other manufacturing defects. External and internal surfaces shall be clean and smooth. They shall be neatly dressed and be truly machined so that the nut smoothly moves on the body.

Waste fitting for wash basins shall be of nominal size of 32 mm. Waste fittings for sinks shall be of nominal size 50 mm. C.I. Brackets also shown in figure 15.8 shall be to IS specification IS 775-1970.

15.1.18. Water closets (Fig. 15.19, 15.20 & 15.21)

15.1.18.1. Squatting pans (Fig. 15.19 & 15.20) : IS:11246-1992 deals with the specification for Glass Fibre Reinforced Polyester resin (GRP) squatting Pans. Squatting pans shall be of white vitreous china conforming to IS : 2556 Part-I for General Requirements and relevant I.S. codes for each pattern as described below :

- i) Long pattern-conforming to IS :2556 (Part-III).
- ii) Orissa pattern-conforming to IS :2556 (Part-III).
- iii) Integrated type conforming to IS :2556 (Part.. XIV).

Preferably Orissa type pan should be used.

Each pan shall have an integral flushing rim of suitable type. It shall also have an inlet or supply horn for connecting the flush pipes, as shown in **Fig. 15.19, 15.20 & 15.21.**

The flushing rim and inlet shall be of the self draining type. It shall have weep hole at the flushing inlet to the pan. The flushing inlet shall be in the front, unless otherwise specified or ordered by the Engineer. The inside of the bottom of the pan shall have sufficient slope from the front towards the outlet and the surface shall be uniform and smooth to enable easy and quick disposal

while flushing. The exterior surface of the outlet below the flange shall be an unglazed surface which shall have grooves at right angles to the axis of the outlet. In all cases a pan shall be provided with a (100 mm) S.C.I. trap 'P' or 'S' type with approximately 50 mm water seal and 50 mm dia vent horn, where required by the Engineer.

The following tolerances may be allowed on the dimensions specified :

- i) Long pattern and Orissa pattern
 - a) On dimension 50 mm and over ± 4 percent
 - b) On dimensions less 50 mm than ± 2 mm
 - c) On all angles ± 3 deg.
- d) The top surface of long pattern pan shall not at any point vary from its designed plane or contour by more than 6 mm for size 580 mm and by more than 10 mm for sizes 630 mm and measured vertically. This value shall not exceed 10 mm in case of Orissa pattern pans.
- ii) Integrated squatting pan:
 - a) On dimension 50 mm and over ± 4 percent
 - b) On dimensions less than 50 mm ± 2 mm
 - c) On all angles. ± 3 deg.

15.1.18.2. Water closet (Wash Down Type) (Fig. 15.20 & 15.21) :

Water closets shall be of white vitreous china conforming to IS : 2556 (Part-I) and 2556 (Part-II), as specified and shall be of "Wash down type". The closets shall be either of the two patterns (Pattern I & Pattern II) and sizes as shown in **Fig. 15.20 & 15.21** as specified. The closets shall be of one piece construction. Each water closet shall have not less than two holes having a minimum diameter of 6.5 mm for fixing to floor and shall have an integral flushing rim of suitable type. It shall also have an inlet or supply horn for connecting the flushing pipe of dimensions confirming to 'E' in table in **Fig. 15.20 & 15.21** the flushing rim may be boxed or open type. In the case of box rims adequate number of holes, on each side together with a slot opposite the inlet shall be provided. The flushing rim and inlet shall be of the self draining type. The water closet shall have a weep hole at the flushing inlet. Each water closet shall have an integral trap with either 'S' or 'P' outlet with at least 50 mm water seal. For P trap, the slope of the outlet shall be 14 deg. below the horizontal. Where required the water closet shall have an

antisiphonage 50 mm dia vent horn on the outlet side of the trap with dimension conforming to those given in **Fig. 15.21** and on either right or left hand or centre as specified set at an angle of 45 deg. and invert of vent hole not below the central line of the outlet. The inside surface of water closets and traps shall be uniform and smooth in order to enable an efficient flush. The serrated part of the outlet shall not be glazed externally. The water closet when sealed at the bottom of the trap in line with the back plate, shall be capable of holding not less than 15 litres of water between the normal water level and the highest possible water level of the water closet as installed.

15.1.18.3. Dimensions and Tolerances : The dimensions of pattern I and II shall confirm to those given in table in **Fig. 15.20 and 15.21** respectively. Where tolerances are not given for a specific dimension, the following shall be permissible.

- a) On dimension 75 mm and over ± 4 percent
- b) On dimensions less than 75 mm ± 2 mm
- c) On all angles ± 3 deg.

15.2. GENERAL REQUIREMENTS FOR INSTALLATION OF WC PAN

15.2.1. General: The work shall be carried cut, complying in all respects with the requirements of relevant byelaws of the local body in whose jurisdiction the work is situated.

15.2.2. Care in installation: Any damage caused to the building, or to electric, sanitary, water supply or other, installations etc. therein, either due to negligence on the part of the contractor, or due to actual requirements of the work, shall be made good and the building or the installation shall be restored to its original condition by the contractor. Nothing extra shall be paid for such restoration works except where otherwise specified.

15.2.3 Specifications for associated works: For making good the damage to the under mentioned items of work, the specifications as given in the following paras shall apply, unless directed otherwise.

a) Masonry Work : The masonry work shall be made good by using the same class of bricks, tiles or stones as was damaged during the execution of the work. The mortar used shall be cement mortar 1:5 (1 cement : 5 fine sand) or as directed by the The Engineer.

b) Plain Concrete Works : Concrete work for sub-grade of the flooring, foundations and other plain concrete works shall be cement concrete 1:5:10 (1 cement : 5 coarse sand : 10 graded stone aggregate 40 mm nominal size). A coat of neat cement slurry shall be applied at the junction with old work, before laying fresh concrete.

c) Cement Concrete Flooring and R.C.C. Works : Cement concrete 1: 2: 4 (1 Cement: 2 Coarse sand : 4 graded stone aggregate 20 mm nominal size) shall be used after applying a coat of neat cement slurry at the junction with old work, and the surface finished to match with the surrounding surface.

d) Plastering : Cement plaster 1:4 (1 cement :4 sand) shall be used. The sand shall be fine or coarse, as used in the original work. The surface shall be finished with two or more coats of white wash, colour wash, distemper or painting as required, but where the surface is not to be white washed, colour washed, distempered or painted, it shall be finished as required to match with the surrounding surface.

e) Other Items : Damage to any other item shall be made good as directed by the Engineer.

Note : In all the above operations the damaged portion shall be cut in regular geometric shape and cleaned before making good the same.

15.2.4 Painting. All exposed G.I., C.I. or lead pipes and fittings shall be painted with approved quality of paint and shade as specified. The painting work shall conform to specification described under sub head Painting.

15.2.5. Workmanship: All sanitary and plumbing work shall be carried out through licensed plumbers.

15.2.6 Cleaning of site: On completion of the work the site shall be cleaned and all rubbish disposed off as directed by the the Engineer .

15.2.7 Payment for items:- Various sanitary fittings described under 15.1 including fixing shall be enumerated individually or in combination under relevant items of works as described below. When used. in combination, specifications as described under relevant paras shall apply but nothing extra shall be paid for making connections required for successful functioning of the combination.

15.3. INSTALLATION OF DRAINING

BOARD:

15.3.1. Fixing : One end of the board shall rest on sink and the other end shall be supported on C.I. bracket embedded in cement concrete (1:2:4) block 100x75x150 mm. The brackets used shall be of cantilever type or wall fixed type as for the sink.

15.3.2. Painting : The brackets shall be painted with two or more coats of approved paint.

15.3.3. Measurements : Draining board shall be enumerated in case payable separately.

15.3.4. Rate : The rate shall include the cost of all materials and labour involved in all operations.

15.4. INSTALLATION OF FLUSHING CISTERN:**15.4.1. Fixing:**

15.4.1.1. High Level Cistern: The cistern shall be fixed on C.I. cantilever brackets which shall be firmly embedded in the wall in cement concrete (1:2:4) block 100x75x150 mm. The cistern shall be provided with 20 mm nominal bore G.I. overflow pipe 185 cm long with fittings. The outlet or flush pipe from the cistern shall be connected to the pan by means of cement or putty joint. The flush pipe shall be fixed to wall by using holder bat clamps of required shape and size so as to fit tightly on the pipes when tightened with screwed bolts. The clamps shall be embedded in brick work in cement mortar 1:3 (1 cement : 3 coarse sand). If connection between cistern and pan is made with G.I. pipe the bends and offsets shall be made cold.

15.4.1.2. Low Level Cistern: Para 15.4.1.1 shall apply except that connection between cistern and closet shall be made by means of 40 mm dia flush bend with rubber or G.I. inlet connection as specified.

15.4.1.3. Automatic Cistern: Para 15.4.1.1 shall apply except that CP Brass stop cock shall be provided for cistern having a capacity of more than 5 liter. The main & distribution flush pipe shall be fixed to the wall by means of standard pattern holder bat clamp shown in Fig. 15.10.

15.4.2. Painting: The cistern, brackets, overflow and flush pipe etc. shall be painted, if specified, with two or more coats of paint of approved shade and quality.

15.4.3. Measurements: Cistern, including all fittings, shall be enumerated.

15.4.4. Rate: The rate shall include the cost

of all materials and labour involved in all the operations described above.

15.5. INSTALLATION OF MIRROR:

15.5.1. Fixing: The mirror shall be mounted on backing with environmentally friendly material other than asbestos cement sheet and shall be fixed in position by means of 4 C.P. brass 'screws and C.P. brass washers, over rubber washers and wooden plugs firmly embedded in walls. C.P brass clamps with C.P brass screws may be an alternative method of fixing, where so directed. Unless specified otherwise the longer side shall be fixed horizontally.

15.5.2. Measurements: Mirror shall be enumerated.

15.5.3. Rate: Rate shall include the cost of all the materials and labour involved in all the operations described above.

15.6. FIXING AND JOINTING OF PIPES AND FITTINGS ,

15.6.0 General: The specifications described in para 10.26.3 shall apply, as far as applicable, except that the joint shall be lead caulked. All soil pipes shall be carried up above the roof and shall have sand cast iron / wire cowls /A.C terminal guard.

15.6.1. Height of Ventilating Pipes : The ventilating pipe or shaft shall be-carried to a height of atleast 60 cms above the outer covering of the roof of the building or in the case of a window in a gable wall or a dormer window it shall be carried upto the ridge of the roof or atleast 2 metres above the top of the window. In the case of a flat roof to which access for use is provided it shall be carried upto a height of 2 metres above the roof and shall not terminate within 2 metres, measured vertically from the top of any window opening which may exist upto a horizontal distance of 3 meters from the vent pipe into such building and in no case shall be carried to a height less than 3 metres above plinth level. In case the adjoining building is taller, the ventilating pipe shall be carried higher than the roof of the adjoining building, wherever it is possible.

The pipes above the parapet shall be secured to the wall by means of M.S. stay and clamps as specified in para 15.1.8.

The connections between the main pipe and branch pipes shall be made by using branches and bends with access doors for, cleaning. The waste from lavatories, kitchen, basins, sinks, baths and other floor traps

shall be separately connected to respective waste stack of upper floors. The waste stack of lavatories shall be connected directly to manhole while the waste stack of others shall separately discharge over *gully* trap. Where single stack system is provided, the connection shall be made direct to the manhole.

15.6.2. Jointing: The interior of the socket and exterior of the spigots shall be thoroughly cleaned and dried. The spigot end shall be inserted into the socket right upto the back of the socket and carefully centered by two or three laps of treated spun yarn, twisted into ropes of uniform thickness, well caulked into the back of the socket. No piece of yarn shall be shorter than the circumference of the pipe. The jointed pipe line shall be at required levels and alignment.

The leading of pipes shall be made by means of ropes covered with clay or by using special leading rings. The lead shall be melted so as to be thoroughly fluid and each joint shall be filled in one pouring. caulking lead shall conform to IS:782-1978. Lead required per joint for 50 mm, 75 mm and 100 mm diameter pipes is 0.77 Kg, 0.88 Kg., and 0.98 Kg respectively.

The following precautions shall be taken for melting lead :

- a) The pot and the ladle in which lead shall be put shall be clean and dry.
- b) Sufficient quantity of lead shall be melted.
- c) Any scum or dross which may appear on the surface of the lead during melting shall be skimmed off.
- d) Lead shall not be overheated.

After the lead has been run into the joint the lead shall be thoroughly caulked. Caulking of joints shall be done after a convenient length of the pipes has been laid and leaded.

The leading ring shall first be removed and any lead outside the socket shall be removed with a flat chisel and then the joint caulked round three times with caulking tools of increasing thickness and hammer 2 to 3 kg weight. The joints shall not be covered till the pipe line has been tested under pressure.

Use of collars for jointing is not permitted in any concealed or embedded location. However, in exposed locations where full length pipes can not be fixed due to site constraints, collars (and not loose sockets) may be used subject to the following:

Note : The dimensions of loose sockets and collars for different sizes of pipes are given in **Figure 15.22.**

- a) No two consecutive joint shall be with the use of collars.
- b) The joint of collar with the cut/spigot end of the pipe shall be made on the ground in advance and tested against leakage before fixing.
- c) Cut/spigot end of the pipes shall be inserted in the collars upto the projection inside the collar and jointing shall be done as in the case of socket and spigot joint. The jointed pipe line shall be at required level/slope and alignment.

Note : The dimensions of loose sockets and collars for different sizes of pipes are given in **Figure 15.22.**

15.6.3. Testing :

In order to ensure that adequate lead is poured properly into the joints and to control waste in use of lead, at the beginning of work three or four sample joints shall be made and the quantum of lead per joint approved by the Engineer. All sand cast iron/cast iron (Spun) pipes and fittings including joint shall be tested by smoke test to the satisfaction of the Engineer and left in working order after completion. The smoke test shall be carried out as under :-

Smoke shall be pumped into the pipes at the lowest end from a smoke machine which consists of a bellows and burner. The material usually burnt is greasy cotton waste which gives out a clear pungent smoke which is easily detectable by sight as well as by smell, if there is leak at any point of the drain.

15.6.4. Painting : All sand cast iron/cast iron (Spun) pipes and fittings shall be painted with shade to match the colour of the background as directed by the Engineer.

15.6.5. Measurements:

15.6.5.1. The pipes shall be measured net when fixed in position excluding all fittings along its length, correct to a cm.

15.6.5.2. When collars are used for jointing SCI pipes these shall be measured as fittings and shall be paid for separately.

15.6.5.3. No allowance shall be made for the portions of the pipe lengths entering the sockets of the adjacent pipes or fittings. The above shall apply to both cases i.e. whether

the pipes are fixed on wall face or embedded in masonry.

15.6.5.4. No deduction shall be made in the former case from the masonry measurement for the volume of concrete blocks embedded therein. Similarly no deduction shall be made for the volume occupied by the pipes from the masonry when the former are embedded in the later.

15.6.6. Rates : The rate shall include the cost- of all labour and materials involved in all the operations described above, excluding fittings, lead caulk jointing, the supply and fixing M.S. holder bat clamps and M.S. stays and clamps, floor trap and painting, which shall be paid for separately.

15.6.7 FIXING AND JOINTING OF LEAD PIPES:

15.6.7.1. General : Lead pipes shall be used only for short branch soil, waste or vent connections. The lead pipe shall conform to IS:404-1977. The minimum weight of lead pipes for use as soil, waste, or vent pipes shall be 3.28 kg per metre and 3.95 kg per metre for 32mm and 40mm nominal internal diameter respectively. When not supported

on bearers, all lead pipes shall be supported by strong lead tacks atleast 38mm wide soldered on to the pipes at suitable intervals. All joints of lead pipes shall be wiped solder joints.

15.6.7.2 Wiped solder joints: The pipe ends to be jointed shall be cleaned with wire brush and freed from oxide, if any. Chalk shall then be rubbed to kill the greasy nature of the lead. After this, plumbers black shall be applied. The length of the joint as given below shall then be marked on the pipe. A fine shaving of lead shall be removed from this length with shave hook. Tallow shall then be smeared over the prepared surface. The molten solder, an alloy composed of 3 parts of tin and 7 parts of lead, shall be poured in a thin stream from a ladle moved in an elliptical direction over the joint position including a portion of the soil pipe at each end beyond the mark. When sufficient solder has been poured the joint shall be wiped with a pad of wiping cloth with long continuous movements in one direction only so as to leave a neatly formed elliptical shaped joint. Surplus solder remaining on the joint shall be removed with a tool called "draw off".

Length of the wiped solder joint shall be as follows :

Diameter of pipe	Length of wiped solder	
	Minimum	Maximum
15mm	60mm	70mm
20mm	65 mm	70 mm
25 mm	70 mm	75 mm
32 mm	70 mm	80 mm
40 mm	70 mm	80 mm
50 mm	75 mm	90 mm

The joints shall be watertight, airtight and shall be free from tears, burrs, strings ribands or droppings.

15.6.7.3 Lead pipe connections:

(a) For joints between lead pipe and C.I. or stoneware pipe, one end of the brass ferrule or thimble shall be slipped into or over the lead pipe and jointed to it by means of a wiped solder joint. The other end of the ferrule shall then be inserted into the socket of the cast iron or stoneware pipe. In the case of former, the joint shall be made with molten lead (lead caulked) and in case of the latter with cement mortar as in stoneware pipe drains.

(b) For joints between outgo of a W.C. pan and a lead pipe, the lead pipe shall be slipped into a brass socket and jointed to it

by wiped solder joint. The outgo of a W.C. pan shall then be inserted into the socket and jointed by using cement mortar as in stoneware pipe drains.

15.6.7.4 Painting: All exposed lead pipes shall be painted as in S.C.I. pipes and fittings.

15.7. INSTALLATION OF SEAT AND COVER TO WATER CLOSET:

15.7.1. Fixing: The seat shall be fixed to the pan by means of two corrosion resistant hinge bolts with a minimum length of shank of 65 mm and threaded to within 25 mm of the flange supplied by the manufacturer

along with the seat. Each bolt shall be provided with two suitably shaped washers of rubber or other similar materials for adjusting the level of the seat while fixing it to the pans. In addition, one non-ferrous or stainless steel washer shall be provided With each bolt. The maximum external diameter of the washer fixed on the underside of the pan shall not be greater than 25 mm. Alternative hinging devices as supplied by the manufacturer of the seat can also be used for fixing with the approval of the Engineer.

15.7.2. Measurements : Seat with cover shall be enumerated.

15.7.3. Rate: Rate shall include the cost of all the materials and labour involved in all the operations described above.

15.8. INSTALLATION OF SINK:

15.8.0. General: The installation shall consist of assembly of sink, C.I. brackets, union and G.I. or P.V.C. waste pipe.

15.8.1. Fixing: The sink shall be supported on C.I. cantilever brackets, embedded in cement concrete (1:2:4) block of size 100x75x150 mm: Brackets shall be fixed in position before the dado work is done. The C.P. brass or P.V.C. union shall be connected to 40 mm nominal bore G.I. or PVC waste pipe which shall be suitably bent towards the wall and shall discharge into a floor trap. C.P. brass trap and union and waste shall be paid separately. The height of front edge of sink from the floor level shall be 80 cm.

15.8.2. Measurements : The sinks shall be enumerated.

15.8.3. Rate: Rate shall include the cost of all materials and labour involved in all the operations described above but shall not include the cost of waste fitting and brackets which shall be paid for separately.

15.9. INSTALLATION OF URINAL LIPPED, HALF STALL (SINGLE OR RANGE) (FIG.15.9 & 15.11)

15.9.0. General: Urinal installation shall consist of a lipped urinal (Single or range), an automatic flushing cistern, G.I. flush and waste pipe. The capacity of flushing cistern and relevant size of flush pipe for urinals in a range shall be as prescribed in **Table 15.2**.

Waste pipe shall be of 32 mm nominal bore G.I. pipe and shall be paid separately.

15.9.1. Fixing : Urinals shall be fixed in position by using wooden plugs and screws. It shall be at a height of 65 cm from the standing level to the top of the lip of the urinal, unless otherwise directed by the Engineer. The size of wooden plugs shall be 50 mm x 50 mm at base tapering to 38 *mm x38 mm at top and of length 5.0 cms. These shall be fixed in the wall in cement mortar 1:3 (1 cement : 3 fine sand). After the plug is fixed in the wall, the mortar shall be cured till it is set.

Each urinal shall be connected to 32 mm dia waste pipe which shall discharge into the channel or a floor trap. The connection between the urinal and flush or waste pipe shall be made by means of putty or white lead mixed with chopped hemp.

TABLE 15.2

No. of in range Urinals	Capacity of Flushing Cistern	(Galvanised iron)	
		Main	Distribution
One	5 Litres	15 mm	15mm
Two	10 Litres	20 mm	15 mm
Three	10 Litres	25 mm	15 mm
Four	15 Litres	25 mm	15 mm

15.9.2. Measurements : Urinals shall be enumerated.

15.9.3. Rate : Rate shall include the cost of all the materials and labour involved in all the operations described above.

15.10. INSTALLATION OF STALL URINAL (SINGLE OR RANGE) (FIG. 15.10) :

15.10.0. General : The installation shall consist of stall urinal (single or range), automatic flushing cistern, C.P. brass standard flush pipes, C.P. brass spreader and C.I. trap with tail piece and outlet grating of C.P. brass. Capacity of flushing cistern and relevant size of flush pipe, C.I. trap shall be as prescribed in **Table 15.3**.

15.10.1. Fixing: The floor slab shall be suitably sunk to receive the stall urinal. Where the floor slab is not sunk, the stall urinal shall be provided over a platform. The lip of the stall urinal shall be flush with the finished floor level adjacent to it. The stall urinal shall be laid over a fine sand cushion of average 25 mm thickness. A space of not less than 3mm shall be provided around, in front, sides and filled with water proofing plastic compound. Care shall be taken that after the sub-grade for the floor is cast, one week should lapse before urinals are

installed. Generally fixing of the tread plate shall be as specified in 15.12.1. The trap and fittings shall be fixed as directed by the Engineer. Payment for the floor and its sub-grade shall be made separately.

15.10.2. Measurements : Stall urinals shall be enumerated.

15.10.3. Rate : The rate shall include the cost of all the materials and labour involved in all the operations described above.

TABLE 15.3

No. of Urinals in range	Capacity of Flushing cistern	Size of flush pipe(Chromium Plated)		Diameter of C.I. traps
		Main	Distribution	
One	5 Litres	15 mm	15 mm	50 mm
Two	10 Liters	20 mm	15 mm	50 mm
Three	15 Litres	25 mm	15 mm	80 mm
Four	15 Litres	25 mm	15 mm	80 mm

15.11. INSTALLATION OF WASH BASIN (FIG. 15.14, 15.15, 15.16, 15.17 & 15.18)

15.11.0. General. The installation shall consist of an assembly of wash basin, pillar taps, C.I. brackets, C.P. brass or P.V.C. union, as specified. The wash basin shall be provided with one or two 15 mm C.P. brass pillar taps, as specified. The height of top of the rim of wash basin from the floor level shall be within 750 mm to 800 mm.

15.11.1. Fixing : The basin shall be supported on a pair of C.I. cantilever brackets conforming to IS : 775 & be embedded in cement concrete (1:2:4) block 100x75x150 mm. Use of M.S. angle or Tee section as bracket is not permitted. Brackets shall be fixed in position before dado work is done. The brackets have been shown in Fig.

15.15. The wall plaster on the rear shall be cut to rest over the top edge of the basin so as not to leave any gap for water to seep through between wall plaster & skirting of basin. After fixing the basin, plaster shall be made good and surface finished to match with the existing one S.C.I. floor traps conforming to IS : 1729 having 50 mm water seal (minimum 35 mm in two pipe system with gully trap) should be used. Waste pipes laid horizontally should have gradient not flatter than 1 in 50 and not steeper than 1 in 10.

The waste water from wash basin shall be discharged directly to vitreous semi-circular open drain, discharging to a floor trap and finally to the vertical stack (**Fig-15.15**) on upper floors and in case of ground floor, the waste water shall be discharged either directly to the gully trap or through the floor trap (**Fig.15.16**). C.P. brass trap and union are not to be used in such situations.

If waste pipe is concealed or crosses the wall, waste water shall be discharged through non ferrous trap like PVC Engineering plastic or C.P. brass and union (**Fig.15.17**) to vertical stack. The C.P. brass trap and union shall be paid for separately.

Where so specified a 20 mm G.I. puff pipe terminating with a perforated brass cap screwed on it on the outside of the wall or connected to the anti-syphon stack shall be provided.

15.11.2. Measurements : Wash basins shall be enumerated.

15.11.3. Rate : The rate shall include the cost of all the materials and labour involved in all the operations described above.

15.12. INSTALLATION OF SQUATTING PAN

15.12.0. General: The installation shall consist of squatting pan, flushing cistern,

flush pipe and a pair of foot rests.

15.12.1. Fixing : The pan shall be sunk into the floor and embedded in a cushion of average 15 cm thick cement concrete 1:5:10 (1 Cement : 5 fine sand : 10 graded brick ballast 40 mm nominal size). The concrete shall be left 115 mm below the top level of the pan so as to allow flooring and its bed concrete. The pan shall be provided with a 100 mm S.C.I., P or S type trap with an approximately 50 mm seal and 50 mm dia vent horn, where required by the Engineer. The joint between the pan and the trap shall be made leak proof with cement mortar 1:1 (1 cement : 1 fine sand).

15.12.0. General. The installation shall consist of squatting pan, flushing cistern, flush pipe and a pair of foot rests.

15.12.1. Fixing : The pan shall be sunk into the floor and embedded in a cushion of average 15 cm thick cement concrete 1:5:10 (1 Cement : 5 fine sand : 10 graded brick ballast 40 mm nominal size). The concrete shall be left 115 mm below the top level of the pan so as to allow flooring and its bed concrete. The pan shall be provided with a 100 mm S.C.I., P or S type trap with an approximately 50 mm seal and 50 mm dia vent horn, where required by the Engineer. The joint between the pan and the trap shall be made leak proof with cement mortar 1:1 (1 cement : 1 fine sand).

15.12.2. Measurements: The squatting pans shall be enumerated.

15.12.3. Rate : Rate shall include the cost of all the materials and labour involved in all the operations described above. Cost of concrete shall be paid separately

15.13. INSTALLATION OF WATER CLOSET:

15.13.0. General: Installation shall consist of water closet with seat and cover, flushing cistern and flush bend.

15.13.1. Fixing : The closet shall be fixed to the floor by means of 75 mm long 6.5 mm diameter counter-sunk bolts and nuts embedded in floor concrete.

15.13.2. Measurements : Water closets shall be enumerated

15.13.3. Rate : Rate shall include the cost of all the materials and labour involved in all the operations described above

15.14. INSTALLATION OF FOOT RESTS :

15.14.1. General: After laying the floor around squatting pan as specified a pair of foot rests shall be fixed in cement mortar 1 : 3 (1 cement : 3 coarse sand). The position of foot rests with respect to pan shall be as per **Fig. 15.4.**

15.14.2. Measurements : Pair of foot rests shall be enumerated.

15.14.3. Rate : Rate shall include the cost of all the materials and labour involved in all the operations described above.

15.15. INSTALLATION OF SQUATTING PLATE (SINGLE OR RANGE) (FIG. 15.12):

15.15.0.General: The installation shall consist of an assembly of squatting plates (single or range), vitreous China channel, automatic flushing cistern, flush pipe with fittings spreader and C.I. trap. The capacity of flushing cistern and relevant size of flush pipes shall be as specified in **Table 15.4.**

15.15.1. Fixing : The floor slab shall be suitably sunk to receive the squatting plate. Where the floor slab is not sunk, the plates shall be provided over a platform. The top edge of, the squatting plate shall be flush with the finished floor level adjacent to it. It shall be embedded on a layer of 25 mm thick cement mortar 1:8 (1 cement : 8 fine sand) laid over a bed of 'cement concrete 1:5:10 (1 cement : 5 fine sand : 10 graded brick aggregate 20 mm nominal size).

There shall be 100 mm dia, white glazed vitreous China channels with stop and outlet pieces suitably fixed in the floor in° cement mortar 1:3 (1 cement :3 coarse sand) and joint finished with white cement. The squatting plate shall have 1200 high and half brick thick wall in front and on either side of the squatting plate. The brick work for the walls shall be paid separately. The exposed surface of walls shall be lined with white glazed tiles / wall tiles with proper corners and angles set in neat cement mortar, the face of the joints shall be gone over with whiting so as to match with the colour of the tiles. The tiles shall be 15 mm square or of approved size. Space if any, left between the side walls and squatting plate shall be finished to match the colour of the squatting plate. The trap and fittings shall be fixed as directed by the Engineer. The vitreous China channel shall discharge into a 65 mm diameter standard urinals, C.I. trap with vent arm having 65 mm C.P. brass outlet grating.

15.15.2. Measurements : Squatting plates shall be enumerated.

15.15.3. Rate: The rate shall include the cost of all the materials and labour involved in all the operations described above.

TABLE 15.4

No. of squat- ting plates in range	Capacity of flushing cistern	Size of flush pipe (<u>galvanised iron</u>)	
		Main	Distribution
One	5 liters	-	20 mm
Two	10 liters	25 mm	20 mm
Three	15 liters	32 mm	20 mm
Four	15 liters	32 mm	20 mm

15.16. INSTALLATION OF TOWEL RAIL

15.16.0 General: It shall be fixed in position by means of C.P. brass screws on wall surface by PVC fasteners, firmly embedded in wall.

15.16.1. Measurements: Tower rails shall be enumerated

15.16.2. Rate : Rate shall include the cost of all the materials and labour involved in all the operations described above.

ANNEXURE 15.1**EXTRACTS OF ITEMS COVERED IN IS:5329-1983, IS:1172-1993, IS:2064-1993**

A) IS:5329-1983 CODE OF PRACTICE FOR SANTIARY PIPE WORK ABOVE GROUND FOR BUILDINGS

- 1) Scope
- 2) Terminology (Definition of items)
- 5) Material (Choice of materials for pipes & fittings – Asbestos cement, cast iron, salt glazed stoneware pipe, Galvanised steel & wrought iron, any other materials approved by the Local authority)
- 3) Design consideration (Pipe systems – Two pipe system, one pipe system, single stack system; pipe capacities, layout of pipes,; connection of fixtures; traps; soil pipes; waste pipe; ventilating pipe; design data for single stack plumbing).
- 4) Inspection and Testing (Inspection, Testing of system – Water test, air test, smoke test, hydraulic performance).

B) IS 1172-1993 CODE OF BASIC REQUIREMENTS FOR WATER SUPPLY, DRAINAGE AND SANITATION

- 1) Scope

2) References (IS codes that are necessary adjuncts)

3) General requirements

4) Water supply requirements (For Residences; For buildings other than residences; For different types such as Factories, Hospitals, Hostels, Hotels, Offices, Schools etc.)

5) Drainage and sanitation requirements (For residences; for other than residences; for different types such as office buildings, factories, hospitals, schools, educational institutions, Hostels etc.)

6) Water supply, drainage and sanitation requirements for Railway platforms, bus stations, bus terminals etc.).

C) IS 2064-1993 CODE OF PRACTICE ON "SELECTION INSTALLATION AND MAINTENANCE OF SANTIARY INSTALLATIONS"

- 1) Definition of sanitary appliances
- 2) Collection of data for selection of appliances
- 3) Time schedules
- 4) Materials
- 5) Design consideration for kitchen, bath rooms, bidet, shower, toilet, water closet,

wash basins, urinals.

6) Work on site – Chases and ducts, siting of appliances, fixing of appliances,

priorities, inspection and testing, maintenance

ANNEXURE 15.2

METHOD OF INSPECTION FOR DEFECTS OF BATH TUBS

The surface of the bath tubs shall be visually inspected for blemishes from a distance of 600 mm after being inked. The light source shall be partially diffused daylight supplemented, if necessary, with diffused artificial light to provide illumination comparable to that usually available within short distance of the outside window facing north, but not in direct sunlight. The illumination shall have an intensity of 1,000 to 2,000 lux. Blemishes other than those given in **Table 2** shall not be allowable.

INK TEST : To do the visual examination of the surface of the bath tub, ink is applied to the area to be inspected as follows :

a) Wash the entire area to be inspected with a water soluble ink.

b) Rinse the surface with fresh water and dry. Ink will remain entrapped in cracks pits etc.

All references to visible defects shall refer to defects apparent to the eye upon close inspection, after the surface has been ink tested.

Defects whose Presence cannot be Permitted : The defects whose presence cannot be permitted are listed in **Table 1**.

TABLE 1 - DEFECTS WHICH CANNOT BE PERMITTED

Part	Non-Permissible Defects
Upper rim, inner wall, bottom, apron, readily other visible faces	Small pores, wrinkle, craze, bubbles, injuries, defective impregnation, superficial defects, , aggregate defects.
Obscure faces	Defective impregnation, Superficial defects.

The Permissible Range of Defects :

The permissible range of various defects are listed in **Table 2**.

TABLE 2 - PERMISSIBLE DEFECTS

Defects/Parts	Upper Rim	Inner Wall	Apron	Bottom	Visible Parts
Traces of mending	2	2	2	2	Not conspicuous
Impurities	2	3	2	3	-do-
Pinholes	2	3	2	3	-do-
Colour blot	Should not be conspicuous				
Unevenness	Should not be conspicuous				
Deformity	The horizontal section of the upper rim shall drain off water readily. The bend of the section in contact with wall shall be less than 5 mm. Deformities of the other sections of the bath tub shall not be conspicuous				

ANNEXURE 15.3**STANDARD WEIGHTS AND THICKNESS OF C.I. PIPES****FOR SAND CAST IRON PIPES IS : 1729**

Nominal dia of bore (mm)	Thickness (mm)	Over all weight of pipe excluding ears		
		1.5 m long (Kg)	1.80 m long (Kg)	2.0 m long (Kg)
50	5.0	9.56	11.41	12.65
75	5.0	13.83	16.52	18.37
100	5.0	18.14	21.67	24.15
150	5.0	26.70	31.92	35.66

For Cast Iron Spun Pipes IS: 3989

Nominal dia (mm)	Thickness (mm)	Overall weight in Kg. for an effective length in metres of				
		3.000	2.500	2.000	1.800	1.500
50	3.5	13.40	11.3	9.2	8.4	7.1
75	3.5	20.0	16.8	13.8	12.5	10.6
100	4.0	30.0	25.5	21.0	18.8	16.0
150	5.0	56.0	47.0	38.5	34.9	29.5

Tolerances

- a) Tolerances on the external diameter of the barrel, the internal diameter of the socket and the depth of socket shall be as follows

Dimensions (mm)	Nominal Diameter (mm)	Tolerance(mm)
External, diameter of barrel	50,75	± 3.0
	100	± 3.5
	150	± 4.0
Internal diameter of socket	All diameters	± 3.0
Depth of socket	All diameters	± 10.0

The maximum and minimum jointing space resulting from these tolerances shall be such that the jointing of the pipes and fittings is not adversely affected. The tolerance on

length of pipes shall be ± 20 mm.

- b) The tolerances on dimensions of fittings shall be as given below :

Type of Casting	Dimension	Tolerance mm	
Bend pipes	a	+25	-10
	b	+20	-10
Branches with equal branch pipes	a	+25	-10
	b	+25	-10
Branches with unequal branch pipes	L	+30	-20
S. Shape casting	L	+50	-10

Taper collars	L	+25	-10
Other	L	+20	-10

Note :

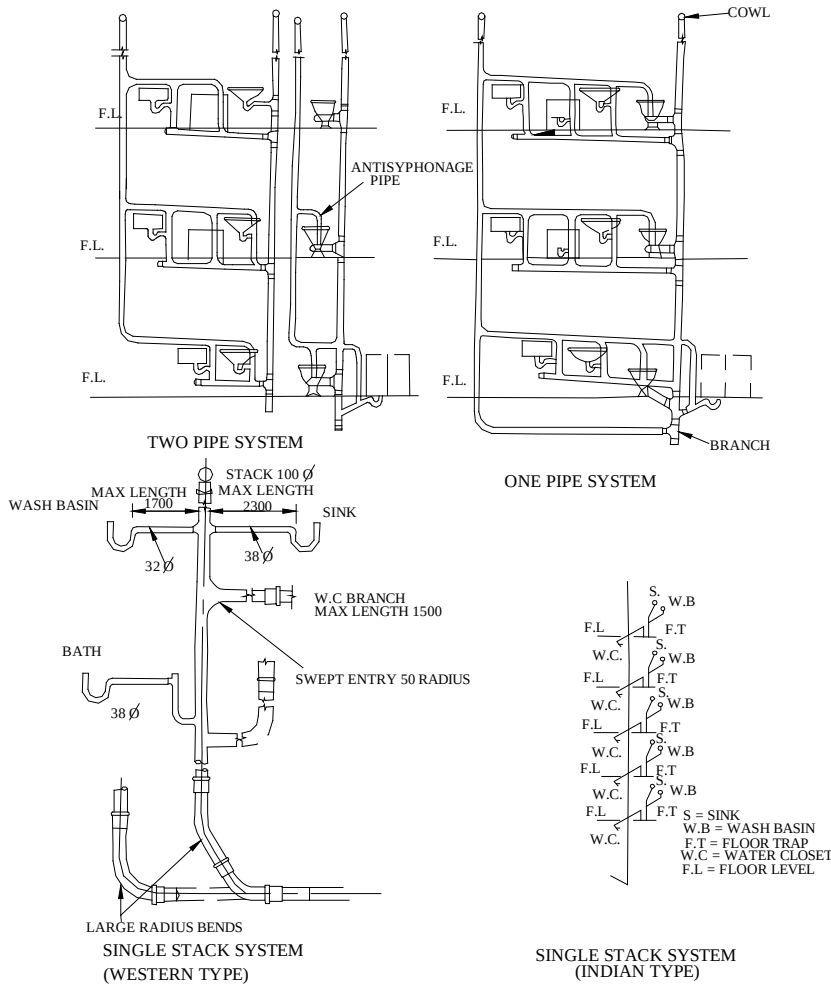
- 1) Tolerance on wall-thickness shall be limited to. -15 percent. No limits for plus tolerance is specified.
- 2) Tolerance for dimensions other-than those specified above shall be as specified in

IS : 5519.

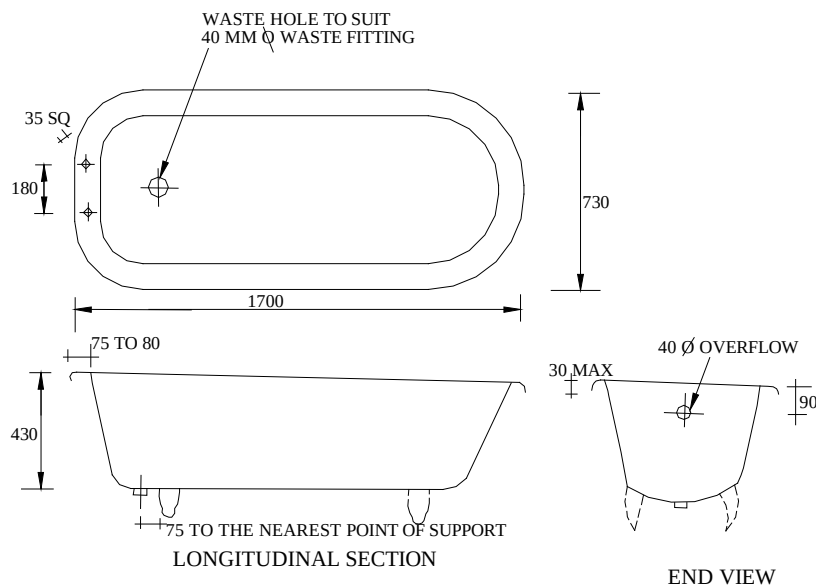
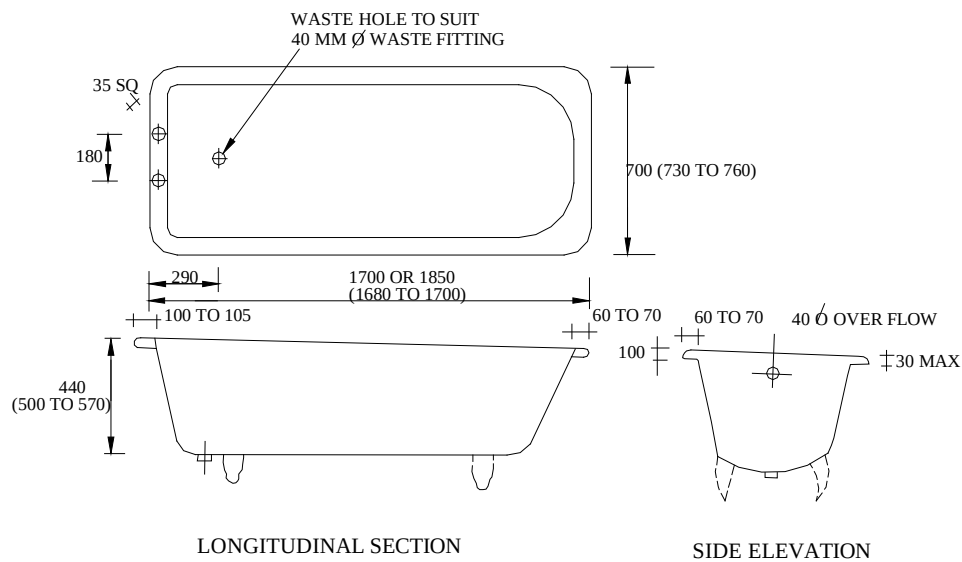
- 3) Tolerance on mass shall be limited to -10 percent. No limit for plus tolerance is specified.

PIPE SYSTEMS AND PARTS

FIGURE 15.1



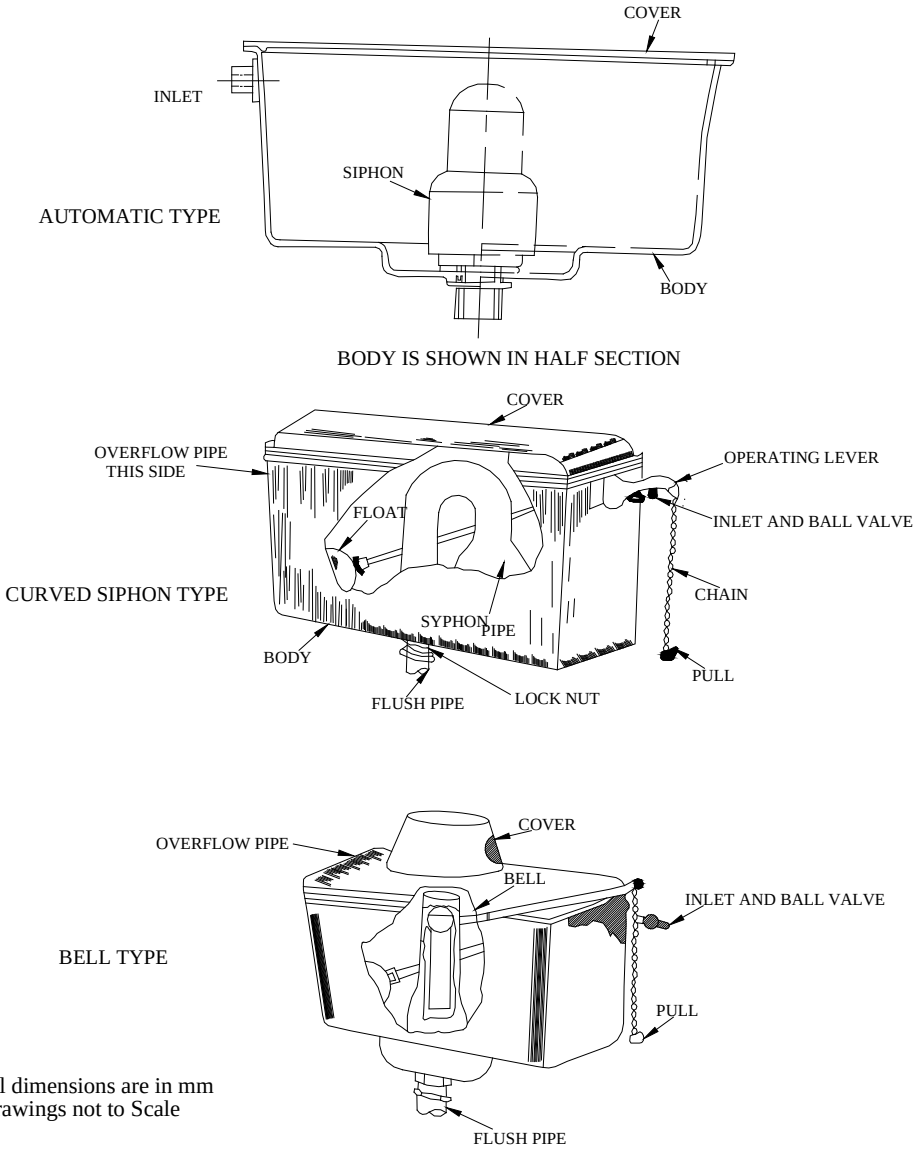
All dimensions are in mm
Drawings not to Scale

BATH TUB**FIGURE 15.2**

- 1 All dimensions are in mm
 2 Drawings not to Scale
 ③ 3 ENAMELLED STEEL/GEL COATED
 4 DIMS. WITHIN PARENTHESIS ARE FOR GELL COATED
 ⑤ 5 ENAMELLED STEEL ONLY.

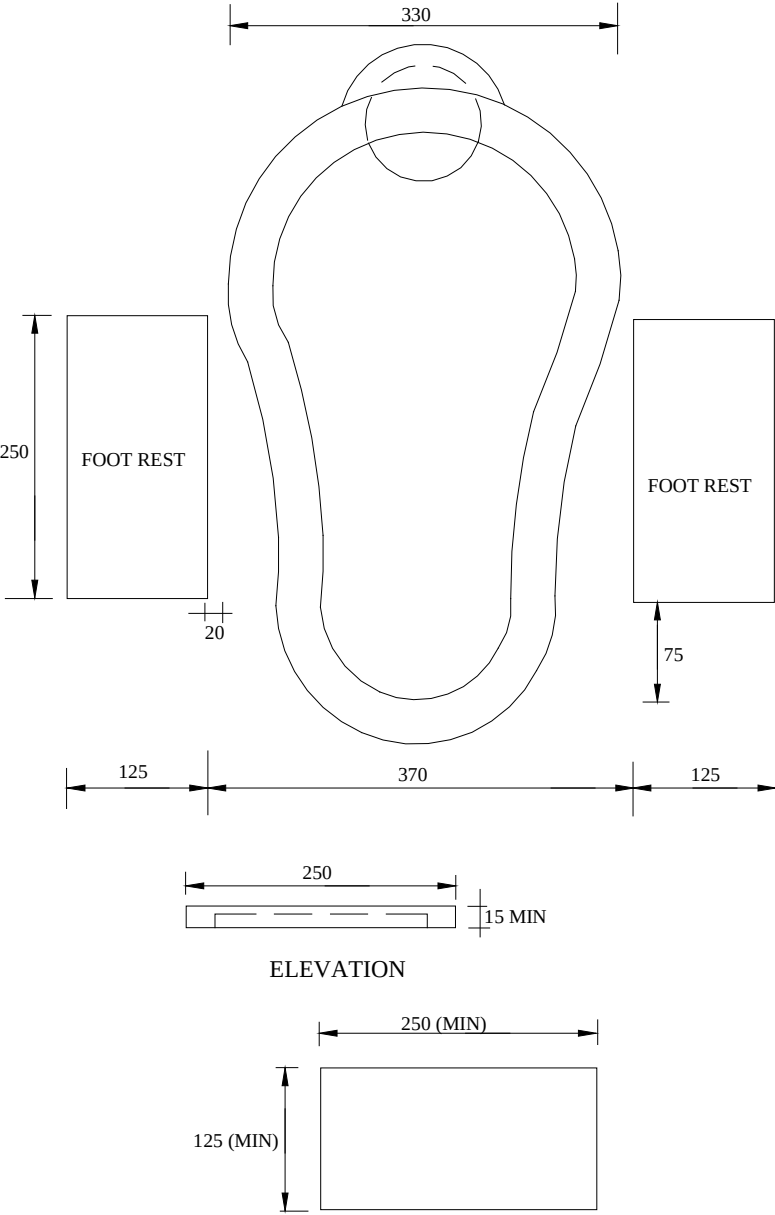
FLUSHING CISTERNS

FIGURE 15.3



FOOT REST

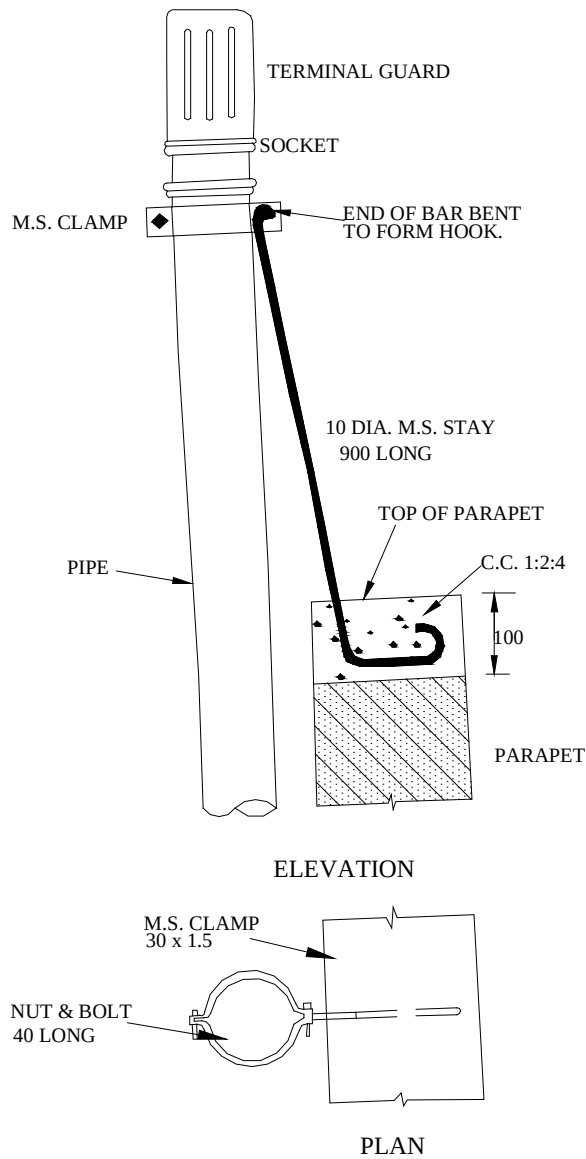
FIGURE 15.4



All dimensions are in mm
Drawings not to Scale

M.S. STAYS AND CLAMP

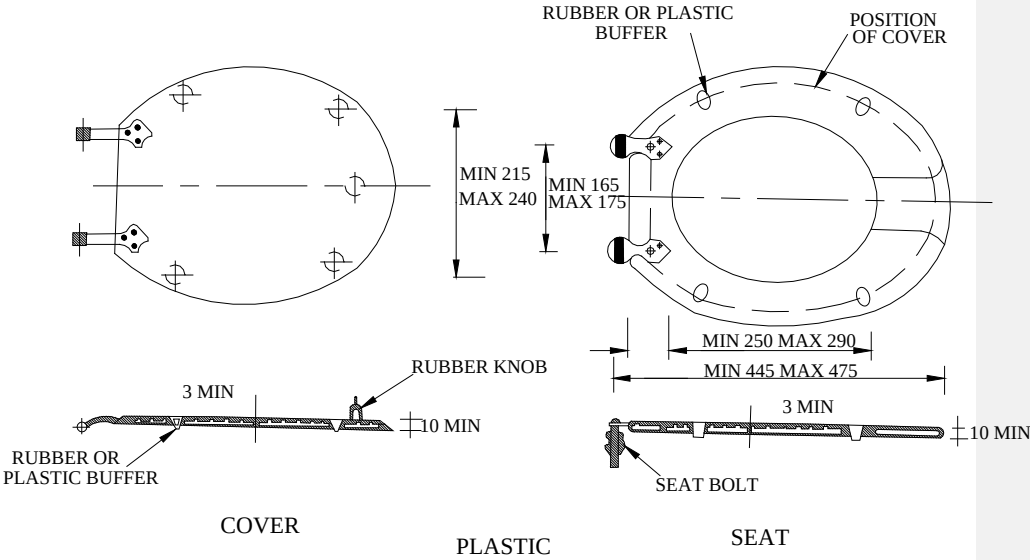
FIGURE 15.5



All dimensions are in mm
Drawings not to Scale

W.C. SEAT AND COVERS

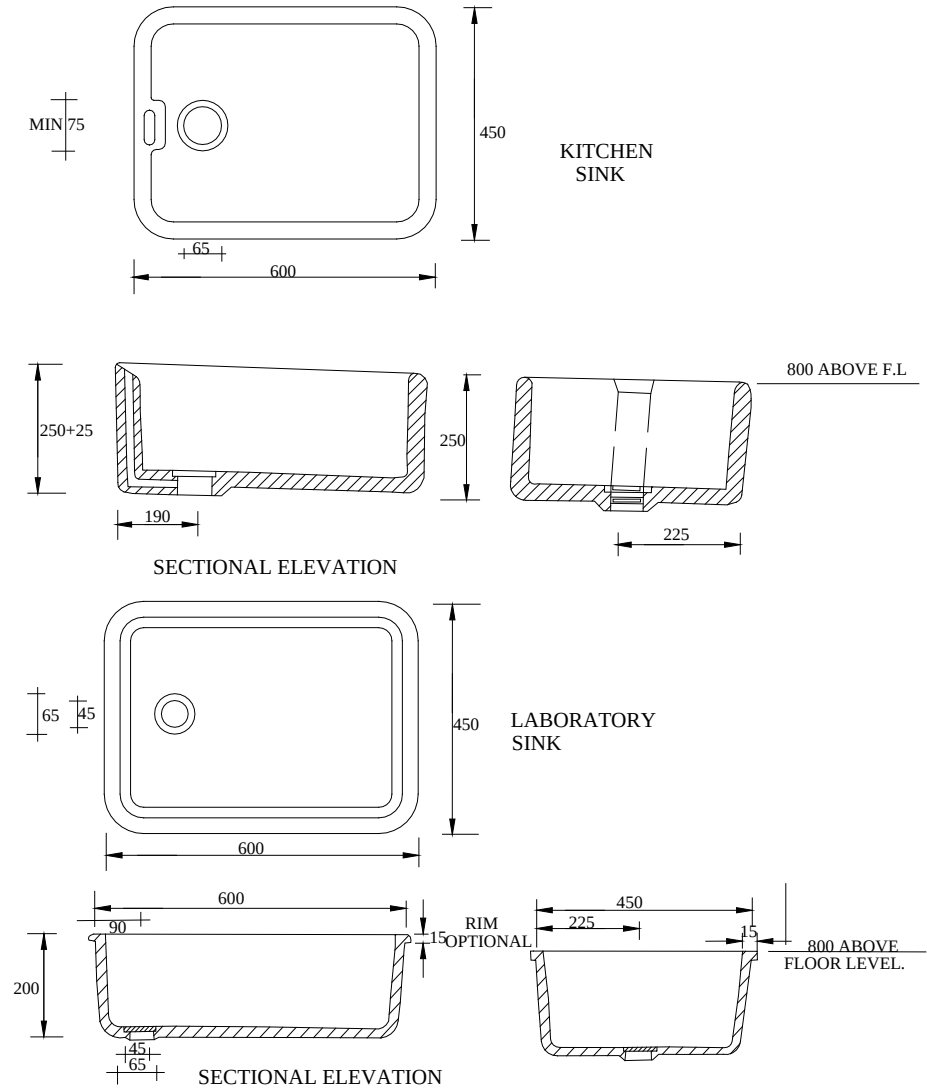
FIGURE 15.6



All dimensions are in mm
Drawings not to Scale

SINKS

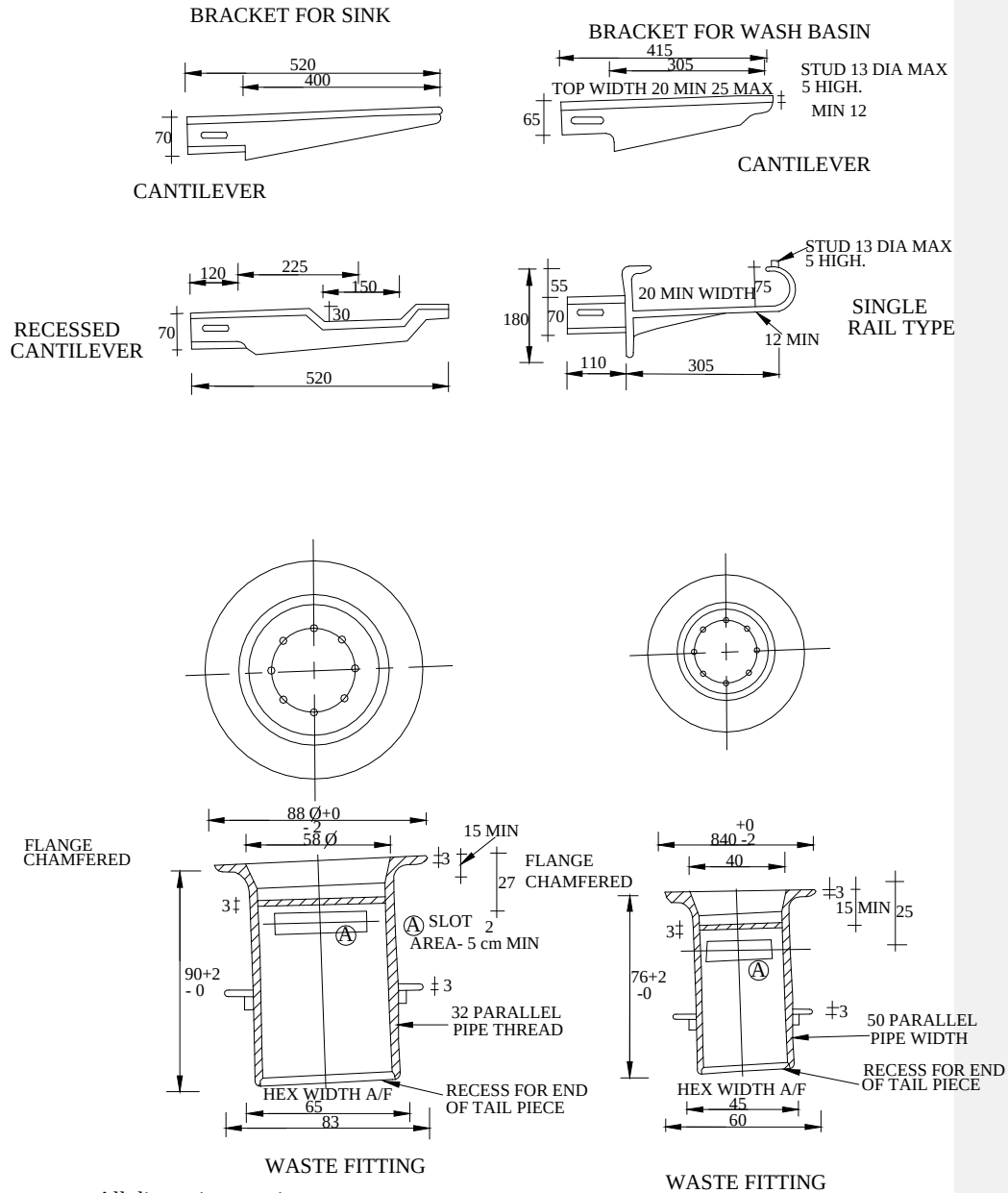
FIGURE 15.7



All dimensions are in mm
Drawings not to Scale
Hight of front edge of sink from floor level = 800

C.I. BRACKETS AND WASTE FITTINGS

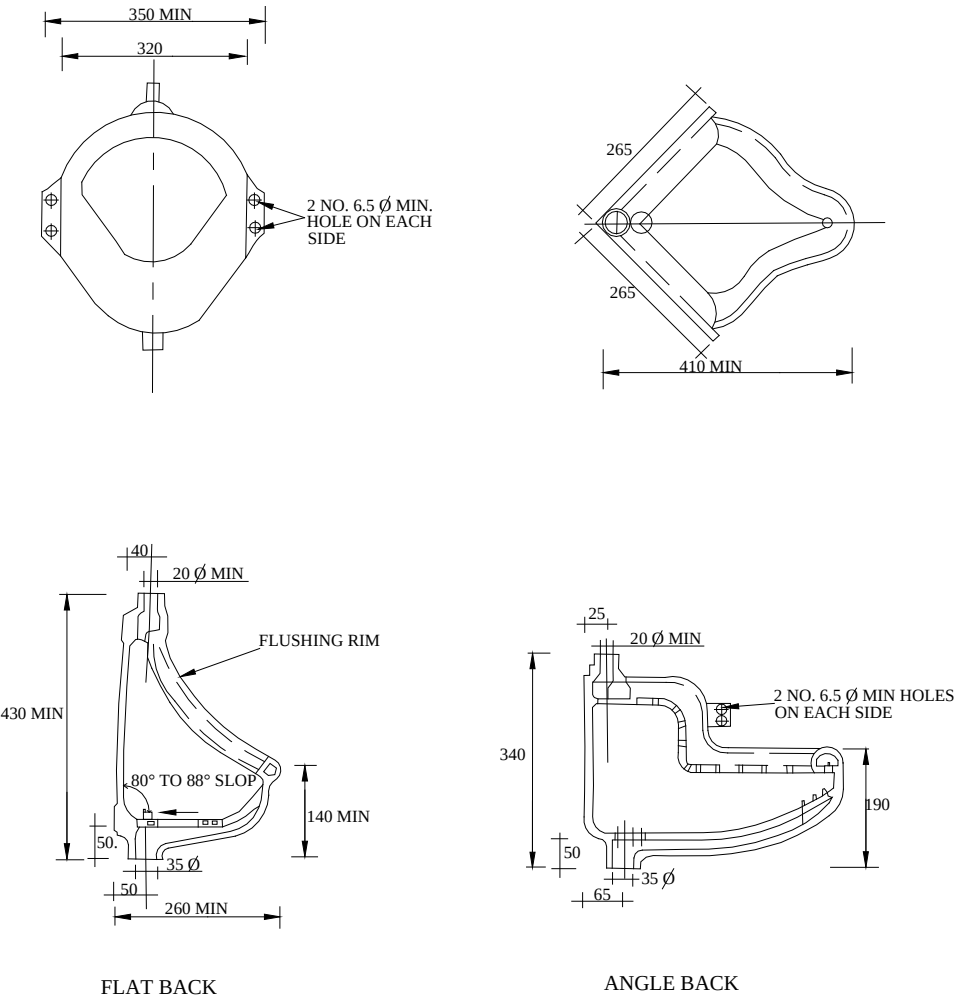
FIGURE 15.8



All dimensions are in mm
 Drawings not to Scale
 No and size of holes indicative.

URINAL BOWL TYPE

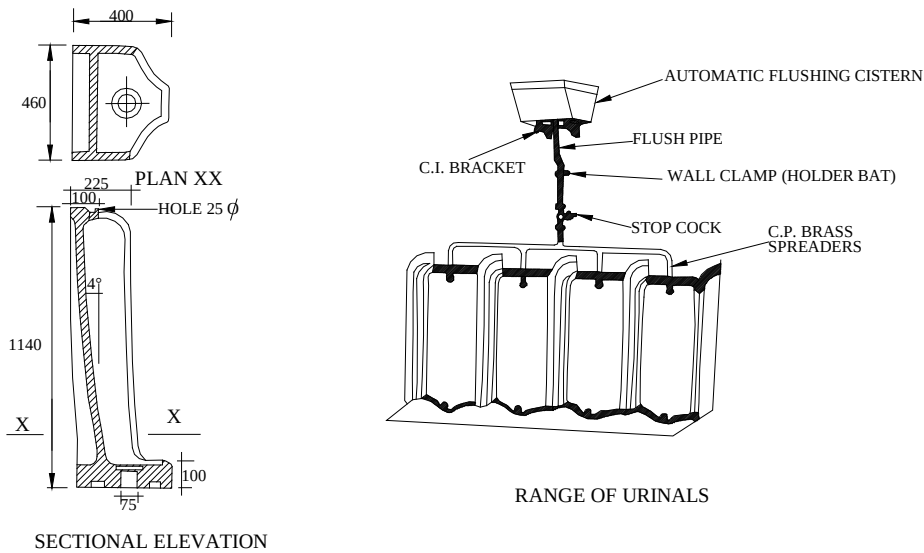
FIGURE 15.9



All dimensions are in mm
Drawings not to Scale

URINAL - STALL

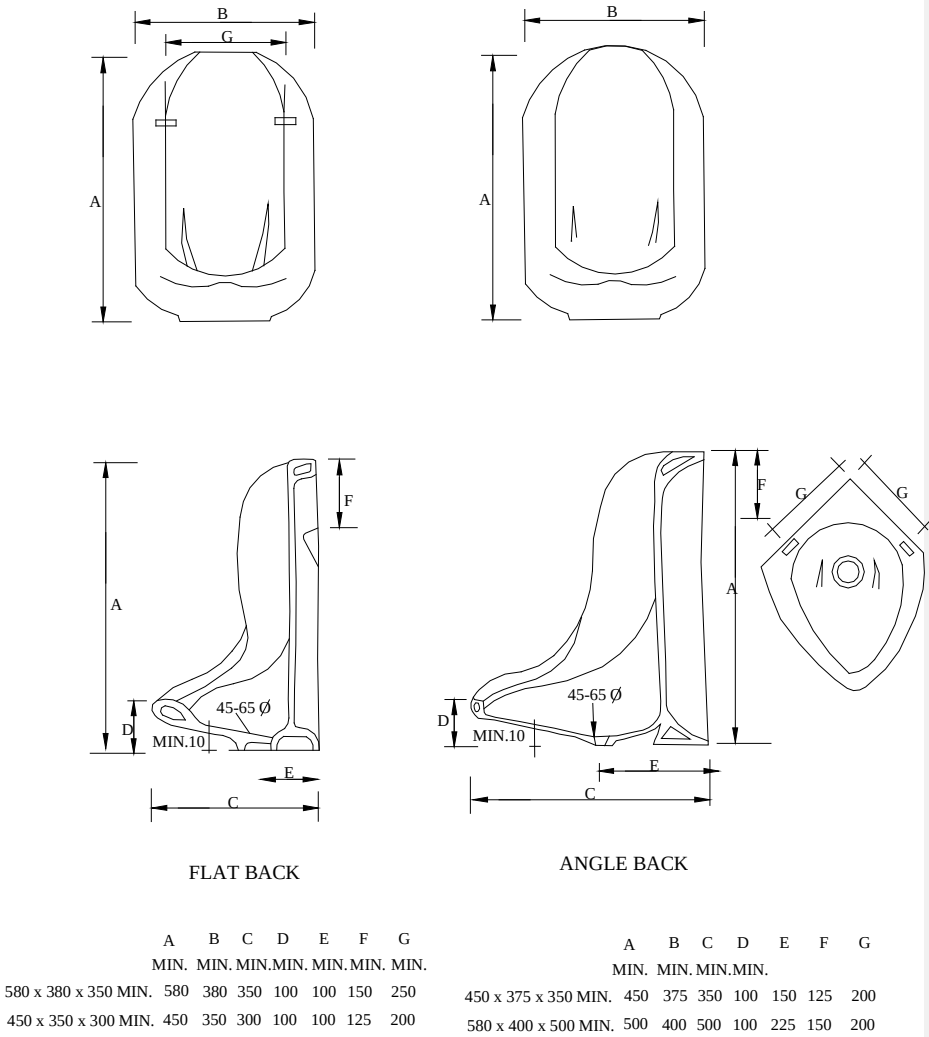
FIGURE 15.10



All dimensions are in mm
Drawings not to Scale

URINAL HALF STALL

FIGURE 15.11

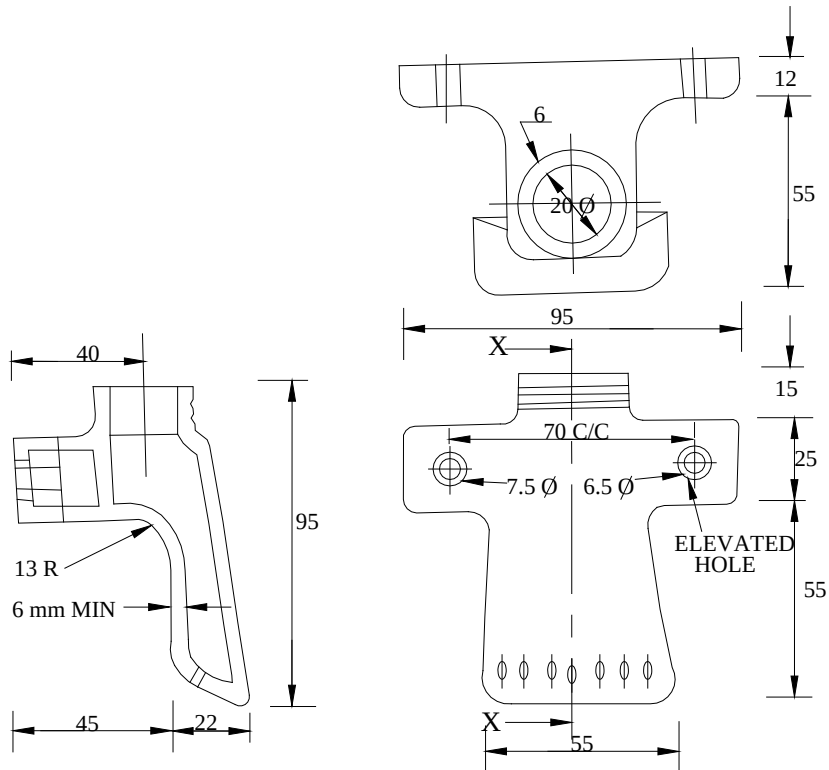


Height from standing level to the top of dip of urinal = 650

All dimensions are in mm
Drawings not to Scale

SPEADER FOR URINAL

FIGURE 15.12

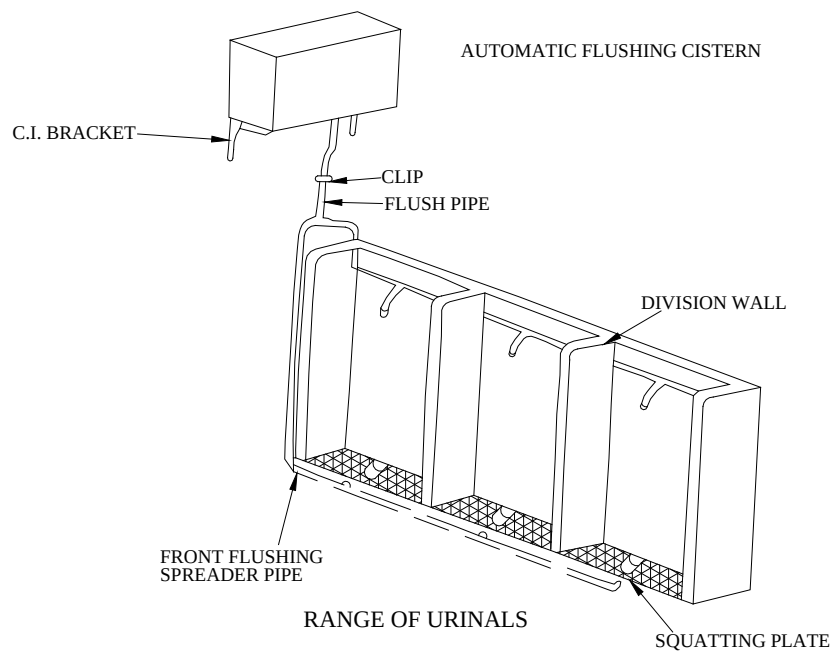
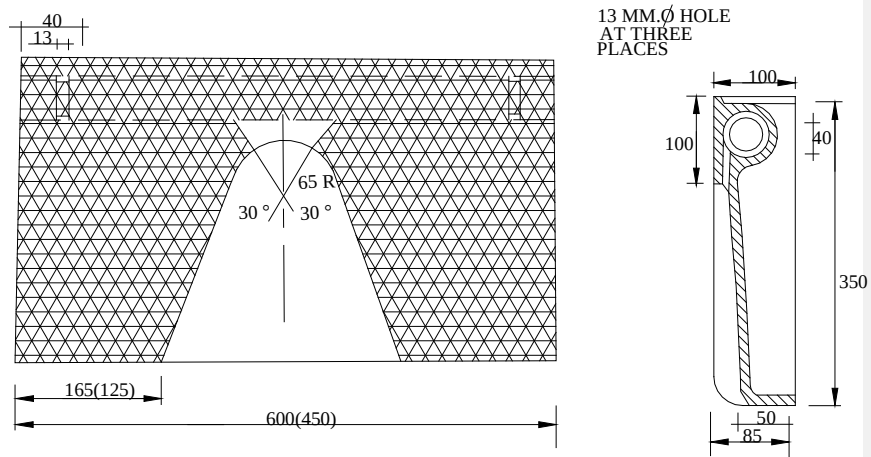


SECTION X-X

All dimensions are in mm
Drawings not to Scale

URINAL SQUATTING PLATE

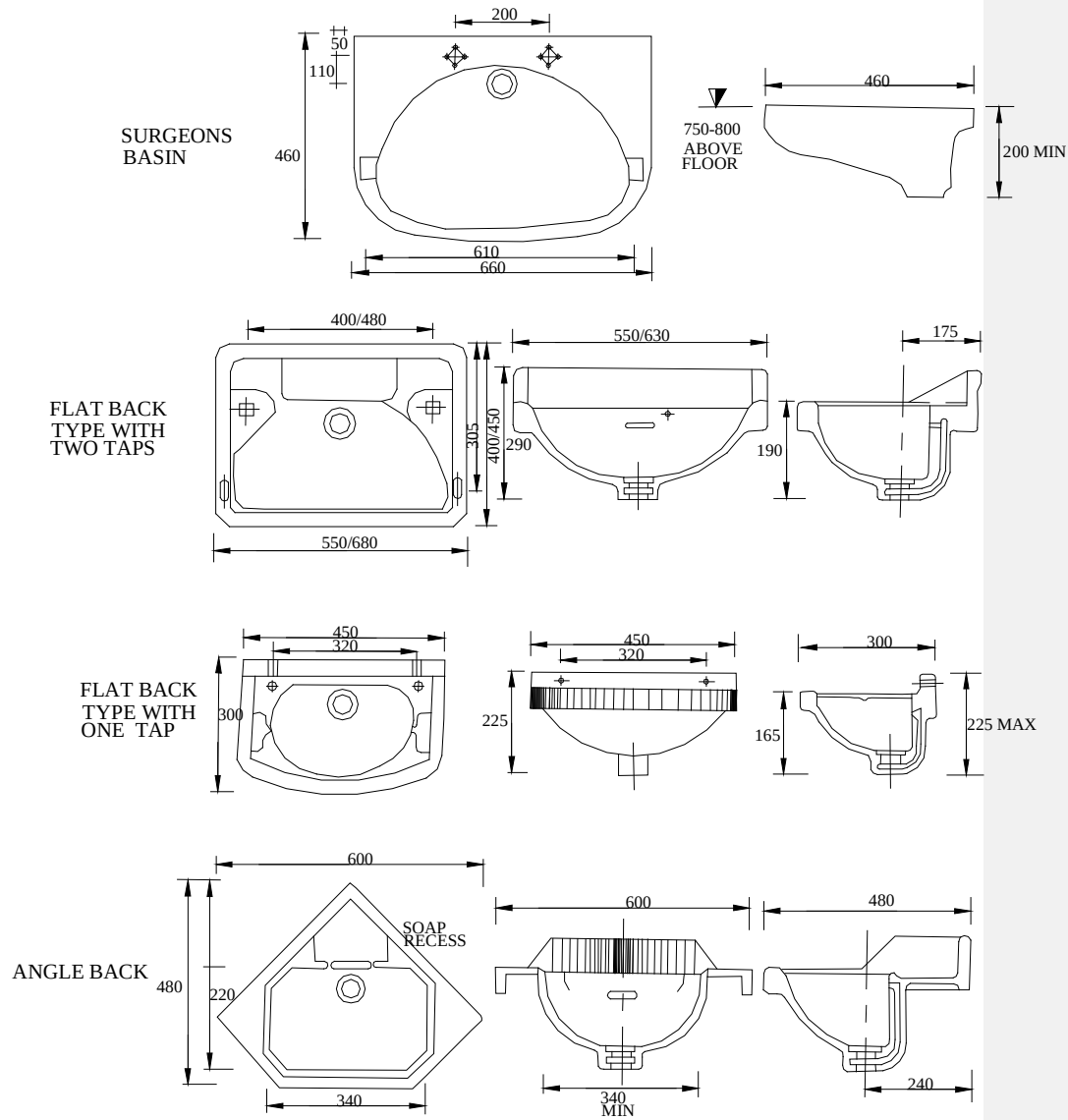
FIGURE 15.13



All dimensions are in mm
Drawings not to Scale

WASH BASING

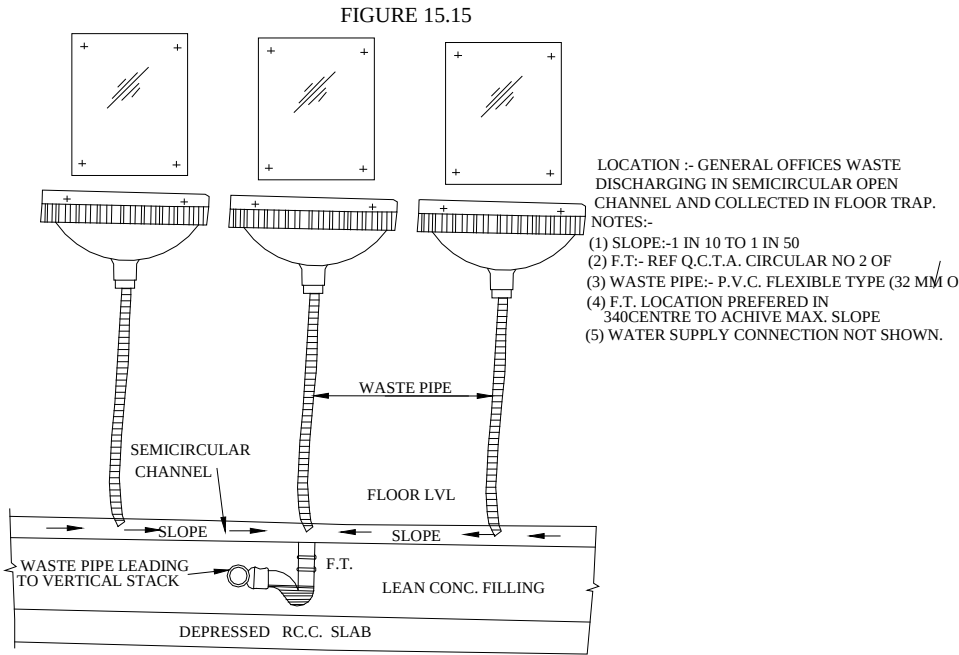
FIGURE 15.14



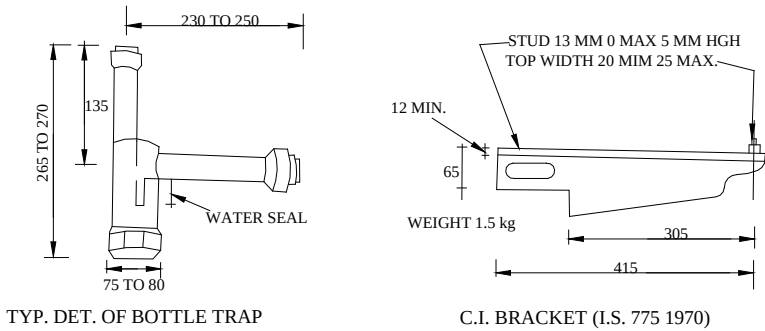
All dimensions are in mm
Drawings not to Scale

Height of rim of basin from floor = 750 to 800

FIXING ARRANGEMENT OF WASH BASIN
TYP. ELEVATION OF WASH BASIN



TYP. ELEVATION OF 3 WASH BASINS IN A ROW

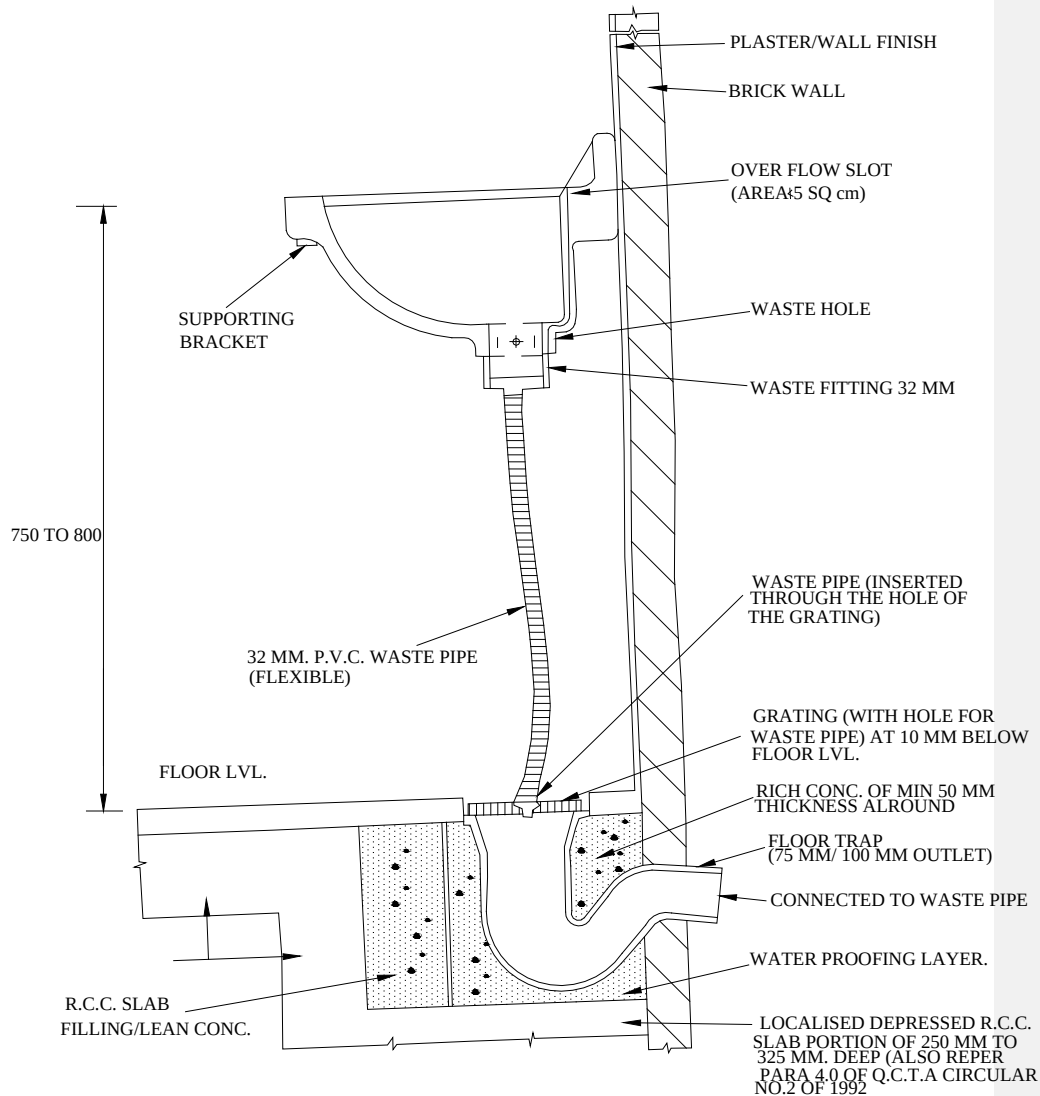


All dimensions are in mm
Drawings not to Scale

NOTE:-
STUD SHALL BE PROVIDED FOR SUPPORTS
INTENDED FOR GLAZED EARTHENWARE,
VITREOWARE WASH BASINS ONLY

TYP. VERTICAL SECTION OF WASH BASIN (WASTE PIPE OPEN TO VIEW)

FIGURE 15.16

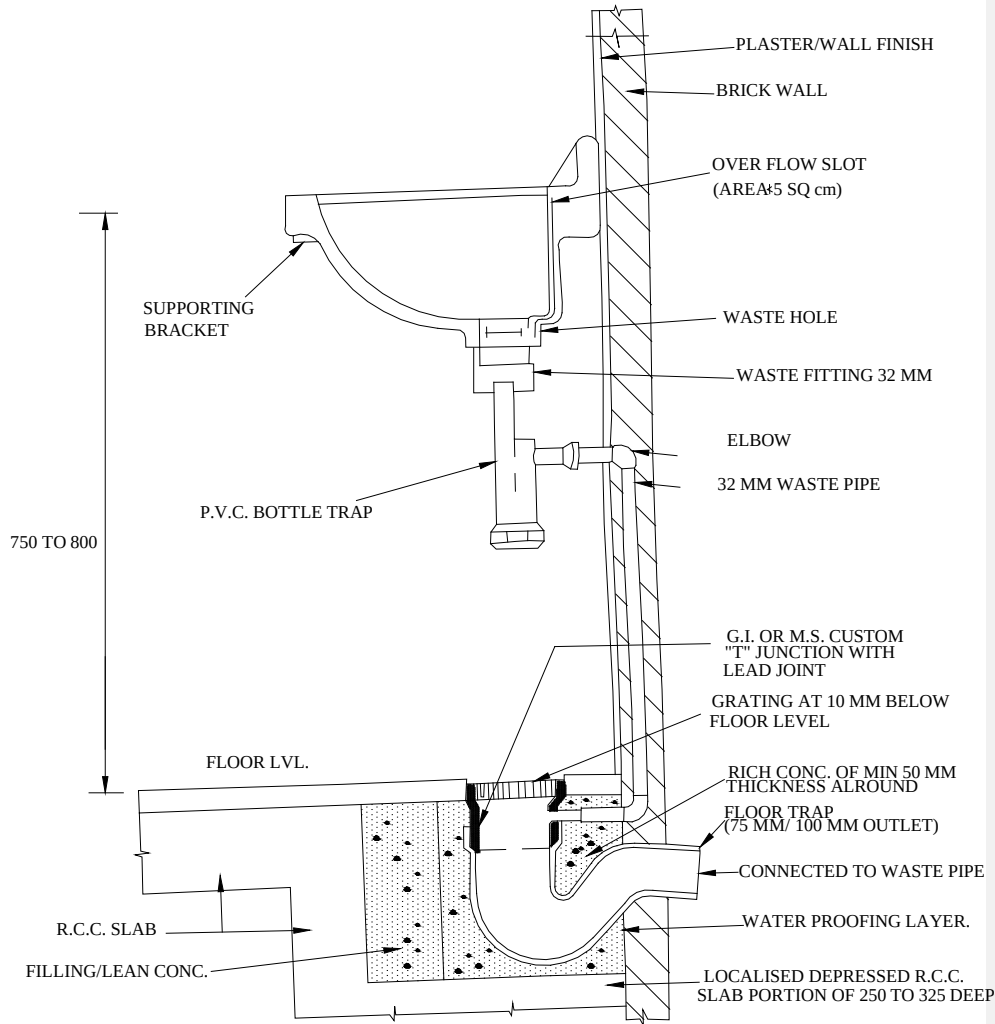


NOTE:-
Recommended for use up to type 3 quarters
& in general offices

All dimensions are in mm
Drawings not to Scale

**TYP. VERTICAL SECTION OF WASH BASIN
(WASTE PIPE CONCEALED FROM VIEW)**

FIGURE 15.17

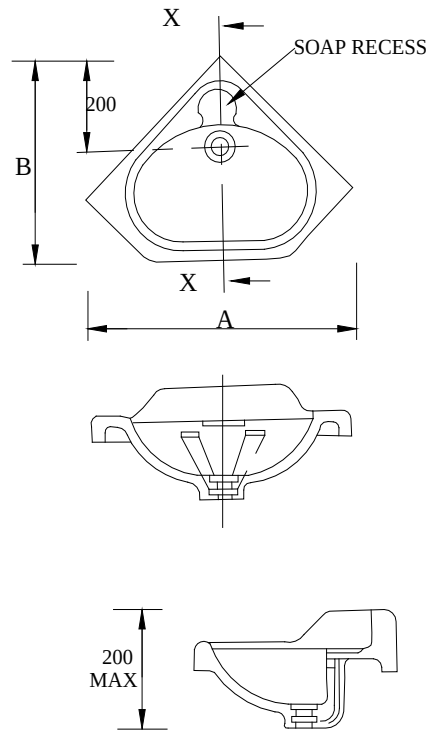


NOTE:-
Recommended for type 4 & above quarters
banglows V.I.P. locations five star hotels &
for personalised use

All dimensions are in mm
Drawings not to Scale

ANGLE BACK WASH BASIN (PATTERN-2)

FIGURE 15.18



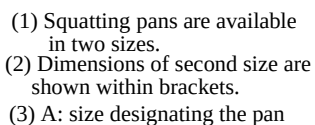
SECTION -X-X

NOTES:-

- (1) Tap hole provisions are not shown, however provision shall be made for 1 or 2 tap holes in any suitable position.
- (2) Stud provisions are not shown but suitable provision shall be made for fixing purposes.
- (3) Provision of/soap recess need not be central in The case of single tap hole.

All dimensions are in mm Drawings not to Scale

FIGURE 15.19



All dimensions are in mm
Drawings not to Scale

WATER CLOSET (WASH DOWN EUROPEAN - PATTERN 1)

FIGURE 15.20

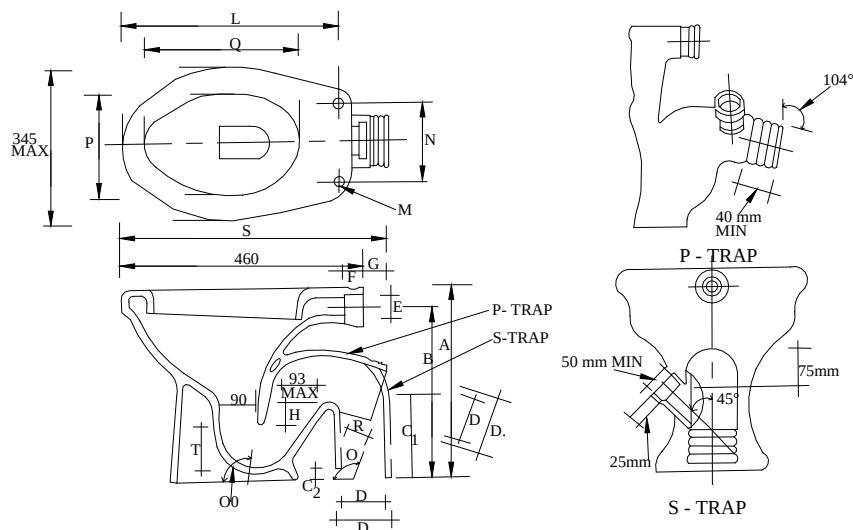


TABLE 1 DIMENSIONS AND PERMISSIBLE TOLERANCE OF
PATTERN 1 WATER CLOSETS
CLAUSE (2.3.1, 2.4 AND FIG.1)
All dimensions are in mm

S.NO.	DESCRIPTION	REF. IN FIG.2	PATTERN 1 (S-TRAP P-TRAP)		TOLERANCE
(1)	(2)	(3)	(4)	(5)	(6)
(1)	HEIGHT	A	390	390	±20
(2)	HEIGHT OF CENTRE LINE OF FLUSH INLET	B	350	350	±20
(3)	HEIGHT OF CENTRE LINE OF OUTLET FOR P-TRAP ONLY	C ₁	-	180	±10
(4)	DISTANCE FROM END OF TRAP TO FLOOR FOR S-TRAP ONLY	C ₂	20	-	±5
(5)	INTERNAL DIAMETER OF OUTLET, MIN. (SEE NOTE)	D	80	80	-
(6)	EXTERNAL DIAMETER OF OUTLET, MAX. (SEE NOTE)	D ₁	110	110	-
(7)	INTERNAL DIAMETER OF FLUSH INLET SOCKET	E	50	50	±3
(8)	DEPTH OF FLUSH INLET SOCKET	F	30	30	±5
(9)	DISTANCE FROM END OF FLUSH INLET SOCKET TO OUTSIDE OF OUTLET, MIN.	G	45	45	-
(10)	DEPTH OF WATER SEAL	H	NOT LESS THAN 50 mm WATER SURFACE		-
(11)	LENGTH FROM SEAT BOLT HOLES TO FRONT RIM	L	430	430	-
(12)	DIAMETER OF SEAT BOLT HOLES	M	13	13	-
(13)	DISTANCE BETWEEN CENTRE OF SEAT BOLT HOLES	N	{ MIN. 160 MAX. 175	{ 160 175	-
(14)	WIDTH OF OPENING, MIN.	P	240	240	-
(15)	LENGTH OF OPENING, MIN.	Q	290	290	-
(16)	LENGTH OF SERRATED PART OF OUTLET, MIN.	R	40	40	-
(17)	OVERALL LENGTH	S	500 TO 575	500 TO 575	-
(18)	ANGLE OF BACK PLATE	α	90 TO 135	90 TO 135	-
(19)	ANGLE OF OUTLET	θ	-	104	-
(20)	TRAP INLET DEPTH, MIN.	T	75	75	-

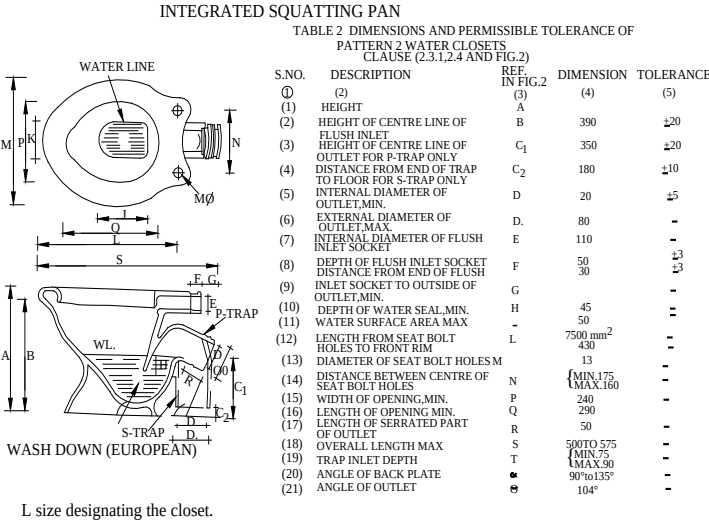
OVALITY PERMISSIBLE WITHIN THE DIMENSIONS FOR INLET AND OUTLET DIAMETERS.

THE DIMENSIONS FOR INTERNAL DIAMETER OF FLUSH INLET SOCKET

SPECIFIED IN THE 1973 VERSION OF THE STANDARD NAMELY, 55.5, SHALL
CONTINUE TO BE PERMITTED UP TO 31 DECEMBER 1981 AS ALTERNATE DIMENSIONS
AFTER WHICH DATE ONLY THE DIMENSIONS GIVEN IN THE ABOVE TABLE SHALL APPLY.

WATER CLOSET
(WASH DOWN EUROPEAN-PATTERN 2)

FIGURE 15.21



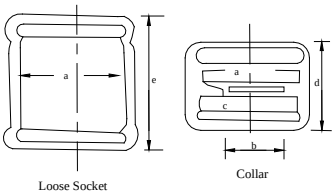
OVALITY PERMISSIBLE WITHIN THE DIMENSIONS FOR INLET AND OUTLET DIAMETERS.

THE DIMENSIONS FOR INTERNAL DIAMETER OF FLUSH INLET SOCKET SPECIFIED IN THE 1973 VERSION OF THE STANDARD NAMELY, 55+5, SHALL CONTINUE TO BE PERMITTED UP TO 31 DECEMBER 1981 AS ALTERNATE DIMENSIONS AFTER WHICH DATE ONLY THE DIMENSIONS GIVEN IN THE ABOVE TABLE SHALL APPLY.

All dimensions are in mm
Drawings not to Scale

LOOSE SOCKET & COLLARS FOR PIPES

FIGURE 15.22



As marked in Fig.	Pipe Dia (Size in mm)			
	50	75	100	150
(a)	76	101	129	131
(b)	50	75	100	150
(c)	10	10	10	10
(d)	79	89	95	108
(e)	89	101	114	140

Note : The dimensions of loose sockets shall correspond to those of appropriate nominal size of pipe.

Chapter 16

Horticulture And Landscaping

16.0 GENERAL

Horticultural operations shall be started on ground previously levelled and dressed to required formation levels and slopes. In case where unsuitable soil is met with, it shall be either removed and replaced or it shall be covered over to a thickness decided by the Engineer with good earth. In the course of excavation or trenching during horticultural operations, any walls, foundations, etc., met with shall not be dismantled without pre-measurement and prior to the written permission of the Engineer.

16.1 MATERIALS

16.1.1 Grass :

- 1) Cynodon Dactylon-Doob, Calcutta, Rajghat Bermuda
- 2) Improved/hybrid strains of Bermuda grass
- 3) Zoyasia grasses.

The grass shall be fresh, free from weed and rank vegetation but having #Rhizome# with sufficient nodes and shall be approved by the Engineer before planting.

16.1.2 Dump Manure:

Dump Manure shall be of well decayed organic or vegetable matter obtained in the dry state from the municipal dump or other similar source approved by the Engineer. The manure shall be free from earth, stone, brick bats or other extraneous stuff.

Manure sieved through sieve of I.S designation 16mm., is generally used for mixing with the excavated soil to be refilled in trenches for shrubbery, rose and vegetable gardens and trees and lawns while that sieved through sieve of I.S. designation 4.75mm. is used for forming lawns for tennis courts, sports etc.

16.1.3. Good Earth :

The soil shall be agricultural soil of loamy nature suitable for gardening free from kanker, Moorum, shingle, rocks, stones, brick-bats, building rubbish and any other foreign matter. The earth shall be free from clods or lumps of sizes bigger than 75 mm in any direction. It shall have P.H. Value ranging between 6 to 8.5.

16.1.4. Oil Cake (Neem/Castor) :

The cake shall be free from husk, dust, grit and any other foreign matter

16.1.5. Sludge :

It shall be obtained from approved sewage

disposal works.

16.2 SUPPLYING AND STACKING OF MATERIALS

16.2.1 Dump Manure : It shall be transported to the site in lorries duly screened through sieve of designators 16mm or 4.75mm as stated. It shall be stacked at site in stacks of not less than 50 cm height and of volume not less than 3 cum.

16.2.1.1 Measurements : Length, breadth and depth of stacks shall be measured correct to a cm. The volume of the stacks shall be reduced by 8% for looseness in stacking to arrive at the net quantity for payment.

16.2.1.2. Rate : The rate shall include the cost of all the labour and material involved in all the operations described above, including carriage within a lead of one Km. the rate shall include royalty and other taxes.

16.2.2. Good Earth

16.2.2.1. The earth shall be stacked at site in stacks not less than 50 cm high and of volume not less than 3.0 cum.

16.2.2.2. Measurements : Length, breadth and height of stacks shall be measured correct to a cm. The volume of the stacks shall be reduced by 20% for voids before payment, unless otherwise described.

16.2.2.3. Rate : The rate shall include the cost of excavating the earth from areas lying at distances not exceeding one Km. from the site, transporting the same at site, breaking of clods and stacking at places indicated. The rate shall also include royalty if payable.

16.2.3. Oil cake

16.2.3.1. (Neem/Castor) :

The cake shall be free from grit and any other foreign matter. It should be undecorticated and pulverised. The material shall be packed in old serviceable gunny bags of 50 kgs capacity approximately. The weight of gunny bag shall be deducted @ 1 kg per bag and payment shall be made for net quantity. The quantity of cake should be got approved by the Engineer before supply.

16.2.3.2. Measurement :

The arrangement for weighing shall be made at site of work by the department. The gunny bags shall be the property of the Railways.

16.2.3.3. Rate : The rate shall include the cost of labour and material involved in all the operations described above, including

carriage upto site of work with all leads and lifts, weighing etc.

16.2.4. **Sludge:**

16.2.4.1. It shall be transported to the site in lorries with efficient arrangement to prevent spilling enroute. It shall be stacked at site in stacks of. not less than 50 cm. height and of volume not less than 3 cum.

16.2.4.2. **Measurement** : Length, breadth and depth of stacks shall be measured correct to a cm. The volume to the stacks shall be reduced by 8% for looseness in stacking, to arrive at the net quantity for payment

16.2.4.3 **Rate:** The rate shall include the cost of all labour and materials involved in all the operations described above including carriage to site upto one km. The rate shall also include royalty, if payable.

16.3 EXCAVATION IN DUMPED STONE OR MALBA, BAJRI PATH AND WATER BOUND MACADAM ROAD

16.3.1 General: As directed by the Engineer, the serviceable and unserviceable material shall be stacked properly. After the unserviceable material is disposed off, the site shall be neatly dressed.

16.3.2. **Measurements** : The relevant portion of earth work shall apply. Excavation in (i) dumped stone of malba (ii) Bajri path and (iii) water bound macadam road shall be measured separately.

16.3.3. **Rate** : The rate shall include the work involved in the operations described above. Nothing extra shall be paid for sorting and stacking the unserviceable and serviceable material, including dressing.

16.4. TRENCHING IN ORDINARY SOIL

16.4.0. **General:** Trenching of soil is done in order to loosen the soil, and turn over and bury the top layer containing weeds etc. in the base and to bring up the lower layers of good earth to form a proper medium for grassing, re~~g~~ grassing, hedging and shrubbery. Trenching shall be done to the depth ordered by the Engineer. The depth is generally 30 cm. for grassing and 60 cms for regressing in good soil.

16.4.1. **Dressing of Ground:** The trenched ground shall, after rough dressing, be flooded with water by making small kiaries to enable the soil to settle down. Any local depression unevenness etc. shall be made good by dressing and/or filling with good soil.

16.4.2 **Removal of weeds:** Weeds or other vegetation which appear on the ground are then uprooted and removed and disposed off and paid for separately. The surface when

hard enough is fine dressed. These operations when carried out are, however, payable separately from trenching.

16.4.3. Trenching : Trenching shall consist of the following operations : (Note:- **Figure 16.1** may be referred to).

(1) The whole plot shall be divided into narrow rectangular strips of about 1.5 m. width or as directed by the Engineer.

(2) These strips shall be sub-divided lengthwise into about 1 m. long sections. Such sections shall be excavated serially and excavated soil deposited in the adjacent section preceding it.

(3) In excavation and depositing care shall be taken that the top soil with all previous plant growth including roots, get buried in the bottom layers of trenched area, the dead plants so buried incidentally being formed into humus.

(4) The excavated soil shall be straight away dumped into the adjoining sections so that double handling otherwise involved in dumping the excavated stuff outside and in backfilling in the trenches with leads is practically eliminated.

16.4.4: **Measurements** : Length and breadth of superficial area shall be measured correct to 0.1 metres and depth correct to a cm. Cubical contents shall be calculated in cubic metres, correct to two places of decimal. No deduction shall be made nor extra paid for removing stones, brick bats and other foreign matter met with during excavation upto initial lead of 50m and stacking the same.

16.4.5. **Rate** : The rate shall include the cost of all labour and material involved in the operations described above, with the exceptions noted in paras 16.4.1. and 16.4.2 and 16.4.3. The rate includes cost of all precautionary measures to be taken for protections and supporting all services etc. met with during trenching. It does not include the cost of mixing of earth, sludge/manure.

16.5. ROUGH DRESSING THE TRENCHED GROUND

16.5.0. **General:** Rough dressing the area shall include making kiaries for flooding.16.5.1. **Procedure:** The trenched ground shall be levelled and rough dressed

and if there are any hollows and depressions resulting from subsidence which cannot be so levelled, these shall be filled properly with earth brought from outside to bring the depressed surface to the level of the adjoining land and to remove discontinuity of slope and then rough dressed again. The supply and spreading of soil in such depressions is payable separately. In rough

dressing, the soil at the surface and for 75 mm depth below, shall be broken down to particle size not more than 10 mm in any direction.

16.5.2. Measurements : Length and breadth of superficial area shall be measured correct to 0.1 metres. The area shall be calculated in sqm. correct to two places of decimal.

16.5.3. Rate : The rate shall include the cost of all labour and materials involved in the operations described above.

16.6. SPREADING GOOD EARTH

16.6.1. General: Good earth shall be removed from stacks by head load and spread evenly over the surface to the thickness ordered by the Engineer. It shall be spread with a twisting motion to avoid segregation and to ensure that spreading is uniform over the entire area.

16.6.2 Measurements : The quantity of good earth spread shall be, determined by the difference in the volume of good earth in stacks before and after spreading duly reduced for looseness in stacking by 20% of good earth.

16.6.3. Rate : The rate shall include the cost of all labour and materials involved in all the operations described above, but does not include the cost of the good earth which shall be paid for separately unless specifically described in the item.

16.7. UPROOTING WEEDS FROM TRENCHED AREAS

16.7.1. General: After 10 days and within 15 days of flooding the rough dressed trenched ground with water, the weeds appearing on the ground, shall be rooted out carefully and the rubbish disposed off as directed by the Engineer.

16.7.2. Measurements : Length and breadth shall be measured correct to 0.1 metre. Superficial area of the weeded ground shall be measured for purpose of payment

16.7.3. Rate : The rate shall include the cost of all labour and materials involved in all the operations described above.

16.8. SPREADING SLUDGE/MANURE

The specifications shall be as described in para 16.4 except that the stacks shall be reduced by 8% for looseness.

16.9. FINE DRESSING THE GROUND

16.9.1. General: Slight unevenness, ups and downs and shallow depressions resulting from the settlement of the flooded ground, in drying and from the subsequent weeding

operations, shall be removed by fine dressing the surface to the formation levels of the adjoining land as directed by the Engineer, and by adding suitable quantities of good earth, brought from outside, if necessary. Such supply and spreading of good earth stacked at site is however, payable separately. In fine dressing, the soil at the surface and for 40 mm depth below shall be broken down to particles of size not exceeding 6: mm in any direction.

16.9.2. Measurements : Length and breadth of the dressed ground shall be measured correct to 0.1 metre. The area shall be calculated in sqm. correct to two places of decimal.

16.9.3. Rate : The rate shall include the cost of all labour and materials involved in all the operations described above.

16.10. EXCAVATION AND TRENCHING FOR PREPARATION OF BEDS FOR HEDGE AND SHRUBBERY

16.10.0. General: Beds for hedges and shrubbery are generally prepared to width of 60 cm. to 125 cm. and 2 to 4 metres respectively.

16.10.1. Preparation of Beds: Beds for hedges and shrubbery shall be prepared in the following manner.

The beds shall first be excavated to a depth of 60 cm. and the excavated soil shall be stacked on the sides of the beds. The surface of the excavated bed shall then be trenched to a further depth of 30 cm. in order to loosen the soil, in the manner described in 16.4.3. No Flooding will be done at this stage but the top surface shall be rough dressed and levelled. The excavated soil from the top 60 cm. depth of the bed stacked at the site shall then be thoroughly mixed with sludge or manure in the proportion 8:1 by volume (8 parts of stacked volume of earth after reduction by 20%. to 1 part of stacked volume of sludge or manure after reduction by 8%) or other proportion as described in the item. The mixed earth and manure shall be refilled over the trenched bed, levelled neatly and profusely flooded so that the water reaches even the bottom most layers of the trenched depth of the bed. The surface after full subsidence shall again be refilled with the earth and manure mixture, watered and allowed to settle and finally fine dressed to the level 50 mm to 75 mm below the adjoining ground or as directed by the Engineer. Surplus earth if any, shall be disposed off as directed by the Engineer. Any surplus earth if removed beyond initial lead, shall be paid for separately.

Stones, brick bats and other foreign matter if met with during excavation or trenching shall be removed and stacked within initial lead and lift, such material as is declared unserviceable by the Engineer shall be disposed by spreading and levelling at places ordered by him. If disposal is outside the initial lead and lift, then the transport for the extra leads will be paid for separately. If a large proportion of material unsuitable for the hedging and shrubbery operations is met with and earth from outside is required to be brought in for mixing with manure and filling, the supply and stacking of such earth will be paid for separately.

16.10.2. Measurements : Length, breadth and depth of the pit excavated and trenched shall be measured correct to a cm. The cubical contents shall be calculated in cubic metre correct to two places of decimal.

16.10.3. Rate : The rate shall include the cost of all labour and materials involved in all the operations described above with the exceptions noted in para 16.9.1. The rate shall not include the cost of supplying and stacking sludge or manure unless the same is specifically included in the description of the item.

16.11. MIXING OF GOOD EARTH AND SLUDGE / MANURE

16.11.1. General: The stacked earth shall, before mixing, be broken down to particles of sizes not exceeding 6 mm in any direction. Good earth shall be thoroughly mixed with sludge or manure in specified proportion as described in the item or as directed by the Engineer. The mixing shall be spread as described in para 16.5.1 to the thickness ordered by the Engineer.

16.11.2. Measurements : The quantity of good earth and sludge or manure mixed shall be determined by the difference in the volume of good earth, sludge or manure in stack, before and after spreading duly accounted for voids and looseness in stacks.

16.11.3. Rate :- The rate shall include the cost of all labour and materials involved in all the operations described above, but does not include the cost of good earth, sludge or manure which shall be paid for separately, unless otherwise described in the item.

16.12. UPROOTING RANK VEGETATION AND WEEDS AND PREPARING THE GROUND FOR PLANTING DOOB GRASS.

16.12.1. General: Initially the area shall be dug up to a depth of 30 cm and weeds and rank vegetation with roots removed therefrom by repeated forking. The whole

area then shall be retrenched to a depth of 60 cm. in the same manner as described in 16.4.3.

Clods of excavated earth shall then be broken upto the size not more than 75 mm in any direction. The area shall then be flooded with water and after 10 days and within 15 days of flooding, weeds that re-germinate shall be uprooted carefully. The rubbish arising from the above operations shall be removed and disposed off in a manner directed by the Engineer, away from the site. The earth shall then be rough dressed and fine dressed as described in para 16.9.1.

16.12.2. Measurements : The length and breadth of uprooted area shall be measured correct to 0.1 metre. The area shall be calculated in sqm correct to two places of decimal.

16.12.3. Rate : The rate shall include the cost of all labour and materials involved in all the operations described above

16.13. GRASSING WITH DOOB GRASS

16.13.0. General: The area from where the grass roots are to be obtained shall be specified by the Engineer at the time of execution of the work and no royalty shall be charged on account from the contractor if it is from within the railway land.

16.13.1 Procedure: The soil shall be suitably moistened and then the operation of planting grass shall be commenced. The grass shall be dibbled at 10 cm, 7.5 cm., 5cm., apart in any direction or other spacing as described in the item. Dead grass and weeds shall not be planted. The contractor shall be responsible for watering and maintenance of levels and the lawn for 30 days or till the grass forms a thick lawn free from weeds and fit for mowing whichever is later. Generally planting in either direction at 15 cm., 10 cm, spacing is done in the case of large open spaces, at 7.5 cm. spacing in residential lawns and at 5 cm, spacing for Tennis Courts and sports ground lawns.

16.13.2. Precautions : During the maintenance period, any irregularities arising in ground levels due to watering or due to trampling by labour, or due to cattle straying thereon, shall be constantly made upto the proper levels with earth as available or brought from outside as necessary. Constant watch shall be maintained to ensure that dead patches are replanted and weeds are removed.

16.13.3. Measurements : Length and breadth of the lawn grassed shall be measured correct to 0.1 metre and the area shall be calculated in square metre correct to

two places of decimal.

16.13.4. Rate : The rate shall include the cost of all labour & materials involved in all the operations described above, excluding supply of the requisite quantity of good earth if so needed for properly maintaining the levels of the lawns.

16.14. RENOVATING LAWNS:

16.14.1. General : The area shall be first weeded out of all undesirable growth. The entire grass shall be scrapped (cheeled) without damaging roots and levels of the grounds. Slight irregularities in surface shall be levelled off and the area shall then be forked so as to aerate the roots of the grass without, however up-rooting them. Specified quantity of sludge or manure shall then be spread uniformly with wooden straight edge (phatti) as directed by the Engineer. The area shall then be slightly sprinkled with water so as to facilitate proper integration of the manure or sludge with the soil and later flooded. The contractor shall be responsible for watering, proper maintenance and tending of the lawn for 30 days or till the grass forms a lawn fit for mowing, whichever is later.

During the above operations, all undesirable growths shall be constantly weeded out and all rubbish removed and disposed off as directed by the Engineer.

16.14.2. Measurements : Length and breadth of the lawn renovated shall be measured correct to 0.1 m. The area shall be calculated in sqm correct to two places of decimal.

16.14.3. Rate: The rate shall include the cost of all labour and T&P (excluding pipe/grass) involved in all the operations described above, including the supply of the requisite quantity of good earth if so needed for proper maintenance of the levels of the lawns. The cost of the sludge or manure shall be measured and paid for separately, unless its supply is specifically included in the description of the item.

16.15. DIGGING HOLES FOR PLANTING TREES

16.15.1. In ordinary soil

16.15.1.1. Holes of circular shape in ordinary soil shall be excavated to the dimensions described in the items and the excavated soil, broken to clods of sizes not exceeding 75 mm in any direction, shall be stacked outside the hole. Stones, bricks bats, unsuitable earth and other rubbish, all roots and other undesirable growth met with during excavation shall be separated out and

unservicable material removed from the site as directed. Useful material, if any, shall be stacked properly and separately. Good earth in quantities as required to replace such discarded stuff shall be brought and stacked at site by the contractor which shall be paid for separately. The tree hole shall be manured with powdered neem/castor oil cake at the specified rate along with farm yard manure or sludge which shall be uniformly mixed with the excavated soil after the manure has been broken down to powder (size of particles not to exceed 6 mm in any direction) in the specified proportion. The mixture shall be filled into the hole upto the level of adjoining ground and then profusely watered to enable the soil to subside. The refilled soil shall then be dressed evenly with its surface about 50 to 75 mm below the adjoining ground level or as directed by the Engineer.

16.15.1.2 Measurement : Holes shall be enumerated.

16.15.1.3 Rate: The rate shall include the cost of all labour and materials involved in all the operations described above excluding the cost of supplying and stacking the requisite quantity of manure/sludge and oil cake.

16.15.2. In soil other than ordinary soil

16.15.2.1. Where holes are dug in (a) Hard soil (b) Ordinary rock or (c) Hard rock, the above soils occurring independently or in conjunction with each other and/or ordinary soil in any hole, the different excavated soils shall be stacked separately. Excavation in hard rock shall be carried out by chiselling only.

16.15.2.2. The stack measurement of ordinary or hard rock shall be reduced by 50% and of hard soil by 20% to arrive at the excavated volume. These excavations shall be paid for as extras over the rate for holes dug in ordinary soil above, at rates appropriate to the particular soil concerned under earth work chapter.

16.15.2.3. Sufficient quantity of good soil to replace the solid volume of stones, brick bats, unsuitable earth and other rubbish, all roots and other undesirable growth, ordinary and hard stacks shall be brought and stacked at site but the supply and stacking of such earth shall be paid for separately.

16.15.2.4. The useless excavated stuff shall be disposed off by spreading at places ordered by the Engineer. If such places are outside initial lead, carriage for the extra lead shall be paid for separately.

16.15.2.5. The ordinary soil excavated from the hole and the earth brought from outside

shall then be mixed with manure screened through sieve of IS designation 16 mm in the proportion specified in the description of the item and filled into the pit and the same watered and finally dressed as described in para 16.15.1.1.

16.15.2.6. Measurements : The pits shall be enumerated. The volume of excavation in soil other than ordinary soil shall be determined by reducing the stack volume of the relevant soil with the respective percentage deduction for voids specified in para 16.15.2.2.

16.15.2.7. Rate : The rate shall include the cost of labour and material involved in all the operations described above including mixing, refilling, watering dressing etc. but shall not include (a) cost of manure or sludge (b) cost of supplying and stacking good earth for replacement and (c) the cost of carriage beyond initial lead for disposing off useless materials. The excavation other than that of ordinary soil shall be paid for extra over and above the rate of excavation in ordinary soil.

16.16. TREE GUARDS

16.16.1. Circular brick tree guard (Fig. 16.2)

16.16.1.0. The internal diameter shall be 1.25 metre, height above ground level 1.20 metre and depth below ground level 0.20 metre; walls half brick thick.

16.16.1.1. This shall be built of bricks of class designation 7.5. Bricks shall comply with the specifications described in chapter on Brick work. The first two courses from bottom shall be built dry (without mortar) with the bricks laid close to each other, without honey-comb. Subsequent courses upto 0.30 metre from top of tree guard shall be built dry in honey-combed pattern, using 15 bricks in each course, with equal opening in between. Thereafter the top three courses shall be built without honey-combing, in lime surkhi mortar 1:2 (1 lime putty : 2 surkhi) or in cement mortar 1:6 (1 cement 6 fine sand) as directed. In the bottom most 2 courses. and in the top most 3 courses bricks in adjacent courses shall be laid with 10 cm laps. In the honey-combed portion of the work, the vertical edges of bricks in alternate courses shall be in the same line. The laps of bricks on either side of openings shall be equal.

16.16.1.2 Measurements: The tree guard shall be enumerated.

16.16.1.3 Rate: The rate shall include the cost of all labour and materials involved in all the operations described above.

16.16.2. Ornamental circular iron tree guard with bars (Fig. 16.3)

16.16.2.0. The tree guard shall be 50 cm. in diameter.

16.16.2.1. The tree guards shall be formed of (i) 3 Nos. 25 x 25 x 3 mm angle iron verticals 2.00 m. long excluding splayed outward at lower end upto an extent of 10 cms.

(ii) 3 Nos. 25 x 5 mm MS flat rings fixed as per design

(iii) 15 Nos. 1.55 metres long 6 mm dia bars. Each ring shall be in two parts in the ratio of 1 : 2 and their ends shall be turned in radially for a length of 4 cm. at which they are bolted together with 8 mm. dia and 30 mm. long MS bolts and nuts.

The vertical angle irons shall be welded to rings along the circumference with electric plant 15 Nos. bars shall be welded to rings at equal spacing along the circumference of ring. The lower end of the angle iron verticals shall be splayed outwards upto an extent of 10 cm. The lower end of the flat of lower ring shall be at a height of 45 cm. and upper end of the flat of top ring shall be at the height of 2.00 metres. The middle ring shall be in the centre of top and lower ring. The bars shall be welded to rings as shown in the drawing. The entire tree guard shall be given two coats of paint of approved brand and of required shade over a priming coat of ready mixed primer of approved brand. The design of the tree guard shall be as shown in the drawing.

16.16.2.2. Measurements : The tree guard shall be enumerated.

16.16.2.3. Rate : The rates shall include the cost of all labour and materials involved in all the operations described above.

16.16.3. Ornamental circular iron tree guard with welded mesh (Fig. 16.4)

16.16.3.0. The tree guard shall be 50 cm. in diameter.

16.16.3.1. The tree guard shall be formed of :

(i) 3 Nos. 25 x 25 x 3 mm angle iron verticals 2.00 metres long excluding splayed outwards at lower end upto an extent of 10 cms.

(ii) 3 Nos. 25 x 5 mm MS flat rings 50 cm. dia as per design.

(iii) 1.55 m high Welded mesh 50 x 75 mm size of 3 mm thick wire. Each ring of the tree guard shall be in two equal parts and their end shall be turned in radially for a length of 4 cms. at which they shall be bolted together with 8 mm dia, 30 mm long MS bolts and nuts.

The vertical angle iron -shall be welded to rings along the circumference with electric plant. Welded mesh shall be welded to rings in such a way so as to make it sufficiently strong; The lower and of the angle iron

verticals shall be splayed outwards upto an extent of 10 cm. The lower end of the lower rings shall be at 45 cm. height and upper end of the upper ring shall be at 2.00 metre height, the middle ring shall be in the centre of the two. The entire tree guard shall be given two coats of paint of approved brand and of required shade over a priming coat of ready mixed primer of approved brand and manufacture. The design of the tree guards shall be as shown in the drawing.

16.16.3.2. Measurement : The tree guard shall be enumerated.

16.16.3.3. Rate : The rates shall include the cost of all labour and materials involved in all the operations described above.

16.16.4 Ornamental Circular MS flat iron tree guard

16.16.4.0 The Tree Guard shall be 60cm in dia-meter and 2.0m in height

16.16.4.1 The tree guard shall be formed of 8 nos. 25x3mm. MS flat verticals 2.0m long, 4 nos. 25x6mm flat verticals 2.25m , long, and 3 nos. 25x6mm.flat iron rings at top, middle and bottom. Each ring shall be in two semicircular halves with their ends turned out radially for a length of 4 cm, at which they are bolted together with 8mm dia, and 30mm long MS bolts and nuts. The verticals shall be riveted to the rings at equal spacing along the circumference with 6mm. dia rivets, each 25x6mm MS flat verticals being placed after every two 25x3mm. M.S flat verticals. The top ends of all the verticals both 25x3mm. and 25x6mm. shall be cut to form pointed ends at the top and shall be at the same level. The circular rings shall be at 10cm., 1.0m and 1.9m above ground. The bottom 5cm. of the extra 25cm. length of the 25x6mm. M.S flat verticals projecting below the 25x3mm. M.S flat vertical, shall be turned horizontally at right angles , the 4 Nos. 20cm. long legs thus formed being buried below ground. The entire tree guard shall be given two coats of ordinary paint over a priming coat of red lead, the portions buried under ground being painted with bitumastic or

anticorrosive paint before fixing. The tree guard as fixed shall be truly vertical.

16.16.4.2. Measurements: The tree guard shall be enumerated.

Rate: The rate shall include the cost of all labour and materials involved in all the operations described above.

16.16.5 Empty Bitumen/Coal Tar Drum Tree Guard

16.16.5.1. Tree guards shall be made from empty bitumen or coal tar drum supplied free by the Railway. These shall be of 50cm. average diameter and 1.30 metre or 2.0 metre height as specified in the description of the item. The ends of the drums shall be cut and the coal tar or bitumen sticking inside the drum shall be burnt off. The tree guard shall then be fabricated as per design approved by the Engineer. The 1.3/2 metre high tree guard shall have four legs formed of M.S flat sections 30mmx3.0mm of 40cm. length riveted to the tree guard with 6mm dia rivets and projecting sufficiently below for being buried in the ground. Tree guard shall be finished with a coat of coal tar, or two or more coats of ready mixed paint of approved quality and shades after applying a priming coat inside and outside, before fixing.

16.16.5.2. Measurements: The Tree guard shall be enumerated.

16.16.5.3 Rate: The rate shall includes the cost of all labour and materials (except empty bitumen and coal tar drums) involved in all the operations described above.

16.17. EARTHEN POTS

16.17.0. **General:** The earthen pots shall be moulded with good earth. These shall be thoroughly baked without being vitrified, regular in shape and size. All the pots shall be free from visible defects such as cracks, chips, stones and flaws of any kind. The pots shall give a dear ringing sound when struck together or with a light stick.

16.17.1. **Size :** The sizes of the earthen pots are given in table as below :

Size (cms)	Upper dia (cms)	Bottom dia (cms)	Perpendicular height (cms)
30	30	20	30
25	25	15	25
20	20	12	20
15	15	10	15
10	10	6	10
30	30	15	30
25	25	13	25

20	20	10	20
15	15	8	15
10	10	5	10
20	13	8	20
25	20	10	25
30	25	15	30

Upper diameter will be taken from inside and bottom dia. and perpendicular height shall be measured from outside.

16.17.1.1. Tolerance : A margin for variation of 1.5 cm for pots of size 20 cm. and above and a margin of 1 cm. for pots of size 15 cms. and below will be permitted.

16.17.2. Measurements: The pots shall be stacked properly in a countable manner but not in more than 3 layers. The net quantity for payment will be arrived after deducting the broken pots, improperly baked or otherwise damaged in any form assessed by physical appearance etc.

16.17.3. Rate : The rate shall include the cost of all the labour and material required, including carriage to the site of work or the place specified.

16.18 FILLING OF POLYTHENE BAGS/EARTHEN POTS WITH MANURE AND GOOD EARTH AS SPECIFIED.

16.18.1. Mixing : The separately stacked earth and manure or sludge shall before mixing, be broken down to particles or sizes not exceeding 6 mm in any direction. Good earth shall be thoroughly mixed with sludge or manure in specified proportion as directed in the item or as directed by the Engineer.

During the process of preparing the mixture as above and before actual filling in bags/containers etc. required quantity or water should be sprinkled to keep mixture cool & damp.

The polythene bags/containers shall be brought to the site of mixture within 50 m lead and filled with the help of jhaba/hand trowel or any other required tool and instruments. Polythene bags/ containers thus filled in with mixture should be properly pressed & tapped to consolidate the mixture and final level of the mixture should be about 2.6 cm below the top edge of the polythene bags/containers.

The polythene bags /containers thus filled in, shall be arranged in countable manner in

properly prepared beds/ground as directed with in 50 mm lead.

16.18.2 Measurement: In numbers

16.18.3 Rate: The rate shall include the cost of all labour etc involved in all the operations described above, but do not include the cost of good earth, sludge or manure, polythene bags and containers which shall be paid separately unless specifically described in the item.

16.18.3: The rate shall include the cost of all labour etc, involved in all the operations described above, but do not include the cost of good earth, sludge or manure, polythene bags and containers which shall be paid separately unless specifically described in the item.

16.19. BRICK EDGING

16.19.1 General : Bricks of specified class designation shall be used. These shall be laid in one of the following patterns:- (i) Vertical bricks, half brick projecting above ground (ii) Alternate bricks laid horizontally and vertically (iii) Brick inclined at 60 deg. To the horizontal (iv) Brick laid lengthwise with half brick depth.

Trenches of specified width and depth shall first be made along the edging line to accommodate the bricks in one of the above patterns. The bottom of the trench shall be consolidated to form a firm base for the brick edging . Bricks shall be laid true to line and gradient, as directed. The trench shall then be refilled with excavated earth and consolidated by hand packing . The adjacent earth surface shall be then neatly leveled. Surplus earth shall be disposed off by spreading at places directed within 50m lead.

16.19.2 Measurements : In running metres

16.19.3 Rate: The rate shall include the cost of all labour and materials required involved in all the operations described above.

16.20 DEVELOPMENT OF NURSERY AND AFFORESTATION.

16.20.1 **General:** **Annexure 16.1** gives useful details on the following aspects of Horticulture for guidance of the staff engaged in these operations.

- (i) Nursery
- (ii) Method of improving the soil – Manure

- (iii) Manure
- (iv) Planting Trees on road side
- (v) Method of planting Trees on Road side
- (vi) Spacing of Trees
- (vii) Maintenance of trees.

ANNEXURE 16.1

1. NURSERY

The site for nursery should be a level land and of sandy loam soil, and plenty of water should be available. The location of nursery should be convenient for inspection as well as transplantation of plants. The trenches with the width at top as 300mm and bottom width as 200mm and a height of 230 to 300mm should be dug, 1800mm apart or as required as per the requirement of the plant. Berms on both sides of the excavated trench are formed by dumping the excavated soil about 300mm away on both sides of the trench. The berms are used for sowing the seeds. The berms thus formed should be made level prior to sowing is taken up. Normally the work on nursery should be completed before the end of March. In practice the seedlings grow faster over ridges than in beds and even the transplanting would be easy. The seedlings in any nursery is raised from seeds but in case of certain species which do not grow from seeds they will have to be raised from cutting or grafting. The plants should be retained in the nursery till they are sufficiently hard to withstand the planting out operation at the same time they should not be kept for a longer time in the nursery, with the result the roots of the plant will unduly cramp for space.

When the plants are to be carried over long distances for transplanting the earthen ball around the roots should be neatly wrapped with leaves, grass matting or polythene sheets, or the balls may be packed in boxes or baskets with empty space filled by good earth and kept moist by sprinkling water.

The nursery should have a good provision for paths, trenches and fallow. As a matter of fact failure rate of plants can be considered as 25%. Also as per general practice about one third or one fourth area available, should be used in rotation, every year. The actual

size of nursery will mainly depend upon the number of seedlings to be produced, and the age of seeding to be supplied, during the year. The most important factor is the period of keeping the plants in the nursery.

2. METHOD OF IMPROVING THE SOIL – MANURING

Sandy loams and clay loams are fertile and most suitable for the growth of a tree. Every tree or plant needs good depth for the root to develop; however the depth required varies from plant to plant. For example a garden plant just needs 450mm to 900mm depth whereas the fruit trees need about 3500 mm to 4500 mm. Similarly the grain crop would need 1200mm to 1500mm. On the contrary the timber tree would require a depth of 4m to 9m. If no scope is available for the roots to go deep they start spreading side ways.

Stiff clay soil: This type of soil can be improved with mixing of sand, silt from canal, charcoal or brick dust. Lime also can be added. The stiff clay and loose sands are improved by the addition of small quantities of old lime.

Plantation in low laying and water logged areas: A mound of about 900mm dia and 600mm height can be made and plantation done on the mound.

Plantation in Kalar soil: In such soil the planting should not be done directly but pits should be excavated of size 1.00m dia and 1.00m depth and fresh good soil should be filled in the pit to take up the plantation.

Sandy soil: Sheesham stumps of large roots of 300mm to 600mm length can easily be planted in these soils, Kikar and ber also can be easily tried.

3. MANURE

Chemical Manure: This manure is made by the mixture of equal parts of ammonium sulphate and bone meal or super phosphate

of lime. Usually when the plant grows about 150mm height the manure is applied.

Compost: Compost is a mixture of dung and other organic materials and earth. The pit is dug in the ground and sun dried organic matter is placed in the pit covering the same with some earth and lightly watered. This process is repeated till the pit is full.

Cow dung or sheep dung is most useful. The horse dung is less rich in manure. The manure out of dung should never be used fresh but should be thoroughly rotted, otherwise the grubs contained in the manure will attack the plant roots. The dung thus collected should not be exposed to the atmosphere as otherwise we may not be in a position to prevent the escape of valuable gasses. Hence the dung should also be collected in a pit covered with earth, we can also add urine but after diluting the same with a quantity of water four times the quantity of urine. Normally the compost should be about 2 years old but in hot places the compost takes lesser time to mature. The quantity of compost that is used is about 3 to 4 kgs per sqm.

Leaf moulds: This is a best addition to the nursery soil. A pit of 600mm to 900mm depth is dug in a shady place. This pit is filled with fallen leaves of avenue trees particularly at the time when the fruit trees shed their leaves. After a lapse of nearly one to one and half years the leaves thus collected in the pit will be converted into invaluable manure. The decay can be quickened if the pit is thoroughly soaked two or three times during the hot season. The manure will be containing worms and other vermins which should be removed completely before the same is used.

4. PLANTING TREES ON ROAD SIDE

The trees for road side planting should be selected very carefully. The most common and ever green one would be mango or nearly ever green like margosa or neem. The trees should be suitable for the atmospheric condition. Mostly shady trees which do not spread sending large branches should be selected. In short the trees should be fairly hardy and robust and should not be of a variety which grows very fast and ultimately dies fast. Generally the trees that grow about 3m to 4m in a straight direction and spread are most suitable ones. Similarly the roots of the trees should go deep because shallow rooted trees would spoil the pavement as it

would absorb the moisture from the sub-grade.

Trees with thin and small leaves like tamrind or margosa etc. should be preferred as they need less water and with stand the drought very well.

Trees with thick and broad leaves require more moisture and water. Similarly, trees producing valuable fruits or timber or even a babool tree which sheds thorns are not at all suitable one. Certain trees which shed their leaves during the month of April/May should not be preferred at all. One should bear in mind the nature of the road i.e if the road has to run close to the houses just like in a colony etc the thick growing large trees would not be suitable.

It is a common knowledge that in summer the trees dry up the soil almost upto 6% with the result the volume of the sub-grade gets reduced and the pavements crack. Hence in heavy clayey soils the fast growing trees should be planted at least 15m away from the road.

Only mixed planting should be resorted to so that plants flower and bear fruits in different seasons and also the shade of trees take place in different parts of the season. Also by mix planting only some of the trees get uprooted during storms and hale. To serve as an effective land mark, tall growing varieties with straight stem may be planted at selected spots. Planting the trees of divergent habits like banyan, babool and cork etc should be avoided.

5. METHOD OF PLANTING TREES ON ROAD SIDES

The trees on opposite side of the road should be planted in staggered fashion i.e each tree should not come in line with the tree on the opposite side but should be located at middle portion. The planting of the tree should be 2m to 3m away from the edge of the berm. It is mandatory to take particular care that the trees do not interfere with the traffic on the road and the same should be free from off shoot of the branches at least for a height of 3.5m to 4m on high ways and little more on streets in towns. In case the branches grow horizontally they should be cut maintaining a minimum height as 3.5m. The trees should be pruned in such manner that the natural shape is retained. Telephone and telegraph poles should be so fixed that there will not be any interference due to the growth of tree. However, they can

be fixed at least 1.5m outside the road edge or preferably at the boundaries of the road.

A major precaution that should be taken is a tree of less than 3.5m height should not be planted on the road side. It has been observed that most of the failures on the road side planting is due routine use of small seedlings or trees which have not had their roots formed fully before being transplanted from the nursery.

The trees on the south and west sides of a road give most shades hence while widening a road as far as possible these trees should be retained and those in north and east side can be removed.

The planting of trees on road sides is helpful for all types of roads. For Tar/Bitumen roads shielding of direct sun rays prevents licking up of tar and formation of pot holes, because the sun rays have a harmful effect on both tar and bitumen.

Again in case of cement concrete roads the obstruction to direct Sunrays would protect the surface of concrete due to temperature effect. Thus the value of shade due to trees apart from comfort is much more than keeping the road surfaces in good condition.

6. SPACING OF TREES

On an average, tree planting on road sides in our country is about 80 to 90 trees per kilometer. Generally distance between two trees kept at 10m to 15m is suitable.

However, at places where rainfall is less the trees can be planted at 15m apart and fast growing trees are planted in between so that some shade would be available in between. The intermediate trees can be trimmed or cut down once the main trees grow to more than 3.5 to 4m height.

A particular care should be taken while planting the trees on curves so that it does not obstruct the vision. The roots of the trees spread wildly hence no tree should be planted within 6m of any masonry work. The above distance should be increased depending upon the type of tree. The distance may be kept between 20m to 25m as the roots of trees, like pipal, gutar, pikhan and barged grow into the masonry joints and create the damage. The distances that can be maintained for the different types of trees is given below

SL	Name of tree	Safe spacing
1.	Teak	10m to 15m
2.	Pipal	17m to 20m
3.	Neem	8m to 10m
4.	Siris	12mm to 15m
5.	Tamarind or Imli	12m to 15m
6.	Mango	10m to 12m
7.	Jamun	12m to 15m
8.	Mahwa	10m to 15m
9.	Banyan	10m to 15m
10.	Bahera	12m to 18m
11.	Khimi	10m to 12m
12.	Karanj	10m to 12m
13.	Indian Cork	5 m to 8m

Numbering Trees : The trees should be numbered carefully. They should be numbered at a height of 1.25m above the ground level in a specially made space of 150mmx150mm by scraping the bark. Only dry scales should be scrapped without peeling the tree. The numbers should be

written in black colour over the white back ground.

7. MAINTENANCE OF TREES:

In spite of providing all equipments like pipes etc still on an average we will need one mali

to maintain about 2 to 2.5km road side trees. The length will be drastically reduced if the mali has to in addition attend the plantation in the divider portion as well.

Controlling the attack by pests: This can be done by spraying chemicals as follows

- i. Dissolve 50 gms of copper sulphate in a litre of boiling water and this mixture is added to four times the quantity of lime water just before spraying. Spraying this mixture is very effective.
- ii. Boil 100 gms of well dried tobacco leaves in one litre of water for one full hour. Dissolve 25gms of hard soap in this tobacco water, and before use add 6 litres of cold water and this mixture can be sprayed to arrest the pests.

For any tree a parasitic plant is most dangerous. Hence the parasite plant should be removed completely with roots and destroyed. The affected branch or a dead branch should be cut to save the main tree. The cutting or removing a branch should not be done in a haphazard manner. The most systematic method would be as follows:-

The cutting of a branch should not be done by an axe but a cut should be made with a sharp knife/saw close to the affected portion taking care not to leave the stub of amputated branch on the good limb or the tree trunk.

If one has to remove a large heavy branch the same should be done as follows.

The branch should be cut keeping a distance of about 350mm from the trunk. The bark around should be cut with a pruning knife. Then leaving about 300mm space cut the under side with a saw to a distance of half the depth; then cut the remaining portion from top, so that the bark will not be torn off. Small branches can be cut with the pruning knife. The wounds or cuts caused should be protected against moisture or decay and this can be easily done by painting the cut portion with tar. The more systematic method is as follows: Treat the woody portion with a dilute solution of any good wood preservative

or tar and the stripped bark should be treated with a solution of lac in methylated spirit.

Cavity filling: Some times due to careless pruning a cavity gets formed in the trunk and this should not be left untreated. The damage to the tree can be prevented with following method. The dead wood should be scraped very carefully and the hollow portion should be washed thoroughly with a strong solution of permanganate of potash and then fill up the entire gap with cement concrete 1:2:4 well packed and finished neatly till below the level of the bark.

As a matter of fact good maintenance will help prolong the life of a tree. No excavation should be allowed to be done near the tree unless totally unavoidable as it may disturb the roots. The stem should be coal tarred upto 600mm height from the ground at least once in two years. The pruning should be done regularly and wounds if any treated properly.

Pruning a tree: The pruning should be started when the tree is about 2 years old. The pruning will help the growth of a tree in a straight direction and keep it healthy. The best season for pruning is end of cold season or say beginning of the month of March. This is the period when the leaves just appear and the growth in a tree is least active. On the contrary if the pruning is done in summer i.e when the trees are in full growth and the wounds bleed which will not allow the use of tar and bitumen to adhere properly.

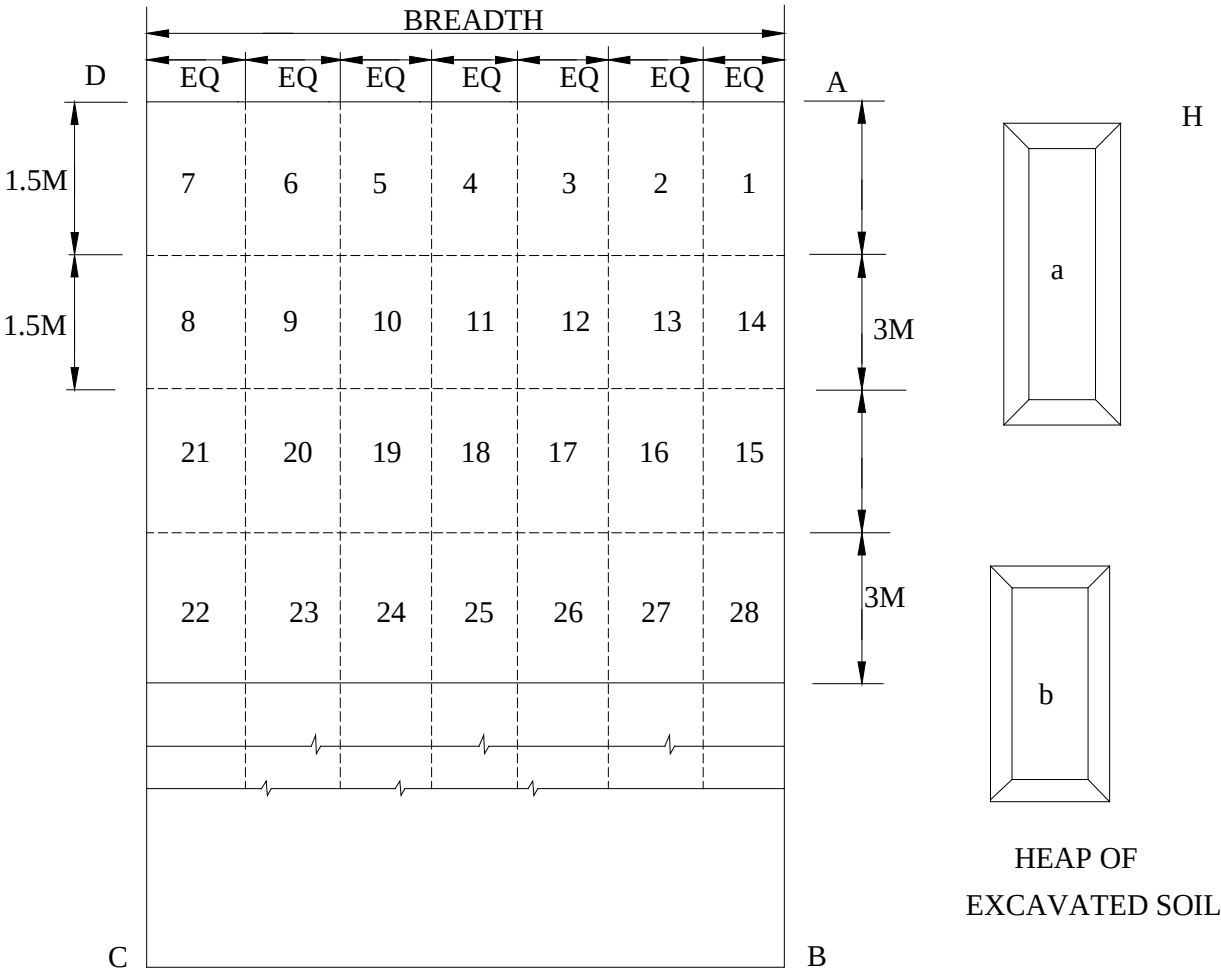
To keep the tree health only two rows or tiers of branches should be removed in a year. Axe should not be used for the purpose of pruning. One can choose the different types of tools as per IS codes.

Weeding: The removal of excessive growth of grass around the tree is called weeding. The grass should be removed with roots.

Felling trees: When a tree is cut a hollow space should be dug around the base and the trunk cut as low down as possible. The hollow portion is then filled properly.

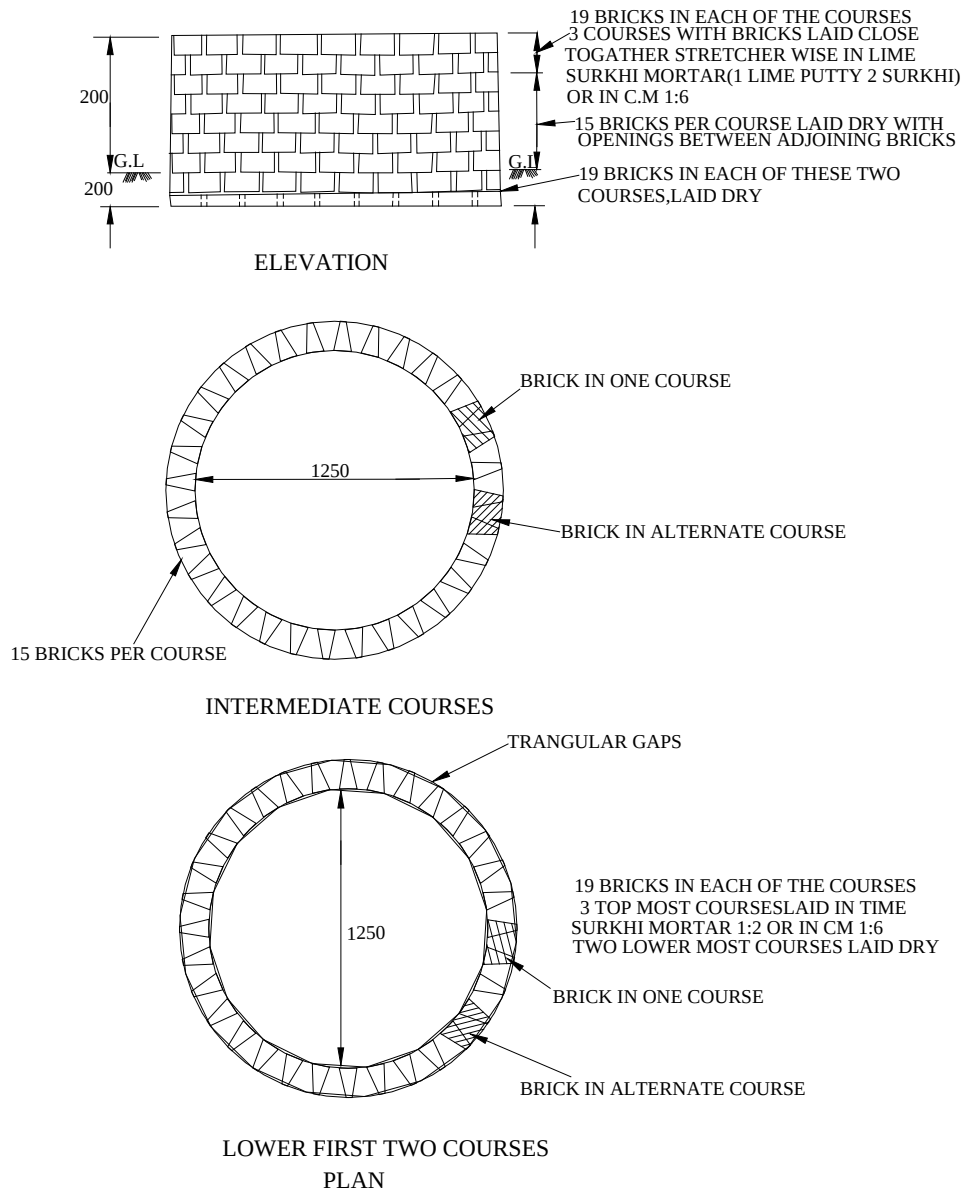
TRENCHING

FIGURE 16.1



BRICK TREE GUARD

FIGURE 16.2

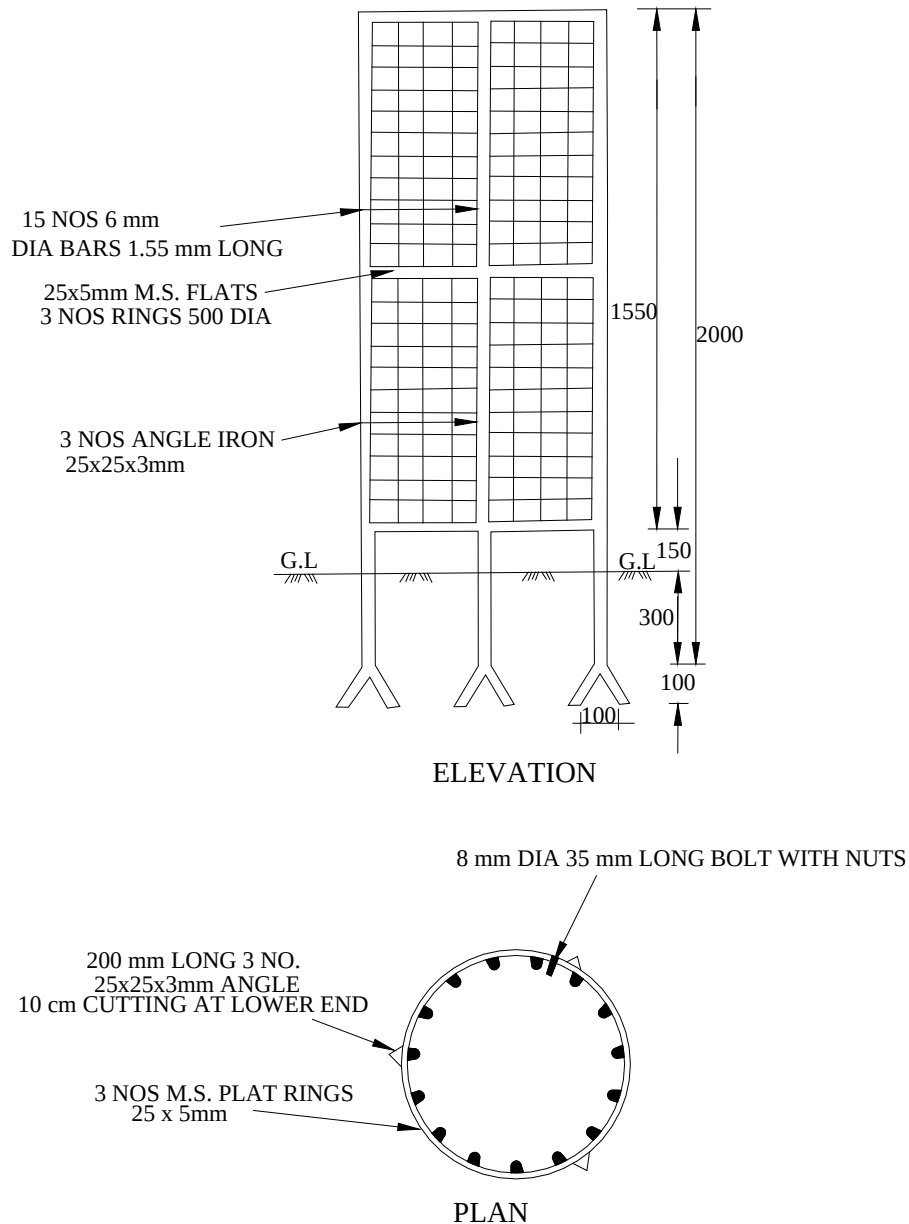


All dimensions are in mm

Drawings not to Scale

ORNAMENTAL TREE GUARD WITH M.S. BARS

FIGURE 16.3

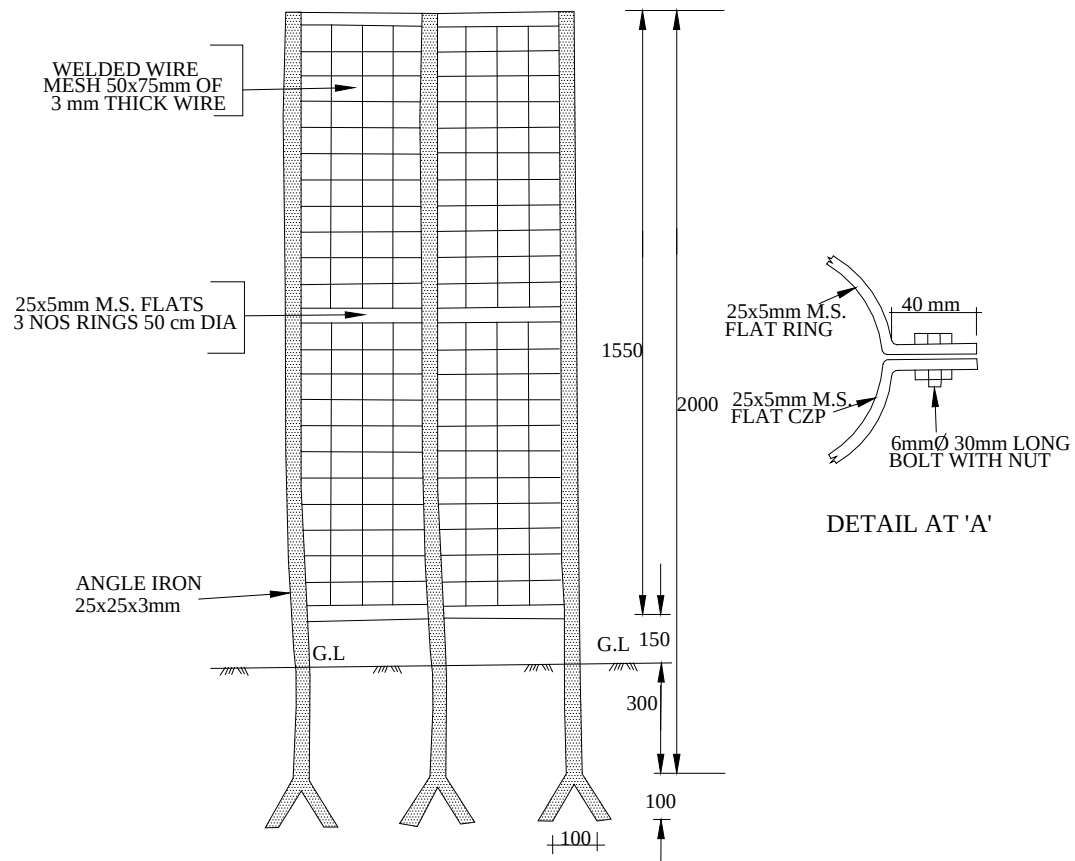


All dimensions are in mm

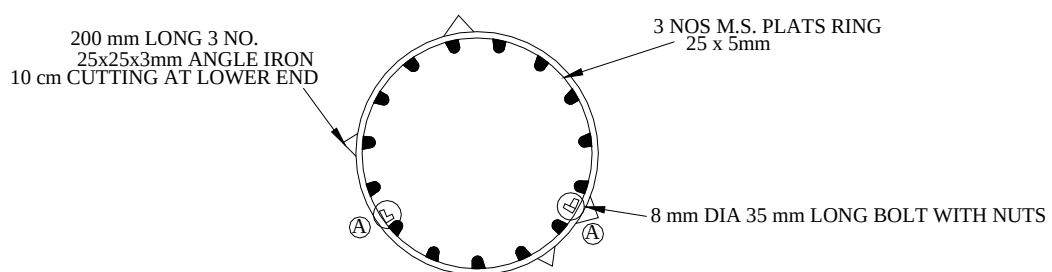
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ORNAMENTAL TREE GUARD WITH WELDED MESH

FIGURE 16.4



ELEVATION



PLAN

All dimensions are in mm

Drawings not to Scale

Chapter 17

Miscellaneous Building Works

17.1 DAMP PROOFING AND WATER PROOFING

17.1.1 General

17.1.1.1 Damp Proofing of basements and floors and waterproofing of roofs is necessary for protection against entry of moisture either from ground capillary action or from rain water.

17.1.2 Preparatory Works

In order to obtain satisfactory performance, special care has to be taken in preparing the building surface (sub-floor) for receiving the treatment.

17.1.2.2 Damp Proofing and waterproofing shall be taken up only when the sub-soil water level is at its lowest, that is, in the dry season.

Sufficient working space shall always be provided for external Damp-proofing on new buildings which shall in no case be less than 600 mm suitably protected all-round the basement.

Dewatering shall be continued during the laying of the layers of damp-proofing materials until they have hardened and the surface has developed enough strength to resist full hydrostatic pressure.

17.1.3 Damp Proof Treatment above ground level for buildings

17.1.3.1 Damp Proofing of walls:- The mortar bed on which the Damp proofing treatment is to be laid shall be levelled and made free from projection liable to cause damage to the Damp Proofing treatment. The treatment shall cover the full thickness of wall and shall not be set back from wall face for pointing. The DPC must be continuous with the floor and shall not be carried across doorways, verandah arches and similar openings. To arrest the passage of moisture between the flooring and the masonry, the faces of walls, pillars etc coming into contact with the flooring on the inside will be painted with hot Tar or Bitumen.

a) Damp Proof Course may be one of the following types as specified by the Engineer-in-charge

i) Cement Concrete :

Generally it will be of CC 1:2:4 mix with coarse aggregate of size 6mm to 20mm and

of thickness 4 cm unless otherwise directed by the Engineer. Where an approved Water Proofing compound to IS 2645-1975 is specified, it shall be done in accordance with the directions of the Manufacturer. The top of the DP Course shall be criss crossed and made rough for receiving the course of masonry over it. The DP course may be built over after curing for 3 days. Where no water proofing compound is used, the concrete may be cured for not less than 7 days and allowed to dry. When properly dried, it shall be cleaned with brushes and thereafter rubbed with cloth soaked in kerosene oil for priming. Hot Tar or Bitumen shall then be applied uniformly all over in two separate coats each coat being closely followed by sprinkling of dry sand over it while still hot. Coal Tar shall not be mixed with oxidised bitumen. The building up of masonry may be done thereafter.

ii) Cuddappah or similar slabs

The Cuddappah or similar slab shall be of uniform thickness of not less than 5 cms. The slabs shall be of the same width as the wall and laid on a bed of Cement Mortar 1:3 of thickness 12mm. The vertical joint between consecutive slabs shall be kept clear of mortar and shall be filled thoroughly with a hot mixture of tar or bitumen and dry sand.

Where so specified, the DPC may be made up of 2 layers each of 4 cm thickness of flat bedded dense grained flagging stone of non absorbent texture. The stones shall be bedded solidly in Cement Mortar 1:1 and neatly pointed on the exposed surface.

17.1.3.2 Damp Proofing of Floor

a) Where the horizontal damp proofing treatment has to be carried over to a vertical face a Cement Mortar 1:4 Fillet 75mm in radius shall be provided at the junction with both horizontal and vertical surfaces finished smooth.

b) Damp proofing of Floors may be by one of the following methods as specified:-

i) Treatment with Bitumen Felt

The Bitumen felt shall conform to the requirements of IS 1322-1993 and IS 7193-1974 as specified. Bitumen Primer shall conform to IS 3384-1986. Blown Bitumen shall conform to IS 702-1988 of Grades

85/25 or 90/15. Where specified surface on which felt is to be laid shall be made up of Cement Mortar 1:4 which shall be paid for separately. The surface on which the DPC is to be laid shall be first sprayed with Bitumen Primer conforming IS 3384-1986 @ 0.4 litre / m² Over it, the following will be applied.

- Hot applied Blown Bitumen at the rate of 1.50 kg/ m²

- Hessian Base self-finished Felt Type 3, Grade 2 or Glass fibre base Type 2, Grade II (as specified) and

- Hot applied Blown Bitumen at the rate of 1.50 kg/ m²

The method of laying the Bitumen Felt has been described in subsequent Para 17.1.4.2 (i) (c)

17.1.4 Water Proofing of Roof

17.1.4.1 Waterproofing with Bitumen Felt Para 10.15 may be referred to.

17.1.4.2 Water Proofing with Cement Slurry mixed with Fibre Glass Cloth consisting of applying:

After surface preparation, first layer of slurry of cement @ 0.488 kg/sqm mixed with Armourcrete or Tapecrete manufactured by M/s The Structural Water Proofing Co. Pvt. Ltd. or Tapecrete of M/s CICO Engineering Services @ 0.253 kg/sqm.

Laying second layer of Fibre glass cloth manufactured by M/s. The Structural Water Proofing Company Pvt. Ltd. when the first layer is still green. Overlaps of joints of fibre cloth should not be less than 10 cm.

Third layer of 1.5mm thickness consisting of slurry of cement @ 1.289 kg/sqm. mixed with Armourcrete or Tapecrete @ 0.670 kg / sqm and coarse sand @ 1.289 kg./sqm. This will be allowed to air cure for 4 hours followed by water curing for 48 hours.

The entire treatment will be taken upto 30 cm on parapet wall and tucked into groove in parapet all around.

Fourth and final layer of brick tiling with cement mortar (which will be paid for separately)

For the purpose of measurement the entire treated surface will be measured.

17.1.4.3 Integral cement based water proofing treatment- This shall be carried out as under for roofs, balconies, terraces etc.

a) Applying and grouting a slurry coat of neat cement using 2.75 kg/sqm of cement admixed with proprietary water proofing compound conforming to IS 2645 over the

RCC slab including cleaning the surface before treatment.

b) Laying 20mm thick layer of cement mortar of mix 1:5 (1 cement : 5 coarse sand) admixed with proprietary water proofing compound conforming to IS: 2645 to required slope and treating similarly the adjoining walls upto 300mm height including rounding of junctions of walls and slabs.

c) Laying cement concrete using broken bricks / brick bats 25mm to 100mm size with 50% of cement mortar 1:5 (1 cement: 5 coarse sand) admixed with proprietary water proofing compound conforming to IS 2645

d) After two days of proper curing, applying a second coat of cement slurry admixed with proprietary water proofing compound conforming to IS 2645. Finishing the surface with 20mm thick joint less cement mortar of mix 1:4 (1 cement: 4 coarse sand) admixed with proprietary water proofing compound conforming to IS 2645 and finally finishing the surface with trowel with neat cement slurry and making of 300 x 300mm square.

e) The whole terrace so finished shall be flooded with water for a minimum period of two weeks for curing and for final test.

All above operations to be done in order and as directed and specified by the Engineer.

17.1.4.4 Procedure for waterproofing of underground/overhead tanks

(1) Placing and fixing **12mm N.B.M.S.** threaded Nozzles of **75mm length** with dummy rod for maintaining the hole up to required depth in an approximate grid pattern at a spacing not exceeding **1.5 M c/c** on the entire surface prior to or during concreting. Similar threaded Nozzles along with dummy rod shall also be fixed at a regular interval not exceeding **1.5 M** apart along the construction joints. Similar Nozzles shall also be post fixed at critical points, if required by drilling or making holes with suitable tools.

(2) Casting of RCC slab (Minimum **M-20** grade and W/C ratio not exceeding **0.50**) admixed with '**CICO PLAST-N**' Normal Plasticiser-cum-Cement Waterproofer/ '**CICO PLAST SUPER**' – Superplasticiser /High Range Water Reducing Admixture as per recommended dosage.

(3) Injection of '**CICO NON- SHRINK POLYMERIC WATERPROOF GROUTING COMPOUND**' admixed with Cement Slurry through the Nozzles under pressure by pump. The grout should flow through all pores and voids thereby sealing them.

(4) Sealing off the Nozzles after the injection operation is over with '**CICO QUICK SETTING ADMIXTURE**' admixed with cement wherever required.

(5) After sealing the nozzles, the concrete surface to be cleaned from all debris, loose material, dust etc.

(6) Application of two coats of '**TAPECRETE-P151**'- Acrylic polymer Modified Cementitious Slurry coating over the properly rendered RCC surface.

(7) Providing **12mm** plaster in the ratio **1: 4 (Cement : Sand)** admixed with CICO SUPER over the '**TAPECRETE-P151**' applied surface to protect the 'Tapecrete' applied surface .

17.1.4.5 WALLS

(1) Casting of RCC Walls (minimum M-20 grade and W/C ratio not exceeding 0.50) admixed with 'CICO PLAST-N' Normal Plasticiser-cum-cement Waterproofer /'CICO PLAST SUPER' – Superplasticiser /High Range Water Reducing Admixture, as per recommended dosage.

(2) Placing and fixing **12mm N.B.M.S.** threaded Nozzles of **75 mm length** in an approximate grid pattern in a spacing not exceeding **1.5 M c/c** on the entire Retaining Wall after concreting by drilling or making holes with suitable tools up to required depth of the Wall. Similar threaded Nozzles shall also be provided at a regular interval not exceeding 1.5 M apart along the construction joints. Similar Nozzles shall also be post fixed at critical joints, if required by drilling or making holes with suitable tools.

(3) Injection of '**CICO NON-SHRINK POLYMERIC WATERPROOF GROUTING COMPOUND**' admixed with Cement Slurry through the Nozzles already fixed under pressure by pump. The grout should flow through all pores & voids thereby sealing them.

(4) Sealing off the Nozzles after the grouting operation is over with '**CICO QUICK SETTING ADMIXTURE**' admixed with cement wherever required.

(5) Application of two coats of '**TAPECRETE-P151**'- Acrylic Modified Cementitious Slurry Coating over the properly rendered internal face of the Wall.

(6) Providing **12mm thick** plaster in the ratio **1:4 (Cement: Sand)** admixed with CICO SUPER on the external face of the retaining wall if backfilling is not done with Sand or Earth.

17.1.4.6 Water Proofing with Polymeric Membrane

a) Material

(1) APP (Atactic Poly Propylene) modified Polymeric membrane manufactured by Bengal Bitumen Integrated Water Proofing Ltd. or General Membranes:-This shall be one of the following as specified:-

A) 1.5mm thick of 2.25 kg/sqm. weight consisting of five layers prefabricated with centre core as 20 micron HMHDPE (High Molecular High Density Polythylene) film sandwiched on both sides with polymeric mix and the polymeric mix is protected on both sides with 20 micron HMHDPE film. or

B) 2.0 mm thick of 3.00 kg/sqm weight consisting of five layers pre-fabricated with centre core as 100 micron HMHDPE film sandwiched on both sides with polymeric mix and the polymeric mix protected on both sides with 20 micron HMHDPE film or

C) APP (Atactic Polypropylene Polymer) modified prefabricated five layer 2mm thick waterproofing membrane black finished reinforced with glass fibre matt manufactured by Bitumat Co.Ltd. Soprema or Tamko, or

D) As above but 3mm thick, or

E) As above 3mm thick but with non woven polyester matt instead of glass fibre matt.

(2) Bonding Material:- Blown type Bitumen of Grade 85/25 conforming to IS 702.

(3) Bitumen Primer manufactured by Bitumat Co. Ltd., Supreme or Tamko of density at 25° C 0.87 to 0.89 kg/litre and viscosity 70-160 cps.

b) **Seven Course** Water proofing treatment with APP modified Polymeric Membrane of Bengal Bitumen or similar.

1st Layer – Bitumen primer (a) (3) above @ 0.40 kg/sqm.

2nd, 4th & 6th Layer Bonding material (a) (2) above @ 1.20 kg/sqm

3rd & 5th Layer – APP Membrane 1.5mm or 2mm thick as specified as at (a) (1) above.

7th Layer – Finishing layer of Brick Tiles of class designation 100 grouted with Cement Mortar 1:3 (1 cement: 3 fine sand) mixed with 2% integral water proofing compound by weight of Cement over 12mm layer of cement mortar 1:3 (1 cement: 3 fine sand) finished neat.(7th layer shall be paid for separately)

c) **Five Course** water proofing treatment with APP modified Polymeric membrane of Bengal Bitumen or similar

1st Layer - Bitumen Primer 1(a) (3) above @ 0.40 kg/sqm.

2nd & 4th Layer - Bonding material (a) (2) above @ 1.20 kg/sqm.

3rd Layer - APP Membrane 2.00mm thick a(1) above.

5th Layer of - Finishing layer of Brick Tiles as described as 7th Layer in (b) above. (to be paid for separately)

(d) **Seven Course Water Proofing treatment with APP Modified Polymeric Membrane of Bengal Bitumen or similar**

1st Layer - Bitumen Primer 1(a) (3) above @ 0.40 kg/sqm.

2nd, 4th and 6th Layer of - Bonding material (a) (2) above @ 1.20 kg/sqm.

3rd and 5th Layer - APP Membrane 2.00mm thick a(1) above.

7th Layer of - Finishing layer of Brick Tiles as described as 7th Layer (b) above.

(e) **Waterproofing Treatment with 2mm thick APP modified membrane with glass fibre matt of Bitumat Co. Ltd. or similar (For corrugated roof sheets)**

1st Layer - Bitumen Primer 1(a) (3) above @ 0.40 Ltr./sqm.

2nd Layer - 2mm thick APP modified membrane with glass fibre(a) (1) above laid using Butane torch and sealing all joints etc.

The vital physical and chemical parameters of the membrane shall be as under :

Joint strength in longitudinal and transverse direction at 23° C as 350/300 N/5 cm. Tear strength in longitudinal and transverse direction as 60 /80N. Softening point of membrane not less than 150° C. Cold flexibility shall be upto (-)2° C when tested in accordance with ASTM, D-5147. The laying of membrane shall be got done through the authorized applicator of the manufacturer of membrane.

(f) Water proofing Treatment with 3mm thick APP modified membrane with glass fibre matt or Bitumat Co. Ltd. or similar

Same as in (e) above.

(g) Water proofing Treatment with 3mm thick APP modified membrane with non-woven polyester matt of Bitumat Co. Ltd. or similar.

Same as in (e) above.

17.2 ANTI TERMITE TREATMENT

17.2.0 General : Sub-terranean termites are responsible for most of the termite damage in buildings. Typically, they form nests or

colonies underground, in the soil near ground level in a stump or other suitable piece of timber in a conical or dome shaped mound. The termites find access to the super-structure of the building either through the timber buried in the ground or by means of mud shelter tubes constructed over unprotected foundations.

Termite control in existing as well as new building structures is very important, as the damage likely to be caused by the termites to wooden members of building and other household article like furniture, clothing, stationary etc. is considerable. Anti-termite treatment can be either during the time of construction, i.e. pre-constructional treatment or after the building has been constructed, i.e. treatment for existing buildings.

Prevention of the termite from reaching the super structure of the building and its contents can be achieved by creating a chemical barrier between the ground, from where the termites come and other contents of the building which may form food for the termites. This is achieved by treating the soil beneath the building and around the foundation with a suitable insecticide.

17.2.1 Materials

17.2.1.0 Chemicals : The following chemical in water emulsion to achieve the percentage concentration specified against the chemical shall be used for anti-termite treatment.

(1) Chemical Imidacloprid 30.5% SC shall be used @ 0.075% concentration, mixed at the ratio of 2.1 ml of Imidacloprid 30.5% SC to 1 litre of water.

or

(2) Chemical Chloropyrifos emulsifiable concentrate (IS:8944) mixed with water @ 1% concentration by volume.

Chemicals are available in concentrated form in the market and concentration is indicated on the sealed containers. To achieve the specified percentage of concentration, chemical should be diluted with water in required quantity before it is used. Graduated containers shall be used for dilution of chemicals with water in the required proportion to achieve the desired percentage of concentration. For example, to dilute chemical of 30% concentration, 59 parts of water shall be added to one part of chemical for achieving 0.5% concentration.

The Engineer shall procure the chemical of required concentration in sealed original containers directly from the reputed and authorised dealers. The chemical shall be kept in the custody of the Engineer or his authorised representatives and issued for

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use to meet the day's requirements. Empty containers after washing and concentrated chemical left unused at the end of the day's work shall be returned to the Engineer or his authorised representative.

17.2.1.1. Measurements: Concentrated chemical in sealed containers shall be measured in litres. Chemicals of different concentration shall be measured separately.

17.2.1.2. Rate : The rate for the concentrated chemical shall include the cost of material, containers and all the operations involved in transportation and delivery at the place specified.

17.2.2 Safety Precautions

All chemicals used for anti termite treatment are Poisonous. These chemicals can have an adverse effect upon health when absorbed through the skin, inhaled as vapours or spray mists or swallowed.

The containers having emulsifiable concentrates shall be clearly labelled and kept securely closed in stores so that children or pets cannot get at them. Storage and mixing of concentrates shall not be done near any fire source or flame. Persons using these chemicals shall be warned that absorption through skin is the most likely source of accidental poisoning. Particular care shall be taken to prevent skin contact with concentrates. Prolonged exposure to dilute emulsion shall also be avoided. After handling the concentrates or dilute emulsion, workers shall wash themselves with soap and water and wear clean clothing, especially before eating. In the event of severe contamination, clothing shall be removed at once and the skin washed with soap and water. If chemical has splashed into the eyes, they shall be flushed with plenty of soap and water and immediate medical attention should be sought.

Care should be taken in the application of chemicals to see that they are not allowed to contaminate wells or springs which serve as source of drinking water.

In case of poisoning, suitable measures shall be taken for protection in accordance with IS 4015 (Pt I) and (Pt II) as stipulated in IS 6313.

17.2.3 Pre-construction Chemical Treatments

17.2.3.0. Chemical treatment of soils for the protection of buildings from attack of subterranean termites shall be done as per IS: 6313 (Part II). Treatment shall be got done only from the approved specialised agencies using the chemical procured

directly by the Engineer from reputed and authorized dealers. Graduated containers shall be used for dilution and spraying of the chemical shall be done using hand operated pressure pumps. Proper check should be kept to ensure that the specified quantity of chemical is used for the required area during the operation.

17.2.3.1 Time of application : Soil treatment should start when foundation trenches and pits are ready to take bed concrete / levelling course in foundations. Laying of bed concrete / levelling course should start when the chemical emulsion has been absorbed by the soil and the surface is quite dry. Treatment should not be carried out when it is raining or soil is wet with rain or sub soil water. Treatment to the surface of earth filling within the plinth shall also be done in the same manner before laying the sub-grade for flooring.

17.2.3.2 Disturbance: The treated soil barrier shall not be disturbed. If for some reasons the treated soil barriers are disturbed, immediate steps shall be taken to restore the continuity and completeness of the barrier system.

17.2.3.3 Treatment for Masonry Foundations & Basements : (a) The bottom surface and the sides (upto a height of 300mm) of the excavations made for masonry foundations and basements shall be treated with the chemical at the rate of 5 litres per square metre of surface area (**Annexure A**)

b) After the masonry foundations and the retaining wall of the basements come up, the backfill in the immediate contact with the foundation structure shall be treated at the rate of 7.5 litres per sqm of the vertical surface of the sub-structure for each side. If water is used for ramming the earth fill, the chemical treatment shall be carried out after the ramming operation is done by rodding the earth at 150mm centres close to the wall surface and spraying the chemical with the above dosage. The earth is usually returned in layers and the treatment shall be carried out in similar stages. The chemical emulsion shall be directed towards the concrete or masonry surfaces of the columns and walls so that the earth in contact with these surfaces is well treated with the chemical (**Annexure-A**)

17.2.3.4 Treatment for RCC Foundation and Basements : In the case of RCC foundations, the concrete mix is dense (being 1:2:4 or richer). It is, therefore, unnecessary to start the treatment from the bottom of excavations. The treatment shall start at the

depth of 500mm below ground level except when such ground level is raised or lowered by filling or cutting after the foundations have been cast. In such cases, the depth of 500mm shall be determined from the new soil level resulting from the filling or cutting mentioned above, and soil in immediate contact with the vertical surfaces of RCC foundations shall be treated at the rate of 7.5 litres per square metre of surface area. The other details of treatment shall be as laid down in Para 17.2.3.3 (b)

17.2.3.5 Treatment of Top Surface of Plinth Filling: The top surface of the filled earth within the plinth walls shall be treated with chemical emulsion at the rate of 5 litres per sqm of the surface before the sand / sub-grade is laid. Holes upto 50 to 75mm deep at 150mm centres both ways shall be made with crow bars on the surface to facilitate saturation of the soil with chemical emulsion.

17.2.3.6 Treatment at Junction of the Walls and the Floor: To achieve continuity of the vertical chemical barrier on inner wall surfaces from the ground level, a small channel 30 x 30 mm shall be made at all the junctions of walls and columns with the floor (before laying the sub-grade) and rod holes made in the channel upto ground level 150mm apart and the chemical emulsion poured along the channel @ 7.5 litres per sqm of the vertical wall or column surface so as to soak the soil right up to bottom. The soil shall be tamped back into place after this operation.

17.2.3.7 Treatment of Soil along External Perimeter of Building: After the building is complete, 300 mm deep holes shall be provided in the soil with iron rods along the external perimeter of the building at intervals of about 150mm and these holes shall be filled with chemical emulsion at the rate of 7.5 litres per sqm of vertical surface of the external walls. If the depth of filling is more than 300mm, the external perimeter treatment shall extend to the full depth of filling upto the ground level so as to ensure continuity of the chemical barrier. In case the earth outside the building is graded on completion of building, this treatment shall be carried out on completion of such grading.

17.2.3.8 Treatment of Soil under Apron (Plinth Protection) along External Perimeter of Building: Top surface of the consolidated earth over which the apron is to be laid shall be treated with chemical emulsion at the rate of 5 litres per square metre of the surface before the apron is laid. If consolidated earth does not allow emulsion to seep through,

holes 50 to 75mm deep at 150mm centres both ways may be made with 12mm diameter mild steel rod on the surface to facilitate saturation of the soil with the chemical emulsion.

17.2.3.9 Treatment for expansion joints: Anti termite treatment shall be supplemented by treating with chemical emulsion through the expansion joint after the sub-grade has been laid @ 2 litres per linear metre of expansion joint.

17.2.3.10 Treatment of Walls Retaining Soil above Floor Level: Retaining walls like the basement walls or outer walls above the floor level retaining soil need to be protected by providing chemical barrier by treatment of retained soil in the immediate vicinity of the walls, so as to prevent entry of termites through the voids in masonry, cracks and crevices, etc. above the floor level. The soil retained by the walls shall be treated at the rate of 7.5 litres per square metre of the vertical surface so as to effect a continuous outer chemical barrier, in continuation of the one formed under 17.2.3.3.

17.2.3.11 Treatment of Soil Surrounding Pipes, Wastes and Conduits: When pipes, wastes and conduits enter the soil inside the area of the foundations, the soil surrounding the points of entry shall be loosened around each such pipe or conduit for a distance of 150mm and to a depth of 75mm before treatment is commenced. When they enter the soil external to the foundations, they shall be similarly treated for a distance of over 300mm unless they stand clear of the walls of the buildings by about 75mm.

17.2.3.12 Measurements: All dimensions shall be measured correct to a cm. The measurements for all the operations described above shall be the plinth area of the building in square metres at floor 1 level (Ground Floor). Nothing extra shall be measured for payment.

17.2.3.13 Rate: The rate for the anti-termite treatment shall include the cost of labour and all other inputs (except concentrated chemical) involved in all the operations described above.

17.2.4 Treatment for Existing Buildings

17.2.4.0 Once the termites have an ingress into the building, they keep on multiplying and destroy the wooden and cellulosic materials, and as such it becomes essential to take measures for protection against termites. Anti-termite measures described below are necessary for the eradication and control of termites in existing buildings. To

facilitate proper penetrations of chemical into the surface to be treated, hand operated pressure pump shall be used. To have proper check for uniform penetration of chemical, graduated containers shall be used. Proper check should be kept so that the specified quantity of chemical is used for the required area during the operation. Chemical treatment for the eradication and control of sub-terranean termites in existing buildings shall be done as per IS 6313 (Part III). Treatment shall be got done only from the approved specialised agencies using the chemical procured directly by the Engineer from reputed and authorised dealers.

17.2.4.1 Treatment Along Outside of Foundations: The soil in contact with the external wall of the building shall be treated with chemical emulsion at the rate of 7.5 litres per square metre of the vertical surface of the sub-structure to a depth of 300mm. To facilitate this treatment a shallow channel shall be excavated along and close to the wall face. The chemical emulsion shall be directed towards the wall at 1.75 litres per running metre of the channel. Rodding with 12mm diameter mild steel rods at 150mm apart shall be done in the channel, if necessary, for uniform dispersal of the chemical to 300mm depth from the ground level. The balance chemical of 0.5 litre per running metre shall then be used to treat the backfill earth as it is returned to the channel directing the spray towards the wall surface.

If there is a concrete or masonry apron around the building, approximately 12mm diameter holes shall be drilled as close as possible to the plinth wall about 300mm apart, deep enough to reach the soil below and the chemical emulsion pumped into these holes to soak the soil below at the rate of 2.25 litres per linear metre.

In case of RCC framed structures, the soil (backfill) in contact with the column sides and plinth beams along the external perimeter of the building shall be treated with chemical emulsion at the rate of 7.5 litres/sqm of the vertical surface of the structure. To facilitate this treatment, trenches shall be excavated equal to the width of the shovel exposing the sides of the column and plinth beams upto a depth of 300 mm or upto the bottom of the plinth beam, if this level is less than 300mm. The chemical emulsion shall be sprayed on the backfill earth as it is returned into the trench directing the spray against the concrete surface of the beam or column as the case may be.

17.2.4.2 Treatment of Soil Under Floors:- Chemical treatment shall be done by drilling 12mm holes at the junction of floor and walls along the cracks on the floor and along the construction joints at the interval of 300mm to reach the soil below. Chemical emulsion shall be squirted into these holes using a hand operated pressure pump to soak the soil below until refusal or upto a maximum of one litre per hole. The holes shall then be sealed properly with cement mortar 1:2 (1 cement: 2 coarse sand) finished to match the existing floors. The cement mortar applied shall be cured for atleast 10 days as per instructions of the Engineer.

17.2.4.3 Treatment of Voids in Masonry: The movement of termites through the masonry wall may be arrested by drilling holes in masonry wall at plinth level and squirting emulsions into the holes to soak the masonry. The holes shall be drilled at an angle of 45° from both sides of the plinth wall at 300mm intervals and emulsion squirted through these holes to soak the masonry using a hand operated pump. This treatment shall also be extended to internal walls having foundations in the soil. Holes shall also be drilled at wall corners and where door and window frames are embedded in the masonry or floor at ground. Emulsion shall be squirted through the holes till saturation or to a maximum of one litre per hole. Care shall be taken to seal the holes after the treatment.

17.2.4.4 Treatment at Points of Contact of Wood Work : All existing wood work in the building which is in contact with the floor or walls and which is infested by termites, shall be treated by spraying at the points of contacts with the adjoining masonry with the chemical emulsion by drilling 6mm holes at a downward angle of about 45° at the junction of wood work and masonry and squirting chemical emulsion into these holes till refusal or to a maximum of half a litre per hole. The treated holes shall then be sealed.

17.2.4.5 Measurements : All dimensions shall be measured correct to a cm. The measurements shall be made of the surface actually provided with anti-termite treatment. Measurements shall be done separately for treatment of foundations, soils under floors, voids in masonry and wood work as detailed below:

Treatment along outside of foundations : The measurements shall be made in running metres taking lengths along the plinth of the building.

Treatment of soil under floors : The measurements shall be made in square metres. Inside clear dimensions of rooms, verandah, etc shall be taken.

Treatment of voids in masonry : The measurements shall be made in running metres along the plinth of the building.

Treatment to wood work: The measurements shall be made in running metres for chowkhats, joists, purlins, beams etc.

17.2.4.6 Rates : The rates shall include the cost of labour and all other inputs (except concentrated chemical) involved in all the operations described above including drilling, refilling and making good the holes.

17.2.5 Pest Management :

17.2.5.1 Rodent Control :

Rodenticide to be used should be safe and highly effective single dose anticoagulant rodenticide like (OR having active ingredient 'BROMADIOLONE'). Rodenticides should not have the disadvantages that the other rodenticides have such pre-baiting, secondary poisoning and bait shyness.

Mode of Treatment :

The treatment would commence with closing of all the burrows within the compound area of the railway property to identify live burrows. The opened burrows shall be baited with Bromadiolone bait to bring the infestation under control. Subsequently, fortnightly visits to continue the baiting and to keep vigil on rodent population. The baits shall be placed in "Rodent Bait Station Box" along the external wall, to keep the bait safe.

TRUBBLE GUM traps shall be placed indoors to trap the rodents entering the structures. These traps shall be placed in "Rodent Bait Station Box" to simulate a burrow & to keep the traps safe.

17.2.5.2 General Pests (Cockroaches, ants etc.) :

This treatment comprises of placing Cockroach Gel dots at strategic places in the cabinets, drawers, cupboards, cracks & crevices. This is followed by thorough insecticidal spray especially at the cracks, vices and wall & floor junction of rooms, toilets, passages, staircase and common drainage manholes harboring cockroaches.

Chemicals to be used for Household Pest management :

Active Ingredient	Formulation%	%Emulsion concentrate	Dilution/ ltr of water	Dosage per sqm
Lambdacyhalothrin	10 WP	0.05	05 gms	020 ml
Deltamethrin	2.5 SC	0.02	10 ml	100 ml
Cyfluthrin	050 EW	0.04	08 ml	050 ml
Imidacloprid	2.15 %	RTU Gel Bait		300 dots/ cartridge
Fipronil	0.03%	RTU Gel Bait		300 dots/ cartridge
Fipronil	0.05%	RTU Gel Bait		1100 dots/cartridge
CMT	Ready to use Cockroach Monitoring Traps			
Deltamethrin	2.5 WP	0.1	40 gms	030 ml
Cyphenothrin	05 EC	0.1	20 ml	050 ml
PestSeal™	PCI RTU Formulation		RTU	

(B) Frequency : Quarterly i.e. 4 services in a year at an interval of 3 months. If the infestation seen in interim period same shall be treated without extra charge.

17.3 CEMENT CONCRETE PLINTH PROTECTION

17.3.0 General: Plinth protection shall be provided, as specified, to required width. It normally comprises 5 cm. thick cement concrete 1 : 3 : 6 (1 cement : 3 coarse sand :

6 graded stone aggregate 20 mm nominal size) over 7.5 cm bed of dry brick aggregate 40 mm nominal size, grouted with fine sand. The outer edge shall be lined with bricks of the class specified in the item laid on edge and joints laid in cement-mortar 1 : 4 (1 cement : 4 fine sand). Plinth protection shall be laid with a minimum outward slope of 1 in 50.

17.3.1. Preparing Ground : The ground, where plinth protection is to be laid shall first be prepared to the required slope. The high

portions of ground shall be excavated, hollows and depressions filled upto the required level with the excavated earth and watered and rammed to give uniform outward slope. Preparation of any area involving cutting and filling upto a depth of 15 cm shall not be paid for separately. Cutting and filling beyond 15 cm shall be paid for separately. The bed shall be watered adequately and rammed with iron rammers. Surplus earth, if any, obtained shall be disposed off within a lead of 50 metres or as directed by the Engineer.

17.3.2. Brick Edging : The edging shall be of bricks of class specified in the item. The specifications of bricks shall be as described in 5.1. Trenches of required depth and width shall first be made along the edge of the plinth protection to receive the bricks for edging. The bed of trenches shall be compacted to a firm and even surface. The brick shall be laid true to line in cement mortar 1:4 (1 cement : 4 fine sand) with length parallel and abutting the plinth protection. The top face of the brick edging shall be in one level, to conform to the finished level of the plinth protection adjacent to the edging. After the concreting is done, no portion of the brick edging shall project above the adjacent concrete surface. Cement mortar shall conform to the specifications described in 2.2.2.

17.3.3 Sub-grade : The sub-grade shall consist of a bed of dry brick aggregate of 40 mm nominal size. Brick aggregate shall be spread evenly over the prepared surface to 7.5 cm depth (unconsolidated) and given a minimum outward slope of 1 in 50. The aggregate shall be carefully laid and packed, bigger size being placed at the bottom. The brick aggregate shall be consolidated dry with heavy iron rammers. After the brick aggregate has been consolidated the surface shall be checked with a straight edge and any depressions etc. filled up and consolidated. The aggregate shall then be grouted evenly with fine sand @ 0.06 cubic metre/10 sq. metre area, adequately watered to ensure filling of the voids by sand and again rammed with heavy iron rammers. The finished surface shall give uniform appearance.

17.3.4. Cement Concrete Topping : After the subgrade has been compacted and prepared as under 17.3.3, 5 cm thick cement concrete 1:3:6 (1 cement : 3 coarse sand : 6 graded stone aggregate 20 mm, nominal size or as specified in the item) shall be laid in one operation as described in 9.2.4,

except that the top shall not be finished with neat cement slurry but shall be finished with only wooden floats. The concrete surface shall not be finished with mortar. The length of each panel shall not be more than 5 m. The finished surface shall have a minimum outward slope of 1 in 50.

17.3.5 Curing : Specification shall be as described in 3.2.12.

17.3.6 Measurements : The length and breadth of cement concrete topping shall be measured correct to a cm and the area calculated in square metre correct to two places of decimal. No deduction shall be made not anything extra paid for any opening' for pipes etc. upto 0.1 sqm. Brick edging shall be measured in running metre correct to a cm and paid for separately.

17.3.7. Rate : The rate shall include cost of material and labour described in all the above operations except for brick edging which will be paid for separately.

17.4 BRICK PLINTH PROTECTION

17.4.0 General: Plinth protection shall be provided as specified, to the required width. It shall consist of a layer of bricks of class specified, in cement mortar 1:6 (1 cement : 6 fine sand) over a bed of dry graded brick aggregate of 40 mm nominal size grouted with fine sand. The top brick layer shall be finished with pointing in Cement mortar 1:2 (1 cement : 2 fine sand). Plinth protection shall be laid with a minimum outward slope of 1 in 50.

17.4.1. Specifications:- The specifications for 'Preparing ground' and 'Sub-grade' shall be as described in paras 17.3.1 and 17.3.3 respectively.

17.4.2. Brick Topping : After the sub-grade had been compacted thoroughly, brick flooring with bricks of **class** designation 75 in cement mortar 1:6 (1 cement : 6 fine sand) or as specified shall be laid to the required slope. The bricks shall be **laid as** described in para 9.1.5.

17.4.3. Pointing : The pointing which shall be in 1:2 cement mortar (1. cement : 2 fine sand) shall conform to the specifications given in para 11.24 'Pointing' under sub-head 'Finishing'.

17.4.4 Curing : Specification for curing shall be as in paras 5.2.6.

17.4.5 Measurements: Length and breadth shall be measured correct to a cm and area calculated in square metre correct to two places of decimal. No deduction shall be

made nor anything extra paid for any openings for pipes etc. upto 0.1 square metre.

17.4.6 Rate : The rate shall include the cost of all materials and labour involved in all the operations described above.

17.5 URINAL PARTITIONS

17.5.1 Marble Slab Partition

17.5.1.0. The partition shall be of marble slab, embedded in the wall. The size of the marble slab shall be 105 cm high and 60 cm deep (overall). The finished thickness shall be 2.5 cm. The marble shall be of white Makrana unless otherwise specified. The marble shall be cut into slabs of required thickness and shall be one piece.

17.5.1.1. Finishing: The partition of the slab to be embedded in the masonry shall be rough dressed. The exposed faces and sides of stones forming joint upto 6mm from the face shall be fine tooled such that a straight edge laid along the face of the stone is in contact with every point in it. These surfaces shall then be rubbed smooth. All visible angles and edges shall be true, square and free from chipping. The surface of the stone coming in contact with backings need not be dressed. The dressed slab shall be of the thickness as specified with a tolerance of ± 1.5 mm. The slab shall be got approved from the Engineer before fixing. **(Annexure-D)**

17.5.1.2. Fixing shall be as in para 17.5.1.1 except that the recess shall be 7.5 cm wide.

17.5.1.3. Measurement shall be as in para 17.5.1.4.

17.5.1.4. Rate : The rate shall include the cost of labour and materials involved in all the operations described above including the leaving/cutting of recess in the wall.

17.6. CUP BOARD

17.6.0. General: The work shall be carried out as per drawing or as directed by the Engineer. The timber shall conform to the specifications given in 7.1.

17.6.1. Frame Work : Frame work shall be made to the sizes and shape as shown in the drawings, or as specified. The specifications given in 7.3 shall be applicable to frame work.

17.6.2 Shutters : The quality and the thickness of the shutters shall be as specified or as shown in the relevant drawings. The shutters shall be flush/panelled/ glazed or panelled and glazed as specified or as shown in the drawings.

Specifications for flush shutters shall be as described in para 7.7. Specifications for panelled glazed or paneled and glazed shutters shall be as described in para 7.6.

17.6.3 Shelves : The number, size and thickness of the shelves shall be as shown in the relevant drawings or as specified. The planks for shelves shall be of specified timber and planed on all faces and edges. The shelves shall rest on wooden supports, 25 x 25 mm, for their full depth. The wooden supports shall be fixed in the masonry by means of wooden plugs and screws or as shown in the drawings, at suitable intervals. The shelves shall be fixed to the supports with wood screws of suitable size at 10 cm centre to centre. The shelves, when fixed, shall be truly horizontal.

17.6.4 Internal partitions: Where specified or shown in the drawings, the vertical partition of timber of size and thickness shown shall be provided and shall be of one piece upto 30 cms. It shall be secured to shelves by means of screws to avoid slipping or lateral movement. The partition, when fixed, shall be truly vertical.

17.6.5. Hanger-rod : The hanger rod, where specified or shown in the drawing, or as directed by the Engineer, shall be provided at the top of cup board. The clear gap above the rod shall be not less than 8 cm. The rod shall be of single piece. The diameter of wooden rod shall be 25 mm while that of metal shall be 20 mm, unless otherwise specified. The end supports shall consist of brass or C.P. brass bracket of approved quality fixed to the side masonry of the cup board with suitable plugs and screws.

17.6.6 Fittings : These shall be provided and fixed as per specifications and schedule of fittings given in **Chapter 7** unless otherwise specified.

17.6.7. Finishing : All the wood work shall be painted or finished as specified. After fixing the plugs for supports, the plaster should be neatly repaired with cement mortar 1:4 (1 cement : 4 coarse sand). Where wood lining is not specified, the inside plaster portion shall be finished with two coats of oil bound distemper or flat wall paint of approved colour, as specified. When required, the inside of the cup board shall be lined with wooden planks/ply wood of specified quality where shown on the drawings or specified in the description of the item. The lining shall be directly fixed without any battens on the masonry surface by means of plugs and screws spaced at not more than 20 cm apart in both directions.

The finishing of the exposed surface of the lining shall be as specified above in this clause.

17.6.8. Measurements :

The cup boards shall be paid as per individual items.

17.6.9. Rate : Payment will be made at the rate specified in the contract. Separate rates shall be payable for each type of cup board, depending upon the size, the shelves, finishing and other features.

The rate shall include the cost of all materials and labour involved in all the above operations. However, the rate does not include any brick work, plastering, R.C.C. work, flooring and holdfasts for frames, which shall be paid for separately under relevant items, if executed.

17.7 PROVIDING AND FIXING ALUMINIUM STRIP EDGING TO STAIRS

17.7.1. Aluminium Sections : Size and shape of aluminium sections shall be as specified in the relevant items of work/drawings.

17.7.2. Fixing : A suitable recess shall be provided in the step, both in tread and riser portions, to receive the step edging so that, after fixing, the top surface of the edging and the top surface of the tread shall be perfectly in one level. Similarly the outer face of the vertical leg of the edging shall be flush with the finished surface of the riser.

In cases where the finish over the risers and treads consists of plain cement concrete flooring and cement mortar respectively, the edging shall be fixed after the flooring/plastering are completed. Where the finish consists of marble chip flooring and marble chips plastering, the edging shall be fixed after the polishing of the flooring/plastering.

The recess shall be thoroughly cleaned of all loose material, mortar droppings etc. before fixing the edging. The surface of the recess shall be given a coat of cement mortar 1:3 (1 cement : 3 coarse sand). Holes shall be drilled in the leg of the edging coming on the tread, to receive the screw of specified size. The edging shall be kept in position, tapped gently to make it sit firmly on the mortar bedding and then fixed in position with necessary 25 mm size wood screws. Each edging shall be in one piece only. After the work is completed and the mortar has set, no hollow sound shall be given when the edging is tapped. Any edging giving hollow sound shall be taken out and re-fixed properly. Wooden plugs of suitable size at

approximately 20 cm apart shall be fixed at desired level during laying of cement concrete in steps for fixing the edging. The fixing may be done using rawl plugs/detefix also, instead of wooden plugs.

17.7.3. Measurements : The length of aluminium step edging shall be measured in running metres correct to 3 mm.

17.7.4. Rate : The rate shall include the cost of labour and the material required for all the operations described above including making holes, providing wooden plugs/rawl plugs etc.

17.8 SHOTCRETE (GUNITING)

17.8.1 General

17.8.1.1 Shotcrete is mortar or concrete conveyed through a hose and pneumatically projected at high velocity on to a surface. Shotcrete can be either plain or reinforced, as specified

17.8.1.2 Shotcrete is done by two processes, namely, drymix process and wet mix process. Pneumatically conveyed shotcrete in which most of the mixing water is added at the nozzle is dry mix process. Shotcrete wherein all the ingredients, including mixing water, are mixed in the equipment before introduction into the delivery hose in wet mix process.

17.8.2 Materials

17.8.2.1 Cement, aggregates, water, admixtures and reinforcement are generally as specified in Chapters 26,3 and 4.

17.8.2.2 Aggregates

a) Fine aggregate (sand) – Sand for concrete shall comply with the requirements of IS 383: 1970 and graded evenly from fine to coarse as per Zone II and Zone III grading. Further sand for finish or flash coats may be finer from the above grading.

b) Coarse aggregate – Coarse aggregates, when used, shall comply with IS 383: 1970. It shall conform to one of the gradings given in Tables 3.1 and 3.2.

17.8.3 Shotcreting process

17.8.3.1 General - The two basic processes are - Dry mix process and Wet mix process

17.8.3.2 Dry Mix Process - In this process, a mixture of cement and moist sand is conveyed through the delivery hose to a nozzle where most of the mixing water is added, under pressure (see **Figure 17.7 Annexure-B**). The mortar is jetted from the nozzle at high velocity on to the surface to be shotcreted.

17.8.3.3 Wet Mix Process – In this process, all the ingredients including water are mixed before they enter the delivery hose. The mortar or concrete is jetted from the nozzle at high velocity on to the area to be shotcreted.

17.8.3.4 Shotcrete may be produced by either of the processes for normal constructional requirements unless specified

17.8.4 Properties of Shotcrete

17.8.4.1 Shotcrete, if properly applied is a structurally adequate and durable material capable of excellent bond with concrete, masonry, steel, and other materials. However, these favourable properties of sound shotcrete are contingent on proper supervision, and on the skill and continuous attention by the operating staff.

17.8.4.2 The water cement ratio for shotcrete in place normally falls within a range of 0.35 to 0.50 by mass

It will tend to give more shrinkage cracking and may require a closer joint spacing. The durability of shotcrete is good.

17.8.5 Pre-Construction testing

17.8.5.1 Testing shall be done prior to the commencement of the work in order to check the operation of equipment, skill of the operating staff and the quality of shotcrete. The procedure is detailed in 17.8.5.2 to 17.8.5.7.

17.8.5.2 Test panels shall be fabricated, simulating actual job conditions, by the operating staff using the equipment, materials and mix proportions proposed for the job.

17.8.5.3 For the dry mix process, the amount of water added at the nozzle is adjusted so that the in – place shotcrete appears to be adequately compacted and neither sags nor shows excessive rebound. Where justified by the size and importance of the job or lack of previous experience with the materials, it may be advisable to test two or three mixes, generally within the range of 1 part of cement to 3 to 4 ½ parts of sand, before deciding on the final mix proportions.

17.8.5.4 The procedure for wet-mix process is similar to the dry mix process except that the entire concrete mix is premixed to give a workability judged to be appropriate for the work, before it is introduced to the chamber of delivery equipment. Tests on more than one mix design are usually recommended where it is desired to include coarse aggregate in the mix. Normally 20 to 40 percent of coarse aggregate is first tried with

subsequent mixes adjusted to reflect the results of the first trial.

17.8.5.5 The panels are fabricated by gunning on to a back form of plywood. A separate panel shall be fabricated for each mix design being considered, and also for each gunning position to be encountered in the structure, that is, slab, vertical and over head sections. At least part of the panel shall contain the same reinforcement as the structure, to show whether sound shotcrete is obtained behind the reinforcing rods. The panel shall be large enough to obtain all test specimens needed, and also to indicate what quality and uniformity may be expected in the structure. Generally, the size of the panel shall be not less than 75 cm x 75 cm. The thickness shall be the same as in the structure, except that it shall normally be not less than 7.5cm.

17.8.5.6 Cubes of cores shall be taken from the panels for testing. The cores shall have a minimum diameter of 7.5cm and length to diameter ratio of at least one if possible. The specimens shall be tested in compression at the age of 7 and 28 days both.

17.8.5.7 The cut surfaces of the specimens shall be carefully examined and additional surfaces shall be exposed by sawing and breaking of the panel when it is considered necessary to check the soundness and uniformity of the material. All cut and broken surfaces shall be dense and free from laminations and sand pockets.

17.8.6 Mixing

17.8.7.1 Dry Mix Process

a) Batching by mass is preferred. The moisture content of the sand shall generally be within 5 to 6 percent to permit flow at a uniform rate.

b) The mixing equipment shall be capable of thoroughly mixing the sand and cement in sufficient quantity to maintain continuity of placing. The mixing time shall be not less than a minute in a drum type mixer. The mixer shall be thoroughly cleaned to prevent accumulations of batched materials.

c) Supply of clean dry air under pressure should be ensured through an air compressor. The air pressure should be uniformly steady (non-pulsating). The operating pressure shall drive the material from the delivery equipment into the hose.

d) For length of hose up to 30m, the operating pressure shall be 0.3N.mm² (3 kg/cm²) or more; for each additional 15m length of hose, pressure may be increased by 0.035 N/mm² (0.35 kg/cm²) and the same

increase allowed for each 7.5m that the nozzle is raised above the gun.

e) Water under pressure shall be supplied; the water pressure shall be sufficiently greater than the operating air pressure at the discharge nozzle. Water pressure shall also be steady and non pulsating.

17.8.7.2Wet Mix Process

a) Batching by mass is preferred. Aggregates may be batched by volume. Periodic checks are to be made to ensure that the masses are maintained within the required tolerance. Water may be batched either by volume or mass.

b) The mixing time will depend on the mix being used and the efficiency of the mixer.

c) The other details are as per dry-mix.

17.8.7 Application of Shotcrete

17.8.7.1Surface Preparation

a) Shotcrete shall not be placed on any surface which is frozen, spongy or where there is free water.

b) Surfaces shall be kept damp for several hours before shotcreting.

c) In case of repairs, all existing deteriorated concrete shall be removed. The final cut surface shall be examined to make sure that it is sound and perfectly shaped; all edges shall be tapered. The surface shall be cleaned of all loose and foreign materials.

d) Exposed reinforcement shall be free of rust, scales, etc.

17.8.7.2Form work

Forms may be plywood sheeting or other material, true to line and dimension. They shall be so constructed as to permit the escape of air and rebound during gunning operations. Forms shall be oiled and dampened just before gunning. Short removable bulkheads may be used at intersections.

Appropriate scaffolding shall be erected to permit suitable positions for holding the nozzle.

17.8.7.3Reinforcement

a) Reinforcement shall be so placed as to cause least interference to gunning operations.

b) Minimum clearance may be 12mm to 50mm between form work and reinforcement for mortar work and concrete mix respectively.

c) Clear spacing between bars shall be not less than 65 mm.

d) As far as possible, bars shall be so arranged as to permit shooting from the opposite side.

e) Lapped reinforcing bars shall not be tied together, they shall be separated by atleast 50mm.

f) For repair work, existing work may be fixed with reinforcement by nails.

g) All detailing shall be as per IS 456: 2000.

17.8.7.4Alignment Control

Adequate ground wires shall be installed to ensure thickness and surface planes of shotcrete build up.

17.8.7.5Placing of Shotcrete

a) Shotcrete may be built up in layers, Shotcrete shall be forced behind bars. When bars are closely spaced more than one bar may be shot from each position of the nozzle to avoid building up on the front face of the bar.

b) The first layer shall completely embed the bar for walls, columns and beams, beginning at the bottom.

17.8.7.6Rebound

a) Rebound is aggregate and cement paste which ricochets (reflects) off the surface during the application of shotcrete. Rebound may be as below :

Surface	Percentage of Rebound
Floors or slabs	5-15
Sloping and vertical walls	15-30
Overhead work	25-50

b) Rebound shall not be worked back into the concrete; it shall not be included in later batches.

17.8.7.7. Preparation for Succeeding Layers

The earlier layer shall be allowed to take initial set before the second layer is commenced. Then laitance, loose material and rebound shall be removed. The surface shall be thoroughly sounded with a hammer for drummy areas resulting from rebounding

pockets or lack of bond. Drummy areas shall be cut off and replaced with succeeding layers. Surfaces to be shot shall be damp.

17.8.7.8 Construction Joints

Construction Joints shall generally follow the principles for normal concrete constructions.

17.8.7.9 Finishing

The natural gun finish is preferred both from structural and durability considerations. Finishing may be difficult for dry-mix work.

17.8.7.10 Suspension of work

a) The work shall be suspended when exposure to high wind, breezing or rain is likely.

b) When work is stopped, the shotcrete shall be sloped off to a thin edge and then the work resumed after cleaning the surface.

17.8.7.11 Curing

The surfaces shall be kept continuously wet for atleast 7 days.

17.8.7.12 For more details reference may be made to IS 9012: 1978 on recommended practice for shotcreting.

17.9 UNDER-REAMED PILE FOUNDATION

17.9.1 Description

Under-reamed piles are of bored cast in situ and bored compaction concrete types having one or more bulbs formed by suitably enlarging the bore hole of the pile stem.

17.9.2 Materials:

a) Cement: The cement used shall conform to the requirements of IS 269: 1989 or IS 455: 1989 or IS 8041 : 1990 or IS 6909: 1990 or IS 1489 (Parts 1 and 2) 1991: of IS 12269: 1987 as specified

b) Steel – Reinforcement steel shall conform to IS 432 (Part I): 1989 or IS 1786:1985 or IS 2062: 1992 as specified

For under-reamed bored compaction piles, the reinforcement cage shall be prepared by welding the hoop bars to withstand the stresses during compaction process.

c) Concrete

1) Slump of concrete shall range between 100mm and 150mm for concreting in water free unlined bore holes. For concreting by tremie, a slump of 150mm to 200mm shall be used.

2) In case of tremie concreting of piles of smaller diameter and depth upto 10m, the minimum cement content should be 350 kg/cum of concrete, unless otherwise specified For piles of larger diameter and /

or deeper piles, the minimum cement content should be 400 kg/ cum of concrete, unless otherwise specified

In case the piles are subsequently exposed to water or in case piling is done under water or drilling mud is used in methods other than tremie, 10 percent extra cement shall be used over and above that required for the grade of concrete at specified slump.

For making concrete, aggregate as described in IS 456: 2000 shall be used. For tremie concreteing, aggregates having nominal size more than 20mm should not be used.

For bored compaction piles Rapid Hardening Cement to IS 8041-1990 shall not be used.

17.9.3 Equipment

Normally the equipment required for manual operations are:

- a) auger
- b) under-reamer
- c) boring guide and
- d) accessories.

For piles of deeper and larger size greater than 30 cm a portable tripod hoist with manually operated winch is required.

For piles in high ground water table and unstable soil conditions, boring and under reaming shall be carried out using suitable equipment. Tremie pipe shall be used for concreting.

For compact piles, the additional equipment required are drop weight for driving the core assembly and pipe or solid core.

17.9.4 Construction

a) Bore holes may be made by earth augers. In case of manual boring, an auger boring guide shall be used to keep the bores vertical or at the desired inclination and in position. After the bore is made to the required depth, enlarging of the bore shall be carried out by means of an under-reaming tool.

b) Drilling mud shall be used for boring and under-reaming in a site with high water table. Bentonite may also be used.

c) To avoid irregular shape and widening of borehole in a very loose strata at top, a casing pipe of suitable length shall be temporarily used, as specified

d) For batter under-reamed piles, the reinforcement cage should be placed guiding it by a chute or any other means.

e) In order to achieve proper under-reamed bulb, the depth of bore hole should be checked before starting under-reaming. It should also be checked during under-reaming, any extra soil at the bottom of bore hole shall be removed by auger before reinserting the under-reaming tool.

f) The completion of the desired under reamed bulb is ascertained by vertical movement of the handle and when no further soil is cut.

g) In multi under-reamed piles, the boring is first completed to the depth required for the first (top) bulb only, and after completing under-reaming bulb, the boring is extended further down to the second bulb and so on.

h) The piles shall be installed as correctly as possible, both at the correct location and truly vertical (or at the specified batter). Piles shall not deviate by more than 75mm or one quarter the stem diameter whichever is less. For piles of diameter more than 600mm, the deviation may be 75mm or 10 percent of the stem diameter.

i) Concreting shall be done as soon as possible after completing the bore. The bore hole full of drilling mud should be concreted between 12 to 24 h depending on the stability of the hole.

j) The method of concreting should be such that the entire volume of the pile bore is filled up without formation of voids and / or mixing of soil and drilling fluid in the concrete. For placing concrete in pile bores, funnel should be used.

In the empty bore holes for under-reamed piles a small quantity of concrete is poured to give about a 100mm layer of concrete at the bottom. Reinforcement is lowered next and positioned correctly. The concrete is poured to fill the bore hole. Care shall be taken that soil is not scrapped from sides if rodding is done for compaction. Vibrators shall not be used.

If the subsoil water level is confined to the bucket length portion at the toe, the seepage is low, the water should be bailed out before commencing concreting.

In case the pile bore is stabilized with drilling mud or by maintaining water head within the bore hole, the bottom of bore hole shall be carefully cleaned by flushing it with fresh drilling mud and the pile bore be checked before concreting.

k) Concreting shall be done by the tremie method. The tremie should have a valve at the bottom and lowered with the valve closed at the start and filled up with concrete. The

valve is then opened to permit concrete which permits the upward displacement of drilling mud. The pouring should be continuous and the tremie is gradually lifted up such that the pipe opening remains always in the concrete. In the final stage the quantity of concrete shall be enough so that on the final withdrawal some concrete spills on the ground.

l) In inclined piles, concreting should be done through a chute or by tremie method.

m) A bored compaction pile is one in which the compaction of surrounding ground as well as fresh concrete in the bore is simultaneously accomplished. In under-reamed bore compaction piles, the pile shall be filled up with concrete, without placing reinforcement. Immediately, the core assembly shall be driven and extra concrete shall be poured in simultaneously to keep the level of concrete up to ground level. If a hollow driving pipe is used in core assembly, the pipe shall be withdrawn after filling it with fresh concrete.

In these compaction piles it shall be ensured that concreting should be done uninterruptedly. Accidental withdrawal should be completely avoided.

n) The top of the concrete pile shall be brought above the cut off level to permit removal of all laitance and weak concrete before capping and to ensure good concrete at the cut off level for proper embedment into the pile cap.

o) Where cut off level is less than 1.5m below working level, concrete shall be cast to minimum of 300mm above cut off level, for every excess of 0.3m over 1.5m, additional of 50mm shall be cast over and above 300mm.

When tremie method is employed, it shall be cast to the piling platform level to permit overflow of concrete for visual inspection or to a minimum of 1m above cut off level.

When the cut off level is below the ground water level, there is a need to maintain a pressure on the unset concrete equal to or greater than the water pressure and a length of extra concrete above the cut off level may be permitted to provide this.

p) When defective piles are formed, they shall be removed or left in place whichever is convenient, without affecting the performance of adjacent piles or the cap as a whole.

Any deviation beyond permissible limits from the designed location, alignment or load capacity of any pile shall be noted and

adequate measures taken well before the concreting of the pile cap and plinth beam. The pile should project 50mm into the cap concrete.

17.10 STORAGE OF MATERIALS

17.10.1 General

17.10.1.1 Material shall be so stored as to prevent deterioration or intrusion of foreign matter and to ensure the preservation of their quality and fitness for use in the work. Materials shall also be stored to protect against atmospheric agencies, fire and other hazards.

17.10.1.2 Materials like timber, coal, paints etc. shall be stored in such a way that there may not be any fire hazards. Inflammable materials like kerosene, petrol, etc shall be stored in accordance with the relevant rules and regulations in force prescribed by the Authority, so as to ensure safety during storage (see also IS 7969: 1975).

Explosives like detonators shall be stored in accordance with the rules and regulations in force.

Materials which are likely to be affected by subsidence of soil, like precast elements, large size timber sections, etc shall be provided with unyielding supports.

In areas, likely to be affected by floods, the materials shall be suitably stored to prevent their being washed away or damaged by floods.

During construction, stairways, passageways and gangways shall not be obstructed due to storage of materials, tools or rubbish.

17.10.2 Cement

Cement shall be stored at the work site in a building or shed which is dry, leak proof and as moisture proof as possible. The building shall have minimum number of windows and close fitting doors which shall be kept closed as far as possible.

Cement stored in bags shall be stacked and shall be kept free from the possibility of any dampness or moisture coming in contact with the bags. Cement bags shall be stored / stacked off the floor on wooden planks in such a way as to be clear above the floor by 150mm to 200mm and a space of 450mm minimum around between the bags and external walls. In the stacks, cement bags shall be kept close together to reduce circulation of air as much as possible. Owing to pressure on the bottom layer of bags

'warehouse pack' is developed in these bags. This can be removed easily by rolling the bags when the cement is taken for use.

The height of the stack shall be not more than 15 bags to prevent the possibility of lumping up under pressure. The width of the stack shall not be more than four bags length of 3m. In stacks more than 8 bags high, the cement bags shall be arranged alternately lengthwise and cross wise so as to tie the stacks together and minimize the danger of toppling over. Cement bags shall be stacked in a manner to facilitate their removal and use in the order in which they are received.

During the monsoon or when it is expected to be stored for a long period, the stack shall be completely enclosed by a waterproofing membrane, such as, polyethylene sheet. Care shall be taken to see that the membrane is not damaged any time during use.

Different types of cements shall be stored separately.

17.10.3 Lime

Quick lime deteriorates rapidly on exposure by taking up moisture and carbon dioxide from atmosphere. Therefore, it should be stacked as soon as possible before deterioration sets in. If unavoidable, quicklime may be stored in compact heaps having only minimum of exposed area. The heaps shall be stored on a suitable platform and covered to avoid direct contact with moisture/ rain or being blown away by wind. In case it is stored in a covered shed, a minimum space of 300mm should be provided around the heaps to avoid bulging of walls.

Hydrated lime is generally supplied in containers such as jute bags, lined polyethylene or HDPE woven bags lined with polyethylene or craft paper bags. It should be stored in a building to protect lime from dampness and to minimize warehouse deterioration.

Dry slaked lime should be stored on a platform suitably covered from rain and wind if it is to be used within a few days. If required to be stored for longer periods not exceeding 2 months it may be kept in a dry and closed godown.

17.10.4 Bricks

Bricks shall not be dumped at site. They should be stacked in regular tiers as and when they are unloaded to minimize breakage and defacement of bricks.

Bricks shall be placed close to the site of work so that least effort is required to unload

and transport the bricks again by loading on pallets or barrows. Unloading of building bricks or handling in any other way likely to damage the corners or edges or other parts of bricks shall not be permitted.

Bricks shall be stacked on firm ground. For proper inspection of quality and ease in counting, the stacks shall be 50 bricks long and 10 bricks high, the bricks being placed on edge. The width of each stack shall be 6 to 8 bricks. Clear distance between adjacent stacks shall not be less than 0.8m.

Bricks of different types and class shall be stacked separately.

17.10.5 Aggregate

Aggregate shall be stored at site on a hard and dry level patch of ground. If such a surface is not available, a platform of planks or of corrugated iron sheets, or a floor of dry bricks, or a thin layer of lean concrete shall be made so as to prevent the admixture of clay, dust, vegetable and other foreign matter.

Stacks of fine and coarse aggregate shall be kept in separate stack piles, sufficiently removed from each other to prevent the materials at the edge of the piles getting intermixed. On a large job it is desirable to construct dividing walls to give each type of aggregate its own compartment. Fine aggregate shall be stacked in place where loss due to the effect of wind is minimum.

Unless specified otherwise or necessitated by site conditions, stacking of aggregate should be carried out in regular sizes.

17.10.6 Fly Ash

Fly ash shall be stored in such a manner as to permit easy access and proper inspection and identification of each consignment. Fly ash in bulk quantities shall be stored in a stack similar to fine aggregate as referred to above, avoiding any inclusion of foreign matter. Fly ash in bags shall be stored in stack not more than 15 bags high.

17.10.7 Timber

Timber shall be stored in stacks upon well treated and even surfaced beams, sleepers or brick pillars as to be above the ground level by atleast 150mm. The various members shall preferably be stored separately in different lengths, and material of equal lengths shall be piled together in layers with wooden battens, called crossers, separating one layer from another. The crossers shall be of sound wood, straight and uniform in thickness. In any layer, air space of about 25mm shall be provided between adjacent members. The larger

pieces shall be placed in the bottom layers and the shorter pieces in the upper layers, but one end of the stack including crossers shall be in true vertical alignment. The most suitable width and height of a stack are recommended to be about 1.5m and 2m. Distance between adjacent stacks is shown in **(Annexure-C)**. The stacks shall be protected from hot dry winds or direct sun and rain. Heavy weights, such as metal rails or large sections of wood, are recommended to be placed on top of the stack to prevent distortion or warping of timber in the stack. In case timber is stored for about a year or more, to prevent end cracking in the material, the ends of all members shall be coated with coal tar, aluminium leaf paints (hardened gloss oil), micro crystalline wax or any other suitable material.

17.10.8 Steel

Separate areas shall be earmarked for storing each classification (type and grade) of steel. It is desirable that the ends of bars and sections of each class be painted in distinct separate colours.

Steel reinforcement shall ordinarily be stored in such a way as to avoid distortion and to prevent deterioration and corrosion. It is desirable to coat reinforcement with cement wash before stacking to prevent scaling and rusting. The cement collected from sweepings may be used for this purpose.

Bars of different classification, sizes and lengths shall be stored separately to facilitate issue in such sizes and lengths so as to minimize wastage in cutting from standard lengths.

In case of long storage, reinforcement bars shall be stacked above ground level by atleast 150mm. A coat of cement wash shall be given, for such long storage, to prevent scaling and rusting.

Other structural steel sections of different classification (types and grades), sizes and lengths shall be stored separately. It shall be stored above ground level by atleast 150mm upon platforms, skids or other suitable supports to avoid distortion of sections.

For long storage, suitable protective coating of primer shall be given to prevent scaling and rusting.

For storage in coastal area, similar protective treatment shall be given for reinforcement bars and structural steel sections.

17.10.9 Doors, Windows and Ventilators

While unloading, shifting, handling and stacking timber door and window frames and shutters care shall be taken to ensure that the material is not dragged one over the other as it may cause damage to the surface of the material, for example, in case of decorative shutters. The material should be lifted and carried preferably flat to avoid damage to corners or sides.

Metal doors, windows, and ventilators shall be stacked upright (on their sills) on level ground preferably on wooden battens and shall not come in contact with dirt and ashes. If received in crates they shall be stacked according to manufacturer's instruction and removed from the crates as and when required for the work.

Metal frames for doors, windows and ventilators shall be stacked upside down with the kick plates at the top. They shall not be allowed to stand for long in this manner before being fixed so as to avoid the door frames getting out of shape and hinges being strained and shutters drooping.

During period of storage aluminium doors, windows and ventilators shall be protected from loose cement and mortar by suitable cover such as tarpaulin. The tarpaulin shall be hung loosely on temporary framing to prevent circulation of air and prevent condensation.

All wooden frames and shutters shall be stored in dry and clean covered space away from any infestation and dampness. The storage shall be preferably in well ventilated dry rooms. The frames shall be stacked one over the other in vertical stacks with cross battens at regular distances to keep the stack vertical and straight. The cross battens should be of uniform thickness and placed vertically one above the other. The door shutters shall be stacked in the form of clean vertical stacks one over the other and at least 80mm above ground on pallets or suitable beams or rafters. The top of the stack shall be covered by a protecting cover and weighed down by means of scantlings or other suitable weights. The shutter stack shall rest on hard and level ground.

Separate stacks shall be built for each size, each grade and each type of material. When materials of different sizes, grades and types are to be stacked together for want of space, the bigger size shall be stacked in the lower portion of the stacks. Suitable pallets or separating battens shall be kept in between two types of material.

If any wooden frame or shutter becomes wet during transit, it shall be kept separate from

undamaged material. The wet material may be dried by stacking in shade with battens in between adjacent boards with free access of dry air generally following the guidance laid down in IS 1141:1993.

17.10.10 Roofing Sheets

Roofing sheets shall be stored in such a way as not to damage them in any way.

Asbestos cement sheets shall be stacked to a height of not more than one metre on a firm and level ground with timber or other packing beneath them. If stacked in exposed position, they shall be protected from damage by wind.

Asbestos cement sheets of the same variety and size shall be stacked together. Damaged sheets shall not be stacked with sound materials. All damaged sheets shall be salvaged as early as possible.

17.10.11 Boards

Gypsum boards shall be stored flat in a clean covered and dry place.

Boards shall not be stored in the open and exposed to sun and rain, particularly if they are wood based boards, such as plywood, fibre board, particle board, block board etc.

The boards shall be stacked on a flat dunnage, on top of which a wooden frame shall be constructed with 50mm x 25mm battens in such a way that it will give support to all the four edges and corners of the boards with intermediate battens placed at suitable intervals to avoid warping.

The boards shall be stacked in a solid block in a clear vertical alignment. The top sheet of each stack shall be suitably weighed down to prevent warping.

The boards shall be unloaded and stacked with utmost care avoiding damage to corners and surface. In case of decorative plywood and decorative boards the surfaces of which are likely to get damaged by dragging one over the other it is advisable that these boards are lifted in pairs facing each other as far as possible.

17.10.12 Glass Sheets

It is important that all sheets whether stored in crates or not shall be kept dry. Suitable covered storage space shall be provided for the safe storage of glass sheets. In removing glass sheets from crates great care shall be taken to avoid damage to glass. The glass sheets shall be lifted and stored on its long edges and shall be put into stacks not more than 25 panes, supported at two points by fillets of wood at 300mm from each end. The first pane laid in each stack shall

be so placed that its bottom edge is about 25mm from the base of the wall or other support against which the stack rests. The whole stack shall be as close and as upright as possible.

17.10.13 Asbestos Cement, Pipes and Fittings

The pipes shall be unloaded where they are required, when the trenches are ready to receive them.

The pipes shall be stored on firm, level and clear ground and wedges shall be provided at the bottom layer to keep the stack stable.

The stack should be in pyramid shape or the pipes be arranged lengthwise and cross wise in alternate layers. The pyramid stack is advisable for smaller diameter pipes for conserving space in the store room. The height of the stack shall not exceed 1.5m.

Each stack shall contain only pipes of same class and size, with consignment or batch number marked on it with particulars of suppliers wherever possible.

Cast iron detachable joints and fittings shall be stacked under cover and separated from asbestos cement pipes and fittings.

Rubber rings shall be kept clean, away from grease, oil, heat and light.

17.10.14 Polyethylene Pipes

Black polyethylene pipes are suitably protected from ageing due to sunlight by the addition of appropriate quantity and type of carbon black during manufacture. Therefore they may be stored even in the open; however, it is preferable that they are stored under cover.

Natural polyethylene pipes, however, shall be stored under cover and protected from direct sun.

Pipe coils may be stored either on edge or stacked flat one on top of another, but in either case they should not be allowed to come in contact with heat, such as, through hot water or steam pipes. They should also be kept away from hot surfaces.

Straight lengths of pipes should be stored on horizontal racks giving continuous support to prevent the pipe getting a permanent set if allowed to sag. Storage of pipes in heated areas exceeding 27° C shall be avoided.

17.10.15 Unplasticised PVC Pipes

These pipes shall be given support at all times. Pipes should be stored on a reasonably flat surface free from stones and sharp projections so that the pipe is supported all along its length. Pipes should not be stored on racks.

Pipes should not be stacked in large piles especially under warm temperature conditions as the bottom pipes may be distorted, thus creating problems in jointing. Socket and spigot pipes should be stacked in layers with sockets placed at alternate ends of the stacks to avoid lopsided stacks. Stacks shall not be more than 1.5m high. Avoid storing one pipe in another.

Pipes of different sizes and classes should be stacked separately.

On no account should pipes stored in a stressed or bent condition. The ends of pipes should be protected from abrasion particularly those specially prepared for jointing.

In tropical conditions, pipes should be stored in shade. In wintry conditions or cold weather the impact strength of PVC is reduced making it brittle; therefore more care shall be exercised in handling of the pipes.

If due to improper storage or handling, a pipe becomes kinked, the damaged portion should be cut out completely. Kinking is likely to occur in thin walled pipes.

17.10.16 Bitumen, Road Tar and Asphalt

All types of bitumen, road tar, asphalt, etc in drums or containers shall be stacked vertically on their bottoms upto 3 tiers. Leaky drums should be segregated. Empty drums shall be stored in pyramidal stacks neatly in rows.

17.10.17 Water

Wherever water is to be stored for construction purposes, it shall be done in proper storage tanks to prevent any organic impurities polluting the water.

17.10.18 Flat tiles

Flat tiles shall be stacked on well treated and hard surface. Tiles shall be stacked at site in proper layers and tiers and they shall not be dumped in heaps.

In a stack, the tiles shall be so placed that the mould surface of one faces another. The height of the stack shall not be more than 1 m.

Tiles when supplied in packed boxes / crates shall be stored as such. They shall be opened only at the time of use.

17.10.19 Oil Paints

All containers of paints, thinners and allied materials shall preferably be stored on floors with sand cushions in a separate room which is well ventilated and free from excessive heat, sparks of flame and direct rays of the sun. The containers of paint shall be kept

covered or properly fitted with lid and shall not be kept open except when in use.

17.10.20 Sanitary Appliances

All sanitary appliances shall be carefully stored under cover to protect from damage. When accepting and storing appliances, consideration shall be given to sequence of removal from the store to the assembly positions. Proper stacking to assist the later stage will be advantageous. As nearly all assemblage have need for separating brackets, these shall be readily accessible as they will be required at an early stage.

17.10.21 Piles

Pile shall be stored on firm ground free from liability to unequal subsidence of settlement under the weight of the stack of piles. The piles shall be placed on timber supports which are truly level and spaced so as to avoid undue bending in the piles. The supports shall be left around the piles to enable them to be lifted without difficulty. The order of stacking shall be such that the older piles can be withdrawn for driving without disturbing the new piles. Separate stacks shall be provided for different lengths of piles. Whenever curing is needed during storage, arrangements shall be made to enable the piles to be watered if the weather conditions so require.

Care shall be taken at all stages of transporting, lifting and handling of piles to see that they are not damaged or cracked during handling. During transportation the piles shall be supported at appropriate lifting holes provided for the purpose. If piles are put down temporarily after being lifted, they shall be placed on trestles or blocks located at the lifting points.

17.10.22 Other Materials

Small articles like screws, bolts, nuts, door and window fittings, polishing stones, protective clothing, spare parts of machinery, linings and packings, water supply and sanitary fittings etc shall be kept in a suitable and properly protected store rooms. Valuable small materials shall be kept under lock and key.

17.10.23 Special Considerations

Material constantly in use shall be relatively nearer the place of use. Heavy units like precast concrete members shall be stacked near the hoist and the ramp. Materials which normally deteriorate during storage shall be kept constantly moving by replacing old materials with new stocks. Freshly arrived materials shall never be placed over materials which had arrived earlier. Fire

extinguishers and fire buckets shall be provided wherever necessary for safety.

17.11 OPEN WELLS FOR WATER SUPPLY General Details

17.11.1 General: Open wells may be used for water supply for individual households colonies; and wayside stations. Percolation wells can be sunk in bed of streams within Railway boundary. Open wells for water supply may be unlined kutcha wells, pervious lined wells or impervious lined wells.

17.11.2 Well Curb and Cutting edge

(a) Well Curb: Well curbs shall be made of wood, steel or reinforced concrete. Wooden well curbs shall be made of hard and durable wood e.g. keekar, sheesham, padak, sal or tamarind which do not rot due to continuous immersion in water. Curbs for large size wells, or where the nature of soil demands are also provided with a suitable cutting edges.

(b) Cutting edge : The cutting edge shall be fabricated from old rails or the steel sections specified on the drawings. The steel sections shall not be heated and forged into shape. 'V' cuts may be made in the horizontal portion uniformly throughout the length to facilitate bending. Such 'V' cuts shall not be less than 8 in number. The sections shall then be cold-bent and pressed to shape and 'V' cuts electrically welded together. For larger wells they will be cold bent and site riveted at joints with cover plates.

17.11.3 Steining : The steining shall be of brick work, dry stone masonry, precast concrete blocks or cast in situ concrete as specified and or shown in the Drawing. The steining shall be constructed to the relevant standard specification for the type of masonry specified. The well curb shall be secured to the steining by iron tie rods as shown in the drawings. The steel work involved in tie rods, bond plate etc shall be paid for under item for steel work in single sections in the chapter of "Steel work".

17.11.4 Well sinking

a) Excavation : Open excavation in the form of a pit shall be carried down to the sub-soil water level or to the bottom of clay or non-water bearing strata whichever is higher, before the well curb is laid. Where the ground water level is quite deep, the depth of open excavation shall take into account the nature of the soil and the safety of the workmen. The contractor shall obtain prior

written approval of the Engineer before resorting to dry sinking.

b) Laying the well curb : The well curb shall be laid at the bottom of the open excavation where dry sinking has to be resorted to. Where the open excavation is carried down to the ground water level, the well curb shall be laid within 15 cm of the ground water level. Wet sinking shall be paid from a level 15 cm above the sub-soil water level irrespective of the exact level at which the well curb is laid. The sub-soil water level shall be recorded before wet sinking is commenced. The curb shall be levelled truly, and placed in exact position before the steining is commenced.

c) Building up Steining: In order to obtain perfectly vertical descent and to enable the direction of sinking of the well to be easily corrected, the first height of the steining shall be built up to a much shorter height. Generally, the first height shall not exceed 2 metres and the second height 2.5 metres. Subsequent steining masonry shall be built to convenient heights generally not exceeding the diameter of the well. While building up the steining masonry in stages, it should be checked for continuity with the surface of the preceding masonry by straight edges and not with a plumb bob, for verticality. The height of the steining shall be marked continuously from the bottom of cutting edge in metres (subdivided into 0.1 metre) painted on the inside to record the well height as the steining work progresses. Nothing extra shall be paid for this marking.

d) Sinking:- After the steining masonry has set and is sufficiently strong to withstand loading and accidental shock, a temporary loading platform shall be constructed on the top of the steining. Load may be applied in the form of gunny bags filled with earth or in any other manner, subject to the approval of the Engineer. The load shall be placed on the outer edges of the platform leaving sufficient clear space in the middle for lifting the excavated materials. Sinking may be facilitated by excavation of soil inside the well and below the curb. Where substantial flow of water is encountered, excavation by 'Jham' dredging, pumping or bailing may be resorted to, if permitted or ordered by the Engineer.

a) Clay puddle backing: In case of drinking water wells, the space between the excavation and the back of the steining shall be filled with good clay puddle for a depth atleast 2.5 to 3 metres below the ground level, the average thickness of this puddle

being atleast one metre. This is necessary to prevent contamination by infiltration of surface water. The clay shall be consolidated by ramming and watering in successive layers of about 30 cm depth. Average thickness of puddle shall be 1.0 m.

(b) In case of "Sinking water wells" inside face of steining should be flush cement pointed or plastered to depth required by Engineer or as shown in Drawing to prevent seepage.

(c) Also, in case of domestic water wells a paved impervious platform should be provided above ground level for a minimum width of 1.5m and sloping outwards. The platform should be built after the earth around the well has settled down. A coping should be provided around the well of such a design as not to permit buckets or pots being placed on top of it and it should prevent spilled water falling into the well.

Well steining will be paid for the volume of masonry / concrete in the steining. Additional cost incurred for doing a trial bore and testing of water for its suitability for drinking and providing pebble / shingle / boulder at the bottom of well, if ordered to be done will be paid for extra.

17.11.4-17.11.5 Drinking Water wells

a) In the case of "drinking water wells" though the procedure is similar to the one adopted on well sinking for Bridge foundation additional steps that will have to be taken in the case of sinking of well for shall be as follows:-

b) Records of sample of strata and sample of underground water are to be collected by the Contractor and made over to the Engineer for chemical and meteorological analysis. If necessary and if so ordered by the Engineer, the trial boring at the spot may be carried out before actual sinking of the well to get the samples of strata and the underground water. For the trial boring extra payment will however be made.

c) When the walls have been sunk to the full depth required, any sump below the bottom of the wall curb may be filled with clean shingle 50-75mm and shingle boulders 150mm size both mixed together. This should only be done where it is feared that due to pumping from the well critical velocity of flow may be exceed at any time disturbing the finer particles of the sub-soil and there is the need for keeping it within safe limit. This shall be paid for separately.

17.11.5-17.11.6 Yield Test

The yield test of the well should be assessed at the cost of the Contractor in presence of the Engineer or his authorized representative and according to his instructions. All arrangements for carrying out yield test should be done by the Contractor at his own cost. On satisfactory completion of the yield test the Contractor will be finally paid.

17.11.7 Rate: Unless otherwise specified, the rates for well sinking will cover the cost of all tools, plants, steam hoist, dredger, pulsometer, gantry, kentledge, etc as well as loading and unloading of kentledge and bailing or pumping of water where required, including removing the excavated soil to a distance of 50 metres or as specified. Steining will be paid for in cum at the rate specified.

- a) Cost of cutting edge, curb, tie rods, sand filling in the well, plugging and plastering, if any, shall be paid extra.
- b) Wet sinking shall be paid from a level 15 cm above the sub-soil water level, irrespective of the exact level at which the well curb is laid.
- c) The item of well sinking shall be paid on the basis of volume displaced. For calculating the volume, the gross cross sectional area enclosed within the external edge or edges of the steining will be multiplied by the depth through which the bottom of cutting edge of well curb has been sunk.

17.12 TUBE WELL SINKING

17.12.1 Shallow Tube Wells

(a) Shallow tube wells or deep tube wells are to be sunk according to the directive of the Engineer and at the spot fixed / shown by the Engineer. Shallow tube wells will, however, be sunk for tapping shallow water table upto a depth of 20-25 metres where only a small quantity of water is required.

(b) For supplying small quantity of water (upto 50 lts./min.) tube wells can be sunk in shallow water table area. The tube is driven into the ground at the lower end of which a strainer is fixed. Driving of pipe is done by percussion or rotary tools or by jetting with the excavated materials being taken out by means of bailer or by some hydraulic process.

17.12.2 Deep Tube Wells-Drilling

a) In Percussion method, drilling is done by chiselling action of a tool which is alternately lifted and dropped into the bore

hole which pounds the strata in small fragments and the pulverised materials are taken out to surface by means of a bailer. This can be operated by hand or by machine according to the strata. Hand operated method is convenient upto 40m to 60m depth with bore holes of 40mm to 80mm dia.

b) Core drilling method is used for drilling in hard and rocky strata. A core drill bit is made of artificial diamond or chilled steel shots or steel teeth and these are fixed to a ring. The ring is attached to a drill rod and rotated and as the cutter advances a core rises inside the ring which is removed from time to time. This core gives a sample of material met with. Water is pumped into the bore hole to act as lubricant.

c) Rotary drills can be employed in drilling in almost all types of formations, hard or soft. Power driven machines are used with tripod or four legged derrick. Drilling is accompanied by rapid rotation of a pipe fitted with a toothed cutting shoe at the lower end. Rotary rings perform the operations like breaking, loosening, grinding and removing rocks simultaneously. Water is continuously pumped into the well under pressure through holes in the cutting shoe to rise to the surface between the side of the hole and the pipe, carrying the loosened material with the water. The mud or slush thus coming out gives an idea of the type of strata met without their depth. A 200mm dia hole may be drilled upto 6m in 2 hours in soft rock by this method.

d) Water jet boring is used for boring through hard and tenacious soluble clays and for deep boring. Drilling is accomplished with the help of water jet pipe with a nozzle at the end which is introduced into the casing pipe and water forced through it under pressure. The water formed into slurry comes up to the surface through the space between the casing pipe and the jet pipe. Casing pipe sinks by its own weight or by weight added on top.

17.12.3 Provision of Strainers

a) During sinking of pipes, samples of strata are to be collected for examination and to decide on the likely yield of water. The samples of such strata and water samples should be preserved for deep boring. These are to be presented to the Engineer for his consideration and whenever necessary sent for analysis of soil and quality of water. From this analysis the Engineer will decide on the type and length of strainer necessary

depending on quantity of water available and locations for placing the strainer.

b) Strainers fitted over an iron shoe or a blind pipe (upto 1.5m) having a cap or plug fixed at the bottom and plain pipe above the strainer will be assembled. The whole assembly is lowered and fixed at the required depth of the bore hole as decided earlier and the casing pipe taken out. Plain pipes screwed to the strainer and lowered along with strainer to the required depth of the bore hole shall be as decided by the Engineer. The top of pipe should be above HFL or level as directed by the Engineer so that in case of unusual flood in the location, outlet is not submerged.

c) After sinking the casing pipe to the requisite depth if it is found that the strata is not sufficiently water bearing or a suitable sandy or gravity strata in which the strainer can be placed is not available and if it is decided by the Engineer to abandon the bore hole, payment will be made to the contractor for only sinking and withdrawing the casing pipe. The work of sinking at any other new site decided by the Engineer or his authorized representative should then be done.

d) In cases where the strainer is in fine sand, it will be necessary to complete the tube well by putting in fine clean ballast or gravel in the annular space between the casing pipe and the tube well strainer as a "shrouding". The extraction of the casing pipe after the work of "shrouding" as narrated above should be done under the direction of the Engineer.

e) Mild steel and cast iron are attacked by sodium salt and copper pipe is attacked by sodium carbonate and sodium chloride while brass is not readily attacked by the salts usually present in soil. Hence the strainer material shall be chosen to suit local conditions and the type of strata in which is to be placed and chemical content of water.

f) Verticality of bore-hole

The casing pipe or the housing pipe shall be placed reasonably vertical in the boring. The deviation from verticality of the housing pipe shall not be more than 50mm (at any stage) upto 20 metres below the ground level.

17.12.4 Yield Tests After the strainers and the pipes have been lowered the tube well will have to be tested for the yield by experienced staff of tube boring section or of any specialised agency under the guidance of the Engineer. The yield test of the tube

well shall be carried out by the Contractor at his own cost and in the presence of the Engineer or his authorized representative. Expenses incurred in arranging for presence of the expert (in absence of Railways staff) will be borne by the Contractor at his cost. The yield test will have to be carried out for a period of 3 days and not less than 8 hours continuous pumping shall be carried out a day. On satisfactory completion of the yield test final payment for the tube well will be made.

17.12.5 Pumps

Pumps of approved quality and make should be fixed on the shallow tube wells operated by hand. In deep tube wells, however, pumps will be arranged by the department concerned.

17.12.6 Remedial Measure of (clogged) choked screen

a) Clogging of screen is generally due to following two causes

1) excessive pumping with velocity of inflow more than the optimum velocity of the strata which disturbs the materials surrounding the strainer drawing in sand particles.

2) Chemical action on the strainer metal due to the presence of corrosive salts in water which gradually corrode the strainer.

17.12.7 Back washing and cleaning Tube wells

Back washing under pressure will dislodge the sand particles clogging the strainer holes. Water is forced into the well with a pump or from a high level storage tank through a water jet tube over the strainer openings and compressed air blown into the strainer. If a turbine pump is operated without a foot valve and suddenly stopped the water in the pump column will cause the back flow. Incrustation of lime in the strainer can be removed by introducing weak hydrochloric acid into the well and allowing it to act for several hours. This will dissolve the salt (lime particles) and heavy pumping will bring up the incrustations. Where screen is obstructed by heavy growth of iron bacteria, a 50 ppm chlorine solution will be injected, which will clear the bacterial agents.

17.12.8 Measurement for Payment

Drilling, provision of case pipe, provision of strainer and main pipe of the tubewell will each be paid for in terms of running meter for the specified diameter, unless otherwise specified. Linear measurements will be made to nearest centimetre.

Supply and filling the annular space in the tube well with pebbles will be paid for actual quantity used or theoretical requirement plus 5%, whichever is less. It will be measured in cubic meters reckoned correct to nearest 0.001 cum.

Supply of pump (hand or power) will be measured in unit.

Yield test of tube well and testing the water for quality is considered part of the job and will not be paid for extra unless specified otherwise.

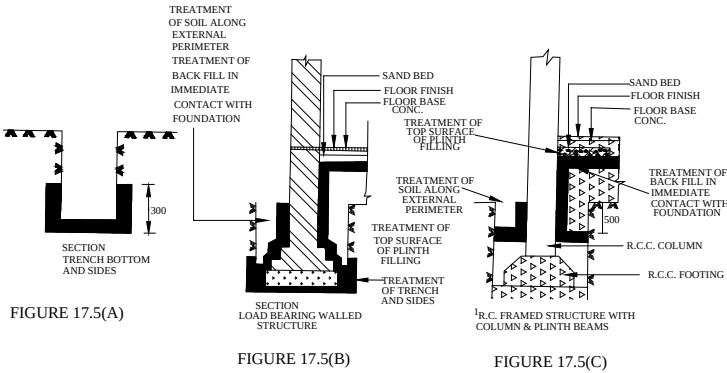
17.12.9 Rate

The contract unit rate will include cost of all labour, materials, tools and plant and

equipment required for doing the boring and provision of tube well with strainer filling annular space, if any, yield test, testing of water, supply of pump, if any. Rate for drilling bore includes supply of bentonite, drilling, installing casing and removal of casing etc., as required. Supply of pump includes provision of necessary foundation base/ suspension arrangements and installation of foot valve, if any, required. It also includes extraction and supply of soil samples of strata passed through. All masonry work in and around the pump will be paid separately as per relevant item.

Annexure-A

ANTI TERMITE TREATMENT (PRE-CONSTRUCTION)

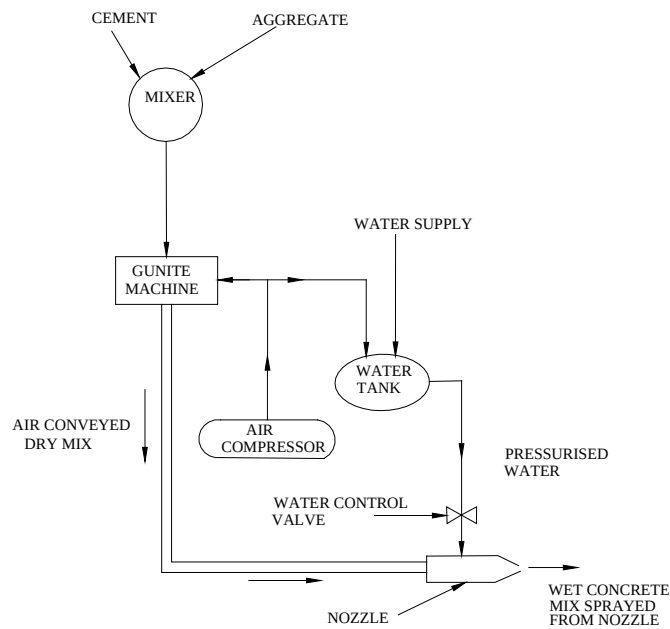


All dimensions are in mm

Drawings not to Scale

Annexure-B

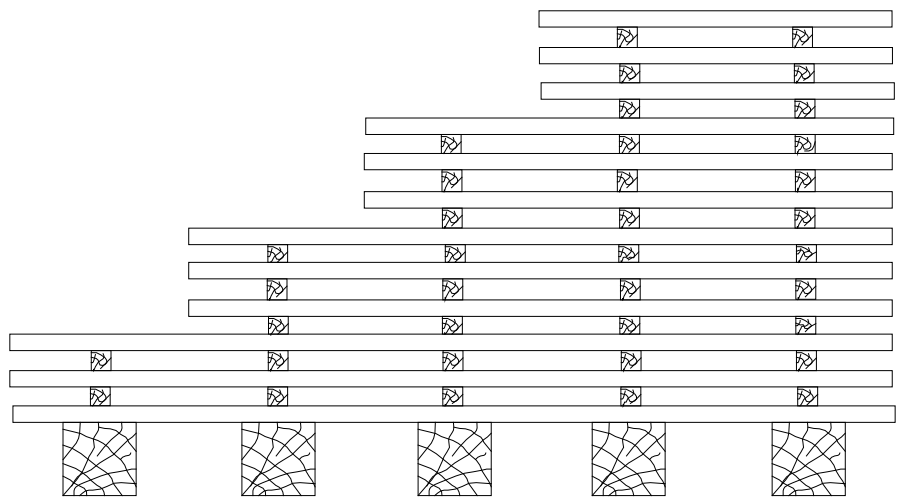
DIAGRAMATIC REPRESENTATION OF GUNITE PROCESS



Annexure-C

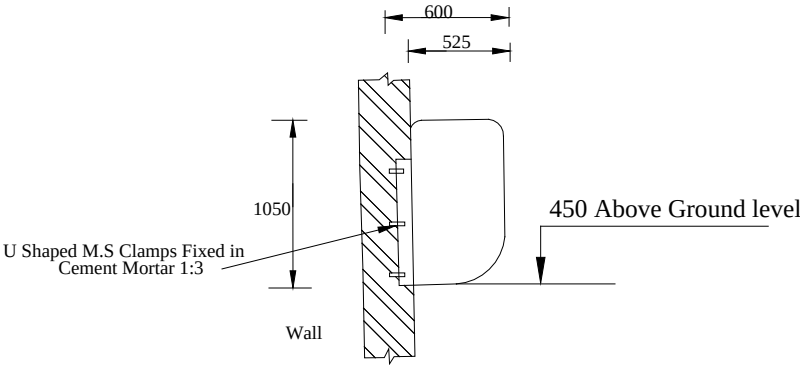
TYPICAL TIMBER STACK

FIGURE 17.8



Annexure-D

URINAL PARTITION FIXING



All dimensions are in mm Drawings not to Scale

Chapter 18

Dismantling And Demolition

18.0 TERMINOLOGY

18.0.1 Dismantling

The term "Dismantling" implies carefully separating the parts without damage and removing. This may consist of dismantling one or more parts of the building as specified or as shown on the drawings.

18.0.1 Demolition

The term "Demolition" implies breaking up. This shall consist of demolishing whole or part of work including all relevant items as specified or as shown on the drawings.

18.1 GENERAL

18.1.1 Need for Special Care:- Demolition of any structure is, inherently, more hazardous than the construction or erection of the same. From the point of view of safety, the conditions usually encountered while dismantling a structure, whatever its magnitude, do not lend themselves to the degree of control possible in the construction operations, where, more stable conditions are generally obtainable. It is all the more imperative, therefore, that adequate attention is paid to planning and execution of demolition work, in its various stages, so as to minimize the risk of accidents and injuries to the personnel engaged in demolition operations. Dismantling requires greater care than in case of Demolition so as to ensure that the portion of the building to be left intact is not affected in any way by the dismantling of the adjacent portion.

18.1.2 Basic Requirements:- The demolition work shall be proceeded in such a way that:

- a) it causes least damage and nuisance to the adjoining building and the members of the public; and
- b) it satisfies all safety requirements to avoid accidents.

18.1.3 Sorting out materials: Any serviceable material obtained during dismantling or demolition shall be separated out and stacked properly as directed by the Engineer within a lead of 50 metres. All unserviceable materials, rubbish etc shall be disposed off as directed by the Engineer. The serviceable material should be handed over to the Engineer or his authorized

representative properly before the payments for this operation are made.

18.2 PLANNING

Before beginning the actual work of demolition, a careful study shall be made of the structure which is to be pulled down and also of its surroundings. This shall include the following:

- a) The manner in which the various parts of buildings are supported and how far the stage by stage demolition would affect the safety of the adjoining structure;
- b) A definite plan and procedure of demolition work shall be prepared, taking into account the loads on various structural parts and their supports;
- c) Before commencement of each stage of demolition, the supervisor shall brief the workmen in detail regarding the safety aspects to be kept in view;
- d) It should be ensured that the demolition conditions do not, at any stage, enhance the nuisance value of demolition work on the use of adjacent buildings;
- e) No structure or part of the structure or any floor or temporary support or scaffold, side wall or any device for equipment shall be loaded in excess of the safe load bearing capacity, in its then existing condition; and
- f) Stairs and stair railings, passage ways and ladders shall be left in place as long as possible. These should be maintained in a safe condition.

18.3 PRECAUTIONS AND PROTECTIVE MEASURES BEFORE STARTING DEMOLITION WORK

The following precautions and protective measures shall be taken before commencement of demolition work:

- a) On every demolition job, danger signals shall be conspicuously posted all round the structure and all doors openings giving access to structures shall be kept barricaded or manned except during the actual passage of workmen or equipment. However provision shall be made for at least two independent exits for escape of workmen during any emergency.

b) Walkways and passageways shall be provided for the use of the workmen who shall be instructed to use them and all such walkways and passageways shall be kept adequately lighted, free from all debris and other materials.

c) Where in any work of demolition it is imperative, because of existing danger, to ensure that no unauthorized person shall enter the site of demolition outside working hours, a watchman shall be employed. In addition to watching the site he shall also be responsible for maintaining all signs, notices, lights, barricades, etc. During nights, red lights shall be placed on or about the barricades.

d) The power on all electrical service lines shall be shutoff and all such lines cut or disconnected at or outside the property line. The only exception would be any power lines required for the demolition work itself. Prior to cutting of such lines, the necessary approval of the concerned Authority shall be obtained.

e) All mains and meters of the building shall be removed or protected from damage.

f) All gas, water, steam and other service lines shall be shut off and capped or otherwise controlled at or outside the property line.

g) If a structure to be demolished has been partially wrecked by fire, explosion or other catastrophe, the walls and damaged roofs shall be shored and braced suitably.

h) Construction sheds and tool boxes should be so located as to protect workers from injuries of falling objects, wall, etc.

j) A warning device should be installed in the area to be used to warn the workers, in case of danger.

k) Screens shall be placed, where necessary, to prevent flying pieces from injuring the fellow workmen.

m) No demolition work shall be carried out during storm or heavy rain.

n) No demolition work shall be carried out at night specially when the building or structure to be demolished is in habited area except in special circumstances and when specifically approved by the Engineer.

p) All necessary safety appliances shall be issued to the workmen and their use explained. It shall be ensured that the workers are using all the safety appliances while at work. The safety appliances should be as follows:

1) Safety helmets as per IS 2925: 1984;

2) Goggles made of celluloid lens to be worn at the time of demolition of floors, walls, tearing of plaster, etc, specially when equipment like jack hammers are used for demolition work, to protect the eyes from flying pieces, dust, dirt, etc that may be blown up by wind.

3) Leather or rubber gloves worn during demolition of RCC work or removing steel work, where the hands of workers are likely to be injured.

4) Safety belts while working at higher level to prevent falling from the structure.

q) First-aid equipment shall be available at all demolition works of any magnitude. Also, by prior arrangement, a qualified doctor should be available at call.

r) When there is a possibility of fire breaking out, appropriate portable first-aid fire appliances (see IS 2190:1992) shall be kept at hand.

s) The removal of a member may weaken the side wall of an adjoining structure and to prevent possible damage, these walls shall be supported until such time as permanent protection is provided. In case any danger is anticipated to the adjoining structure, the same shall be got vacated to avoid any danger to human life.

t) Ladders, when used, shall conform to IS 3696 (Part 2): 1991. Ladders or their side rails shall extend not less than 1.0m above the floor or platform to which the ladder gives access. All ladders shall be secured against slipping out at the bottom and against movement in any direction at the top.

u) All exterior wall openings which extend down to the floor level shall be barricaded to a height not less than 1m above the floor level. All floor openings and shafts not meant as material chutes shall be floored over and endorsed with ground rails and toe boards.

v) All existing fixtures/ services required during demolition operations shall be well protected with substantial covering to the satisfaction of the Engineer.

w) When demolition is to be done by mechanical means such as weight ball and power showels, the following additional precautions are necessary:

1) The area shall be barricaded for a minimum distance of $1\frac{1}{2}$ times the height of the wall;

2) While the mechanical device is in operation no workmen shall be allowed to enter the building being demolished;

- 3) The device shall be so located as to avoid falling debris; and
- 4) The device when being used shall not cause any damage to adjacent structure, power_line, other services etc.

18.4 PROTECTION OF THE PUBLIC

Protection of the public before and during demolition is important and the following point should be kept in mind:

- a) Every sidewalk or road adjacent to the work shall be closed or protected. All main roads, which are open to the public shall be kept open to the public clear and unobstructed at all times.
- b) Children and public shall be kept out of the building and the adjoining yards.
- c) If the structure to be demolished is more than two-storeyed or 7.5m high, measured from the sidewalk or street which cannot be closed or safely diverted, and the horizontal distance from the inside edge of the side walk to the structure is 4.5m or less, a substantial side walk shed (**FIGURE 18.1**) (see also (k)) shall be constructed over the entire length of the sidewalk adjacent to the structure, of sufficient width with a view to accommodating the pedestrian traffic without causing congestion. The sidewalk shall be lighted sufficiently to ensure safety at all times.
- d) A toe board atleast 1m high above the roof the shed shall be provided on the outside edge and ends of the sidewalk shed. Such boards may be vertical or inclined outward at not more than 45°.
- e) Except where the roof of a sidewalk shed solidly abuts the structure, the face of the sidewalk shed towards the buildings shall be completely closed by providing sheeting / planking to prevent the falling material penetrating into the shed.
- f) The roof of the sidewalk shed shall be capable of sustaining a load of 730 kg/m². Only in exceptional cases, (say) due to lack of other space, the storing of the material on a sidewalk shed may be permitted in which case the shed shall be designed for a load of 1460 kg/m². Roof of sidewalk shed shall be designed taking into account the impact of the falling debris. By frequent removal of loads it shall be ensured that the maximum load, at any time, on the roof of the shed is not more than 600 kg/m². The height of the sidewalk shed shall be such as to give minimum clearance of 2.4m.

g) Sidewalk shed openings, for loading purposes, shall be kept closed at all times except during actual loading operations.

h) The deck flooring of the sidewalk shed shall consist of plank of not less than 50mm thickness closely laid and deck made watertight.

j) All members of the shed shall be adequately braced and connected to resist displacement of members or distortion of frame work.

k) When the horizontal distance from the inside edge of the sidewalk to the structure is more than 4.5m and less than 7.5m, a sidewalk shed or fence may be built or in their place a substantial railing shall be constructed on the inside of the sidewalk or roadway along the entire length of demolition side of the property with movable bars as may be necessary for the proper prosecution of the work.

l) Where workers' entrances to the building being demolished are not completely protected by sidewalk sheds, all such entrances shall be protected by canopies extending from the face of the building to a point not less than 2.5m from it. In such a case, overhead projection shall be atleast 0.6m wider than the building entrance or opening and every canopy shall be as strong as the sidewalk shed.

18.5 SEQUENCE OF DEMOLITION OPERATIONS

The sequence of demolition shall generally be as given below:

- a) The demolition shall always proceed systematically storey by storey in descending order and the demolition of upper floors shall be completely over before any of the supporting member or other important portion on the lower floor is disturbed. No unnecessary work shall go on below when the demolition is in progress above. When some work is to be done at the lower level, adequate protection shall be provided for all the workmen so engaged.
- b) The requirements of (a) shall not prohibit the demolition of structures by sections, if means are taken to prevent injuries to persons or damage to property.
- c) Roofs (or floors) should generally, be demolished first before demolishing the supporting walls / structural elements.
- d) All glazed sash, glazed doors and windows etc shall be removed before the demolition of roofs and walls starts. All

fragile and loose fixtures shall be removed. Lath and loose plaster should be stripped off throughout the entire structure. This is advantageous because it reduces glass breakage and also eliminates a large amount of dust producing material before more substantial parts of the building are removed.

18.6 DEMOLITION OF FLOORS

For demolition of floors the following procedure may be followed:

- a) A slit in width not exceeding 300mm shall be cut at the first stage for the entire length of the slab along which it spans (see **Figure 18.2**). The opening shall thereafter be increased to the desired width by suitable installments.
- b) Planks of sufficient strength not less than 50mm thick and 250mm wide shall be provided at a spacing not greater than 0.4m. These planks shall be so placed as to give workmen firm support to guard against any unexpected collapse.
- c) Stringers of same strength shall be installed to support the planks where necessary and the ends of stringers shall be supported by floor beams, girders and not by floor slab alone.
- d) When floors are being removed, no workmen shall be allowed to work in the area, directly underneath and such area shall be barricaded to prevent access to it.
- e) The demolition of the floor in question shall be started only after the surrounding area for a distance of 6m has been entirely cleared of persons, and the debris and other unnecessary material removed.
- f) Planks used for temporary protection shall be sound and at least 50mm thick. They shall be laid close together with ends overlapping at least 100mm over solid bearing to prevent tipping under load.

18.7 DEMOLITION OF WALLS

18.7.1 Procedure

The following procedure should be followed when demolishing walls:

- a) While walls or sections of masonry are being demolished it shall be ensured that they are not allowed to fall as a single mass on the floors of the building so as not to exceed the safe carrying capacity of the floors; wherever practicable, they may fall away from the floors (see para 18.7.2) on to catch platforms. Overloading of floors shall be prevented by removing the accumulating debris through chutes or by other means

immediately (see para 18.9). The floor shall be inspected by the Engineer before undertaking demolition work and if the same is found incapable of carrying the load of debris, necessary precautions shall be taken to prevent any unexpected collapse of the floor.

b) Walls shall be removed part by part. Stages shall be provided for the men to work on, if the walls are very thin and dangerous to work by standing over them.

c) No section of the wall whose height is more than 15 times the thickness, shall be permitted to stand without lateral bracing unless such a wall is in good condition and was originally designed to stand without such lateral bracing or support.

d) Structural or load supporting members on any floor shall not be removed or cut until all the storeys above that floor have been demolished and removed.

e) Before demolishing any interior or exterior wall within 3m of the opening in the floor immediately below, such opening shall be substantially planked over, unless access is denied to workmen to that portion of the floor immediately below the opening, in the floor of the storey being demolished, where any debris passing through the opening may fall.

f) In framed structures, the frame may be left in position during demolition of masonry work. Where there is done all beams, girders, etc shall be cleared of all loose materials as the demolition of masonry work progresses downward provided it is still strong enough to stand as an independent structure.

g) Walkways shall be provided to enable workmen to reach or leave their work on any scaffold or wall. Such walkways shall neither be less than 3 planks wide, nor less than 0.8m in width.

h) After completion of each day's work, all walls shall be left stable to avoid any danger of getting overturned.

j) Foundation walls which serve as retaining walls to support the earth or adjoining structure, shall not be demolished until such time an adjoining structure has been underpinned or braced and the earth removed by sheet piling or sheathing.

18.7.2 Catch Platforms

Catch platforms shall be provided in case of demolition of exterior walls in multi-storey buildings. The following details may be considered.

a) Catch platform shall generally be provided for multi-storey buildings more than 20m high to prevent injuries to the workers and to the public when exterior walls are being demolished.

b) Such platforms shall be constructed and maintained not more than three storeys below the storey from which the exterior wall is being demolished. When demolition has progressed to within three storeys of ground level, catch platforms will not be considered necessary.

c) Catch platforms shall not be less than 1.5m in width measured in a horizontal direction from the face of the structure and shall consist of outriggers supported not more than 3m apart. Planks shall be laid tight together, without openings between them and the walls. Catch platforms shall be provided with a continuous solid parapet along its outer edge of atleast 1m height. The parapet may be constructed with the same material as the platform.

d) Catch platform shall be capable of sustaining a live load of not less than 610 kg/m^2 .

e) Catch platforms shall neither be used for storing of materials nor dumping of materials.

18.8 DEMOLITION OF DIFFERENT TYPES OF STRUCTURES AND ELEMENTS

18.8.1 General

Structures may be dealt with as masonry, concrete, steel and timber. The structures or their elements shall be dealt with as below, in addition to other requirements as applicable.

18.8.2 Masonry Structures

a) Jack Arches – Where tie rods are present between main supporting beams, these should not be cut until after the arch or series of arches in the floor have been removed. Particular care should be exercised and full examination of structure be made before the demolition is commenced (see **Fig. 18.3**). The floor should be demolished in strips parallel to the span of arch rings (at right angles to the main floor beam).

b) Brick Arches – 1) As much dead load as possible may be removed provided it does not interfere with stability of main arch rings; it should be noted that the load carrying capacity of many old arches relies on the filling between the spandrels. On no account should the restraining influence of the abutments be removed before the dead load

of the spandrel fill and the arch rings are removed. The normal sequence of demolition shown in **Figure 18.4A** includes the following:

- remove the spandrel filling down to the springing line
- remove the arch rings
- remove the abutments
- special temporary support shall be provided in the case of skew bridges.

2) A single span arch can be demolished by hand, by cutting narrow segments progressively from each springing parallel to the span of the arch, until the width of the arch has been reduced to a minimum which can then collapse (see **Figure 18.4B**) Where it is impossible to allow debris to fall to the ground below, centering designed to carry the load should be erected and the arch demolished progressively. The design of the centering should make appropriate allowance for impact.

3) Where deliberate collapse is feasible the crown maybe broken by the demolition ball method working progressively from the edges to the centre (see **Figure 18.4C**)

4) Collapse of structure can be effected in one action by the use of explosives. Charges should be inserted into boreholes drilled in both arch and abutments. This method is the most effective for demolition of tall viaducts. The work should be done by observing all the provisions of Indian Explosive act.

5) In multi-span arches, before individual spans are removed, lateral restraint should be provided at the springing level. Demolition may be proceeded as for a single span care being taken to demolish the spandrels down to the springing line as the work proceeds (see **Figure 18.4D**) Where explosives are used it is preferable to ensure the collapse of the whole structure in one operation to obviate the chance of leaving unstable portions standing.

18.8.3 Reinforced Concrete Cast in situ

a) Before commencing demolition, the condition and position of reinforcement and possibility of lack of its continuity should be ascertained. Demolition should be commenced by removing partitions, non load bearing cladding, etc and similar non structural elements.

b) Where hand demolition methods are used, the following procedures should be used:

1) Beams – For beams, supporting rope should be attached to the beam. Then the concrete should be removed from both ends by pneumatic drill and the reinforcement exposed. The reinforcement should then be cut in such a way as to allow the beam to be lowered under control to the floor (see **Figure 18.5A**)

2) Columns – For columns reinforcement should be exposed at the base after restraining wire guy ropes have been placed around the member at the top. The reinforcement should then be cut in such a way as to allow the column to be pulled down to the floor under control (see **Figure 18.5B**)

3) Walls – Reinforced concrete walls should be cut into strips and demolished as for columns (see **Figure 18.5C**)

4) Suspended Floors and Roofs – Solid slabs should be demolished as described in para 18.6 and **Figure 18.2**. Where ribbed construction is used, the principle of design and method of construction should be ascertained before demolition. Care should be taken not to cut the ribs inadvertently.

18.8.4 Precast Reinforced Concrete

a) Precast reinforced concrete units in a structure are normally held in position by the strength of the joints in-situ or on supporting walls, etc. As such before starting on demolition the joint structures or the supporting mechanisms shall be studied and understood.

b) In devising and following demolition sequences, due precaution shall be taken to avoid toppling over of the prefabricated units or any other part of the structure and wherever necessary temporary supports shall be provided.

18.8.5 Prestressed Concrete

Before commencing of the demolition work involving such structures advice of an expert engineer should be obtained. Work should be done only as per approved dismantling plan or drawing.

18.8.6 Steel

a) No beams shall be cut until precautions have been taken to prevent it from swinging freely and possibly striking any worker or equipment or any part of the structure being demolished.

b) All structural steel members shall be lowered from the building and shall not be allowed to drop.

c) Tag lines shall be used on all materials being lowered or hoisted up and a standard signal system shall be used and workmen

instructed on the signals. No person shall be permitted to ride the load line.

d) When a derrick or hoisting equipment is used care shall be taken to see that the floor on which it is supported shall be strong enough for the loading. If necessary heavy planking shall be used to distribute the load to floor beams and girders. Overloading / overturning of the equipment shall be avoided.

18.8.7 Other Elements

a) Roof Trusses – Roof trusses shall be removed to wall plate level by hand methods. Sufficient purlins and bracing should be retained to ensure stability of the remaining roof trusses while each individual truss is removed. Temporary bracing should be added, where necessary, to minimize instability. The end frame opposite to the end where dismantling is commenced, or a convenient intermediate frame should be independently and securely guyed in both directions before work starts. On no account should the bottom tie of a truss be cut until the principal rafters are prevented from making outward movement.

b) Cantilevers – A cantilever type of construction depends on the balancing superimposed structure for its stability. Canopies, cornices, staircases and balconies should be demolished or supported before the balancing load is removed.

c) Heavy Floor Beams – Heavy baulks of timber should be supported before cutting at the extremities and should then be lowered to a safe working place.

18.9 REMOVAL OF MATERIALS

18.9.1 General

Removal of dismantled materials should be done carefully; they may be thrown / lowered to the ground. The materials shall preferably be dumped inside the building. Normally such materials shall be lowered to the ground or to the top of the sidewalk shed where provided by means of ropes or suitable tackles.

18.9.2 Through Chutes

a) Wooden or metal chutes shall be provided for removal of materials. The chutes shall preferably be provided at the centre of the building for efficient disposal of debris.

b) Chutes if provided at an angle of more than 45° from the horizontal shall be entirely enclosed on all sides, except for opening at

or about the floor level for receiving materials.

c) Opening for chutes shall not exceed 1.20m in height measured along the wall of the chute and in all storeys below the top floor such opening shall be kept closed when not in use.

d) To prevent the descending material attaining a dangerous speed, the chute shall not extend in an unbroken line for more than two storeys. A gate or step shall be provided with suitable means of closing at the bottom of each chute to stop the flow of materials.

e) Chutes at an angle less than 45° to the horizontal may be left open on the upperside provided that at the point where such chute discharges into the chute steeper than 45° to the horizontal, the top of the steeper chute shall be boarded over to prevent the escape of materials.

f) Any opening into which workmen dump debris at the top of the chute shall be guarded by a substantial guard rail extending at least 1_m above the level of the floor or other surface on which men stand to dump the materials into the chute.

g) A toe board or bumper not less than 50mm thick and 150mm high shall be provided at each chute opening, if the required material is dumped from the wheel barrows. Any space between the chute and the edge of the opening in the floor through which it passes shall be solidly planked over.

18.9.3 Through openings

a) Debris may also be dropped through holes in the floor without the use of chutes. In such a case the total area of the hole cut in the intermediate floor, one which lies between floor that is being demolished and the storage floor shall not exceed 25 percent of such floor area. It shall be ensured that the storage floor is of adequate strength to withstand the impact of the falling material.

b) Openings in all floors below the floor from which materials are being removed, shall be protected by standard railings and toe boards (see IS 4912: 1978) or preferably planked over if the holes are not being used for dumping materials (see para 18.3(s))

c) All intermediate floor openings for passage of materials shall be completely closed with barricades or guard rails not less than 1m high and at a distance of not less than 1m from the edge of the general opening. No barricades or guard rails shall be removed until the storey immediately above has been demolished down to the floor line and all debris cleared from the floor.

d) When cutting a hole in an intermediate floor, between the storage floor and the floor which is being demolished, makes the intermediate floor or any portion of it unsafe, then such intermediate floor shall be properly shored. It shall also be ensured that the supporting walls are not kept without adequate lateral restraints.

18.10 MEASUREMENTS

(a) All work shall be measured net in the decimal system, as fixed in its place, subject to the following limits, unless otherwise stated hereinafter.

(a) Dimensions shall be measured correct to a cm.

(b) Areas shall be worked out in sqm correct to two places of decimal

(c) Cubical contents shall be worked out to the nearest 0.01 cum.

(b) Parts of work required to be dismantled and those required to be demolished shall be measured separately.

(c) Measurements of all work except hidden work shall be taken before demolition or dismantling and no allowance for increase in bulk shall be allowed.

(d) Specifications for deduction for voids, openings etc. shall be on the same basis as that adopted for new construction of the work.

(e) Work executed in the following conditions shall be measured separately.

(a) Work in or under water and / or liquid mud

(b) Work in or under foul position

18.11 RATES

The rate shall include the cost of all labour involved and tools used in demolishing and dismantling including scaffolding. The rate shall also include the charges for separating out and stacking the serviceable material properly and disposing off unserviceable material within a distance of 50 metres unless specified otherwise.

The rate shall also include for temporary shoring for the safety of portions of buildings not required to be pulled down, or of adjoining properly, and providing temporary enclosures or partitions, where considered necessary.

18.12 ROOFS

(a) Roof coverings generally including battens boarding, mats, bamboo jaffari or other subsidiary supports shall be measured in square metres except lead sheet roof covering which shall be measured in quintals and stone slab roof covering which shall be measured in cubic metres.

Ridges, hips and valleys shall be girthed and included with the roof area. Corrugated or semi corrugated surfaces shall be measured flat and not girthed.

(b) Mud phuska on roofs shall be measured in square metres.

(c) Lead sheets in roofs shall be measured in quintals and hips, valleys, flashings, lining to gutter etc. shall be included in this weight.

(d) R.B. or R.C.C. roofs shall be measured as specified in para 18.17

(e) Supporting members, such as rafters, purlins, beams, joists, trusses etc where of wood shall be measured in cubic metres and steel or iron sections in quintals.

18.13 CEILINGS

The stripping of ceilings shall be measured in square metres

(a) Dismantling of supporting joists, beams etc shall be measured in cubic metres or in quintals as specified in para 18.12 (e)

18.14 FLOORING AND PAVINGS

Dismantling of floors (except concrete and brick floors) shall be measured in square metres. Supports such as joists, beams etc. if any shall be measured as per para 18.12 (e)

(e) Concrete and bricks paving shall be measured as per para 18.15.

18.15 CONCRETE AND BRICK ROOFS AND SUSPENDED FLOORS

Demolition of floors and roofs of concrete or brick shall be measured in cubic metres. Beams, cantilevers or other subsidiary supports of similar materials shall be included in the item. In measuring thickness of roofs provided with water proofing treatments with bitumen felts, the thickness of water proofing treatment shall be ignored.

18.16 WALLS AND PIERS

(a) Taking down walls and independent piers, columns of brick, stone or concrete shall be measured in cubic metres. All copings, corbels cornices and other

projections of the same building materials shall be included with the wall measurements.

In measuring thickness of plastered walls, the thickness of plaster shall be ignored.

(b) Ashlar face stones, dressed stone work, precast concrete articles, etc if required to be taken down intact shall be so stated and measured separately in cubic metres.

(c) Cleaning bricks stacking or measurements including all extra handling and removal and disposing off the rubbish as stated shall be enumerated in thousand of cleaned bricks.

(d) Cleaning stone obtained from demolished /dismantling stone masonry of any description including ashlar facing dressed stone work, stone slabs or flagging and precast concrete blocks including all extra handling and disposing off the rubbish as stated shall be measured in cubic metres of cleaned stone.

(e) Honey comb works or cavity walls of bricks, stone or concrete shall be measured as solid.

18.17 REINFORCED CONCRETE AND BRICK WORK

(a) Reinforced concrete structures and reinforced brick roofs and walls shall be measured in cubic metres and if reinforcement is required to be salvaged, it shall be so stated.

(b) Where reinforcement is required to be separated, scraped and cleaned, the work shall be measured separately in quintal of salvaged steel.

18.18 PARTITIONS, TRELLIS WORK ETC.

Partitions or light walls, of lath and plaster, trellis work, expanded metal, thin concrete or terracota slabs and other similar materials including frame work if any shall be measured in square metres stating the over all thickness.

18.19 WOOD WORK

(a) All wood work including karries average 40 sqcm or over in section, shall be measured in cubic metres, while that under 40 sq_cm in section, in running metres. Ballies shall be measured in running metres.

(b) Boarding including wooden chajjas and sunshades along with supports shall be measured in square metres in its plane.

18.20 STEEL AND IRON WORK All steel and iron work shall be measured in quintals. The weight shall be computed from standard tables unless the actual weight can readily be determined.

18.21 Riveted work, where rivets are required to be cut, shall be measured separately.

(a) Marking of structural steel required to be re-erected shall be measured separately.

(b) In framed steel items, the weight of any covering material or filling such as iron sheets and expanded metal shall be included in the weight of the main article unless such covering is not ordered to be taken out separately.

18.22 DOORS AND WINDOWS

Dismantling of doors, windows, clerestory windows, ventilators etc (wood or metal) whether done separately or along with removal of wall by making recess in the wall shall be enumerated. Those exceeding 3 sqm each in area shall be measured separately. The item shall include removal of chowkhats architraves, hold fasts and other attachments.

If only shutters are to be taken out it shall be measured separately.

18.23 PIPES AND SEWER LINES

(a) Water pipe lines including rain water pipes with clamps and specials, sewer lines (salt glazed ware or concrete) etc shall be described by their diameter and length measured in running metres inclusive of joints.

(b) If the joints, specials and fittings etc are required to be separated, it shall be so stated and enumerated.

(c) Pucca drains shall be measured under relevant items.

(d) Valve cistern, public fountain platform, fire hydrants, etc shall be enumerated.

(e) Manholes and inspection chambers shall be enumerated stating the size and depth of manhole/ inspection chamber. They shall be classified into different groups depending upon the depth, in unit of half and one metre depth. The depth of the manhole shall be the distance between the top of manhole cover and invert level of the drain.

(f) Ventilating shafts, gully traps, flushing cisterns and other appurtenant items of work shall be enumerated.

18.24 POSTS AND STRUTS

Posts or struts (wood, steel or RCC) section including taking out embedded portion shall be measured in running metres.

18.25 FENCING WIRE MESH

Wire mesh fencing of any type with frame shall be measured in square metres.

18.26 GLAZING

(a) Taking out any portion of serviceable glass except polished plate, from old slashes, skylights, etc (any thickness, weight or size) raking out old putty, etc shall be measured in square metres.

(b) Irregular or circular panes shall be measured as rectangle or square enveloping the same. The width and height being measured correct to the nearest 0.5cm.

18.27 ROAD WORK

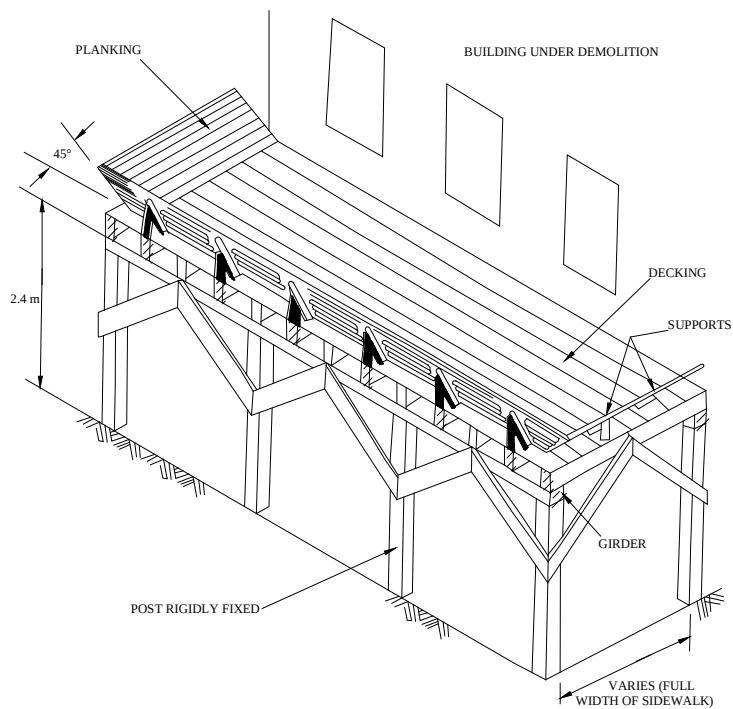
a) Different types of road surfaces shall be measured separately.

b) Road surfaces metalling or soling (base) shall be measured in-cubic metres.

c) Concrete paving shall be measured as in 18.15 or 18.17 as the case may be.

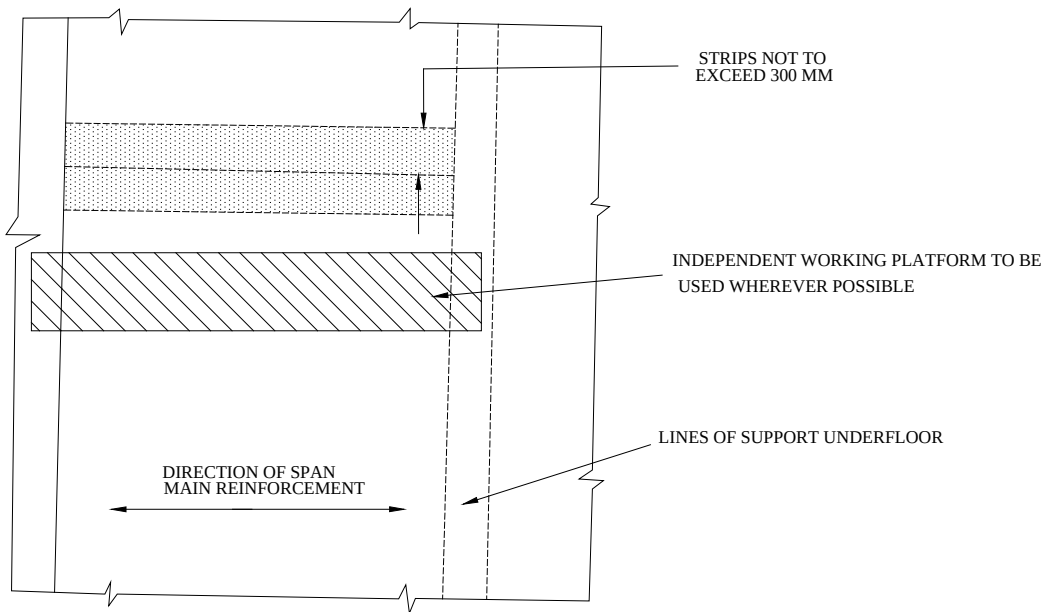
SKETCH OF SIDE WALK SHED

FIGURE 18.1



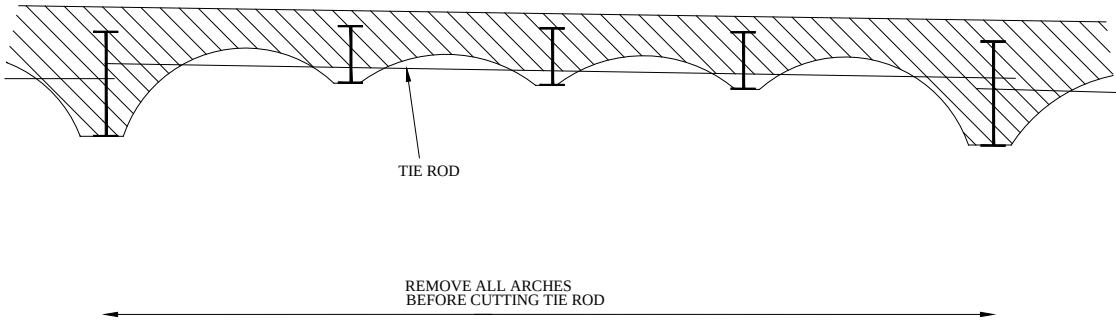
DEMOLITION OF REINFORCED CONCRETE FLOOR

FIGURE 18.2



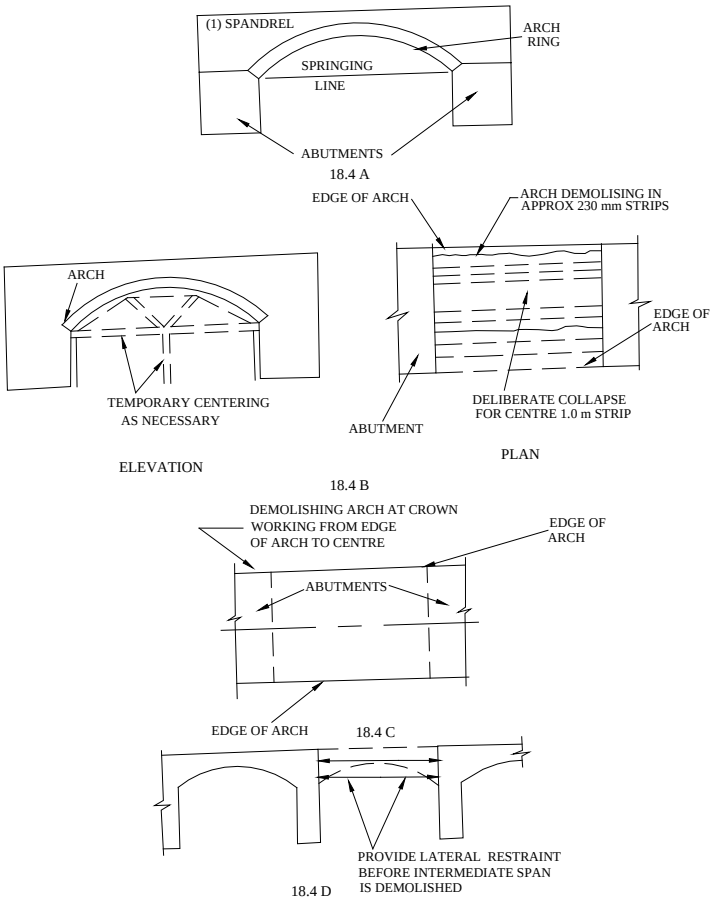
DEMOLITION OF JACK ARCHES

FIGURE 18.3



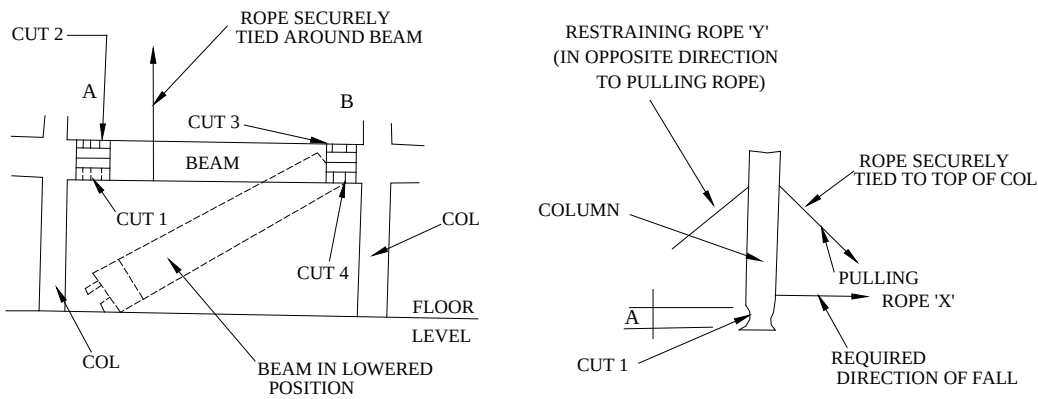
DEMOLITION OF MASONRY AND BRICKWORK ARCHES

FIGURE 18.4



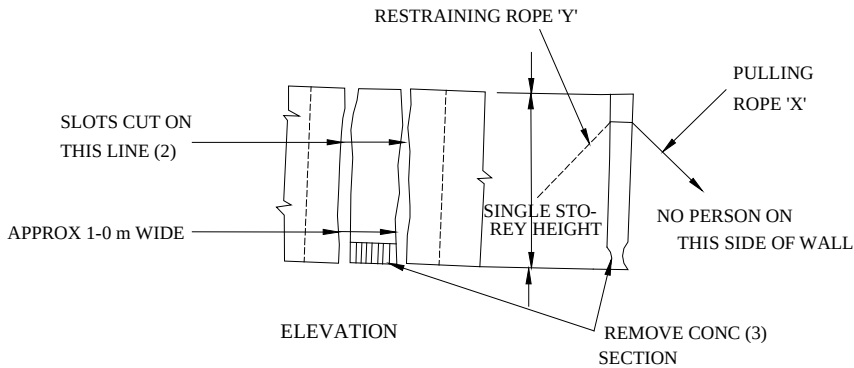
HAND DEMOLITION OF CONCRETE STRUCTURE CAST IN SITU

FIGURE 18.5



18.5 A RC Beams

18.5 B RC Columns



18.5 C RC Walls

Chapter 19

Bridge Works : Substructure

19.1 GENERAL

19.1.1 Scope

The Specifications given in this chapter deal with items pertaining to all types of foundations for bridges and bridge superstructure viz., Piers, abutments, wing walls, bed blocks and ballast walls / dirt walls. A section is included at end to cover water supply wells and tube wells.

19.1.2 Types of Foundations

Bridge foundations can be of

i) Open or Shallow Foundations including footings, blocks and raft foundations.

ii) Pile Foundations

iii) Well Foundations

Types of sub-structures:-

Abutment :

i) Wall Type abutment

ii) Spill through abutment

Pier

i) Wall type

ii) Columns - Solid or hollow

iii) Trestle type

Wing Walls

i) Splayed Wing walls

ii) Box Type Wing walls

19.1.3 Design and inspection aspects of bridges

Design and inspection aspects of bridges are not covered in these Specifications. User may refer to the Codes and Specifications listed above and Indian Railways Bridge Manual and departmental instructions for same. Provisions made in other chapters of the specifications are applicable to the extent they are relevant.

19.2 SETTING OUT FOR FOUNDATIONS

19.2.1 Setting out for Minor Bridges and Culverts

Shall be carried out by a competent / qualified engineer employed by the Contractor and checked by the Engineer's representative for all bridges and culverts. Contractor shall provide necessary instruments, linear tapes, pegs etc.

The setting out for foundations and sub-structure shall be carried out with a theodolite and steel tapes / Invar tapes in case of works not involving deep foundations or standing water. All levels will be measured using a precise levelling instrument. Errors in location of piers / abutments and fixing levels shall be within following limits.

Linear Measurements ± 5 mm

Levels ± 3 mm

19.2.2 Setting out for Major Bridges

a) Locations of piers and abutments along with the centre line of the bridge should be accurately laid out by establishing one or more base lines as directed and a system of pegs and posts. Also sufficient reference pegs and pillars should be established for checking the positions with ease during progress of work. Reference Bench Marks for levelling should be established nearby on a permanent structure or on a pillar to be built up in vicinity.

b) The principal reference lines and level pegs should be established at easily accessible locations. They include

i) Longitudinal Centre line

ii) Transverse Centre lines of abutments and piers

iii) Tangent points of the curve at either end, if alignment is on a curve.

c) For Bridge Works involving deep excavations, pile driving or well sinking and / or where there is standing water, use of base line is obligatory. They should be preferably at right angle to centre line of bridge, with one on either end on high bank in case of long bridges or on one side bank of bridge for shorter ones.

d) In case of bridges of length exceeding 1000 Metres, base lines and reference towers will have to be established. Provision of all assistance in form of measuring instruments, linear tapes as may be required by the surveyor, technical and skilled staff and labour required to assist them, fixing pegs, pillars and towers including all building materials, and maintaining and guarding them including supply of all materials, tools and plant shall be done by the Contractor at his cost.

Nothing extra will be payable to them on this account. Important points to be observed in this activity are:

1. Linear Measurement shall be carried out with invar tape or electronic distance measuring instruments
2. Spring balances shall be used for giving specified tension to the tape. Tape readings shall be corrected for tension, temperature and slope.
3. Concrete pillars with steel plates fixed over them shall be located at intermediate points (at tape lengths) and ends.
4. Reference pillars at pier and abutment position along centre lines and reference pillars on base lines shall be to standards to be prescribed by the Engineer. During construction, since centre line pillars at abutment / pier locations will be disturbed, reference pillars and lines shall be fixed around each structure by the Contractor under Site Engineer's supervision. Reference diagrams at Annexures 4/1 and 4/2 and Clause 401 of IRBM shall be referred to for more details.

19.3 SOIL EXPLORATION

19.3.1 Shallow Foundations

.1 Shallow Foundations are provided where sufficiently hard soil is available at shallow depths. They shall be taken down at least 1.5m below bed level or anticipated scour level except in case of pipe and Box culverts. The bearing capacity of soil and nature of soil should be ascertained by making trial pits at location of culvert/bridge.

.2 The depths of such pits shall extend for sufficient depth below the proposed founding level. If the soil in the pit by observation is found hard and stable plate load test shall be conducted at a level to be decided by the Engineer but not less than 0.60m below proposed foundation level for determining safe bearing capacity of soil and the characteristics of the strata in accordance with provisions of IS: 1888. (Plate Load Test)

.3 In addition, at the discretion of the Engineer, exploratory bores or sounding shall be done for depth of about 1.5 times the proposed width of foundation below proposed founding level. In case of exploratory bores, sample shall be collected and laboratory tests conducted as detailed in Para 19.3.4.

.4 The results of laboratory tests and of plate load tests and penetration tests shall be compared for conformity. It shall be ensured that no layer of soft soil is met with upto 1.5 times depth below the founding level.

19.3.2 Soil Exploration for Deep Foundations

.1 At least one exploratory bore shall be drilled at the location of each pier. The bore shall be taken down to a minimum depth of 1.5 times the proposed width of foundation below design founding level. If rock is met with in the bore, the bore should be taken down at least 5m into the rock.

.2 In case the rock layer is suspected to be sloping or dipping or fissures are noticed, more than one bore per foundation will be required to be done. Additional bores should be done as instructed by the Engineer. See also Para 19.3.7.

.3 Only rotary drills shall be used for drilling bore holes and collection of samples. Use of percussion or wash boring equipment may be permitted by the Engineer in certain types of soils, based on his judgement.

.4 SPT tests and collection of undistributed samples shall be done at intervals of 1.5 m depth unless otherwise specified in contract or directed by the Engineer, and in accordance with IS:1892. Samples collected shall be properly protected, packed and sent for tests. Tests shall be conducted as per provisions in relevant part of IS: 2219.

19.3.3 Tests:- In-situ and laboratory tests listed below shall be carried out according to soil type and site requirement.

Cohesionless soils

a) Classification tests, density etc.

Standard Penetration Test or Dynamic Penetration Test (as per IS 2131) when considered appropriate.

b) Laboratory Tests:

Triaxial or shear or box shear test on collected samples and saturated samples where sub soil water level is likely to reach that level.

Cohesive soils

a) Classification tests, density etc.

b) Field Tests

i) Plate Load Tests

ii) Unconfined compression Test (IS 2720-Part IX)

iii) Vane Shear Test (IS 4434)

- iv) SPT (IS 4968 Part III)
- c) Laboratory Tests
 - i) Shearing strength Test Triaxial Tests (IS:2720-Part XI)
 - ii) Consolidation Test (IS 2720-Part XV)
 - iii) Special Tests
 - a) Permeability tests should be conducted on samples in case need for dewatering is expected for / during excavation / or well sinking.
 - b) Chemical tests of soils and sub-soil water where considered necessary
 - c) Look out should be maintained for presence of any gas, in case peaty soils are met with or otherwise suspected, specially when well foundations are proposed.

19.3.4 Coverage

- a) The exploration shall cover the entire length of the bridge and also extend at either side for a distance of about twice the depth below bed of the lowest main foundations.
- b) The depth of exploration should be at least $1\frac{1}{2}$ times the minimum width of foundation below the proposed foundation level. Where such investigation ends in any unsuitable or questionable foundation material the exploration shall be extended to a sufficient depth into firm and stable soils or rock but not less than four times the minimum depth of foundation below the earlier contemplated foundation level. In case of good sound rock the stipulation of minimum depth may be decreased based on difficulty to conduct core drilling and the minimum depth may then be restricted to 3 metres.
- c) *Locations of Boring* - Where the data made available by detailed exploration indicates appreciable variation or where variations in a particular foundation are likely to appreciably affect the construction (specially in case of bridge foundations resting on rock), it will be necessary to resort to additional bores / soundings to establish complete profile of the underlying strata. The additional borings / soundings shall be decided by the Engineer depending upon the extent of variation at a particular foundation location and should cover the entire area of the particular foundation.

19.3.5 Construction Stage Exploration

Whenever a change in the sub-soil strata / rock profile is encountered during construction, detailed explorations shall be resorted to establish the correct data for further decisions.

19.3.6 Logging of bore holes:- Logging of bore holes by radio active methods shall be done for detailed investigations as specified in the contract or in special provisions.

19.4 EXPLORATION FOR BRIDGE FOUNDATIONS RESTING ON ROCK

19.4.1 Scope of Work

To arrive at the characteristic strength of rock mass, reliance shall be placed more on in situ tests in comparison to laboratory tests.

19.4.2 Identification and classification

Identification and classification of rock types for engineering purposes may in general be limited to broad, basic geological classes in accordance with accepted practice. Apart from strength of parent rock, investigation should cover study of spacing and distribution of discontinuities of the rock mass, such as the joints, bedding planes, faults and weathered seams. A major factor affecting the behaviour is the weathered zone at top.

19.4.3 Basic Information Required from Exploration in rock

- i) Depth or rock strata and its variation over the site,
- ii) Whether isolated boulder or massive rock formation.
- iii) Extent and character of weathered zone,
- iv) Structure of rock – including bedding planes, faults, fissures, solution cavities etc
- v) Properties of rock material-strength, geological formation, etc
- vi) Erodibility or rock to the extent possible
- vii) Colour of water.

19.4.4 Extent of Exploration

The extent of exploration shall be adequate enough to give a complete picture of the rock profile both in depth and across the channel width to assess the constructional difficulties in reaching the foundation levels.

19.4.5 Depth of Boring

The depth of boring in rock should be such that it shall pass through the upper weathered or otherwise weak zone, well into the sound rock. Minimum depth of boring in sound rock shall be 3 metres.

19.4.6 Special Features in Drilling through Rock

During drilling through rock every care shall be taken to notice and record any small change during drilling. The time required to

drill through a certain depth, amount of core recovery, physical condition, length of pieces of core, joints, colour of water residue, weathering and evidence of disturbance and other effects shall be carefully noticed and entered in the drilling log. For guidance, IS:5313 may be referred to. The data shall be presented in accordance with IS:4464. The cores shall be stored properly in accordance with IS:4078.

Laboratory Tests

The rock cores obtained shall be subjected to following laboratory tests:

- i) Visual identification for texture, structure, composition, colour and grain size.
- ii) Laboratory tests shall be done for specific gravity, porosity and moisture content and compressive and shear strength.

19.4.7 In-situ Tests

(a) In-situ tests shall be made in accordance with IS:7292; IS: 7317: and IS 7746. In addition, laboratory tests can also be made on samples. Use of in-situ tests for measuring strength and deformation characteristics shall be made. If required, bore-hole photography may be done to evaluate the presence of faults, fissures or cavities, etc.

(b) In some cases, the foundation behavior will be dominated by a possible mode of failure involving movement along some joint surface, fissures or weak layer within a generally strong rock system and also by possible weathering. In situ shear tests may be conducted wherever feasible, as such tests are likely to give more representative data than the shear tests conducted on core samples.

19.4.8 Special Cases

a) Investigation for conglomerate:

A drill hole shall be made same as for rock. The samples collected shall be subjected to suitable tests depending upon the material. Special care shall be taken to ascertain erodibility of the matrix. Where possible, specially for shallow foundation, Plate Load Test shall be conducted.

b) Investigation for laterites:

The investigation shall be similar to that required for cohesive soils. Use of penetration tests shall be preferred, if suitable correlation charts are available. These may be static or dynamic penetration tests or vane shear tests. In the case of hard laterite, recourse will have to be made to core drilling as for soft rocks.

Presentation of Data

The data shall be given in diagrammatic form in 3 sheets giving the following details:

Sheet 1: Plan to scale (Site Plan) showing the position of bore-holes clearly marked so as to fix the position at a future date.

Sheet 2: This shall contain the bore-log chart and test results of the samples separately for each bore-hole / pit etc.

Sheet 3: This shall contain pictorial representation of the bore log data to get an overall picture of the soil profile at the cross section of the river.

19.5 RECORDS OF BORINGS AND TRIAL PITS AND SAMPLING

19.5.1 Field records

The field records for the preliminary and detailed exploration shall contain the date when the boring was made, the location of the boring with reference to a permanent system of coordinates and the elevation of the ground surface with respect to a permanent bench mark. They shall include elevation at which the water table and the upper boundary of each of the successive soil strata were encountered, the investigator's classification of the layer on the basis of general information obtained from field examination and the Standard Penetration Test values at different depths. The type of tools used for borings shall be recorded. If the tools were changed, the depth at which the change was made and the reason thereof shall also be noted. Incomplete and abandoned borings shall be described with same care as for completed bores including information on any part of pipe or tool left behind in the bore. It should contain details of the job such as the elevation at which wash water was lost from the hole and any other significant information.

19.5.2 Contents of Report

For all borings and trial pits, necessary information as detailed below shall be given in the Reports. It shall include all drawings including site plan listed in Para 19.4.10.

- a) Agency
- b) Location with reference map
- c) Pit/ Bore-hole number
- d) Reduced level (R.L.) of ground surface or other reference point
- e) Dates of starting and completion
- f) Name of supervisor
- g) Scales of plans and sections

- h) Dimensions, methods of advancing exploration such as by hand tools, blasting, boring etc.
- i) General description of strata met with and RLs at which they were met
- j) Position and altitude of contacts, faults, strong joints, slicken sides, etc.
- k) Inflow of water, methods of controlling the water, required capacity of pumps for dewatering
- l) The level at which the sub-soil water was met with
- m) Dip and strike of bedding and of cleavage

- n) Visual description of strata
- o) Results of field tests e.g. SPT, in-situ vane shear test etc
- p) Any other information and remarks

19.5.3 Record of Measurement

Upon removal of sampling tube, the length of the sample in the tube and the length between the top of the tube and the top of the sample in the tube shall be measured and recorded.

19.5.4 Methods of Sampling

- a) The usual methods for sampling conforming to IS:1892 and IS:2132 are given below :

Nature of Ground	Type of Sample	Method of Sampling
Soil	Disturbed	Hand Samples
		Auger Samples
		Shell Samples
	Undisturbed	Hand Samples
		Tube Samples
Rock	Disturbed	Wash samples from percussion or rotary drilling
	Undisturbed	Cores

- b) For proper identification of sub-surface material, sample should be recovered containing all the constituents of the materials in their proper proportion. In clayey deposits such samples could be collected by split spoon samplers. In the case of sandy deposits, sampling spoons shall be fitted with suitable devices for retaining samples. All data required for soil identification should be collected from the samples so extracted when undisturbed samples, which are more desirable for collection of some of the data, are not available. Penetration test should be carried out with the standard split spoon sampler or penetrometers if the soil is coarse grained. When it is known in advance that the soil profile is fairly regular, preliminary and detailed investigation may be combined. Tube samplers can be used in place of split

spoon samplers for collecting samples in clayey strata.

c) Disturbed Soil Samples

- i) Disturbed samples of soil shall be obtained in the course of excavation and boring. For procuring samples from below the ground water level, where possible, special type of sampler shall be used. Where Standard Penetration Test is conducted, representative samples shall be obtained from the split spoon. While collecting disturbed samples from borrow areas it shall be ensured that the samples collected represent all types of borrow materials to be used in the construction of embankment and sub-grade.
- ii) The size of sample generally required shall be as given in **Table 19.1**

TABLE 19 -1 SIZE OF SOIL SAMPLE REQUIRED

SL	PURPOSE OF SAMPLE	SOIL TYPE	WEIGHT OF SAMPLE REQUIRED (Kg)
1.	Soil identification, natural moisture content tests, mechanical analysis and index properties, chemical tests	Cohesive soils	1
		Sands and Gravels	3
2.	Compression tests	Cohesive soils and sand	12.5

3.	Comprehensive examination of construction material and borrow area soil including soil stabilisation	Cohesive soils and sand Gravelly soil	25-50 50-100

iii) While taking out disturbed soil samples, Standard Penetration Test shall also be conducted to find out the bearing capacity of the sub-soils at specified levels.

d) Undisturbed Soil Samples

i) Samples shall be obtained in such a manner that their moisture content and structure do not get altered. This may be ensured by use of correctly designed sampler and by careful protection and packing.

ii) Standard Penetration Test may have to be conducted in each case to obtain additional data as directed by the Engineer. In soft clay, in-situ vane shear test as per IS:4434 may have to be conducted. Where all the three operations have to be carried out in one layer, the sequence shall be undisturbed soil sampling followed by in-situ vane shear test, followed by Standard Penetration Test.

iii) For compression test samples, a core of 40mm diameter and about 150 to 200mm length may be sufficient, but for other laboratory tests, a core of 100mm diameter and 300mm length shall be taken as far as possible, unless otherwise specified by the Engineer.

iv) The upper few millimetres of both types of sample shall be rejected as the soil at the bottom of the bore hole usually gets disturbed by the boring tools.

e) Rock Samples

i) Disturbed Samples:

The sludge from percussion borings or from rotary borings which have failed to yield a core, shall be collected for a disturbed sample. It may be recovered from circulating water by settlement in a trough.

ii) Undisturbed Samples:

Block samples taken from the rock formation shall be dressed to a size of about 90 x 75 x 50mm.

For core samples, undisturbed cores of rock shall be taken by means of rotary drills fitted with a coring bit with core retainer, if warranted.

19.6 EXCAVATION FOR OPEN FOUNDATIONS

19.6.1 Depth of Foundation

Depth of foundation shall be as shown in Drawing. If it is in erodible soil, the depth should be such that it has grip of not less than 1/3 depth of scour. The ground at final level should be inspected by the Engineer or his representative and approved before construction of pier or abutment is started.

19.6.2 Setting Out

The plan dimensions of the foundation shall be set out at the bottom of foundation trench and checked with respect to original reference line and axis. It shall be ensured that at no point the bearing surface is higher than the founding level shown on the drawing or as directed by the Engineer.

19.6.3 Preparation of Foundations

The last 300mm of excavation shall be done just before laying of lean concrete below foundation. In the event of excavation having been made deeper than that shown on the drawing or as ordered by the Engineer, the extra depth shall be made up with M15 concrete as specified in case of foundation resting on soil and foundation grade concrete for foundations in rock, at the cost of the Contractor and shall be considered as incidental work. Special care shall be taken not to disturb the bearing surface. Open foundations shall be constructed in dry conditions and the Contractor shall provide for adequate dewatering arrangements to the satisfaction of the Engineer.

19.6.4 Laying of Lean Concrete base

The base of the pit should be tamped and compacted and kept dry before laying a base concrete or levelling course. A layer of minimum 10 cm thick lean concrete (1:3:6) or equivalent should be laid on the prepared base. After the concrete sets and hardens, the bottom profile of the base of footing shall be accurately marked and got checked by the Engineer before the formwork for footing is laid. Before laying of lean concrete layer, the earth surface shall be cleaned of all loose material and wetted. Care shall be taken to avoid muddy surface. Concrete M 15 or as shown in the drawing shall be laid to the thickness as required. No construction joint shall be provided in the lean concrete.

Before laying foundation concrete, the lean concrete or hard rock surface shall be cleaned of all loose material and lightly moistened. Foundation concrete of required

dimensions and shape shall be laid continuously upto the location of construction joint shown on the drawing or as directed by the Engineer. No form work is necessary for the lean concrete layer.

19.6.5 Special Provisions for Rocky strata

In rocky strata, foundation should be keyed in the rock for depths mentioned below unless otherwise specified or approved. In case of sloping rock, benching should be done so that the size of concrete is in level planes suitably stepped. Keying depths should be

- i) Hard rocks like igneous granites or gneissic rocks with crushing strength of 100 kg./sq.cm or more - 0.6m
- ii) Other type of rocks with crushing strength of 20 kg / sq.cm. or more – 1.5m
- iii) Other cases to be decided by Engineer / Designer after considering presence of fissures, cavities, bedding planes and ultimate crushing strength.
- iv) Well foundation on rock shall be taken to adequate depth and seated evenly all around the periphery on sound rock and provided adequate embedments.

19.6.6 Formwork

Form work shall conform to relevant clauses in Chapter 4 of these specifications. For foundation concrete work, side form work shall be used. Reinforcement shall be laid as shown on the drawing. Form work for top of the foundation concrete shall also be provided, if its top has slopes steeper than 1 (vertical) to 3 (horizontal). When concrete is laid in slope without top form work, the slump of the concrete shall be maintained so as to ensure that compaction is possible without slippage of freshly placed concrete down the slope. In certain cases it may be necessary to build the top form work progressively as the concreting proceeds up the slope.

19.6.7 Concreting

Providing concrete and steel reinforcement shall conform to relevant sections of Chapters 3 and 4. Minimum grade of concrete shall be M 20 unless otherwise specified or directed. The concrete surface

shall be finished smooth with a trowel. The location of construction joint and its treatment shall be done as per specification. Form work shall be removed not earlier than 24 hours after placing of concrete. Where form work has been provided for top surface, the same shall be removed as soon as concrete has hardened. Curing of concrete shall be carried out by wetting of form work before removal. After its removal, curing shall be done by laying not less than 10 cm of loose moistened sand, free from clod or gravel and shall be kept continuously moist for a period of 7 days. Sides will be kept wet for the same period by spraying water or covering with wet gunny bag etc.

19.6.8 Backfilling

Before back filling around the foundation and structure is commenced, loose sand laid on foundation shall be removed and dispersed as directed by the Engineer. All spaces excavated and not occupied by the foundation or other permanent works shall be refilled with earth upto surface of surrounding ground in 150mm layers wetted and compacted by rammers, light rollers and as directed by Engineer. In case of excavation in rock, the annular space around foundation shall be filled with M 15 concrete or as specified upto the top of rock. Protection works, where provided, shall be completed before the floods so that the foundation does not get undermined.

19.6.9 Tests and Standards of Acceptance

The materials shall be tested in accordance with these Specifications and shall meet the prescribed criteria. The work shall conform to these Specifications and shall meet the prescribed standards of acceptance.

No point of the surface of the lean concrete in the case of foundation on soil or the surface of hard rock in the case of foundation of hard rock, shall be higher than the founding level shown on the drawings or as ordered by the Engineer. Levels of the surface shall be taken at intervals of not more than 3 metres centre to centre, subject to a minimum of nine levels on the surface.

Tolerances

a)	Variation in dimensions	:	+50mm - 10mm
b)	Misplacement from specified position in plan	:	15mm
c)	Surface irregularities measured with 3m straight edge	:	5mm
d)	Variation of levels at the top	:	± 25 mm

19.6.10 Measurement for payment

Excavation in foundation shall be measured in accordance with Chapter 1 based on the quantity ordered or as shown on the drawing. Lean concrete shall be measured in cubic metres in accordance with Para 3.2.17 based on the quantity ordered or as shown on the drawing. Concrete in foundation shall be measured in cubic metres in accordance with Para 4.4.9, based on the quantity ordered or as shown on the drawing. Reinforcement steel shall be measured in tonnes in accordance with Para 4.3.3 based on the quantity ordered or as shown on the drawing. Formwork shall be measured in square metres in accordance with Para 4.2.6. All linear measurements will be made correct to nearest cm and areas computed to nearest 0.01 sqm and volumes to nearest 0.001 cum.

19.6.11 Rate

The contract unit rates for excavation in foundation, lean concrete, formwork, and concrete in foundation and reinforcement steel shall include all works as given in respective sections of these specifications and cover all labour, materials, tools and plant, transport, handling and all incidental items for furnishing and providing open foundation including curing and backfilling, as mentioned in this Section.

19.7 PILE FOUNDATIONS**19.7.1 (General)**

20.7.1.1.1 Work shall be done in accordance with IS:2911 Parts 1 to 4 unless otherwise specified herein or in Drawings and Contract specifications. Under reamed piles shall not be used for Railway bridges but used extensively in clayey and black cotton soils for buildings. The Construction of pile foundations requires a careful choice of the piling system depending upon sub-soil conditions and loading characteristics and type of structure. The permissible limits of total and differential settlements, unsupported length of pile under scour, impact / entanglement of floating bodies and any other special requirements of project are other important criteria for selection of the piling system. The method of installing the piles, including details of the equipment shall be submitted by the Contractor and got approved by the Engineer before start of work.

19.7.1.2 Sub-Surface Investigations

Borings should be carried upto sufficient depths so as to ascertain the nature of strata around the pile shaft and below the pile tip. However, unless otherwise specified or

agreed to, depth of boring shall not be less than:

- i) 1.5 times estimated length of pile in soil but not less than 15m beyond the probable length of pile
- ii) 15 times diameter of pile in weak / jointed rock but minimum 15m in such rock
- iii) 4 times diameter of pile in sound, hard rock but minimum 3 m in such rock.
- iv) The investigation shall be adequate for the purpose of selection of appropriate piling system and for estimating design capacities for different diameters and lengths of piles.
- v) For piles socketed into rocks, it is necessary to determine the uniaxial compressive strength of the rock and its quality.
- vi) The investigation shall also include location of ground water table and other parameters including results of chemical tests showing sulphate and chloride content and any other deleterious chemical content in soil and / or ground water, likely to affect durability.

For other details of geo-technical investigations, Paras 19.3 and 19.4 may be referred to.

19.7.2 Materials

The specifications for steel reinforcement, structural concrete, prestressed concrete and structural steel to be used in pile foundations shall be similar to provisions given in the relevant sections of the specifications.

19.7.2.1 Concrete in Piles

Grade of concrete to be used in cast-in-situ piles shall preferably be M 25 or as specified but never less than M 20 and the Cement content shall not be less than 400 kg per cubic metre of concrete. Grades of concrete for precast reinforced and prestressed concrete piles shall not be less than M 25 and M 35 respectively. Maximum water cement ratio shall be 0.5 for cast-in-situ piles and 0.45 for precast piles. The minimum slump of concrete for driven cast-in-situ piles shall be 100mm to 150mm and that of bored cast-in-situ piles 150mm to 200mm. The slump should not exceed 200mm in any case.

Suitable and approved admixtures may be used in concrete mix where necessary. The minimum clear cover for piles will be 40mm over all reinforcement including binding wire. Where piles are to be located in corrosive environment, the cover shall be 50mm. Where piles are exposed to action of harmful chemicals or severe conditions of exposure

due to presence of sulphate, chloride etc, higher grades of concrete, restricting water cement ratio to 0.45 shall be used. Special types of cement, such as sulphate resistant cement may be used where considered appropriate by Engineer-in-Charge.

19.7.3 Test Piles

19.7.3.1 The piles shall be load tested in accordance with provisions laid down in IS 2911. Part 4.

19.7.3.2 Test piles which are shown on the drawings or specified in the contract or installed by the Contractor on his own to determine the lengths of piles to be furnished shall conform to the requirements for piling as indicated in these specifications, if they are to be incorporated in the completed structure.

19.7.3.3 Test piles which are to become a part of the completed structure shall be installed with the same type of equipment that is proposed to be used for piling in the actual structure. Test piles which are not to be incorporated in the completed structure shall be cut off at atleast 600mm below the proposed soffit level of pile cap and head finished properly with cover concrete and the remaining hole shall be back filled with earth or other suitable material. If any test pile in a cluster fails, an additional pile will be provided and incorporated in the Cluster at the position approved by the Engineer.

19.7.4 CAST-IN-SITU CONCRETE PILES

19.7.4.1 Cast-in-situ concrete piles may be either installed by making a bore into the ground by removal of material or by driving a metal casing with a shoe at the tip and displacing the material laterally. The two types of piles are termed as "bored piles" and "driven piles" respectively. Cast-in-situ concrete piles may be cast in metal shells which may remain permanently in place. However, other types of cast-in-situ concrete piles, plain or reinforced, cased or uncased, may be used if in the opinion of the Engineer the soil conditions permit their use and if their design and the methods of placing are satisfactory. The metal casing shall be of sufficient thickness and strength to hold its original form and show no harmful distortion after it and adjacent casings have been driven and the driving core, if any, has been withdrawn.

19.7.4.2 Concreting and reinforcement work will be done in accordance with relevant clauses in Chapters 3 and 4 supplemented by these

specifications. Para 19.7.2.2 may also be referred to for mix details.

19.7.4.3 Cast-in-situ concrete driven piles shall be installed using a properly designed detachable shoe at the bottom of the casing.

19.7.4.4 Any liner or bore-hole which is improperly located or shows partial collapse that would affect the load carrying capacity of the pile, shall be rejected or repaired as directed by the Engineer at the cost of the Contractor.

19.7.4.5 Bored cast-in-situ piles in soils which are stable, may often be installed with only a small casing length at the top. A minimum of 2.0m length of top of bore shall invariably be provided with casing to prevent any loose soil falling into the bore. In cases in which the side soil lower down can fall into the hole, it is necessary to stabilise the side of the bore hole with drilling mud, or a suitable steel casing. The casing may be left in position permanently specially in cases where the aggressive action of the ground water is to be avoided, or in the cases of piles built in water or in cases where significant length of piles could be exposed due to scour.

19.7.4.6 For bored cast-in-situ piles, casing / liner shall be driven open ended with a pile driving hammer capable of achieving penetration of the liner to the length shown on the drawing or as approved by the Engineer. Materials inside the casing shall be removed progressively by air lift, grab or percussion equipment or other approved means. Boring shall be carried out using rotary or percussion type equipment. Unless otherwise approved by the Engineer, the diameter of the bore-holes shall be not more than the inside diameter of the liner.

19.7.4.7 Where bored cast-in-situ piles are used in soils liable to flow, the bottom of the casing shall be kept enough in advance of the boring tool to prevent the entry of soil into the casing, thus preventing the formation of cavities and settlements in the adjoining ground. The water level in the casing should generally be maintained at the natural ground water level for the same reasons. The joints of the casing shall be made as tight as possible to minimise inflow of water or leakage of slurry during concreting. Where mud flow conditions exist, the casing of cast-in-situ piles shall not be allowed to be withdrawn. Prior to the lowering of the reinforcement cage into the pile shaft, the shaft shall be cleaned of all loose materials. Cover to reinforcing steel

shall be maintained by suitable spacers, tied in advance to the reinforcement.

19.7.4.8 Wherever practicable, concrete should be placed in a clean dry hole. Where concrete is placed in dry condition and there is casing present, the top 3m of the pile shall be compacted using internal vibrators.

19.7.4.9 Before concreting under water, the bottom of the hole shall be cleaned of drilling mud and all soft or loose material very carefully. In case a hole is bored with use of drilling mud, concreting should not be taken up when the specific gravity of bottom slurry is more than 1.2. The drilling mud should be maintained at 1.5m above the ground water level.

19.7.4.10 Where the casing is withdrawn from cohesive soils for the formation of cast-in-situ pile, the concreting should be done with necessary precautions to minimise the softening of the soil by excess water. Care shall be taken during concreting to prevent as far as possible the segregation of the ingredients. The displacement or distortion of reinforcement during concreting and also while extracting the tube shall be avoided.

19.7.4.11 The concrete shall be properly graded, shall be self-compacting and shall not get mixed with soil, excess water, or other extraneous matter. Special care shall be taken in silty clays and other soils with the tendency to squeeze into the newly deposited concrete and cause necking. Sufficient head of green concrete shall be maintained to prevent inflow of soil or water into the concrete.

19.7.4.12 The placing of concrete shall be a continuous process from the toe level to the top of the pile. To prevent segregation, a tube or tremie pipe as appropriate shall be used to place concrete in all piles.

19.7.4.13 To ensure compaction by hydraulic static heads, rate of placing concrete in the pile shaft shall not be less than 6m (length of pile) per hour. Under water concreting should be done with tremie.

19.7.4.14 **Concreting under water :-** General requirements and precautions for concreting under water shall be as given in concreting chapter supplemented by following instructions:

a) The concreting of a pile must be completed in one continuous operation. Also, for bored holes, the finishing of the bore, cleaning of the bore, lowering of reinforcement cage and concreting of pile for

full height must be accomplished in one continuous operation without any stoppage.

b) The concrete should be coherent, rich in cement with high slump and restricted water cement ratio.

c) The tremie pipe will have to be large enough with due regard to the size of aggregate. For 20mm aggregate the tremie pipe should be of diameter not less than 150mm and for larger aggregate, larger diameter tremie pipes may be necessary.

d) The first charge of concrete should be placed with a sliding plug pushed down the tube ahead of it to prevent mixing of water and concrete.

e) The tremie pipe should always penetrate well into the concrete with an adequate margin of safety against accidental withdrawal if the pipe is surged to discharge the concrete.

f) The pile should be concreted wholly by tremie and the method of deposition should not be changed part way up the pile to prevent the laitance from being entrapped within the pile.

g) All tremie tubes should be scrupulously cleaned after use.

h) In special circumstances, the Engineer may permit use of any other proved method of concrete placement designed for under water concrete. In such cases, a detailed method statement should be prepared and got approved by the Engineer.

19.7.4.15 The diameter of the finished pile shall not be less than that specified and a continuous record shall be kept by the Engineer as to the volume of concrete placed in relation to the pile length cast.

19.7.5 Pile Cap

i) The minimum embedment of cast-in-situ concrete piles into pile cap shall be 150mm. Any defective concrete at the head of the completed pile shall be cut away and made good with new concrete. The clear cover between the bottom reinforcement in pile cap from the top of the pile shall be not less than 25mm. The reinforcement in the pile shall be exposed for full anchorage length to permit it to be adequately boned into the pile cap. Exposing such length shall be done carefully so as to avoid damaging the rest of the pile. In cases where the pile cap is to be laid on ground, a levelling course of M 15 or as stipulated nominal mix concrete 100mm thick shall be provided. Defective piles shall be removed or left in place as judged

convenient without affecting the performance of adjacent piles or pile cap. Additional piles shall be provided to replace the defective piles.

ii) Pile caps shall be of reinforced concrete of minimum grade of M 25 unless otherwise stated in drawings or work specifications or directed by the Engineer. A minimum offset of 150mm shall be provided beyond the outer faces of the outer most piles in the group. If the pile cap is in contact with earth at the bottom, a levelling course of minimum 100mm thickness of M 15 or as specified nominal mix concrete shall be provided.

iii) The attachment of the pile head to the cap shall be adequate for loads and forces. The top of concrete in a pile shall be brought above cut-off level to permit removal of all laitance and weak concrete before pile cap is laid. This will ensure good concrete at the cut-off level.

iv) Concreting of the pile cap shall be carried out in dry conditions. The bottom of the pile cap shall be laid preferably as low as possible taking into account the water level prevalent at the time of casting. Suitable leak-proof floating form work shall be used for casting caps over piles in water.

19.7.5.1 Driving Equipment

Piles or their casings may be driven with any type of drop hammer, diesel hammer or single acting or double acting steam or compressed air hammer, provided they penetrate to the prescribed depth or attain the designed resistance without being damaged. The weight or power of the hammer should be sufficient to ensure a penetration of atleast 5mm per blow, unless rock has been reached. It is always preferable to employ the heaviest hammer practicable and to limit the stroke, so as not to damage the pile. The minimum weight of the hammer shall be 2.5t. In the case of precast concrete piles the mass of the hammer shall be not less than 30 times the mass of 300mm length of pile.

Steam or air hammers shall be operated with a boiler or air compressor of capacity not less than the capacity that is specified by the manufacturer of the hammer. The boiler or air compressor shall be equipped with an accurate pressure gauge and safety valves at all times. The valve mechanism and other parts of steam, air or diesel hammers shall be maintained in first class condition so that the length of stroke and number of blows per minute for which the hammer is designed, will be obtained. The boiler shall be

inspected by statutory authorities at prescribed intervals. Inefficient steam, air or diesel hammers shall be removed from the work.

19.7.6 Driving

19.7.6.1 General Procedure

Piles shall be installed from cranes or derricks standing on firm ground or from temporary supports or from fixed platform. Piles in water shall be installed from cranes erected on pontoons/ barges properly anchored and held in position. The arrangement shall provide sufficient rigidity to ensure accuracy of pile driving under all conditions of tide, stream flow or hammer drop. During driving, the top of pile shall be protected by a suitable helmet of substantial and well fitting steel construction. The helmet shall provide uniform bearing across the top of the pile and shall hold the pile centrally under the hammer.

No pile shall be driven unless inspected and approved by the Engineer. Forces producing undue bending or torsional stresses in piles shall not be applied during driving. The force of the hammer shall be directed centrally and axially during driving. The stroke of a single acting or drop hammer shall be limited to 1.2m unless otherwise permitted by the Engineer. A shorter stroke may be specified when there is danger of damaging the pile.

Piles shall not be bent or sprung into position but shall be effectively guided and held on-line during the initial stages of driving. Attempts to correct any tendency for the pile to run off-line by the application of significant horizontal restraint will not be permitted. Shortly after the commencement of driving and at regular intervals throughout the driving operation, checks shall be made to ensure that the pile frame does not exert any undue lateral force on the pile due to restraint within the helmet.

To avoid the possibility of premature "set up" pile driving shall be continuous in the later stages, without any deliberate stops. Delays of an hour or less may lead to significant "set-up" in piles i.e. resistance to further driving increases after driving is stopped.

If any pile is damaged in any way during driving, it shall be repaired or replaced as directed by the Engineer, at no extra cost. If during driving, the head of a pile is damaged to the extent that further driving is not possible, the head shall be cut off and helmet replaced and driving continued. The cost of cutting of the head shall be borne by the

Contractor and where, as a result of such cutting of the head, the pile is too short, the Contractor, shall, at his own cost, provide extension or splicing of sufficient length of pile to restore the pile to its correct length.

19.7.6.2 Piles should be driven to the minimum acceptable penetration shown on the drawings. This may require preboring and / or jetting as detailed in the relevant Clause of IS:2911 (Part I/ Section 3).

Piles shall be driven to nominal refusal or the required ultimate dynamic capacity specified on the drawings or until the top of the pile is at the level required and specified on the drawing whichever gives the lowest toe elevation. The Engineer's decision in these matters shall be final. Nominal refusal shall be taken as equivalent to 25mm total penetration for the final 20 blows using a hammer of driving energy as specified and shall be used as the criterion for acceptance for piles founded on rock. Severe driving which results in an average set per blow of less than 0.5mm will not be permitted.

19.7.6.3 Where hard drilling is encountered because of dense strata or obstructions located above the predetermined pile tip level, nominal refusal shall not be considered to have been achieved unless the Engineer is satisfied that the total number of blows, required for achieving the average driving resistance specified for nominal refusal, indicates that further driving will not advance the pile through the dense strata or obstructions.

19.7.6.4 The pile shall be driven as accurately as possible to the vertical or to specified batter. Straining the pile into position can damage it and the driving equipment should be adjusted as much as possible to follow the position of the pile. Any deviation from the proper alignment shall be noted and promptly reported to the Engineer. If the deviation is to such an extent that the resulting eccentricity cannot be taken care of by strengthening the pile cap or pile ties, such a pile shall, at the discretion of the Engineer, be replaced or supplemented by an additional pile. If the indications are that a pile will finish outside the specified tolerances, driving operations on that pile will cease. The pile shall be withdrawn, the hole filled and the pile re-driven at no extra cost.

Unless otherwise specified, the permissible positional deviation for piles shall be limited to those indicated in Para 19.7.13.

19.7.6.5 When employing a tube which is subsequently withdrawn for the formation of

cast-in-situ pile, consideration shall be given to the possibility of doing harm to a pile recently formed by driving the tube nearby before the concrete has sufficiently set. The danger of doing harm is greater in compact soils than loose soils. No pile shall be bored or driven within 3 m of a newly cast pile until at least 24 hours after completion of its installation.

19.7.6.6 Driving piles in loose sand tends to compact the sand which in turn increases the skin friction. Therefore, driving a number of friction piles in a group shall proceed outward from the centre as otherwise it will be difficult to drive the inner piles to the same depth as the others. In the case of stiff clay also, the driving for a group of piles shall proceed outward from the centre. However, in case of very soft soil, the driving may proceed from outside to inside, so that the soil is restrained from flowing out during driving operations.

19.7.6.7 If there is a major variation between the depth at which adjacent foundation piles in a group meet refusal, a boring shall be made nearby to ascertain the cause of this difference. If the boring shows that the soil contains pockets of highly compressive material below the level of the shorter pile, it will be necessary to enforce penetration of all the piles to a level below the bottom of the zone which shows such pockets.

19.7.7 Pile Tests

a) The bearing capacity of a single pile may be determined from test loading a pile. The load test on a concrete pile may not be carried out earlier than 28 days from the time of casting of the pile. The methodology of carrying out load tests and of arriving at safe load on piles shall conform to IS 2911 (Part IV)

b) There shall be two categories of tests on piles, namely, initial tests and routine tests. Initial tests should be carried out on test piles which are not to be incorporated in the work. Routine tests shall be carried out as a check on working piles. The number of initial and routine tests on piles shall be as determined by the Engineer depending upon the number of foundations span length, type of superstructure and uncertainties of founding strata. In any case, the initial load tests shall not be less than 2 in number, while the routine load tests shall not be less than 2 per cent of the total number of piles in the structure and nor less than 2 in number.

c) The above stipulations hold good for both vertical as well as lateral load tests on pile foundations. However, both initial and

routine tests may be suitably increased for important structures or cases with large variation in the sub-surface strata.

d) In case of any doubt of workmanship or load carrying capacity of working piles not subjected to routine tests, or when ordered by the Engineer, or when provided in the Contract, load tests on working piles may be supplemented by non-destructive testing. Such tests may include "Integrity Testing" of concrete in the installed pile and utilisation of "Pile Driving Analyser" which gives an indication of pile capacity in end bearing and side friction.

19.7.8 IMPORTANT CONSIDERATIONS, INSPECTION / PRECAUTIONS Bored Cast-in-Situ Piles

i) While concreting uncased piles, voids in concrete shall be avoided and sufficient head of concrete shall be maintained to prevent inflow of soil or water into the concrete. It is also necessary to take precautions during concreting to minimise the softening of the soil by excess water. Uncased cast-in-situ piles shall not be permitted where mudflow conditions exist.

ii) The drilling mud such as bentonite suspension shall be maintained at a level sufficiently above the surrounding ground water level to ensure the stability of the strata which is being penetrated all through the boring operation and until the pile has been concreted.

iii) Where bentonite suspension is used to maintain the stability of the bore-hole, it is essential that the properties of the material be carefully controlled at stages of mixing, circulating through the bore-hole and immediately before concrete is placed. It is advisable to limit:

a) The density of bentonite suspension to 1.05 g/cc and maintain it.

b) The marsh cone viscosity between 30 and 40

c) The pH value between 9.5 and 12

d) The silt content less than 1 per cent

e) The liquid limit of bentonite not less than 400 per cent

These aspects shall act as controlling factors for preventing contamination of bentonite slurry by clay and silt.

iv) The bores shall be washed by bentonite flushing to ensure clean bottom at two stages viz. (a) after completion of boring and (b) prior to concreting after placing of reinforcement cage. Flushing of bentonite

shall be done continuously with fresh bentonite slurry till the consistency of inflowing and outflowing slurry is similar.

v) Tremie of 150mm to 200mm diameter shall be used for concreting. The tremie should have uniform and smooth cross-section inside, and shall be withdrawn slowly ensuring adequate height of concrete outside the tremie pipe at all stages of withdrawal. Other precautions to be taken while tremie concreting are:

a) The sides of the bore-hole have to be stable throughout

b) The tremie shall be water tight throughout its length and have a hopper attached at its head by a water tight connection.

c) The tremie pipe shall be large enough in relation to the size of aggregates. For 20mm aggregate the tremie pipe shall be of diameter not less than 150mm and for larger size aggregate tremie pipe of larger diameter is required.

d) The tremie pipe shall always be kept full of concrete and shall penetrate well into the concrete in the bore-hole with adequate margin of safety against accidental withdrawal if the pipe is surged to discharge the concrete.

e) For very long or large diameter piles, use of retarding plasticiser in concrete is desirable.

19.7.9 Tolerances for Installation of Piles

a) Permissible Tolerances for Pile

i) Bored Piles

a) Variation in cross-sectional dimensions : + 50mm, - 10mm

b) Variation from vertical or specified rake : 1 in 50

c) Variation in the final position of the head in plan : 50 mm

d) Variation of level of top of piles : ± 25 mm

ii) Permissible Tolerances for Pile Caps

a) Variation in dimensions : + 50mm – 10mm

b) Misplacement from specified position in plan : 15mm

c) Surface irregularities measured with 3m

straight edge : 5mm

d) Variation of levels at the top : ± 25 mm

19.7.10 Measurements for Payment

i) The Engineer shall decide on what depth of excavation is to be made and the level at which the top of pile is to be placed before driving or boring is started. Such excavation shall be paid for at rate specified for excavations for foundations. Rates applicable to driving / casting pile will be paid for the depth below that level only.

(For supply of precast concrete, timber or steel piles of specified cross section, the measurement shall be in metres of the length of piles ordered in writing by the Engineer measured from the head to the butt of the shoe or the tapered point.) Reinforcement in precast concrete piles shall be paid for separately unless otherwise specified in work contract.

vii) For driven cast-in-situ and bored concrete piles of specified cross-section, the measurement shall be the length in metres of the accepted pile that remains in the finished structure complete in place. Reinforcement in cast-in-situ driven and bored concrete piles shall be measured for payment as per RCC Chapter.

iii) Routine and Initial Pile Load Tests shall not be measured for payment, unless otherwise specified in the Contract schedule.

iv) For installation of the pile, i.e. by driving in the case of precast concrete, timber, steel and cast-in-situ driven piles, and by boring in the case of cast-in-situ bored piles the measurement shall be the length in metres that remains in the finished structure complete in place, limited to that shown on drawings or as ordered by the Engineer. No distinction shall be made for penetration through hard strata or rock and socketing into rock.

v) For steel liners / casing shown on the drawings to be permanently left in place, the measurement shall be by weight in tonnes (or in metre lengths of specified thickness as specified in the schedule) that remains in the finished structure complete in place, limited to that shown on drawings or ordered by the Engineer.

vi) For the pile cap, the quantity of concrete shall be measured in cubic metres while reinforcement in pile cap shall be measured in tonnes unless specified otherwise.

19.7.11 Rate

i) The contract unit rate for supplying precast concrete, timber or steel piles shall include cost of all labour, materials, tools and equipment, and other work involved in

making or fabricating the pile complete as shown on the drawing, and where required its loading, transport, delivery to site, unloading and stacking it at the place indicated by the Engineer. The cost of reinforcement in precast concrete piles shall be deemed to be included in the quoted rate for supply of piles, unless otherwise specified.

ii) The contract unit rate for cast-in-situ driven and bored piles shall include the cost of concrete and all other items as per Chapters 3 and 4. The contract unit rate shall also include costs of all labour, materials, equipments and all other incidentals involved in conducting routine and initial pile load tests including installation of piles for initial load tests.

iii) The contract unit rate for installation of piles shall include full compensation for furnishing all labour, materials, tools and equipment, and incidentals for doing all the works involved in driving timber, precast concrete and steel piles, driving or making bores for cast-in-situ driven and bored concrete piles, cutting off pile heads, all complete in place to the specified penetration of piles. Providing temporary liner / casing and its withdrawal and placing reinforcement in position shall also be deemed to be included in the rate for installation of piles and no additional payment shall be made for the same.

iv) The contract unit rate for permanent steel liners shall include cost of all labour, fabrication and placing the steel liner to the required depth as shown on the drawings and as ordered by the Engineer.

v) The contract unit rate for concrete in pile cap shall cover all costs of labour, materials, tools, plant and equipment, form work and staging including placing in position, sampling and testing and supervision, all as per provisions in Chapter 3. Reinforcement in the pile cap shall be paid for separately in accordance with Para 4.3.4.

19.8 WELL FOUNDATIONS**General**

19.8.1.1 In case of larger than 12m in diameter and for wells to be sunk by using special equipment, supplemental instructions / specifications will be necessary. For basic items of work such as Concrete (Plain or RCC) brick work, stone masonry etc which are incidental relevant chapters may be referred to.

19.8.1.2 To facilitate sinking of well, steel cutting edge is fabricated and connected to a concrete well curb of required shape. Minimum grade of concrete for well curb shall be M 20 unless other wise specified in Drawing or directed by Engineer. On top of the well curb, adequate height of well steining is cast and the process of sinking is carried out. After a portion of the well has been sunk, another height of well steining is cast on top of the previous section and further sinking carried out. This process is continued till the bottom level of the well reaches the founding level.

19.8.1.3 At the top of the well steining, an adequately designed "well cap" is laid which transmits the loads and forces from the sub-structure (piers or abutments) to the foundations.

19.8.1.4 The plan dimensions of sand islands, used for forming the well in water, shall be such as to have a working space of at least 2 metres all around the steining. The dimension of the sand islands shall however be not less than twice the dimension in plan of the well or caisson. Sand islands shall be maintained to perform their functions, until the well is sunk to a depth below the bed level at least equal to the depth of water. Sand island shall be protected against scour and the top level shall be sufficiently above the prevailing water level to be decided by the Engineer so that it is safe against waves and induced afflux. Island should be adequately protected against force of water current and wave action.

19.8.1.5 Where depth of water is more than 5 to 6 metres and in fast flowing water, caissons shall be used. Floating caissons are generally fabricated or cast near the banks on dry land or in dry docks. Floating caissons are towed into position in floating condition.

Floating caissons maybe of steel, reinforced concrete or a combination of the two.

19.8.2 Equipment for sinking wells

Equipment shall be deployed for construction of well foundation as required and as directed by the Engineer in quality, performance and quantity. Generally, the following equipments may be required for the work:

- a) Crane with grab buckets capacity 0.5 to 2.0 cum.
- b) Submersible pumps

c) Air compressors, air locks and other accessories where pneumatic sinking of well is anticipated.

d) Chisels of appropriate sizes

e) Aqua header for cutting rocky strata

f) Driving helmets and accessories

g) Concrete Mixer or Batching Plant; Pumps or skips and hoists; vibrators etc.

h) Pre arrangements for blasting equipment in case of unforeseen circumstances.

19.8.3 Well Steining

19.8.3.1 The dimensions, shape, concrete strength and reinforcement of the well steining shall strictly conform to those shown on the drawings. The form work shall preferably be of MS sheets shaped and stiffened suitably. In case timber forms are used, they shall be lined with plywood or M.S. sheets.

19.8.3.2 Steining built in the first lift above the well curb shall not be more than 2 metres high and in subsequent lifts it shall not exceed the diameter of the well or the depth of well sunk below the adjoining bed level at any time. For stability, the first lift of steining shall be cast only after sinking the curb at least partially for stability. Concreting of steining may be carried out in subsequent lifts of about 1.2, or 2 to 2.5 metres. Attempts should be made to minimise the number of construction joints. The concreting layers shall be limited to about 450 mm restricting the free fall of concrete to not more than 1.5m. Laitance formed at the top surface of a lift shall be removed to expose coarse aggregates before setting of concrete at the proposed construction joint. As far as possible, construction joints shall not be kept at the location of laps in the vertical steining bars.

19.8.3.3 The steining of the well shall be built in one straight line from bottom to top such that if the well is tilted, the next lift of steining will be aligned in the direction of the tilt. The work will be checked carefully with the aid of straight edges of lengths approved by the Engineer. Plumb bob or spirit level shall not be used for checking verticality alignment. After sinking of a stage is complete, damaged portions if any, of steining at top of the previous stage shall be properly repaired before constructing the next stage.

19.8.3.4 The height of steining shall be calibrated by making atleast 4 gauges (two in traffic direction and two in a direction normal

to traffic direction) distributed equally on the outer periphery of the well. Each gauge should be in the form of a 100mm wide strip painted on the well, with every metre mark shown in black paint and sub-mark at 10 cm intervals. The gauges shall start with zero at the bottom of the cutting edge. It will be in black or a white background. Marking of the gauges shall be done carefully with a steel tape. Cost of providing the gauges will be presumed to be included in the rate for sinking.

19.8.3.5 After reaching the founding level, the well steining shall be inspected to check for any damage or cracks. The Contractor shall execute the remedial measures as directed by the Engineer before acceptance of the well steining. In case the well cannot be accepted even with any remedial measures, then the well shall stand rejected.

19.8.3.6 Blasting may have to be resorted to in order to facilitate sinking through difficult strata, such as boulders and rocks etc. In case blasting is anticipated, protective / strengthening measures specified in clause 710.6 (IV) of IRC: 78 shall be taken. The grade of concrete and / or Bridge Sub-structure in bottom 3 metres of steining shall not be leaner than M 20 or as shown on the drawings.

19.8.3.7 In case the bore hole data shows the presence of steeply dipping rock, chiselling may have to be resorted to so as to obtain proper seating of the foundation. For this purpose, the well may require to be dewatered completely under high air pressure inside the well. This process is known as pneumatic sinking. Pneumatic sinking may also have to be resorted to in cases where obstacles such as tree trunks, large sized boulders or hard strata etc. cannot be removed by open dredging. The necessity of adopting pneumatic sinking shall be decided by the Engineer.

19.8.3.8 The curb and steining have to be specifically designed for special loadings when pneumatic sinking is adopted. Minimum grade of Concrete should, preferably be M 25.

19.8.3.9 The specifications given in this chapter deal only with such items of work as are peculiar to the construction of wells. For the basic items of work such as concrete (plain and reinforced), brickwork, stone masonry, earthwork, etc which are also incidental to the construction of wells, the relevant specifications as given in the respective chapters shall be followed.

19.8.4 Sinking Wells for Foundations

19.8.4.1 This specification pertains to the actual operation of sinking the well through various kinds of strata to the reduced level shown on the drawing, or to any other level as ordered by the Engineer, to enable it to be founded on a suitable foundation stratum.

19.8.4.2 Programme

The programme for sinking shall be so arranged that every well started during a working season is completed, plugged and sealed at top, and the pier or abutment over it built to a suitable height, within the same season, so as to be safe during the floods. In the event of the Contractor's failure to ensure this, any protective measure or other extra work involved in completing the unfinished portion in the next working season shall be done by the Contractor at his own cost.

19.8.4.3 Strata Variation

a) The Contractor may, at his own expense, make trial bores to ascertain the exact depth to which each well may have to be sunk. If any boring data are indicated by the Railway at the tender stage, these may be taken as a general guide only, and the Contractor shall not be entitled to any compensation on account of variations in the strata as actually met with during sinking.

b) The Contractor shall, during the course of the work, collect and hand over to the Engineer's representative samples of all the different strata passed through, including undisturbed samples, where so required by the Engineer. The cost of collection of these samples shall be included in the rate for sinking.

c) Unless otherwise stipulated, the sinking of wells through (a) Hard Rock, and (b) Soft rock & all soils shall be measured and paid for separately.

19.8.4.4 Level of commencement : Excavation and Island

(a) The sinking of the well shall start from a level not more than 30 cm. above the water level or the spring level (subsoil water level), as the case may be unless any higher level is specially approved by the Engineer, based on local conditions such as tidal or other anticipated variations in water level, stability of existing works etc. The water level, for the purpose of this para, shall be taken as on the date of laying the cutting edge for the well curb.

(b) Where the existing ground level is higher than the level of commencement as specified above, open excavation shall be carried out

to that level. Payment for such excavation shall be made as for ordinary cutting unless any special rate has been agreed upon. Notwithstanding the quantity of work actually done, the quantity payable shall be restricted to the actual area of the capping slab, multiplied by the average depth of excavation upto the level from which sinking starts as per sub-para (a) above.

(c) Where it is necessary to sink the well in water, an island shall be formed. The dimensions of the island shall be as approved by the Engineer, and its top finished to the level from which the sinking is to be commenced. The formation of the island shall be paid for separately at rates specially agreed upon, unless otherwise stipulated in the contract.

(d) If, for his own convenience, the Contractor commences sinking of a well from any level higher than that specified in sub-para (a) above, no payment shall be made to him for the extra depth of sinking resulting therefrom.

19.8.4.5 When the well curb is ready for sinking, it shall be "pitched" by careful removal of the blocking timbers on which the cutting edge was so long supported. The timbers shall be removed after loosening the sand around each, and the removal shall be so phased as to maintain equality of pressure and thereby avoid tilting of the curb.

19.8.4.6 After all the blocking timbers are removed, the soil from within the curb shall be excavated evenly over the whole internal area, excavating first in the centre and then working towards the circumference. In the case of double-D wells or twin octagonal wells, the excavation in both dredge holes shall progress simultaneously. The sinking shall be stopped when the top of the curb is about 15 cm above the ground, after which the building up of the initial lift (of say 1.5m height) of the steining shall be taken up.

19.8.4.7 Methods of Sinking:

All possible care shall be taken to ensure perfect verticality of sinking of the well curb and the first two lifts (or say 3m.) of the steining, since by doing so, the subsequent sinking to plumb becomes easier. The manner of sinking shall continue to be as followed for the well curb. The operation of sinking will, naturally, alternate with that of adding further lifts of steining, which may be done for two lifts in a sequence, except for the first two lifts which shall be done in two stages, with sinking done in between.

The maximum depth of excavation below the level of the bottom of cutting edge of the well at any stage shall not generally exceed the internal diameter of the well.

Where dewatering is resorted to and it gives rise, at any stage, to "blowing" of the surrounding soil into the bottom of the well, the dewatering shall be stopped forthwith and the water levels balanced to prevent further blowing, before attempting to remove the blown material from inside the well.

(b) In deep water, excavation shall be carried out with the use of grabs operated by winches, or preferably by cranes. Harder strata upto soft rock may be loosened by the use of heavy chisels, slung at a suitable angle. Removal of obstructions such as boulders and logs shall be done by employing divers.

(c) Small charges of approved explosive may be used, with the written permission of the Engineer in the following circumstances: (1) To blast through rock or to break boulders, which cannot be done by any alternative method; and (2) To effect sinking, especially in the final stages, when the usual formation of a sump at the bottom of the dredge hole does not result in sinking. In the latter case, the charge of explosive shall be placed at the centre of the dredge hole and exploded to set up a tremor which will serve to help sinking of the well. Any damage caused to the well or to adjoining structure by the use of explosives shall be made good by the Contractor at his own expense.

(d) Where a considerable depth of rock is to be pierced through, and dry sinking i.e. without much water except what can be pumped out is not possible, it will be necessary to resort to pneumatic sinking. This requires the use of proper air locks and ancillary equipment, with special precaution observed for safety and certain modifications to the structure of the well to fit the air locks. Sinking of wells by such method shall be a matter of special agreement and covered by special specifications.

(e) Where two or more separate wells in a group are to be sunk, and the clear distance between any two wells is less than the diameter of the well, such wells shall be sunk alternately, each not having a lead of more than half the diameter over the other at any stage.

19.8.4.8 Use of Kentledge as Sinking Load

Kentledge shall be placed in an orderly and safe manner on the loading platform and in such a way that it does not interfere with the

excavation of the material from inside the dredge hole and also does not in any way damage the steining of the well. Where tilts are present or there is a danger of well developing a tilt, the position of the kentledge load shall be regulated in such a manner as to provide greater sinking effort on the higher side of the well.

19.8.4.9 Use of Water Jetting

Water jetting, on the outside of the well may be employed for well sinking wherever necessary. Where stiff clayey strata is anticipated, small diameter water pipes are encased in the well with jet ends on periphery during casting of steining for this purpose.

19.8.4.10 Use of Explosives

Mild explosive charges may be used as an aid for sinking of the well only with prior permission of the Engineer. Blasting of any sort shall only be done in the presence of the Engineer and not before the concrete in the steining has hardened sufficiently and is more than 7 days old. When likelihood of blasting is predicted in advance, protection of the curb and the bottom portion of the well shall be done as per these specifications. After blasting operations are completed, the well curb and steining should be examined for any cracks and remedial measures taken.

a) The charges shall be exploded well below the cutting edge by making a sump so as to avoid chances of any damage to the curb or to the steining of the well. A minimum sump of 1 metre depth should be made before resorting to blasting. Use of large charges, 0.7 kg or above, may not be allowed except under expert direction and with the permission from the Engineer. Suitable pattern of charges may be arranged with delay detonators to reduce the number of charges fired at a time. The burden of the charge may be limited to 1 metre and the spacing of holes may normally be kept as 0.5 to 0.6 metre. All prevalent laws concerning handling, storing and using of explosives as per "Indian Explosives Act" shall be strictly followed.

b) All safety precautions shall be taken as per IS:4081 "Safety Code for Blasting and related Drilling Operations", to the extent applicable, whenever blasting is resorted to. There should be no equipment inside the well nor shall there be any labour in the close vicinity of the well at the time of exploding the charges.

c) If rock blasting is to be done for seating of the well, the damage caused by

flying debris should be minimised by covering blasting holes by rubber mats before blasting.

If blasting has been used after the well has reached the design foundation level, normally 24 hours shall be allowed to lapse before the bottom plug is laid.

19.8.4.11 Daily records of tilt and shift, with reference to the principal axes of the well, shall be maintained at the site, separately for each well, on the proforma prescribed by the Engineer. Tilts shall be measured along the two axis of the bridge and RL (Reduced Levels) of the marks painted on surface of steining shall be taken. For determination of shift, locations of the ends of the two diameters shall be precisely measured along the two axis, with respect to the fixed reference points. A pair of wells close to each other will have a tendency to come closer during sinking (Tilting towards each other). Timber struts may be introduced in between the steining of these walls to prevent tilting. Record shall also be kept of the daily water levels, commencing from the time of formation of islands or excavation of the site of the well, as the case may be. The Contractor shall further be responsible for maintaining a continuous record of the depth sunk in each working shift and of the types of strata passed through at the various depths, as well as any obstruction met with.

19.8.4.12 It shall be the Contractor's responsibility to sink the wells to the correct alignment, spacings and levels, based on the reference pillars and bench mark provided by the Railway. Unless otherwise specified the completed well shall not have a tilt of more than 1 in 80 in any direction or a shift of more than 5 per cent of the overall diameter or width of the well, as measured in either of the principal directions or 150mm in resultant direction, whichever is less. Where these tolerances are exceeded, the orders of the Engineer shall be sought. These tolerances shall be further subject to the condition that the stability of the foundation is not affected and that any modification thereby necessitated in the design of the substructure or superstructure shall be done at the cost of the Contractor.

Such acceptance shall be subject to

i) Calculations for foundation pressures and steining stresses after accounting for the tilt and shift and consequent relocation of superstructure on top being safe

ii) Remedial measures required for bringing stresses within permissible limits such as increasing dimension of well cap, providing

dummy weights on well cap as well as redesign of structure above shall be carried out by the Contractor at no extra cost to Railway and

iii) The Contractor shall agree to any reduction in rate for such defective work.

19.8.4.13 Tilt observed may, during the sinking, be corrected by one or more of the following methods, as approved by the Engineer:-

- 1) Loading kentledge eccentrically
- 2) Carrying excavation at the bottom of the well deeper on the side which is higher.
- 3) Providing heavy inclined struts bearing against the face of the well steining on the side towards which it leans.
- 4) Jetting to reduce skin friction on the higher side, on the well periphery.
- 5) Pulling or pushing the well by approved methods.

If the well is rejected, the Contractor will dismantle the defective well to the extent desired by the Engineer, at his cost. Further, the Contractor, at his risk and cost, will complete the bridge with modified span arrangements.

19.8.4.14 Seating of Well

When the well approaches the final depth of sinking, the exact height to which the last lift of steining is to be made up shall be decided before it is completed and sunk. When the well has reached the required level and stratum, it shall be properly seated by levelling, the area under the cutting edge. In the case of rock also, every effort shall be made to ensure even seating of the cutting edge, with the use of divers for cutting or benching the rock, as required. No extra payment shall be admissible for the bedding of wells in this manner. Any portion of the rock stratum where the cutting edge cannot be bedded shall be got cleared of the overlying material and filled subsequently with the concrete of the bottom plug.

On completion of the bedding of the well, the bottom of the dredge hole shall be got cleared of all spoil and left in a fit condition for laying of the bottom plug.

19.8.5 ISLANDS FOR WELL SINKING

19.8.5.1 Islands shall be formed where it is necessary to sink wells in water of reasonable depth. The dimensions, method of construction, top level and side-slopes, if any, shall be as specified or got approved by the Engineer, depending on the local conditions.

19.8.5.2 Construction of Island

The island shall be made up of sand, earth or other approved material, deposited in uniform layers. The material shall be free from clods, stones or other hard materials which may obstruct the sinking of the well or deviate it from the correct location or plumb.

Where the water is shallow, the filling may be done within a ring of sand bags laid all round for protection. Alternatively, side-slopes may be formed and protected by pitching of stones or sand bags.

Where the depth of water is such that the above methods are rendered unsuitable, two rows of piling, with bamboos or casuarina piles or any other material as approved by the Engineer, shall be driven all round. The piles shall be of such dimensions and driven to such spacings and depths as considered by the Engineer to be sufficient to withstand any possible scour and at the same time retain the earthfill of the island in a stable manner. Each row shall be lashed round with wire rope or bound together with horizontal bamboos or bullies at top. Two rows of bamboo matting shall be placed on the inside of the piling and the inter space filled up with earth. Alternatively, sand bags may be used for the filling. The inside space, i.e. within the inner row of piling, shall thereafter be filled up with the approved material for forming the island.

19.8.5.3 The island shall be maintained throughout the sinking operation and for any further period as may be necessary for completion of other items of the bridge work. If any of these works gets carried over to the next working season, the Contractor shall not be entitled for any compensation on account of repairs to damages caused to the island during the floods.

19.8.5.4 If so directed by the Engineer in writing, the Contractor shall remove the whole or part of the island when it is no longer required and / or when such removal is necessary to clear the obstruction to the water-way.

19.8.5.5 The rate for forming an island shall, unless otherwise stipulated, include the cost of its construction, its maintenance for the period of utility and its removal to the extent ordered in terms of sub para 4 above.

19.8.6 CUTTING EDGES FOR WELL CURBS

19.8.6.1 Unless otherwise specified, the cutting edges shall be fabricated out of new structural steel. The fabrication shall be done

strictly in accordance with the detailed drawings and shall conform to the specifications.

19.8.6.2 Before being taken to the site, the cutting edge shall be assembled on level ground and verified for the accuracy of its shape and size. If in sections, the individual sections shall be match marked before being dismantled.

At the place for laying, necessary reference points to site the well accurately shall be fixed in advance, based on the permanent reference pillars on either bank and the base line provided on either or both banks. The ground shall be prepared by leveling to an even surface at the level from which sinking of the well is to be commenced.

19.8.6.3 On the prepared bed the cutting edge shall be placed and positioned accurately with respect to the reference points fixed. It shall be supported evenly and to true level on a series of blocking timbers, spaced sufficiently close together to withstand and distribute to the soil below the full weight of the cutting edge plus the weight of shuttering and concrete, without any unequal settlement. Where the cutting edge is in sections, any welding or riveting required shall be done after the cutting edge

has thus been assembled to the correct lay out and level.

19.8.6.4 The rate for the cutting edge shall, unless otherwise specified, include the cost of supply, fabrication, transporting and placing the cutting edge as specified above, to its correct lay out and level including site joining by welding or bolting / riveting with cover/ fish plates.

19.8.7 WELL CURBS AND STEINING

19.8.7.1 The basic items of work shall conform to one or more of the following and relevant specifications as applicable:-

- Cement Concrete
- RCC

Concrete steining shall generally be cast in "lifts" not exceeding 2.0m in height, for the convenience of placing and consolidation without segregation. Sinking shall not be started till the depth of masonry or concrete to be sunk has set properly. In the case of concrete steining and RCC well curbs, the minimum periods as specified below shall be observed, unless any different period is prescribed by the Engineer, taking into account the local conditions or in the Contract.

<i>For well curbs</i>	<i>Minimum period</i>
(a) Removal of outer shuttering	12 hours
(b) Removal of inside shuttering	6 days
© Commencement of sinking	7 days
<i>For Steining</i>	
(a) Removal of outer or inside shuttering	6 hours
(b) Resumption of sinking	48 Hours

In any case, the sinking shall not commence until the work that has been added on has been passed by the Engineer's representative and the commencement of sinking approved.

19.8.7.2 Bond Bars, bond flats, bottle nuts etc which are built into the steining will be paid for separately, but no extra payment will be made for keeping these in the concrete or masonry work nor will any deduction be made for their volume from the total volume of the concrete or masonry unless specified otherwise.

specified mix, conforming to Specification for Cement Concrete

Where the bottom plugging is to be done under water, the special provisions of "Under Water Concreting" shall be observed carefully; and it shall further be ensured that the water inside the well has first been brought to a steady level, and there is no flow of water into the well.

b) Before the concrete is placed, the bottom of the well shall be inspected carefully and cleaned of any debris etc. The concreteing shall be done in such a manner as to ensure thorough and even filling to the desired level. In under-water work, divers shall be engaged for the purpose, as may be required.

19.8.8.2 After the concrete has set fully, water shall be pumped out completely or

19.8.8 PLUGGING AND FINISHING OF WELLS

19.8.8.1 Bottom Plug

a) The concrete used for the bottom and top plugs of foundation wells shall be of the

partially, as directed by the Engineer, to test whether the plugging has been satisfactory. If complete dewatering is done, any kentledge required to counteract buoyancy shall be provided before pumping out. In case appreciable leakage of water into the well is observed, the Contractor shall, at his own cost, arrange for its rectification by grouting etc.

19.8.8.3 Sand Filing

Sand filling shall commence after a period of 3 days of laying of bottom plug. Also, the height of the bottom plug shall be verified before starting sand filling.

Sand shall be clean and free from earth, clay clods, roots, boulders, shingles etc and shall be compacted as directed. Sand filling shall be carried out upto the level shown on the drawing, or as directed by the Engineer.

19.8.8.4 Top Plug

After filling sand upto the required level a plug of concrete of specified mix shall be

provided over it as shown on the drawing, or as directed by the Engineer.

19.8.8.5 Well Cap

.1 A reinforced cement concrete well cap will be provided over the top of the steining in accordance with the drawing. Form work will be prepared conforming to the shape of well cap. Concreting shall be carried out in dry condition.

.2 The bottom of the well cap shall be laid preferably as low as possible, taking into account the water level prevalent at the time of casting. Bond rods of steining shall be anchored into the well cap.

19.8.9 Tolerances

The permissible tilt and shift shall not exceed 1 (horizontal) in 80 (vertical) and the shift at the well base shall not be more than 150mm in any resultant direction or 5% of the overall diameter or width as measured in the principal directions, whichever is less.

For the well steining and well cap the permissible tolerances shall be as follows :

a) Variation in dimension	:	+ 50mm – 10mm
b) Misplacement from specified position in plan	:	15mm
c) Surface irregularities measured with 3m straight edge	:	5mm
d) Variation of levels at the top	:	± 25mm

19.8.10 Tests and Standards of Acceptance

The materials shall be tested in accordance with these Specifications and shall meet the prescribed criteria.

The work shall conform to these Specifications and shall meet the prescribed standards of acceptance.

19.8.11 Measurements for payment

All quantities shall be measured from the drawing, or as ordered by the Engineer, excepting those required to be provided by the Contractor at his cost.

a) The cutting edge shall be measured in tonnes based on the net weight of metal used in it, nearest to one kilogram. However no deduction for the holes drilled will be done.

b) The concrete in curb, well steining and well cap shall be measured in cubic metres separately for each item. The reinforcement shall be measured in tonnes and no deduction for the bottle nuts will be done.

c) The measurement for well sinking shall be made in running metres for different depths and in different types of strata (Hard

rock/ other rock & soils) unless otherwise specified in the Contract. The depth of sinking shall be measured from the Reduced level specified in the Contract. If no level has been specified in the Contract, sinking shall be measured from the low water level or from the level at which the cutting edge was laid whichever is higher.

d) The quantity of concrete in bottom and top plug shall be measured in cubic metres.

e) The quantity of sand filling shall be measured in cubic metres.

f) Pneumatic sinking, where required shall be paid as a separate item and shall be measured in cubic metres of material to be excavated unless otherwise specified in Contract.

19.8.12 Rate

i) The Contract unit rates of cutting edge shall cover all costs of labour, material, tools, plant and equipment, including placing in position, sampling and testing, and supervision, all as per respective Section of Structural Steel Work and as described in this Section.

ii) The Contract unit rates for concrete in curb, steining, bottom plug, top plug and well cap, shall cover all costs of labour, material, tools, plant and equipment, form work and staging including placing in position, sampling and testing, and supervision all as per respective Section of Reinforced Concrete and as described in this section.

iii) The Contract unit rates for reinforcement in curb, steining, and well cap shall cover all costs of labour, material, tools, plant and equipment, including bending to shape, placing in position, sampling, testing and supervision.

iv) The Contract unit rates for sand filling shall cover all costs of labour, material, tools, plant and equipment, including placing in position, sampling, testing and supervision, all as described in this section.

v) The unit rates for sinking shall cover the costs of labour, tools, and equipment and plant and for all operations and other

incidentals for sinking of well including seating excepting provisions of pneumatic sinking as described in this Section. The unit rates shall specify the strata such as types of soil, rock, etc. The rates shall cover all testing, correction of tilt and shift to be within the tolerances and supervision required for the work.

vi) The Contract unit rate of material to be excavated by pneumatic sinking shall cover all costs of labour, material, tools, plant and other equipment and other incidentals and safety provisions and supervision required for pneumatic sinking as per this Section.

vii) Reduction in contract unit rates for sinking as a penalty, in pursuance of Para 19.8.4.13 will be as stated below, unless otherwise specified in contract.

If any well with tilt and / or shift exceeding beyond permissible values is accepted by the Engineer, the Contractor shall give a reduction in the rates as follows:

SL	Amount of tilt and / or shift	Per cent deduction on the rate (s) for sinking of whole well
1	Tilt exceeding the specified permissible value but equal to or within 1 in 60	10 per cent
2	Tilt exceeding 1 in 60 but equal to or within 1 in 50	15 per cent
3	Shift exceeding the specified permissible value but equal to or within 200mm	5 per cent
4	Shift exceeding 200mm but equal to or within 300 mm	10 per cent

Penalties for excessive tilt and shift shall be deducted separately.

19.9 SUB STRUCTURE - The term substructure covers

- a) Piers
- b) Abutments and
- c) Wing walls
- d) Bed Blocks
- e) Ballast retainers or dirt walls
- f) Arches which form integral part of the pier / abutment in Arch bridges and
- g) Face walls or spandrels of Arches.

They can be made of

- i) Brick Masonry
- ii) Stone Masonry
- iii) Plain Concrete or Reinforced Concrete

Some special requirements as provision of temperature or nominal reinforcements with respect to form work are covered in this chapter. Brick work and stone work

specification covered in relevant chapters are applicable.

19.10 FORM WORK

19.10.1 General

This section covers requirement of form work for bridge foundations, sub structure and superstructures. Form work as per **IS-3696**, **IS-4014** shall include all temporary or permanent forms required for forming the concrete of the shape, dimensions and surface finish as shown on the drawing or as directed by the Engineer, together with all props, staging, centering, scaffolding and temporary construction required for their support.

19.10.2 Material and Design

The Contractor shall furnish the design and drawing of complete form work (i.e. the forms as well as their supports) for approval of the Engineer before any erection is taken up.

Materials used for form work will be steel or timber. All bolts shall be counter sunk. Approved internal steel ties, struts and plastic spacers may be used if approved. Steel plate shall be of adequate thickness and thickness of walls of steel tubes used for supporting shall be at least 4mm. If proprietary system of form work is used, the Contractor shall furnish detailed information to the Engineer for approval.

Notwithstanding any approval or review of drawing and design by the Engineer, the Contractor shall be entirely responsible for the adequacy and safety of form work.

The design of the form work shall be such that it shall ensure that the forms can be conveniently removed without disturbing the concrete. The design shall facilitate proper and safe access to all parts of form work for inspection. In the case of prestressed concrete superstructure, careful consideration shall be given to redistribution of loads on props due to prestressing.

19.10.3 Workmanship

i) The form work shall be robust and strong and the joints shall be leak-proof. Balli shall not be used as staging. Staging must have cross bracings and diagonal bracings in both directions. Staging shall be provided with an appropriately designed base plate resting on firm strata. Approved steel or trestles or cribs or standard pipe scaffolding shall be used.

ii) The number of joints in the form work shall be kept to a minimum by using large size panels. The design shall provide for proper "soldiers" to facilitate alignment. All joints shall be leak proof and must be properly sealed. Use of PVC Joint sealing tapes, foam rubber or PVC T-Section is essential to prevent leakage of grout.

As far as practicable, clamps shall be used to hold the forms together. Where use of nails is unavoidable, minimum number of nails shall be used and these shall be left projecting so that they can be withdrawn easily.

iii) Use of ties shall be restricted, as far as practicable. Wherever ties are used they shall be used with HDPE sheathing so that the ties can easily be removed. No parts prone to corrosion shall be left projecting or near the surface. The sheathing holes if permitted shall be grouted with cement mortar of the same strength as that of the structure.

Unless otherwise specified, or directed, chamfers or fillets of sizes 25mm x 25mm

shall be provided at all angles of the form work to avoid sharp corners. The chamfers, bevelled edges and mouldings shall be made in the form work itself. Opening for fixtures and other fittings shall be provided in the shuttering as directed by the Engineer.

Shuttering for walls, sloping members and thin sections of considerable height shall be provided with temporary openings to permit inspection and cleaning out before placing of concrete.

iv) The form work shall be constructed with precamber to the soffit to allow for deflection of the form work. Pre-camber to allow for deflection of form work shall be in addition to that indicated for the permanent structure in the drawings.

Where metal forms are used, all bolts and rivets shall be countersunk and well ground to provide a smooth, plane surface. Where timber is used it shall be well seasoned, free from loose knots, projecting nails, splits or other defects that may mar the surface of concrete.

v) Forms shall be made sufficiently rigid by the use of ties and bracings to prevent any displacement or sagging between supports. They shall be strong enough to withstand all pressure, ramming and vibration during and after placing the concrete. Screw jacks or hard wood wedges where required shall be provided to make up any settlement in the form work either before or during the placing of concrete.

vi) Where centering trusses or launching trusses are adopted for casting of superstructure, the joints of the centering trusses, whether welded, rivetted or bolted should be thoroughly checked periodically. Also, various members of the centering trusses should be periodically examined for proper alignment and unintended deformation before proceeding with the concreting. They shall also be periodically checked for any deterioration in quality due to steel corrosion.

vii) The formwork shall take due account of the calculated amount of positive or negative camber so as to ensure the correct final shape of the structures, having regard to the deformation of false work, scaffolding or propping and the instantaneous or deferred deformation due to various causes affecting prestressed structures. Suitable camber shall be provided to horizontal members of structure, specially in long spans to counteract the effects of deflection. The form work shall be so fixed as to provide for such camber.

viii) The form work shall be coated with an approved release agent that will effectively prevent sticking and will not stain the concrete surface. Lubricating (machine oils) shall be prohibited for use as coating. The inside surfaces of forms shall, except in the case of permanent form work or where otherwise agreed to by the Engineer be coated with a release agent supplied by approved manufacturer or of an approved material to prevent adhesion of concrete to the form work. Release agents shall be applied strictly in accordance with the manufacturer's instructions and shall not be allowed to come into contact with any reinforcement or prestressing tendons and anchorages. Different release agents shall not be used in form work for exposed concrete.

19.10.4 Formed Surface and Finish

The form work shall be lined with material approved by the Engineer so as to provide a smooth finish of uniform texture and appearance. This material shall leave no stain on the concrete and so fixed to its backing as not to impart any blemishes. It shall be of the same type and obtained from only one source throughout for the construction of any one structure. The contractor shall make good any imperfections in the resulting finish as required by the Engineer. Internal ties and embedded metal parts shall be carefully detailed and their use shall be subject to the approval of the Engineer.

19.10.4.1 Precautions in Bridge Works

i) Special measures in the design of form work shall be taken to ensure that it does not hinder the shrinkage of concrete. The soffit of the form work shall be so designed as to ensure that the formwork does not restrain the shortening and / or hogging of beams during prestressing. The forms may be removed at the earliest opportunity

a) Walls, piers, abutments, columns and vertical faces of structural members	:	12 to 48 hours as may be decided by the Engineer
b) Soffits of Slabs (with props left under)	:	3 days
c) Props (left under slabs)	:	14 days
d) Soffit of Girders (with props left under)	:	7 days
e) Props (left under girders)	:	21 days

iii) Where there are re-entrant angles in the concrete sections, the form work should be removed at these sections as soon as possible after the concrete has set, in order to avoid cracking due to shrinkage of concrete.

subject to the minimum time for removal of forms with props retained in position.

ii) Where necessary, form work shall be so arranged that the soffit form, properly supported on props only can be retained in position for such period as may be required by maturing conditions of concrete.

iii) Any cut-outs or openings provided in any structural member to facilitate erection of form work shall be closed with the same grade of concrete as the adjoining structure immediately after removal of form work ensuring water tight joints.

iv) Provision shall be made for safe access on, to and about the form work at the levels as required.

v) Close watch shall be maintained to check for settlement of form work during concreting. Any settlement of form work during concreting shall be promptly rectified.

vi) Water used for curing should not be allowed to stagnate near the base plates supporting the staging and should be properly drained.

19.10.5 Removal of Form work for Reuse

i) The scheme for removal of form work (i.e. de-shuttering and decentering) shall be planned in advance and furnished to the Engineer for scrutiny and approval. The form work shall be so removed as not to cause any damage to concrete. Centering shall be gradually and uniformly lowered in such a manner as to permit the concrete to take stresses due to its own weight uniformly and gradually and any shock or vibration to structure is avoided.

ii) Where not specifically approved, the time of removal of form work (when ordinary Portland Cement is used without any admixtures at an ambient temperatures exceeding 10 degrees Celsius) shall be as under :

iv) When form work is dismantled, its individual components shall be examined for damage and damaged pieces shall be removed for rectification. Such examination and rectification shall always be carried out before being used again. Before re-use all components shall be cleaned of deposits of

soil, concrete or other unwanted materials. Threaded parts shall be oiled after cleaning. All bent steel props shall be straightened before re-use. The maximum deviation from straightness is $1/600$ of the length. The maximum permissible axial loads in used props shall be suitably reduced depending upon their condition. The condition of the timber components, plywood and steel shuttering plates shall be examined closely for distortion and defects before re-use.

19.10.6 Re-use of Form work:

Before re-use of forms, the following actions shall be taken:

- i) The contact surfaces of the forms shall be cleaned carefully thoroughly and dried before applying a release agent.
- ii) It should be ensured that the release agent is appropriate to the surface to be coated. The same type and make of release agent shall be used throughout on similar form work materials and different types should not be mixed.
- iii) The form surfaces shall be evenly and thinly coated with release agent. The vertical surface shall be treated before horizontal surface and any excess wiped out.
- iv) The release agent shall not come in contact with reinforcement or the hardened concrete. All forms shall be thoroughly cleaned immediately before concreting.

19.10.6.1 Specialized Form work

a) Specialised form work may be required in the case of slipform work, underwater concreting, segmental construction etc. Such specialised form work shall be designed and detailed by competent agencies and a set of complete working drawings and installation instructions shall be supplied to the Engineer. The site personnel shall be trained in the erection and dismantling as well as operation of such specialised form work. In case proprietary equipment is used, the supplier shall supply drawings, details, installation instructions etc in the form of manuals along with the form work. Where specialized form work is used, close coordination with the design of permanent structure is necessary.

19.11 SUB STRUCTURE

19.11.1 Piers and Abutments

a) Masonry, form work, concrete and reinforcement for piers and abutments shall conform to relevant sections of these specifications and drawings. In case of concrete piers, minimum grade will be M 20

unless otherwise specified / approved. The number of horizontal construction joints shall be kept to minimum. Construction joints shall be avoided in splash zones unless specifically permitted by the Engineer and provided they are treated in accordance with special provisions. No vertical construction joint shall be provided. Shear connectors in the form of vertical plumbs, dowels, bond bars or rail cut pieces shall be provided at all horizontal joints as directed by Engineer. The work shall conform strictly to the drawings or as directed by the Engineer.

b) In case of tall piers and abutments, use of slipform shall be preferred. The design, erection and raising of slip form shall be subject to special specifications which will be furnished by the Contractor. The concrete shall also be of higher grade and subject to additional specifications as necessary. All specifications and arrangements shall be subject to the approval of the Engineer.

c) The surface of foundation / well cap / pile cap shall be scraped with wire brush and all loose materials removed. In case reinforcing bars projecting from foundations are coated with cement slurry, the same shall be removed by tapping, hammering or wire brushing. Care shall be taken to remove all loose materials around reinforcements. Just before commencing masonry or concrete work, the surface shall be thoroughly wetted.

d) In case of solid (non-spill through type) abutments, weep holes as shown on the drawings or as directed by the Engineer, shall be provided.

e) The surface finish shall be smooth, except the earth face of abutments which shall be rough finished or left as form finished.

f) In case of abutments likely to experience considerable movement on account of backfill of approaches and settlement of foundations, the construction of the abutment shall be followed by filling up of embankment in layers simultaneously with filter backing behind to the full height to allow for the anticipated movement during construction period before casting of superstructure.

19.11.2 Pier Cap and Abutment Cap (Bed Blocks)

a) Form work, Concrete and reinforcement shall conform to relevant paras of Chapters 3 and 4 of these specifications and the Drawings. Unless otherwise specified, minimum grade of concrete mix shall be M 25.

b) The locations and levels of pier cap / abutment cap / pedestals and bolts for fixing bearings shall be checked carefully to ensure alignment in accordance with the drawings of the bridge.

c) The surface of cap shall be finished smooth and shall have a slope for draining of water as shown on the drawings or as directed by the Engineer. For short span slab bridges with continuous support on pier caps, the surface shall be cast horizontal. The top surface of the pedestal on which bearings are to be placed shall also be cast horizontal.

d) The surface on which elastomeric bearings are to be placed shall be wood float finished to a level plane which shall not vary more than 1.5mm from straight edge placed in any direction across the area. The surface on which other bearings (steel bearings, pot bearings) are to be placed shall be cast about 25mm below the bottom level of bearings and as indicated on the drawings. Specified rich levelling mortar shall be provided over this at the time of placing of bearing.

19.11.3 Dirt / Ballast Wall, Return Wall and Wing wall

Dirt and ballast walls shall be in RCC. Minimum grade of concrete will be M25 unless otherwise specified. Return walls and wing walls can be of masonry (brick or stone), concrete or in RCC, as specified in drawings. Minimum grade of concrete for them will be M20 unless otherwise specified.

i) Brick Work Stone:- Masonry, concrete and reinforcement shall conform to relevant chapters of these specifications and Drawings.

ii) In case of cantilever return walls, no construction joint shall generally be permitted. Wherever feasible, the concreting in cantilever return walls shall be carried out in continuation of the ballast wall.

iii) For gravity type masonry and concrete return and wing wall, the surface of foundation shall be prepared in the same manner as prescribed for construction of abutment. No horizontal construction joint shall be provided. If shown on drawing or directed by the Engineer, vertical construction joint may be provided. Vertical expansion gap of 20mm shall be provided in return wall / wing wall at every 10 metre intervals or as directed by the Engineer. Weep holes shall be provided as prescribed for abutments or as shown on the drawings.

iv) Form work, reinforcement and concrete in dirt / ballast wall shall conform to relevant sections of these specifications.

v) The finish of the surface on the earth side shall be rough/form finish while the front face shall be smooth finished.

vi) Architectural coping for wing wall / return wall in brick masonry shall conform to Drawings.

19.11.4 Tests and Standards of Acceptance

The materials shall be tested in accordance with these specifications and shall meet the prescribed criteria.

The work shall conform to these specifications and shall meet the prescribed standards of acceptance.

19.11.5 Tolerances in Concrete elements

a)	Variation in cross-sectional dimensions	:	+ 10mm, -5mm
b)	Misplacement from specified position in plan	:	10mm
c)	Variation of levels at the top	:	± 10 mm
d)	Variations of reduced levels of bearing areas	:	± 5 mm
e)	Variations from plumb over full height	:	± 10 mm
f)	Surface irregularities measured with 3m straight edge		All surfaces except bearing areas : 5mm Bearing areas : 3 mm

19.11.6 Measurements

Reference is drawn to Para 19.6.10

19.11.7 Rates

Reference is drawn to Para 19.6.11.

Chapter 20

Bridge Work : Superstructure-Concrete

20.1 GENERAL

20.1.1 Coverage

This chapter covers specifications for Reinforced Concrete and Prestressed Concrete superstructure of bridges. Bridge superstructure work in form of

- i) Slabs –both RCC and PSC
- ii) RCC Beams and Slabs
- iii) Prestressed concrete girders and slabs

20.1.2 The girders and slabs may be cast-in-situ or precast in units, transported and erected. The precast elements may be in complete units; individual girders or of girders-in segments. Deck slab will be cast in situ in case of I or T section girders.

20.1.3 Codes and Specifications to cover

20.1.3.1 The provisions in codes listed in these specifications and specifications accompanying the contract documents so far as they are applicable to superstructure shall be strictly followed.

20.1.3.2 Contractor shall study the general arrangement drawings (GADs) and other detailed drawings accompanying contract documents and point out any discrepancies, short comings and contradictions and shall have them clarified and reconciled before start of the work. Any delay caused due to contractor seeking such clarification during progress of work will be considered to contractor's account.

20.1.3.3. Contractor will be responsible for preparation of further detailing and preparation of bar bending schedules.

20.1.4 Methodology Statement

20.1.4.1 Contractor will submit a 'methodology statement' if not already included in the bid offer at tendering stage itself and have it approved by the Engineer at start of work. This statement shall include:

- i) Sequencing of work, vis-à-vis the substructure work
- ii) PERT chart to fit in with overall duration within targeted completion date
- iii) Requirement and arrangements proposed in base depot / precasting yard including form work designs and details.
- iv) Scheme for transport of precast elements.

v) Girder erection scheme including prestressing, grouting, alignment etc.

vi) Scheme for providing accessories / appurtenances.

20.1.4.2 Before commencement of work, Contractors will discuss with Engineer and finalise the details listed above. If any changes in the scheme are called for, the Contractor will promptly bring such necessity to notice of Engineers and give his proposals in writing. They will be discussed and finalised in a workmanlike manner. Any delay and cost involved will be to contractor's account unless such change has been called for due to any major change in design or scope of the work or change of policy of Government.

20.1.4.3 Nothing extra is payable for preparation and finalisation of the Methodology / Methods Statement.

20.2 FORM WORK

20.2.1 General Requirement

Form work shall include all temporary or permanent forms required for forming the concrete of the shape, dimensions and surface finish as shown on the drawing or as directed by the Engineer, together with all props, staging, centering, scaffolding and temporary construction required for their support. Unless otherwise specified in contract documents or by the Engineer, the design, erection and removal of form work shall conform to IRC 87 "Guidelines for Design and Erection of False work for Road Bridges" and these specifications.

20.2.2 Materials

Forms shall be constructed with metal or timber. The metal used for forms shall be of such thickness that the forms remain true to shape. All bolts should be countersunk. The use of approved internal steel ties or steel or plastic spacers shall be permitted. Structural steel tubes used as support for forms shall have a minimum wall thickness of 4mm. Other materials conforming to the requirements of IRC 87, or other proven standard products may also be used if approved by the Engineer.

20.2.3 Precamber and Rigidity

20.2.3.1 The form work shall be constructed with precamber to the soffit to allow for

settlement / deflection of the form work. Pre-camber to allow for deflection of form work shall be in addition to that indicated for the permanent structure in the drawings.

20.2.3.2 Where centering trusses or launching trusses are adopted for casting of superstructure, the joints of the centering trusses, whether welded, riveted or bolted should be thoroughly checked periodically. Also, various members of the centering trusses should be periodically examined for proper alignment and levels and unintended deformation before proceeding with the concreting. They shall also be periodically checked for any deterioration in quality due to steel corrosion, loose joints, damaged individual members etc.

20.2.3.3 The form work shall be so made as to produce a finished concrete true to shape, line and levels and dimensions as shown on the drawings, subject to the tolerances specified in respective sections of these specifications, or as directed by the Engineer.

20.2.3.4 Forms shall be made sufficiently rigid by the use of ties and bracings to prevent any displacement or sagging between supports. They shall be strong enough to withstand all pressure, ramming and vibration during and after placing the concrete. Screw jacks or hard wood wedges where required shall be provided to make up for any settlement in the form work either before or during the placing of concrete

20.2.3.5 Unless otherwise specified fillets of size 25mm x 25mm shall be provided at sharp corners. Where ties are used, they shall be used with HDPE sheathing, for ease of removal after concreting. Sheathing shall be grouted with cement mortar of same strength as precast concrete.

20.2.4 Preparation of Form work before Concreting

20.2.4.1 The inside surfaces of forms shall, except in the case of permanent form work or where otherwise agreed to by the Engineer be coated with a release agent supplied by approved manufacturer or of an approved material to prevent adhesion of concrete to the form work. Release agents shall be applied strictly in accordance with the manufacturer's instructions and shall not be allowed to come into contact with any reinforcement or prestressing tendons and anchorages. Different release agents shall not be used in form work for exposed concrete.

20.2.4.2 All forms shall be thoroughly cleaned immediately before concreting.

20.2.4.3 The Contractor shall give the Engineer due notice before placing any concrete in the forms to permit him to inspect and approve the form work, but such inspection shall not relieve the contractor of his responsibility for safety of form work, men, machinery, materials and finish or tolerances of concrete.

20.2.4.4 Where not specifically mentioned otherwise, the time of removal of form work (when ordinary Portland Cement is used without any admixtures at an ambient temperatures exceeding 10 degrees Celsius) shall be as given in Para 19.10.5.

20.2.4.5 In order to verify the time and sequence of striking / removal of specialised form work, routine field tests for the consistency of concrete and strength development are mandatory and shall be carried out before adoption.

20.2.5 Measurements and Rate

(a) Measurements

i) The rate for concrete in Plain Concrete or Reinforced Concrete or Prestressed Concrete shall exclude all form work required in accordance with this section and formwork shall be measured and paid separately.

ii) Measurement of form work shall be taken in square metres of the surface area of concrete which is in contact with form work. For this, linear measurement shall be made covered to nearest cm and area computed to 0.01 sqm.

b) Rate

i) The unit rate of the Plain Concrete or Reinforced Concrete or Prestressed Concrete as defined in respective sections shall be deemed to cover the costs of all materials, labour, tools and plant required for design, construction and supervision as described in this section including properly supporting the members until the concrete is cured, set and hardened as required except form work.

ii) unit rate for form work shall include the cost of all materials, labour, tools and plant required for design, construction and removal of form work and supervision as described in this Section including properly supporting the members until the concrete is cured, set and hardened as required.

20.3 CONCRETE SUPERSTRUCTURE

FOR

20.3.1 General: Concrete used in any of the bridge structures will conform to the provisions made in Chapters 3 and 4, supplemented and / or modified to the extent the following clauses cover.

20.3.2 Basic Requirements: (i) Unless otherwise specified, minimum grades of concrete to be used for superstructure are as given in Table 20.1(a) below or as shown in the drawings.

Table 20.1 (a) Minimum Grade of Concrete

Type of Work	Moderate Exposure	Severe Exposure
RCC Boxes and RCC cast in situ slabs	M 20	M 25
RCC precast slabs	M 25	M 30
RCC T-beam and slab	M 35	M 40
PSC slabs / girders	M 40	M 45

Minimum Cement content and maximum Water -Cement ratio will be as given in Tables 20.1(b) and 20.1(c) below.

Table 20.1 (b) Minimum Cement Concrete and Water Cement Ratio

Type of Work	Minimum Cement kg/cum	Exposure Condition W/c Ratio	
		Normal	Severe
Major Works			
PCC members	360	0.45	0.45
RCC members	400	0.45	0.40
PSC members	400	0.45	0.40

Table 20.1 (c) For minor works upto 30m span girders given

Type of work	Minimum Cement kg/cum	Exposure Condition W/c Ratio	
		Normal	Severe
PCC members	250 to 310	0.50	0.45
RCC members	310 to 400	0.45	0.40

For concrete in very severe and extreme exposure conditions, provisions in Tables 3.12 and 3.13 of Chapter 3 may be referred to. For underwater concreting 10% extra cement will be added.

ii) Requirements of Consistency

The mix shall have the consistency which will allow proper placement and consolidation in the required position. Every attempt shall be made to obtain uniform consistency.

The optimum consistency for various types of structures shall be as indicated in Table 20.2 or as directed by the Engineer. The slump of concrete shall be checked as per IS:516.

Table 20.2 Slump Required for Workability

	Type	Slump (mm)
1	(a) Structures with exposed inclined surface requiring low slump concrete to allow proper compaction	25
	(b) Plain Cement Concrete	25

2	RCC structures with widely spaced reinforcements; e.g. solid columns, piers, abutments, footings, well steining	40-50
3	RCC structures with fair degree of congestion of reinforcement; e.g. pier and abutment caps, box culverts well curb, well cap, walls with thickness greater than 300mm	50-75
4	RCC and PSC structures with highly congested reinforcements e.g. deck slab girders, box girders, walls with thickness less than 300mm	75-125
5	Underwater concreting through tremie e.g. bottom plug, cast-in-situ piling	100-200

iii) Additional Requirements

Concrete shall meet with any other requirements as specified on the drawing or as directed by the Engineer. Additional requirements shall also consist of the following overall limits of deleterious substances in concrete:

- a) The total chloride content of all constituents of concrete as a percentage of mass of cement in mix shall be limited to values given below:
 - Prestressed Concrete : 0.1 per cent
 - Reinforced concrete exposed to chloride in service : 0.2 per cent
(e.g. structures located near sea coast)
 - Other reinforced concrete construction : 0.3 per cent
- b) The total sulphuric anhydride (SO_2) content of all the constituents of concrete as a percentage of mass of cement in the mix shall be limited to 4 per cent.

20.3.3 Admixtures

Use of admixtures such as superplasticisers for concrete may be made with the approval of the Engineer. As the selection of an appropriate concrete admixture is an integral part of the mix design, the manufacturers shall recommend the use of any one of his products only after obtaining complete knowledge of all the actual constituents of concrete as well as methodologies of manufacture, transportation and compaction of concrete proposed to be used in the project.

Manufacturer should provide satisfactory evidence that such admixtures do not have adverse affect the properties of concrete or mortar particularly with respect to strength, volume change, durability and has no deleterious effect on the reinforcement. Admixtures used should conform to provisions of IS: 9103.

Calcium chloride or admixtures containing calcium chloride shall not be used in structural concrete containing reinforcement, prestressing tendon or other embedded metal. Also admixtures containing Cl and SO_3 ions or nitrates shall not be used. Admixtures based on thiocyanate can promote corrosion and hence are prohibited.

20.3.4 Size of Coarse Aggregate

The size (maximum nominal) of coarse aggregates for concrete to be used in various components of bridges shall be given as Table 20.3.

TABLE 20.3 Coarse Aggregate Size

	Components	Maximum Nominal Size of Coarse Aggregate (mm)
i)	RCC well curb	20
ii)	RCC/ PCC well steining	40
iii)	Well cap or Pile Cap Solid type piers and abutments	40
iv)	RCC work in girders, slabs, wearing coat, kerb, approach slab, hollow piers and abutments, pier / abutment caps, piles	20
v)	PSC work	20
vi)	Any other item	As specified by Engineer

Maximum nominal size of aggregates shall also be restricted to the smaller of the following values:

- a) 10mm less than the minimum lateral clear distance between main reinforcements
- b) 10mm less than the minimum clear cover to the reinforcements

The proportions of the various individual size of aggregates shall be so adjusted that the grading produces densest mix and the grading curve corresponds to the maximum nominal size adopted for the concrete mix.

20.3.5 Equipment

Unless specified otherwise, equipment for production, transportation and compaction of concrete shall be as under :

a) For Production of Concrete:

- i) For overall bridge length of less than 200 metres – batch type concrete mixer diesel or electric operated, with a minimum size of 200 litres, automatic water measuring system and integral weigher (hydraulic / pneumatic type)
- ii) For overall bridge length of 200 metres or more – concrete batching and mixing plant fully automatic with minimum capacity of 15 cum. per hour.

All measuring devices of the equipment shall be maintained in a clean and serviceable condition. Its accuracy shall be checked over the range in use, when set up at each site and thereafter periodically as directed by the Engineer.

The accuracy of the measuring devices shall fall within the following limits:

Measurement of Cement	± 3 per cent of the quantity of cement in each batch
Measurement of Water	± 3 per cent of the quantity of water in each batch
Measurement of Aggregate	± 3 per cent of the quantity of aggregate in each batch
Measurement of Admixture	± 3 per cent of the quantity of admixture in each batch

- b) For Concrete Transportation : depending upon actual requirement
- i) Concrete dumpers minimum 2 tonnes capacity
 - ii) powered hoists minimum 0.5 tonne capacity
 - iii) chutes
 - iv) buckets handled by cranes
 - v) transit truck mixer
 - vi) concrete pump
 - vii) concrete distributor booms
 - viii) belt conveyor
 - ix) cranes with skips
 - x) remies
- c) For Compaction of Concrete:
- i) internal vibrators size 25mm to 70mm
 - ii) form vibrators minimum 500 watts
 - iii) screed vibrators full width of carriage way (upto two lanes)

20.3.6 Transporting, Placing and Compaction

i) The method of transporting and placing concrete shall be approved by the Engineer. Concrete shall be transported and placed as near as practicable to its final position, so that no contamination, segregation or loss of its constituent materials takes place. Concrete shall not be freely dropped into place from a height exceeding 1.5 metres.

ii) When concrete is conveyed by chute, the plant shall be of such size and design as to ensure practically continuous flow. Slope of the chute shall be so adjusted that the concrete flows without the use of excessive quantity of water and without any segregation of its ingredients. The delivery end of the chute shall be as close as possible to the point of deposit. The chute shall be thoroughly flushed with water before and after each working period and the water

used for this purpose shall be discharged outside the form work.

iii) All form work and reinforcement contained in it shall be cleaned and made free from standing water, dust, snow or ice immediately before placing of concrete.

iv) No concrete shall be placed in any part of the structure until the approval of the Engineer has been obtained.

v) If concreting is not started within 24 hours of the approval being given, it shall have to be obtained again from the Engineer. Concreting then shall proceed continuously over the area between the construction joints. Fresh concrete shall not be placed against concrete which has been in position for more than 30 minutes unless a proper construction joint is formed.

vi) Except where otherwise agreed to by the Engineer, concrete shall be deposited in horizontal layers to a compacted depth of not more than 450mm when internal vibrators are used and not exceeding 300mm in all other cases.

vii) Concrete when deposited shall have a temperature of not less than 5 degrees Celsius, and not more than 40 degrees Celsius. It shall be compacted in its final position within 30 minutes of its discharge from the mixer, unless carried in properly designed agitators, operating continuously. It may be necessary to add retarding admixtures to concrete if trials show that the periods indicated above are unacceptable. In all such matters, the Engineer's decision shall be final.

viii) Concrete shall be thoroughly compacted by vibration, or other means approved by Engineer, during placing and worked around the reinforcement, tendons or duct formers, embedded fixtures and into corners of the form work to produce a dense homogeneous void-free mass having the required surface finish. When vibrators are used, vibration shall be done continuously during the placing of each batch of concrete until the expulsion of air has practically ceased and in a manner that does not promote segregation. Over vibration shall be avoided to minimise the risk of forming a weak surface layer. When external vibrators are used, the design of form work and disposition of vibrator shall be such as to ensure efficient compaction and to avoid surface blemishes. Vibrators shall not be applied through reinforcement and where vibrators of immersion type are used, contact with reinforcement and all inserts like ducts etc., shall be avoided. The internal vibrators shall be inserted in an orderly manner and

the distance between insertions should be about one and a half times the radius of the area visibly affected by vibration. Additional vibrators in serviceable condition shall be kept at site so that they can be used in the event of breakdowns.

ix) Mechanical vibrators used shall comply with requirement of IS: 2502, IS:2505, IS 2514 and IS:4656.

20.3.7 Construction Joints

Construction Joints shall be avoided as far as possible and in no case the locations of such joints shall be changed or increased from those shown on the drawings, except with express approval of the Engineer. The joints shall be provided in a direction perpendicular to the member axis.

Location, preparation of surface and concreting of construction joints shall conform to the additional specifications given in **Annexure 20.1** and concreting chapter.

20.3.8 Concreting in Adverse Weather Conditions

20.3.8.1 Cold Weather Concreting

Where concrete is to be deposited at or near freezing temperature, precautions shall be taken to ensure that at the time of placing, it has a temperature of not less than 5 degrees Celsius and that the temperature of the concrete shall be maintained above 4 degrees Celsius until it has thoroughly hardened. When necessary, concrete ingredients shall be heated before mixing but cement shall not be heated artificially other than by the heat transmitted to it from other ingredients of the concrete. Stock piled aggregate may be heated by the use of dry heat or steam. Aggregates shall not be heated directly by gas or on sheet metal over fire. In general, the temperature of aggregates or water shall not exceed 65 degrees Celsius. Salt or other chemicals shall not be used for the prevention of freezing. No frozen material or materials containing ice shall be used. All concrete damaged by frost shall be removed. It is recommended that concrete exposed to freezing weather shall have entrained air and the water content of the mix shall not exceed 30 litres per 50 kg of cement.

20.3.8.2 Hot Weather Conditions

When depositing concrete in very hot weather, precautions shall be taken so that the temperature of wet concrete does not exceed 40 degrees Celsius while placing. This shall be achieved by stacking aggregate under the shade and keeping them moist,

using cold water, reducing the time between mixing and placing to the minimum, cooling form work by sprinkling water, starting curing before concrete dries out and restricting concreting as far as possible to early mornings and late evenings. When ice is used to cool mixing water, it will be considered a part of the water in design mix. Under no circumstances shall the mixing operation be considered complete until all ice in the mixing drum has melted.

The Contractor will be required to state his methodology for the Engineer's approval when temperatures of concrete are likely to exceed 40 degrees Celsius during the work.

20.3.9 Protection and Curing

20.3.9.1 Concreting operations shall not commence until adequate arrangements for concrete curing have been made by the Contractor. Curing and protection of concrete shall start immediately after compaction of the concrete to protect it from:

- a) Premature drying out particularly by solar radiation and wind
- b) High internal thermal gradients
- c) Leaching out by rain and flowing water
- d) Rapid cooling during the first few days after placing
- e) Low temperature or frost
- f) Vibration and impact which may disrupt the concrete and interfere with its bond to the reinforcement.

20.3.9.2 Where members are of considerable size and length, with high cement content, accelerated curing methods may be applied, as approved by the Engineer.

20.3.9.3 Water Curing

Water for curing shall be as specified in Chapter 3 and approved by the Engineer. Sea water shall not be used for curing. Sea water shall not come into contact with concrete members unless it has attained adequate strength.

Exposed surfaces of concrete shall be kept continuously in a damp or wet condition by ponding or by covering with a layer of sacks, canvas, Hessian or similar materials and shall be kept constantly wet for a period of not less than 14 days from the date of placing of concrete.

20.3.9.4 Steam curing

i) Where steam curing is adopted, it shall be ensured that it is done in a suitable enclosure to contain the live steam in order to minimise moisture and heat losses. The initial application of the steam shall be after about

four hours of placement of concrete to allow the initial set of the concrete to take place.

ii) Where retarders are used, the waiting period before application of the steam shall be increased to about six hours.

iii) The steam shall be at 100 per cent relative humidity to prevent loss of moisture and to provide excess moisture for proper hydration of the cement. The application of steam shall not be directly on the concrete and the ambient air temperature shall increase at a rate not exceeding 5 degrees Celsius per hour until a maximum temperature of 6 degrees Celsius to 70 degrees Celsius is reached. The maximum temperature shall be maintained until the Concrete has reached the desired strength.

iv) When steam curing is discontinued, the ambient air temperature shall not drop at a rate exceeding 5 degrees Celsius per hour until a temperature of about 10 degrees Celsius above the temperature of the air to which the concrete will be exposed, has been reached. The concrete shall not be exposed to temperatures below freezing for at least six days after curing.

20.3.9.5 Curing Compounds

a) Curing compounds shall only be permitted in special circumstances and will require specific approval of the Engineer. Curing compounds shall not be used on any surface which requires further finishing to be applied. All construction joints shall be moist, cured and no curing compound will be permitted in locations where concrete surfaces are required to be bonded together.

b) Curing compounds shall be continuously agitated during use. All concrete cured by this method shall receive two applications of the curing compound. The first coat shall be applied immediately after acceptance of concrete finish. If the surface is dry, the concrete shall be saturated with water and curing compound applied as soon as the surface film of water disappears. The second application shall be made after the first application has set. Placement in more than two coats may be required to prevent streaking.

20.3.10 Finishing

i) Immediately after the removal of forms, exposed bars or bolts, if any, shall be cut inside the concrete member to a depth of at least 50mm below the surface of the concrete and the resulting holes filled with cement mortar. All fins caused by form joints, all cavities produced by the removal of form ties and all other holes and

depressions, honeycomb spots, broken edges or corners, and other defects, shall be thoroughly cleaned, saturated with water, and carefully pointed and rendered true with mortar of cement and fine aggregate mixed in the proportions used in the grade of concrete that is being finished and of as dry a consistency as is possible to use. Adequate pressure shall be applied in filling and pointing to ensure thorough filling in all voids. Surfaces which have been pointed shall be kept moist for a period of twenty four hours. Special pre-packaged proprietary mortars shall be used where appropriate or where specified in the drawing or by the Engineer.

ii) All construction and expansion joints in the completed work shall be left carefully tooled and free from any mortar and concrete. Expansion joint filler shall be left exposed for its full length with clean and true edges.

iii) Immediately on removal of forms, the concrete work shall be examined by the Engineer before any defects are made good.

a) The work that has sagged or contains honeycombing to an extent detrimental to structural safety or architectural appearance shall be rejected.

b) Surface defect of a minor nature may be accepted. On acceptance of such work by the Engineer, the same shall be rectified as directed by the Engineer.

20.3.11 Tests and Standards of Acceptance

20.3.11.1 Dividing into Lots

a) Concrete shall conform to the surface finish and tolerance as prescribed in these specifications for respective components.

b) Random sampling and lot by lot of acceptance inspection shall be made for the 28 days cube strength of concrete.

c) Concrete under acceptance shall be notionally divided into lots for the purpose of

sampling, before commencement of work. The delimitation of lots shall be determined by the following:

i) No individual lot shall be more than 30 cum. in volume.

ii) At least one cube forming an item of the sample representing the lot shall be taken from concrete of the same grade and mix proportions cast on any day.

iii) Different grades of mixes of concrete shall be divided into separate lots.

iv) Concrete of a lot shall be used in the same identifiable component of the bridge.

Procedure for collection of samples and testing are given in Annexure 4.3.

20.3.11.2 Sampling and Testing

a) Concrete for making 3 test cubes shall be taken from a batch of concrete at point of delivery into construction, according to procedure laid down in IS:1199.

b) A random sampling procedure to ensure that each of the concrete batches forming the lot under acceptance inspection has equal chance of being chosen for taking cubes shall be adopted.

c) 150mm cubes shall be made, cured and tested at the age of 28 days for compressive strength in accordance with IS:516. The 28 day test strength result for each cube shall form an item of the sample.

20.3.11.3 Test Specimen and sample strength:

Three test specimens shall be made from each sample for testing at 28 days. Additional cubes may be required for various purposes such as to determine the strength of concrete at 7 days or for any other purpose. The test strength of the sample shall be the as per IS 456.

20.3.11.4 Frequency of Sampling:

The minimum frequency of sampling of concrete of each grade shall be in accordance with **Table 20.4**.

TABLE 20.4 Frequency of Sampling

Quantity of Concrete in work, m ³	No. of samples
1- 5	1
6-15	2
16-30	3
31-50	4
51 and above	4 plus one additional sample for each additional 50 m ³ or part thereof.

At least one sample shall be taken from each shift of work.

20.3.11.5 Acceptance Criteria

Compressive strength

The quantity of concrete represented by the test results include the batches from which the first and last samples were taken, together with all intervening batches.

Chloride and Sulphate content

The total chloride and sulphuric anhydride (SO_3) content of all the constituents of concrete as a percentage of mass of cement in the mix shall not exceed the values given in this section of the specifications.

20.3.11.6 Density of Fresh concrete

Where minimum density of fresh concrete is specified, the mean of any four consecutive samples shall not be less than the specified value and any individual sample result shall not be less than 97.5 per cent of the specified value.

20.3.11.7 Density of Hardened Concrete

Where minimum density of hardened concrete is specified, the mean of any four consecutive samples shall not be less than the specified value and any individual sample result shall not be less than 97.5 per cent of the specified value.

20.3.11.8 Permeability Test

The concrete should pass the following test if it is properly compacted and is not considered permeable.

- i) Prepare a cylindrical test specimen 150mm dia and 160mm high
- ii) After 28 days of curing, the test specimen is fitted in a machine such that the specimen can be placed in water under pressure upto 7 bars.
- iii) At first a pressure of one bar is applied for 48 hours, followed by 3 bars for 24 hours and 7 bars for next 24 hours.
- iv) After the passage of the above period, the specimen is taken out and split in the middle by compression applied on two round bars on opposite sides above and below.
- v) The water penetration in the broken core is to be measured with a scale and the depth of penetration assessed in mm (max. permissible limit 25mm).

If the concrete is not able to meet any of the standards of acceptance as prescribed, the effect of such deficiency on the structure shall be investigated by the Contractor as directed by the Engineer. The Engineer may accept the concrete as sub-standard work. Any additional work required by the Engineer

for such acceptance shall be carried out by the Contractor at his cost. In case the concrete is not found to be acceptable after investigation, the Contractor shall remove the rejected concrete forthwith.

20.4 PRESTRESSING

20.4.1 General

Concrete and HTS steel for the construction of prestressed concrete members shall conform to the requirements of Chapters 4 and 5 for Structural Concrete and Steel Reinforcement respectively and provisions contained in Clause 20.3 in so far as the requirements of these Sections apply and are not specifically modified by requirements set forth herein.

20.4.2 Sheathing

i) The sheathing ducts shall be of the spiral corrugated type. Unless otherwise specified, the material shall be Cold Rolled Cold Annealed (CRCA) Mild Steel conforming to IS: 513 intended for mechanical treatment and surface refining but not for quench hardening or tempering.

ii) The material shall normally be bright finished. However where specified, as in case of use in aggressive environment, galvanised or lead-coated mild steel strips shall be used. The thickness of sheathing shall be as shown on the drawing, but shall nevertheless not be less than 0.3mm, 0.4mm and 0.5mm for sheathing ducts having internal diameter of 50mm, 75mm and 90 mm respectively. For larger diameter of ducts, thickness of sheathing shall be based on recommendations of prestressing system supplier or as directed by the Engineer.

iii) For major projects, the sheathing ducts should preferably be manufactured at the project site utilising appropriate machines. With such an arrangement, long lengths of sheathing ducts may be used with consequent reduction in the number of joints and couplers. Where sheathing duct joints are unavoidable, such joints shall be made slurry tight by the use of corrugated threaded sleeve couplers which may be tightly screwed onto the outer side of the sheathing ducts.

iv) The length of the coupler should not be less than 150mm but should be increased upto 200mm wherever practicable. The joints between the ends of the coupler and the duct shall be sealed with adhesive sealing tape to prevent penetration of cement slurry during concreting. The couplers of adjacent ducts should be staggered

wherever practicable. As far as possible, couplers should not be located in curved zones. The corrugated sleeve couplers are being conveniently manufactured using the sheath making machine with the next higher size of die set.

v) The internal diameter of the sheathing duct shall be in accordance with the recommendations of the system manufacturer and shall be about three times the area of the tendons. In case of 6T13, 12T13 and 19T13 sizes of tendons comprising 12/13mm dia strands, the inner diameter of the sheathing shall not be less than 50mm, 75mm and 90mm respectively or those shown in the drawing, whichever is greater.

20.4.3 Anchorages

i) Anchorages shall be procured from authorized manufacturers only. Anchorages shall conform to BS 4447. Test certificates from a laboratory fully equipped to carry out the tests shall be furnished to the Engineer. Such test certificates shall not be more than 12 months old at the time of making the proposal for adoption of a particular system for the project.

No damaged anchorages shall be used. Steel parts shall be protected from corrosion at all times. Threaded parts shall be protected by greased wrappings and tapped holes shall be protected by suitable plugs until used. The anchorage components shall be kept free from mortar and loose rust and any other deleterious coating.

ii) Swages of prestressing strand and button heads of prestressing wire, where provided shall develop a strength of atleast 95 per cent of the specified breaking load of the strand or wire as the case may be. Where swaging / button-heading is envisaged, the Contractor shall furnish details of his methodology and obtain approval of the Engineer, prior to his taking up the work.

20.4.4 Testing of Prestressing steel and Anchorages

All materials specified for testing shall be furnished free of cost and shall be delivered in time for tests to be made well in advance of anticipated time of use.

All wire, strand or bars to be shipped to the site shall be assigned a lot number and tagged for identification purposes. Anchorage assemblies to be shipped shall be like-wise identified.

All samples submitted shall be representative of the lot to be furnished and in the case of

wire or strand, shall be taken from the same master roll. The Contractor shall furnish samples of atleast 5.0m length selected from each lot for testing. Also, two anchorage assemblies, complete with distribution plates of each size or types to be used, shall be furnished along with short lengths of strands as required.

20.4.5 Workmanship

20.4.5.1 Cleaning

Tendons shall be free from loose rust, oil, grease, tar, paint, mud or any other deleterious substance.

Cleaning of the steel may be carried out by immersion in suitable solvent solutions, wire brushing or passing through a pressure box containing carborundum powder. However, the tendons shall not be brought to a polished condition.

20.4.5.2 Straightening

High tensile steel wire and strand shall be supplied in coils of sufficiently large diameter such that tendons shall retain their physical properties and shall be straight as it unwinds from the coil. Tendons of any type that are damaged, kinked or bent shall not be used.

The packing of prestressing wire / strand shall be removed only just prior to making of cable for placement. Suitable stands shall be provided to facilitate uncoiling of wires / strands without damage to steel. Care shall be taken to avoid the possibility of steel coming into contact with the ground.

20.4.5.3 Positioning

a) For Post-Tensioning

Prestressing tendons shall be accurately located and maintained in position, both vertically and horizontally, as per drawings. Tendons shall be so arranged that they have a smooth profile without sudden bends or kinks.

The locationing of prestressed cables shall be such as to facilitate easy placement and vibration of concrete in between the tendons. High capacity tendon shall be used to reduce the number of cables thereby eliminating the necessity of grouping. The selected profiles of the tendons shall be such that their anchorages are not located in the top deck surface. Where two or more rows of cables have to be used, the cables shall be vertically in line to enable easy flow of concrete. The clear vertical and horizontal distances between any two cables shall in no case be less than 100 mm anywhere along the length of the superstructure. Where

precast segments are used, the clear distance shall be atleast 150mm.

Sheathing shall be placed in correct position and profile by providing suitable ladders and spacers. Such ladders may be provided at intervals of approximately 1.0m. Sheathing shall be tied rigidly with such ladders / space bars so that they do not get disturbed during concreting.

Sheathing in which the permanent tendon will not be in place during concreting shall have a temporary tendon inserted or shall be stiffened by some other method to be approved by the Engineer. The temporary tendon shall be pulled out before threading the permanent tendon into place by a special threading machine or other contrivance.

Where possible, tendons shall not be placed until immediately prior to stressing. Tendons shall be handled with care to avoid damage or contamination, to either the tendon or the sheathing. Any tendon damaged or contaminated shall be cleaned or replaced.

b) For Pre-Tensioning:

Prestressing steel shall be accurately located and maintained in position, both vertically and horizontally as per drawings.

c) Each anchorage device shall be set square to the line of action of the corresponding prestressing tendon and shall be positioned securely to prevent movement during concreting.

d) The anchorage devices shall be cleaned to the satisfaction of the Engineer prior to the placing of concrete. After concreting, any mortar or concrete which adheres to bearing or wedging surfaces shall be removed immediately.

20.4.5.4 Cutting

Cutting and trimming of wires or strands shall be done by suitable mechanical or flame cutters. When a flame cutter is used, care shall be taken to ensure that the flame does not come in contact with other stressed steel. The location of flame cutting of wire or strand shall be kept beyond 75mm of where the tendon will be gripped by the anchorage or jacks.

In post-tensioning the ends of prestressing steel projecting beyond the anchorages, shall be cut after the grout has set.

20.4.5.5 Protection of Prestressing Steel

Prestressing steel shall be continuously protected against corrosion, until grouted. The corrosion protector shall have no deleterious effect on the steel or concrete or

on the bond strength of steel to concrete. Grouting shall conform to these specifications or as directed by the Engineer or specified in Contract Specifications.

In the case of external prestressing, steel shall be encased in suitable polyethylene pipes before grouting.

20.4.5.6 Sheathing Joints and Couplings

Joints in sheathing shall, if so instructed be sealed with a heat shrink tape.

Special attention should be paid to its junction at the anchorage. It should tightly fit on the trumpet end of anchorage and the junction should be sealed, preferably, with heat shrink tape.

The heat shrink tape is supplied in the form of bandage rolls which can be used for all diameters of sheathing ducts. The bandage is coated on the underside with a heat sensitive adhesive so that after heating the bandage material shrinks on the sheathing duct and ensures formation of a leak-proof joint. The heating is effected by means of a soft gas flame.

The sheathing and all joints shall be water tight. Any temporary opening in the sheathing shall be satisfactorily plugged and all joints between sheathing and any other part of the prestressing system shall be effectively sealed to prevent entry of mortar, dust, water or other deleterious matter. Sheathing shall be neatly fitted at joints without internal projection or reduction of diameter.

Enlarged portions of the sheathing at couplings or anchorages shall be of sufficient length to provide for the extension of the tendons.

20.4.5.7 Grout Vents

Grout vents of atleast 20mm diameter shall be provided at both ends of the sheathing and at all valleys and crests along its length. Additional vents with plugs shall also be provided along the length of sheathing such that the spacings of consecutive vents do not exceed 20m. Each of the grout vents shall be provided with a plug or similar device capable of withstanding a pressure of 1.0MPa without the loss of water, air pressure or grout.

20.4.5.8 Anchorages

All bearing surface of the anchorages shall be cleaned prior to concreting and tensioning. Anchor cones, blocks and plates shall be securely positioned and maintained during concreting such that the centre line of the duct passes axially through the

anchorage assembly. The anchorages shall be recessed from the concrete surface by a minimum cover of 100mm. After the prestressing operations are completed and prestressing wire / strands are cut, the surface shall be painted with two coats of epoxy of suitable formulation having a dry film thickness of 80 microns per coat and entire recess shall be filled with concrete or non-shrink / pre-packaged mortar or epoxy concrete.

20.4.6 Tensioning Equipment

20.4.6.1 All tensioning equipment shall be procured from authorized manufacturers only and be approved by the Engineer prior to use. Where hydraulic jacks are used, they shall be power driven unless otherwise approved by the Engineer. The tensioning equipment shall satisfy the following requirements:

- i) The means of attachments of the prestressing steel to the jack or any other tensioning apparatus shall be safe and secure.
- ii) Where two or more wires / strands constitute a tendon, a single multipull stressing jack shall be used which is capable of tensioning simultaneously all the wires / strands of the tendon. Suitable facilities for handling and attaching the multipull jack to the tendons shall be provided.
- iii) The tensioning equipment shall be such that it can apply controlled total force gradually on the concrete without inducing dangerous secondary stresses in steel, anchorage or concrete; and
- iv) Means shall be provided for direct measurement of the force by use of dynamometers or pressure gauges fitted in the hydraulic system itself to determine the pressure in the jacks. Facilities shall also be provided for the linear measurement of the extension of prestressing steel to the nearest mm and of any slip of the gripping devices at transfer.

20.4.6.2 All dynamo meters and pressure gauges including a master gauge shall be calibrated by an approved laboratory immediately prior to use and then at intervals not exceeding 3 months and the true force determined from the calibration curve.

20.4.6.3 Pressure gauges shall be concentric scale type gauges accurate to within two per cent of their full capacity. The minimum nominal size of gauge shall be 100 mm. The gauge shall be so selected that when the tendon is stressed to 75 per cent of its breaking load, the gauge is reading between

50 per cent and 80 per cent of its full capacity.

Suitable safety devices shall be fitted to protect pressure gauges against sudden release of pressure.

20.4.6.4 Provision shall be made for the attachment of the master gauge to be used as a check whenever requested for by the Engineer.

20.4.7 Post Tensioning Procedure

20.4.7.1 Tensioning force shall be applied in gradual and steady steps and carried out in such a manner that the applied tensions and elongations can be measured at all times. The sequence of stressing, applied tensions and elongations shall be in accordance with the approved drawing or as directed by the Engineer.

20.4.7.2 It shall be ensured that in no case, the load is applied to the concrete before it attains the strength specified on the drawing or as stipulated by the prestressing system supplier, whichever is more.

20.4.7.3 After prestressing steel has been anchored, the force exerted by the tensioning equipment shall be decreased gradually and steadily so as to avoid shock to the prestressing steel or anchorage.

The tensioning force applied to any tendon shall be determined by direct reading of the pressure gauges or dynamo meters and by comparison of the measured elongation with the calculated elongation. The calculated elongation shall be invariably adjusted with respect to the modulus of elasticity of steel for the particular lot as given by the manufacturer.

20.4.7.4 The difference between calculated and observed tension and elongation during prestressing operations shall be regulated as follows:

- a) If the calculated elongation is reached before the specified gauge pressure is obtained, continue tensioning till attaining the specified gauge pressure, provided the elongation does not exceed 1.05 times the calculated elongation. If 1.05 times the calculated elongation is reached before the specified gauge pressure is attained, stop stressing and inform the Engineer.
- b) If the calculated elongation has not been reached at the specified gauge pressure, continue tensioning by intervals of 5 kg./sqcm until the calculated elongation is reached provided the gauge pressure does not exceed 1.05 times the specified gauge pressure.

c) If the elongation at 1.05 times the specified gauge pressure is less than 0.95 times the calculated elongation, the following measure must be taken, in succession, to determine the cause of this lack of discrepancy:

i) Check the correct functioning of the jack, pump and leads.

ii) Distension the cable. Slide it in its duct to check that it is not blocked by mortar which has entered through holes in the sheath. Re tension the cable if free.

iii) Re-establish the modulus of elasticity of steel for the particular lot from an approved laboratory.

d) If the required elongation is still not obtained, further finishing operations such as cutting or sealing, should not be undertaken without the approval of the Engineer.

e) When stressing from one end only, the slip at the end remote from the jack shall be accurately measured and an appropriate allowance made in the measured extension at the jacking end.

f) A complete record of prestressing operations along with elongation and jack pressure data shall be maintained in the prescribed format. The number of stages of prestressing and grouting shall be reduced to a minimum, preferably 2 in the case of simply supported girders.

20.4.7.5 Grouting of Prestressed Tendons

Grouting shall conform to provisions in **Annexure 20.2**. A record of grouting operations shall be maintained in a format given by Engineer.

20.4.8 Pre-tensioning Process

a) General

The planning and construction aspects of the tensioning bed, tensioning bench, abutments at location of anchorage, steam curing system, form work of the concrete elements and arrangements for demoulding, lifting, stacking and transportation of the pre-tensioned concrete elements are all specified items and shall be entrusted to engineers specifically experienced in this type of work.

The Contractor shall submit method of tensioning the tendons including the arrangement and layout of prestressing cables and all tensile deflection points to the Engineer for approval before manufacture commences.

b) Stressing Bed for pre-tensioning

i) The abutments and bed for pre-tensioning of tendons shall be designed to withstand the total tensioning force.

ii) A notice shall be displayed adjacent to the stressing bed showing the maximum tensioning force permitted.

iii) Where concrete elements are cast and prestressed individually, the stressing bench or moulds shall be rigid enough to sustain the reaction of the prestressing force without distortion.

iv) In the long line method of prestressing, sufficient locator plates should be distributed throughout the length of the bed to ensure that the wires are maintained in their proper position during concreting. The moulds shall be free to slide in the direction of their length and thus permit the transfer of the prestressing force to all the concrete elements along the whole line.

v) Sufficient space shall be left in between the ends of concrete elements to permit access for cutting the strands / wires after transfer. Hold downs or deflectors shall be used for holding or deflecting the tendons in required position firmly. Deflectors which are in contact with the tendon shall have a diameter not less than the tendon or 15mm, whichever is greater.

vi) The tensioning force required to be applied as specified on the drawings shall be the force remaining in the strands / wires after all strands / wires have been anchored to the abutments of the stressing bed and after the anchorage slip has already taken place. The tensioning force shall be determined by direct reading of the pressure gauges or dynamo meters and by the measured elongation after slip.

vii) The Contractor shall carry out trial stressing operations to establish the frictional resistance offered by the hold downs and the slip during anchoring.

viii) Where sheathing of pre-tensioned tendons is required to prevent bond over a specified length, it shall consist of plastic tubing or other material approved by the Engineer and shall be of a quality, diameter and thickness such that bond shall be effectively prevented. The tubing shall be fastened to the tendon in such a manner that cement mortar cannot enter. The Engineer may order that the pull-in of the tendon be measured during the transfer of prestress.

ix) The Contractor shall also submit calculations showing that the hold downs and deflectors have been designed and constructed to withstand concentrated loads resulting from the application of the tensioning force.

c) Tensioning procedure

i) The tensioning of the wires and strands shall be done not too much in advance of concreting.

ii) The tensioning force shall be applied gradually and uniformly.

In order to remove slack and to lift tendons off the bed floor, an initial force approved by the Engineer shall be applied to the tendons. Allowance shall be made for this force in calculating the required elongation.

iii) Tendons shall be marked for measurement of elongation after the initial force has been applied. When required by the Engineer, tendons shall be marked at both the jacking end and dead end of the stressing bed and at couplers if used so that slip and draw-in may be measured.

iv) Where deflected strands have been specified, the Engineer may direct the elongation or strain gauge measurements be taken at various positions along the tendon to determine the force in the tendon at those positions.

d) Transfer of Prestress

While the process of tensioning can be accomplished by means of hydraulic jacks, some positive mechanical means shall be provided to maintain the tension during the entire period between the tensioning of the wires / strands and transfer of the prestressing force to the concrete element.

Transfer of prestress shall not proceed until the Engineer has approved the proposed method. Tendons and deflection devices shall be released in such a pre-determined order that unacceptable tensile stresses are not induced in the concrete.

Prior to transfer of the force to the units, all wire tendons shall be tested for tightness and any loose tendon shall be reported to the Engineer who will decide whether the units affected shall be rejected.

The Engineer may require that tendons be marked at each end of any unit to allow measurement of the pull in of the concrete.

Tendons shall be released gradually and preferably simultaneously.

e) Cutting of wires Precautions to be taken

Under no circumstances shall tendons / wire be cut while under tension.

On completion of the transfer of prestress, the projecting lengths of tendon shall be cut off flush with the end surface of the unit, unless otherwise shown, by a method approved by the Engineer.

In no case shall the transfer of prestressing force to the concrete elements take place before concrete attains the strength specified in the drawings. To determine the specified strength, additional cube testing shall be undertaken at the Contractor's cost. In case steam curing is employed, the cubes shall be placed in the same environment as the concrete elements to obtain an accurate assessment of concrete strength at the time of transfer.

The sequence of transfer of prestressing force shall be done strictly as indicated in the drawings and ensuring that eccentricities of the prestressing force in the vertical and horizontal directions of the concrete elements is a minimum during the entire sequence.

The maximum slip of any tendon during transfer shall not exceed 3mm at any end of the concrete element. In case this slip is exceeded, the concrete element in question shall be rejected.

f) Protection of Ends

The exposed ends of the tendons and the concrete surfaces of the ends of the units shall be wire brushed clean of all rust, loose mortar, grease and dirt.

The exposed ends of the tendons and concrete surface within 50mm of tendons shall be then abraded to provide a clean sound surface. An epoxy tar paint suitably formulated to give a dry film thickness of 80 microns per coat shall then be immediately applied over the ends of the tendons unless otherwise directed.

A second coat of paint shall be applied prior to the drying out of the first coat.

20.4.9 Safety Precautions during Tensioning

These are applicable for both pre-tensioning and post tensioning operations.

i) Care shall be taken during tensioning to ensure the safety of all persons in the vicinity.

ii) Jacks shall be secured in such a manner that they will be held in position, should they lose their grip on the tendons.

iii) No person shall be allowed to stand behind the jacks or close to the line of the tendons while tensioning is in progress.

iv) The operations of the jacks and the measurement of the elongation and associated operations shall be carried out in such a manner and from such a position that the safety of all concerned is ensured.

v) A safety barrier shall be provided at both ends to prevent any tendon, which might become loose from recoiling unchecked.

vi) During actual tensioning operation, warning sign shall be displayed at both ends of the tendon. No person will stand behind in line with jacks while tendon / wire are being stressed.

vii) After prestressing, concrete shall neither be drilled nor any portion cut nor chipped away nor disturbed, without express approval of the Engineer.

viii) No welding shall be permitted on or near tendons nor shall any heat be applied to tendons. Any tendon which has been affected by welding, weld spatter or heat shall be rejected.

20.4.10 Transportation and Storage of Units

Precast girders or elements shall be transported in an upright position. Points of support and the direction of reactions with

a) Variation from the specified horizontal profile	: 5 mm
b) Variation from the specified vertical profile	: 5 mm
c) Variation from the specified position in member	: 5 mm

20.4.12 Measurements for Payment

a) Prestressed Concrete shall be measured in cubic metres unless otherwise specified. The volume occupied by mild steel reinforcement / HYSD bars, high tensile steel, sheathing and anchorages shall not be deducted.

b) High tensile (prestressing) steel shall be paid for separately and its length shall be measured as actually incorporated in the finished work. From the length so measured its weight shall be calculated in tonnes on theoretical basis and paid for.

c) Anchorage devices, additional length of cables for attaching jack, ducts or sheathing, grout, non-prestressed steel reinforcement fixed to the anchorage devices, making of recesses and filling the same protection by painting with epoxy and furnishing samples for testing shall all be deemed to be included in the item of high tensile steel and shall not be measured separately.

20.4.13 Rate

a) The contract unit rate for cast in place pre-stressed concrete shall cover the cost of all materials, labour, tools and plant required for mixing, placing in position, vibrating and

respect to the girder shall approximately be the same during transportation, and storage as when the girder is placed in final position.

When members are to be stacked, they shall be firmly supported at such bearing positions as will ensure that the stresses induced in them are always less than the permissible design stresses. Further, inclined side supports shall be provided at the ends and along the length of a precast girder to prevent lateral movements or instability.

Care shall be taken during storage, hoisting and handling of the precast units to prevent their cracking or being otherwise damaged. Units worked or damaged by improper storing or handling or transport shall be replaced by the Contractor at his expense.

20.4.11 Tolerances

Permissible tolerances for positional deviation of prestressing tendons shall be limited to the following :

compacting, finishing as per directions of the Engineer, curing and other incidental expenses for producing concrete of specified strength to complete the structure or its components as shown on the drawings and according to specifications. The contract unit rate shall exclude the cost of making, fixing and removing of all formwork required for the work.

b) For precast prestressed concrete members, the rate in addition to above shall also include the cost of all materials, labour, tools and plant required to transport and place these members in their final position as shown on the drawings and as directed by the Engineer unless otherwise specified.

c) The contract unit rate for high tensile steel shall cover the cost of material, labour, tools and plant required for manufacturing, placing, tensioning, anchoring and grouting the high tensile steel in the prestressed concrete as shown on the drawings and as per specifications herein above or as directed by the Engineer.

d) The cost of anchorage devices, additional length of cables for attaching jack, ducts or sheathing, grout, non-prestressed steel reinforcement fixed to the anchorage devices, making of recesses and filling the

same, protection by painting with epoxy and furnishing samples for testing shall all be included in the unit rate of HTS. Rate shall also include payments if any to be made to the supplier of the prestressing system who has to monitor, ensure and certify the correctness of all operations.

e) Unit rate for form work shall include the cost of all materials, labour, tools and plant required for design, construction and removal of form work and supervision as described in this Section including properly supporting the members until the concrete is cured, set and hardened as required.

Annexure 20.1

SPECIFICATION FOR CONSTRUCTION JOINTS

(Based on Appendix 1700/1 of MOST Specifications for Roads and Bridges)

Location

The construction joints shall be located as shown in the drawings and/ or as specified by the engineer. When not shown in drawing, the following guidelines shall be followed for locating them:-

- i) Construction joint shall be provided in non-aggressive zones and on non-splash zones. If not feasible, joints shall be sealed.
- ii) Location of joints should be easily accessible for preparation and concreting. e.g., where the cross section is relatively small and where there is no congestion of reinforcement.
- iii) Joints should not be near support in beams and slabs. Construction joints between ribs and slabs should be avoided in composite construction.
- iv) Soffit and webs of box girders should preferably cast without any construction joint between.
- v) Locations of construction should be such as to minimize the effects of discontinuity on durability of structure and on appearance of structure are minimized.

Preparation of Surface of the Joint

All laitance shall be removed. The surface shall be roughened without dislodging the

coarse aggregates of the set concrete. If the concrete has partially hardened, it shall be brushed with a stiff wire brush or stiff air jet followed by air jet immediately. Fully hardened concrete shall be roughened with mechanical hand tools or grit blasting, taking care not to split or crack the aggregate particles.

Surface shall be thoroughly cleaned, preferably with air jet to remove all accumulated particles and dust before further concrete is cast. If any delay is expected before placing next layer of concrete, all protruding reinforcement shall be protected (preferably with a cement wash). Before next concreting is done, all rust, loose mortar/ particles and any other contamination of the reinforcement shall be removed thoroughly. In aggressive environment, the concrete shall be cut back so as to expose the rods for about 50mm length and all contaminated concrete around is removed.

Concreting of Joints

Old surface after cleaning shall be soaked with water as directed by Engineer. Any standing water shall be removed just before laying fresh concreting. Further concreting shall be well compacted and carried out continuously upto next construction joint.

Stopping boards shall be fixed in advance for vertical construction joints at predetermined positions and properly stayed. Concreting shall be done continuously upto the board.

Surface retarders can be used for improving quality of joint, if so desired with approval of Engineer, but at no extra cost.

Annexure 20.2**GROUTING POST TENSIONED CABLES IN PRESTRESSED CONCRETE****Extracts from Appendix 1800 Specifications for Roads and Bridges of III MOST****1. Materials**

Cement -Ordinary Portland cement shall be used for preparing the grout. It shall be as fresh as possible and be free from any lumps.

Water- Only clean potable water free from any impurities and conforming to clause 4.3 of IS 456 and with chloride content not exceeding 500mg per litre shall be used.

2. Equipment

Equipments as detailed below will be used or be available at site.

Grout Agitator -A grout agitator shall be used for preparation of the mortar in order to ensure its homogeneity. The grout shall be continuously agitated in a suitable mixer with a minimum speed of 1000 RPM and travel of discharge not exceeding 15 m per second.

Grout Pump -The pump used for grouting should be a positive displacement type and capable of injecting the grout in a continuous operation (and not by way of pulses). The grout pump shall be fitted with a pressure gauge for enabling pressure of grouting to be controlled. Minimum pressure of grouting shall be 0.3 Mpa. The pump shall have a relief arrangement for bypassing when the grout pressure builds up to 1 Mpa. Capacity of the grout pump shall be such as to forward speed of 5 to 10 metres per second. Slower rate is preferable for avoiding occurrence of voids.

If the capacity of grout pump is large, it is usual to grout two or more cables simultaneously using a common manifold.

Use of hand pump for grouting or use of compressed air operated equipment for grouting is strictly prohibited. They are likely to result in some air entrapment in the duct.

Water pump-Before commencement of grouting, a direct feed high pressure water pump should be available at site as a standby. Adequate storage of clean potable water also should be available for use in the pump. In case of any problem in or during grouting operations, this pump shall be directly connected to the duct and all grout shall be

flushed out by use of high pressure water flushing.

Grout Screens -The grouting equipment should include a screen having mesh size of IS -105. The grout shall be passed through this screen before being introduced into the grout pump. The screen should be easily accessible for inspection and cleaning.

3. Properties of Grout

i) Water cement ratio of the grout should be as low as possible consistent with the workability required. It should not exceed 0.45

ii) Before grouting the strength of the grout should be ascertained through laboratory tests and it should be done for each job separately.

Cubes cast shall be moist cured for 24 hrs. and subsequently in water. The compressive strength on 100 mm cubes should not be less than specified.

4. Mixing of Grout

i) Mixing shall be done by measurement of materials by weight. Proportion of materials shall be based on field trials, but within limits specified above.

ii) Water shall be poured into the mixer, followed by cement, keeping the mix stirred. Approved admixture may be added with the Engineer's approval.

iii) Mixing shall be done for 2 to 3 minutes, depending on type of mixer. It should, however, be such as to obtain a uniform and thoroughly blended grout and not subjected to excessive rise of temperature or loss of expansive properties of the admixtures. Grout should be continuously kept agitated till it is injected.

iv) No water shall be added to the grout after it is mixed, for purpose of increasing fluidity.

v) Hand mixing is not permitted

5. Grouting Operation

i) Grouting should be carried out preferably within four hours of stressing the tendon /cables. Whenever this condition can not be complied with due to unavoidable circumstances, adequate temporary protection of the cable against corrosion by methods or products, which will not impair the adherence properties of the injected grout, with the approval of the Engineer.

ii) The ends of anchorage shall be sealed in order to prevent ingress of moisture/ water

and is desirable in all cases. Such sealing is mandatory in structures cast in regressive environment.

iii) Ducts shall be flushed with water before grouting, in order to clean the duct as well as keeping it wet for receiving the grout. Water should be of same quality as used for grouting. It may, however, contain upto about 1 % of slake lime or quick lime.

iv) The water should be blown out with use of oil free compressed air.

v) The connection between the nozzle of the injection pipe should be tight and such that no air can be sucked in. All vent openings should be kept open prior to commencement of injection of grout, unless some other sequence is specified by designers.

vi) All air in the pump and hose should be expelled before commencement of grouting. The junction circuit of the pump should be air tight.

6. Injection of Grout

i) After mixing, the grout should be kept in continuous motion/ movement.

ii) Injection of grout should be continuous and should not be interrupted.

iii) The method of injection used should ensure complete filling of the voids with no voids or air entrained. Volume of the annular space to be filled should be compared with the actual quantity of grout injected actually.

iv) Grouting will be started initially with a low pressure of injection of 0.3 Mpa and increased until the grout comes out at the other end. Grout should be allowed to flow freely at the other end till the consistency of the exiting grout is the same as that at injecting end. When such grout flows at the end, should be closed off and build up of pressure commenced. Full injection pressure of about 0.5 Mpa shall be maintained for at least one minute before closing the injection pipe. If the build up pressure exceeds 1 Mpa and still the grout is not flowing at the other end, the grouting operation shall be stopped and the entire duct flushed with high pressure water. The duct should be examined for any blockage and seizure of cable by moving the cable up and down, and defect remedied before recommencing.

v) Grout should be used up within 30 minutes of mixing and any grout not used within 30 minutes shall be rejected.

Chapter 21

Bridge Works : Superstructure-Steel

21.1 GENERAL

21.1.1 Coverage

All steel work, whether in fabrication or in erection, shall be done in accordance with the relevant Codes of Practice and Standard Specifications, subject to any further provisions contained in this chapter. These specifications are equally applicable to steel structures in buildings and sheds except where specified otherwise. In the event of any of these provisions being at variance with the standard IRS specifications, the latter shall prevail unless otherwise specified by the Engineer or in Drawings.

21.1.2 Weight for Payment

(a) Unless otherwise stipulated, payment for steel work shall be based on the calculated weight of the finished work. In calculating the weight, the overall lengths of the members used in the fabrication (i.e. as measured square) will be taken into account and no deduction will be made for rivet or bolt holes, skew cuts, notches etc. Gussets will be measured as per the dimensions of the smallest enveloping rectangles. Over the total weight of the main components and gussets thus calculated, an addition in weight for welds, river heads, bolts etc used will be made as follows:- Weight of welded structures to be discussed again

- i) 3 per cent in the case of riveted work
- ii) NIL in the case of purely welded work.

(b) Holding down bolts, nuts and washers as well as anchor channels or plates, will be measured separately.

The scope of the work covered by any particular rate shall be as defined in the individual cases, depending on the extent to which materials etc are to be supplied free by the Railway.

21.2 MATERIALS

21.2.1 General requirements

General requirements relating to the supply of material shall conform to the IS Code IS: 1387, for the purpose of which the supplier shall be the Contractor and the purchaser shall be the Engineer.

Mild steel shall be to IS:226 and /or IS 2062 and HTS to IS 561 unless otherwise specified. In case of imported material, Steel

work Specifications of the country of origin or equivalent IS Specifications will be as indicated in the Contract or by the Engineer.

Finished rolled material shall be free from cracks, flaws, injurious seams, laps, blisters, ragged and imperfect edges and other defects. It shall have a smooth and uniform finish, and shall be straightened in the mill before shipment. They shall also be free from loose mill scale, rust, pitting or other defects affecting its strength and durability.

The acceptance of any material on inspection at the mill i.e. rolling mills, foundry or fabricating plant where material for the work is manufactured, shall not be a bar to its subsequent rejection, if found defective. Unless specified otherwise, high tensile steel rivet conforming to IS:1149 shall be used for members of high tensile steel conforming to IS:961 and shall not be used for mild steel members. Unless specified otherwise, bolted connection of structural joints using high tensile friction grip bolts shall comply with requirements of IS:4000. Cast iron shall not be used in any portion of the bridge structure, except where it is subject to direct compression and as shown in the drawings.

21.2.2 Standards Applicable

21.2.2.1 All materials shall conform to requirements of respective IS Codes and IRS Specifications listed below. Special requirements are given below:

Mild steel for bolts and nuts shall conform to IS:226 and IS: 1148 but have a minimum tensile strength of 44 kg/sq.mm and minimum percentage elongation of 14. High tensile steel for bolts and nuts shall conform to IS:961 and IS:1149 but with a minimum tensile strength of 58 kg/sq.mm. High strength friction grip bolts shall be permitted for use only on satisfactory evidence of performance to the requirements (not covered by these specifications) specified by the Engineer or included in the special provisions of the Contract.

21.2.2.2 For cast steel, the yield stress shall be determined and shall not be less than **50 per cent of the minimum tensile strength.**

21.2.2.3 Plain washers shall be of steel. Tapered or other specially shaped washers shall be of steel or malleable cast iron.

21.2.2.4 Parallel barrel drifts shall have a tensile strength not less than 55 kg/ sq.mm.

With elongation of not less than 20 per cent measured on a gauge length of 4 So (So = cross sectional area in sqmm).

21.2.2.5 Materials for castings and forgings, fasteners and welding consumables shall be as per relevant IS code.

21.2.3 Use of Corrosion Resistant steel

In aggressive environment, corrosion resistant steel can be used. These are low-alloy steels containing a total of 1 per cent to 2 per cent alloys, in particular, copper, chromium, nickel and phosphorous.

21.2.4 Paints

All materials for paints and enamels shall conform to the requirements specified on the drawings or other special provisions laid down by the Engineer. Chapter 12 deals with Painting including of steel work and may also be referred to.

21.3 FABRICATION OF STEEL WORK

21.3.1 Codes of Specifications:- The work shall be done in accordance with the following codes and specifications and any other requirements that may be prescribed in special cases.

(a) Bridge Work

1. IRS Steel Bridge Code
2. IRS Specification No.B-1-2001 for Steel Girder Bridges
3. IRS Specification No.M 3-Class I, II, III and IV Steel forgings, blooms for forgings and billets for re-rolling
4. IRS Specification No. M-28 Classification, testing and approval of metal arc welding electrodes for use – Indian Railways.
5. IRS Specification No. M-29 Classification, testing and approval of submerged arc welding with flame combination.
6. IRS Specification No M-41 Corrosion resistance steel
7. IRS Specification No M-42 High strength low alloy structural steel with enhanced corrosion resistance.
8. IRS Specification No M-49 High strength excavating structural steel rivet bars with enhanced corrosion resistance.
9. IRS Specification No P-31 Zinc Chromate red oxide primer.

The fabrication and erection of the steel work shall be in accordance with IRS: B1-2001 supplemented by relevant provisions of this Specifications.

(b) Iron and steel tanks and stagings:- IRS Specification No.B-3-61 Part 4

21.3.2 Quality of Steel:- The steel used for fabrication work shall conform to the appropriate quality as specified below, unless the use of any other quality of steel is specially approved.

i) IS 226:1962 (Standard quality): For non-welded structures subjected to dynamic loading and for welded non-dynamically loaded structures, if the thickness of material welded does not exceed 20mm.

ii) IS:2062-1962 (Fusion welding quality) - For all welded structures for which IS:226 is not suitable.

iii) IS:1977-1962 (Ordinary quality):-

(a) Grade ST 44-0: For non-welded structures not subjected to dynamic loading other than wind (e.g. sheds, buildings, foot over bridges) except structures designed according to plastic theory.

(b) Grade ST-32-0: For general purposes where the load carried is not the main consideration (e.g. grills, railings)

21.3.3 Straightening of members:- All members used shall be straight except those meant to be curved and any straightening necessary shall be carried out before the material is worked upon. The straightening shall be done by pressure and no heating resorted to except with the prior approval of the Engineer and with such safeguards as considered by him to be necessary.

21.3.4 Cutting of Steel

Cutting of steel for fabrication may be done by shearing, sawing or by gas. For less important works the Engineer may permit the use of chisels and jim crows also. Gas cutting for important works shall preferably be done by mechanically controlled torches. Cut edges shall be machined where so specified. If machining is not specified, hand flame cut, chisel cut and jim crowed edges shall be ground smooth where so directed by the Engineer. Para 17 of B1-2001 may also be referred to in this connection.

21.3.5 Making of Holes

(a) In all important works and in splices, the holes for rivets or bolts shall either be drilled to the correct sizes or sub-punched initially to a diameter 6mm less than the finished diameter and reamed subsequently to the correct sizes as indicated in Para 18 of B1-2001. Sub-punching is, however, not permissible in the main truss members of open-web bridge girders.

(b) Forming of holes by gas-cutting is strictly forbidden.

(c) Holes for rivets and black- bolts shall be 1.5mm (1/16 inch) larger in diameter than the rivet bar or the bolt, and care shall be taken not to exceed this limit. In the case of turned bolts the holes shall be drilled to such tolerances as laid down in Cl. 29.5 of I.R.S. B.I.-2001 Specification for Steel girder Bridges and Locomotive turn-tables.

(d) Marking and drilling of holes in members, especially for the end connections, shall preferably be done with the use of templates. Holes in rolled sections shall follow the standard gauge lines unless otherwise indicated in the drawings.

21.3.6 Rivetting

(a) Unless otherwise specified, the size of the rivet shall be designated by the diameter of the rivet bar and not that of the hole or the finished rivet. Rivets and Rivetting shall be in accordance with para 2. Of IRS-B1-2001 supplemented by following specifications.

(b) The rivet shank shall be of length just sufficient to fill the hole thoroughly and to form a full head of the standard proportions as shown below. Generally the sizes in the Table at **Annexure 21.1** will be found sufficient.

(c) Rivets shall completely fill the holes and shall be machine driven, unless otherwise permitted by the Engineer under special circumstances. Riveting will be done by means of pressure or percussion riveters of approved design. Hand riveting shall not be resorted to except with the prior approval of the Engineer. The rivets shall be at the proper heat and in no case shall the tip be hotter than the head. Rivets less than 10mm (or 3/8 in.) in diameter may be driven cold.

(d) Before riveting is commenced, the work shall be kept tightly bolted together. Special care shall be taken to retighten the bolts frequently as the riveting proceeds.

(e) Driven rivets, when struck sharply on the head with a 110 g (1/4 lb) rivet testing hammer, shall be free from movement and vibration. All loose and burnt rivets and those with cracked badly formed, eccentric or deficient heads shall be cut out and replaced. While cutting out rivets care shall be taken not to damage the surrounding metal and not to disturb adjoining rivets. Recupping and caulking shall in no circumstance be resorted to.

21.3.7 Welding

(a) In the case of welded fabrication, the following directions shall be observed in addition to the provisions of the IRS welded Bridge Code.

i) Shop welding shall be adopted wherever possible in fabricating components and sub members for welding shall be done by submerged and welding.

ii) Suitable jigs and fixtures shall be used, both in the field and in the shop, to avoid distortion during welding, and in the case of plated construction, to control distortions within the same limits as applicable to corresponding rolled sections.

iii) Components which are mass fabricated in the shops should be proved in master templates.

(b) Unless specified otherwise, the lowest classes of electrodes to be used for different types of welding work shall be as given in **Table 21.1 (a)** under, based on IRS Specification No.M.28-66 for the classification.

Table 21.1 (a) Testing and Approval of Metal Arc Welding Electrodes

Class of Electrode as per IRS Specification No.M.28.66	Type of work to be welded	I.S. Specification No.	Code (as per IS:815-66)
Class A	Mild steel work where the strength of weld is of no importance e.g. filling of holes, dents etc	814-63	M.100 to M.999
Class B (Normal ductility)	For general welding work on steel – M.S. to IS:226-1962 and cast steel to IS:1030 Grade 3 and IRS M3 Grade 2, for service conditions where the weld is subjected to static or moderate dynamic loading	Do	M 110 to M 997-H, J, K or P.
Class B2 (Moderately high ductility)	For welding of mild steel to IS:2062-1962 (Fusion welding quality) or equivalent, for service conditions where the weldment is rigid and subjected to relatively high dynamic stresses	Do	Do

The classification of the various makes and brands of electrodes in the market, as assessed from time to time will have to be referred to before its use on the work. Lists shall be made out by the M.&C Wing of RDSO and maintained in the Headquarters Works Branch and CAO's Offices. Any electrode to be used shall be verified from

these lists to see if it is of the appropriate class.

(c) The maximum size of electrodes for welding any work and the size of run to be obtained from each shall be based on the following **Tables 21.1(b) and 21.1 (c)** except for close butt welds or other cases where any special technique is approved.

Table 21.1 (b) Size of Electrodes

Average thickness of plate or section	Maximum size of electrode to be used
Less than 5mm	10 S.W.G. (or 3.2mm)
5mm and above but less than 8mm	8 S.W.G. (or 4mm)
8mm and above, but less than 10mm	6 S.W.G. (or 5mm)
10mm and above, but less than 16mm	4 S.W.G. (or 6mm)
16 mm and above, but less than 25mm	5/16" (or 8mm)
25 mm and above	3/8" (or 9mm dia)

Table 21.1 (c) Size of Weld Runs

Gauge of Electrode	Sectional area of separate run (mm ²)		Approximate size of run in cm per electrode 42.5 cm long	
	Maximum	Minimum	Maximum	Minimum
12 S.W.G.	18.00	12.30	10.0	15.0
10 S.W.G.	22.60	12.30	12.7	22.8
8 S.W.G.	25.20	14.20	17.7	30.5
6 S.W.G.	27.10	16.80	22.8	38.0
4 S.W.G.	32.90	19.35	27.9	48.2
2 S.W.G.	36.80	23.25	35.5	55.9
0 S.W.G. (or 5/16")	41.30	27.0	43.2	66.9

Note : In any strength weld, the first run shall not ordinarily be deposited with an electrode of gauge larger than 8 S.W.G. For subsequent runs the electrode shall not be increased by more than two sizes between consecutive runs.

21.3.8 Shop Painting

(a) Fabricated steel work shall not be painted over except to the extent specified in sub para (b) until it has been inspected and passed by the Engineer or his representative and any defect, pointed out by him has been rectified. Till then, all rivet heads and weld metal shall be protected by coating with clean boiled linseed oil.

(b) All surfaces which shall be in permanent contact and any others which will not be accessible for painting later on shall be

cleaned thoroughly and given one coat of Zinc Chrome Red Oxide Priming to IS 2074 or other approved composition in the prescribed number of coats immediately prior to assembly, and for this no extra payment shall be admissible.

(c) After the steel work has been inspected and passed, painting shall be done as stipulated in Para 39 of IRS Specification B-1-2001 for the prescribed number of coats, uniformly over the work. Payment for this painting shall be made separately unless it is specifically included in the rate for the fabrication.

(d) Further reference is drawn to general provisions in Painting Chapter.

21.4 WORKMANSHIP IN STEEL WORK

21.4.1 General

Fabrication - Such work shall be performed only within the plants and by fabricators who have at the tendering stage established, to the satisfaction of the Engineer / Railway, that they have the experience, knowledge, trained man power, quality controls, equipment and other facilities required to produce the steel work to desired quality. Prequalification of the plant and fabricator will be established either by the submission of detailed written proof or through inplant inspection by the Engineer.

The contractor shall advise the Engineer in writing, atleast 20 calendar days in advance of the actual start of fabrication.

21.4.2 Rolling Margin

The rolling margin in plates, sections and bars shall be in accordance with the relevant Indian Standard and all materials outside these limits shall be liable to rejection.

21.4.3 Interchangeability of Parts

The Contractor shall arrange for corresponding parts of each unit manufactured from the same drawing to be interchangeable as far as economic manufacturing conditions permit and shall advise the Engineer of the precise arrangements made in this respect. There should be level, finished concrete floor of sufficient dimensions in the fabrication yard, on which the fabricator will precisely set out the outline of the structure (to full scale) as per drawings for the purpose of preparing templates. Only steel tapes shall be used for all measurements and they will be held tight and level on the floor while measuring or marking.

21.4.4 Templates

The templates for the work shall be steel bushed in cases where the Engineer may consider necessary. Where actual materials from the work have been used as templates for drilling similar pieces, the Engineer will decide whether they are fit for use as part of the finished structure.

21.4.5 Steel Tapes

Steel tapes used for marking out the work shall be calibrated at a temperature of 20° C.

21.4.6 Universal Plates and Flats

Where universal plates or flats are used as part of a built up section and with their edges exposed, such edges shall be true or planed true.

21.4.7 Drilling

a) Rivet and Bolt Holes

No holes shall be punched full size without the permission of Engineer. See also Para 21.3.5.

b) Reamed Holes

All holes for turned bolts shall be reamed in the manufacturer's works.

c) Holes in welded Members

All bolt and rivet holes in members built up by welding shall be drilled after welding has been completed.

d) Removal of Burrs

Holes which are drilled through two or more separable parts shall have all burrs removed after separating the parts.

e) Holes for Countersunk H.S.F.G. Bolts

Holes for countersunk H.S.F.G. bolts shall conform to the proportions for flat countersunk heads with 80° included angle and head diameter approximately twice the diameter of the bolt. The counter sunk shall be truly concentric with the shank holes. Bolt heads shall be dressed flush where necessary for proper construction.

21.4.8 Close Butted Joints

i) Where close butted joints are required they will be indicated on the Drawings and the butting ends of the parts shall be machined to ensure close contact when the joint is made.

ii) Close contact shall be deemed to have been achieved when atleast 90% of the area is in close contact and the remaining 10% or so also has clearance not exceeding 0.2mm.

21.4.9 Shearing of Plates

Shearing and grinding of steel plates shall not be carried out without the permission of the Engineer.

21.4.10 Notches

The roots of all notches shall be smoothened.

21.4.11 Procedure Trials for Welding and Cutting

Where required by the Engineer, welding and flame cutting trials shall be carried out and completed before fabrication on representative samples of materials to be used in the work, as follows:-

a) The samples of materials shall be selected and marked by the Engineer when the materials for the work are inspected at the mills.

b) Trials on material 19mm thick may be taken to include all material under 19mm thick and on material 38mm thick to include

material between 19mm and 38mm thick. Over 38mm thickness material shall be tested for every thickness increment of 6mm. The trials of flame cutting shall be carried out on material representative of all thicknesses to be used in the work.

c) The welding and flame cutting trials shall demonstrate workmanship / quality to the satisfaction of the Engineer. The procedures to be adopted shall include:

i) Welding procedure in accordance with IRS welded Bridge Code supplemented by IS:813 and IS:1980.

ii) The heat control techniques required to ensure that the flame cut surfaces of any imported steel like steel to B.S. 4360 Grade WR 50, 50B, WR 50B, 50C and WR 50C are suitable for inclusion in welds.

(d) The trials shall include specimen weld details from the actual construction which shall be welded in a manner simulating the most unfavourable instances of fit up and preparation which it is expected will occur in the particular fabrication. After welding, the specimens shall be held as long as possible at room temperature, but in any case not less than 72 hours, and shall then be sectioned and examined for cracking.

(e) Procedure Trials: Testing shall be to relevant IS Code or if approved to B.S. 709. The following groups of tests, shall be carried out in accordance with the type of welds.

(i) Butt welds:- Transverse tensile test. Transverse and longitudinal bend test with the root of the weld in tension and compression respectively and Charpy V notch impact test.

(ii) Fillet welds: Fillet weld fracture test

(iii) Tack welds: Inspection for cracking

(iv) All welds: Macro examination specimen for each type of weld. Additional tests not included in (i) and (ii) above will be specified by the Engineer as required. Shop welded joints will be radiographically examined for 100%

21.4.12 Welding Requirements

a) Qualification and Testing of Welders

Only qualified welders will be engaged in the work and they also will be tested for their skill in welding to full satisfaction of the Engineer as directed below.

(i) No welding operator shall be employed on the work until he has, in the presence of the Engineer, passed the appropriate tests laid down in relevant codes.

(ii) Where plates of 12mm thick and over are to be butt welded the tests. Engineer may specify other tests to be conducted.

(iii) Routine re-testing of welding operators may be required every six months if considered necessary by Engineer.

(iv) The Engineer can also require any welding operator to be retested at any time during the Contract.

b) Supervision of Welding

i) The Contractor shall appoint welding supervisors whose competence and qualifications shall be subject to approval of the Engineer and all welds shall be carried out under their direction.

ii) Except where agreed by the Engineer, a record shall be kept to enable butt welds to be identified with the welders responsible for the work but material shall not be marked by hard stamping for this purpose.

c) Welding Plant

The welding plant shall be capable of maintaining at the weld, the voltage and current specified by the manufacturer of the electrodes used. The Contractor shall supply instruments for verifying voltage and current as and when required by the Engineer.

d) Welding

Metal Arc welding shall be carried out in accordance with IRS Welded Bridge Code (and if so required with B.S. 5135) and the following additional requirements.

i) The general welding programme for shop and site welds, including particulars of the preparation of fusion faces, pre-heating where required and methods of making welds shall be submitted in writing to the Engineer for approval before the work is put in hand. No departure from the welding programme or from the details shown on the Drawings shall be made without the prior approval of the Engineer.

ii) Approval of the welding procedure shall not relieve the Contractor of his responsibility for correct welding and for minimising of distortion in the finished structure.

iii) The procedures for welding and flame cutting established by the procedure trials under Para 21.4.11 shall be strictly followed.

iv) All main butt welds shall have complete penetration and shall comply with the requirements of IRS Welded Bridge Code. They shall be made between prepared fusion faces. Where possible they shall be welded from both sides. The ends of the welds shall have full throat thickness. This

shall be obtained on all main welds by the use of extension pieces adequately secured on either side of the main plates. Additional metal remaining after the removal of the extension pieces shall be removed by machining, or by other approved means and the ends and surfaces of the welds shall be smoothly finished.

v) In the fabrication of built-up assemblies all butt welds in the component part's shall be complete before the final assembly.

vi) Pre-heating and temperature conditions, electrodes, and size of single runs shall be as follows:

a) Grades 43A and 43C steel – no welding of these and similar mild steels shall be undertaken where the ambient or plate temperature is 0° C or below.

b) Grades WR 50B and WR 50C Steel - for all welding of steel to Grades 50B and 50 C and similar carbon manganese steels the temperature shall be not less than 10° C when welding is commenced.

vii) Controlled hydrogen electrodes shall be dried out and used in strict accordance with the manufacturer's instructions.

viii) Loose flux used for automatic and semi-automatic welding shall be kept free from contamination and used in accordance with the manufacturer's instruction.

ix) All tack welds shall be of the same quality and size as the first run of the main weld. The main weld shall fuse completely with the ends of the tack welds to form a regular profile. Where preheat is required for the main welds the tack welds shall be made under the same heat conditions. The length of the tack welds shall not be less than four times the thickness of the thicker part or 50mm whichever is the smaller.

x) The position of welds required for temporary attachments shall be approved by the Engineer before the work starts.

xi) Temporary attachments shall be removed without damage to the parent metal, which shall be finished smooth by grinding in the direction of the applied stress in the finished structure.

xii) All cracked welds shall be cut out to the satisfaction of the Engineer before re-welding.

xiii) Where automatic or semi-automatic welding processes are used, back gouging will not be required when it is demonstrated to the Engineer that satisfactory welds are produced.

xiv) Where butt welds are to be ground flush, there shall be no loss of parent metal. The final grinding shall be in the direction of the applied stress.

xv) Run – off plates and run-on plates.

a) One pair of “run-on” plates and one pair of “run-off” plates all prepared to the same thickness and profile as the parent metal shall be attached by clamps to the start and finish respectively of all butt welds so that the direction of rolling of the added plates is parallel to that of the parent metal.

b) Except as directed by the Engineer the plates in approximately 1 in 5 pairs of run-off plates shall each be 150mm wide by 200mm long, the length being measured in the rolling direction of the metal and at right angles to the weld.

c) The welds shall run the full length of the joint and extend at full section for a minimum distance of 25mm into the run-off plates.

d) On completion of the welds the 150mm x 200mm run-off plates shall not be removed until they have been marked by the Engineer to identify them with the joints to which they are attached.

e) When removing the run-off and run-on plates by flame cutting the cuts shall not be nearer than 6mm to the sides of the parent metal and remaining metal shall be removed by grinding in the direction of the applied stress or by other method approved by the Engineer.

f) Specimens for test shall be selected from the run-off plates as required by the Engineer.

21.4.13 Welding Inspection

The Engineer will require radiographic or other non-destructive examinations to be carried out on all main welds carrying tension and on other welds to his satisfaction. If required, samples of the welds in permanent or temporary works shall be cut out for examination by the Engineer.

21.4.14 Stress Relieving

If required by the Engineer or specified elsewhere herein or specified on the Drawings, welds shall be stress relieved and special units may require to be normalised.

21.4.15 Flame Cutting

Where the flame cut surface is not subsequently incorporated in a weld, machine flame cutting may be used subject to the following requirements.

i) Grades 43A and 43C steel. All irregularities in the cut face, edges and

corners shall be removed by grinding in the direction of the main stress to be carried by the material.

ii) Grades WR 50, 50B, WR 50B, 50C and WR 50C steel:- The heat input and cooling condition shall be in accordance with the procedures specified in Clause 13 of B.S. 5135, unless otherwise specified.

21.4.16 Welding of stud shear connectors

The stud shear connectors shall be welded in accordance with the manufacturer's instructions including preheating. The stud and the surface to which studs are welded shall be free from scale, moisture, rust and other foreign material. The stud base shall not be painted, galvanised or cadmium plated prior to welding. Welding shall not be carried out when temperature is below 10 degrees Celsius or surface is wet or during

periods of strong winds unless the work and the welder are adequately protected. The welds shall be visually free from cracks and shall be capable of developing at least the nominal ultimate strength of studs. The procedural trial for welding the stud shall be carried out when specified by the Engineer.

21.4.17 Tolerances

Tolerances in dimensions of components of fabricated structural steel work shall be specified on the drawings and shall be subject to the approval of the Engineer before fabrication. Unless otherwise specified, all parts of an assembly shall fit together accurately within tolerances specified in **Table 21.2**.

A machined bearing surface, where specified by the Engineer, shall be machined within a deviation of 0.25 mm for surfaces that can be inscribed within a square of side 0.5m.

TABLE 21.2 FABRICATION TOLERANCES

A. INDIVIDUAL COMPONENTS		
1.	Length	
	a) Member with both ends finished for contact bearing	$\pm 1\text{mm}$
	b) Individual components of members with end plate connection	+ 0 mm - 2 mm
	c) Other members	
	i) Upto and including 12M	$\pm 2\text{mm}$
	ii) Over 12M	$\pm 3.5\text{mm}$
2.	Width	
	a) Width of built-up girders	$\pm 3\text{mm}$
	b) Deviation in the width of members required to be inserted in other members	+ 0mm - 3mm
3.	Depth	
	Deviation in the depths of solid web and open web girders	+ 3mm - 2 mm
4.	Straightness	
	a) Deviation from straightness of columns	L/3000 subject to a maximum of 15mm where L is length of member
	i) In elevation	+ 5mm - 0 mm
	ii) In plan	L/1000 subject to a maximum of 10mm
5.	Deviation of centre line of web from centre line of flanges in built-up members at contact surfaces	3mm
6.	Deviation from flatness of plate of webs of built-up members in a length equal to the depth of the member	0.005 d to a maximum of 2mm where d is depth of the member

7.	Tilt of flange of plate girders a) At splices and stiffeners, at supports, at the top flanges of plate girders and at bearings	0.005 b to a maximum of 2mm where b is width of the member
	b) at other places	0.015b to a maximum of 4 mm where b is width of the member
8.	Deviation from squareness of flange to web of columns and box girders	$L/1000$, where L is nominal length of the diagonal
9.	Deviation from squareness of fixed base plate (not machined) to axis of column. These dimensions shall be measured parallel to the longitudinal axis of the column at points where the outer surfaces of the column sections make contact with the base plate.	$D/500$ where D is the distance from the column axis to the point under consideration on the base plate
10.	Deviation from squareness of machined ends to axes of columns	$D/1000$, where D is as defined in 9 above
11.	Deviation from squareness of machined ends to axes of beams or girder	$D/1000$, where D is as defined in 9 above
12.	Ends of members abutting at joints through cleats or end plates, permissible deviation from squareness of ends	$1/600$ of depth of member subject to a maximum of 1.5mm

21.5 ERECTION OF STEEL WORK

21.5.1 Reference Specifications

The erection of steel work for different types of structures shall be done in accordance with the respective Indian Railway standard specifications as listed below.

(a) Bridge work: IRS Specification No. B1-2001 for Erection and Riveting of Bridge Girders.

(b) General Structural Work: IRS Specification No.B2 for Steel Structures (other than Girder Bridges)- Part 3.

(c) Iron and Steel tanks and stagings – IRS Specification No.B3- Part 4.

The important provisions of IRS Specification No.B1-2001 (Part 3) which is commonly required to be followed in the field for all steel girders are extracted and given below for ready reference, duly amplified where necessary.

21.5.2 Material Handling

(a) The materials, on receipt, shall be carefully unloaded, examined for defects, checked, sorted and stacked securely on a level bed, out of danger from flood or tide and out of contact with water or ground moisture. They will be supported on timber or concrete plinths so that they do not touch the ground.

(b) The materials shall be verified with the marking shown on the marking plan, if any, or with the detailed drawings issued for the work.

(c) Any material found damaged or defective shall be stacked separately. The materials should, as far as possible, be inspected before unloading from trucks to ascertain if any damage has occurred in transit. The portions found damaged or defective shall be marked with paint of distinctive colour. Such materials shall be dealt with under orders of the Engineer and without delay. Slightly distorted parts may be straightened by gradual pressure without heating, whereas badly damaged portions may require to be replaced. In exceptional cases, where rectification of badly distorted or broken parts is allowed by the Engineer, it shall be done in such manner and with such safeguards as directed by him. Connection plates, if slightly bent or twisted shall be straightened cold. If bent so sharply as to require heating, the whole plate thus treated shall be annealed before use on work. Engineer at his discretion may have such rectified component tested for its load carrying capacity before use on work.

21.5.3 Preliminary Requirements

i) Before starting the work, the method of erection and the details of the erection equipment proposed to be used shall be got approved by the Engineer, but such approval shall not be considered as relieving the Contractor of his responsibility for safety or for carrying out the work in full accord with the drawings and specifications. All temporary works shall be properly designed and substantially constructed for the loads they would be called upon to sustain,

including wind and lateral forces, etc according to the local conditions.

ii) A careful inspection of plant and tackle shall be made to ensure that they are in good order and well upto the capacity required. When chains or ropes are used for lashing, care must be taken to protect them as well as the members lashed, to avoid damage to either.

iii) Frame and steel skeleton structures shall be carried up true and plumb. Temporary bracings shall be provided, if required, to take care of stresses from erection equipment or other loads carried during erection and also to ensure lateral stability of structures during the process of erection.

iv) All surfaces which shall be in permanent contact after assembly shall be thoroughly cleaned to remove all paint and mill scale and shall receive, immediately before being assembled one coat of approved primer like Zinc Chrome Red Oxide to IS 2074 or in accordance with relevant Para in Painting Iron Work, with the prescribed number of coats. Care shall be taken to see that any burr or other surface defects are removed before the parts are assembled. Field rivets, welds and bolted connections shall be protected by a coat of clean boiled linseed oil till the work is inspected and passed by the Engineer's representative. After passing, these shall be cleaned and painted with a coat of red lead paint or other approved primer, irrespective of whether the final painting of the finished structure is to be done by the Contractor or not.

21.5.4 Assembling Steel

21.5.4.1 The parts shall be accurately assembled as shown on the drawings and match marks shall be followed. The material shall be carefully handled so that no parts will be bent, broken or otherwise damaged.

21.5.4.2 Hammering which will injure or distort the members shall not be done. Bearing surface or surfaces to be in permanent contact shall be cleaned, before the members are assembled. The truss spans shall be erected on blocking, so placed as to give the proper camber. The blocking shall be left in place until the tension chord splices are fully riveted and all other truss connections pinned and bolted. Rivets in splices of butt joints of compression members and rivets in railings shall not be driven until the span has been swung.

21.5.4.3 All joint surfaces for bolted connections including bolts, nuts, washers shall be free from scale, dirt, burrs, other foreign materials and defects that would prevent solid seatings of parts. The slope of surface of bolted parts in contact with bolt head and nut shall not exceed 1 in 20, to the plane normal to bolt axis, otherwise suitable tapered washer shall be used.

21.5.4.4 All fasteners shall have a washer under nut or bolt head whichever is turned in tightening. Any connection to be riveted or bolted shall be secured in close contact with service bolts or with a sufficient number of permanent bolts before the rivets are driven or before the connections are finally bolted. Joints shall normally be made by filling not less than 50 per cent of holes with service bolts and barrel drifts in the ratio 4:1. The service bolts are to be fully tightened up as soon as the joint is assembled. Connections to be made by close tolerance or barrel bolts shall be completed as soon as practicable after assembly.

21.5.4.5 Any connection to be site welded shall be securely held in position by approved methods to ensure accurate alignment, camber and elevation before welding is commenced.

21.5.4.6 The field riveting, and bolted and pin connection shall conform to the requirements of Para 21.5.5 as appropriate.

21.5.4.7 The correction of minor misfits involving harmless amounts of reaming, cutting and chipping will be considered a legitimate part of erection. However, any error in the shop fabrication or deformation resulting from handling and transportation which prevents proper assembling and fitting up of parts by moderate use of drifts or by a moderate amount of reaming and slight chipping or cutting shall be reported immediately to the Engineer and his approval of the method of correction obtained. The correction shall be made in the presence of the Engineer.

21.5.5 Rivetting

(a) Riveted connections shall be securely bolted up before the rivets are driven.

(b) Parallel barrel drifts, with their greatest diameter not exceeding that of the rivet hole, may be used for drawing members into position; but no drifting to match up unfair holes shall be allowed. Any apparent error in fabrication work which prevents assembling and fitting up of the parts by the proper use of these drifts shall be investigated immediately. No reamer shall be

undertaken without the written authority of the Engineer, and if it be approved, any special rivets that may be required shall be used to fill such holes, and for this no extra payment shall be admissible to the Contractor. All correspondence relating to the recourse to reamering and the use of special rivets shall invariably be recorded by the Engineer for information.

(c) In cases where the joint has to withstand stresses arising from special methods of erection before being rivetted up, parallel barrel drifts and turned bolts shall be used to withstand the whole of such stresses, the number of drifts being subject to a maximum of 40 per cent of the total.

(d) In the event of any emergency arising, such as stagings being in danger of being carried away by floods before the riveting can be completed, the joints shall be made secure by filling 40 per cent of the holes with drifts and an equal number with service bolts fully tightened up.

(e) Riveting shall not be started until such time as the Engineer or his representative has personally satisfied himself that the alignment and levels of the members are correct, the verticals plumb, all joints and cover plates well in order, service bolts tight and the field rivet holes properly matching.

(f) Joints shall normally be made by filling not less than 50 per cent of the holes with service bolts and parallel drifts in the ratio of 4 to 1. The service bolts shall be fully tightened up.

21.5.6 Bolted Connection:- Permanent bolted connections shall be used only where shown on the drawings or where specially approved by the Engineer. In all such cases, washers not less than 6mm thick shall be used under the heads and nuts, and the nuts drawn tight and "checked" by burring over the threads with a chisel.

21.5.7 Rates: Unless stipulated to the contrary, the rates for erection of steel work shall cover the cost of all labour, tools and plant, tackle and consumable stores and temporary stagings, etc as required for the work. Unless otherwise specified and in other than supply and erection contract the supply of fabricated steel work and the fittings required for making the field connections will be arranged by the Railway. Unless otherwise specified if ordered to be done, painting of the finished structure, will be paid for separately. But no extra payment will be made for cleaning and painting the surfaces of contact or the field connections, as specified in Paras 21.5.5 and 21.5.6.

Field rivets, welds and bolted connections shall be protected by a coat of clean boiled linseed oil till the work is inspected and passed by the Engineer's representative. After passing, these shall be cleaned and painted with a coat of red lead paint or other approved primer, irrespective of whether the final painting of the finished structure is to be done by the Contractor or not.

21.6 PAINTING STEEL WORK

21.6.1 General:-Unless otherwise specified all painting and protection coating work shall be done in accordance with Para 39 of IRS B1-2001 and IS:1477 (Part 1) supplemented by the specifications given below. In locations where girders are subjected to satisfy such as close vicinity of sea and or over creeks, metalising with sprayed aluminium as given in Appendix VIII to IRS B1-2001 will be done, followed by painting with one coat of etch primer to IS: 5666 (ii) or the coat of zinc chrome primer to IS:104 the zinc chrome to be used in the manufacturer conforming to type 2 of IS 51 and (iii) two coats of aluminium paint to IS 2339 by brushing or spraying as specified. One coat is to be applied in shop before despatch and second after erection after touching up the earlier coats if damaged in transit or during erection.

21.6.2 Surface Preparation

Steel surface to be painted either at the fabricating shop or at the site of work shall be prepared in a thorough manner with a view to ensuring complete removal of mill scale by one of the following processes as agreed to between the fabricator and the Engineer.

- Dry or wet grit / sand blasting
- Pickling which should be restricted to single plates, bars and sections
- Flame cleaning

Primary coat shall be applied as soon as practicable after cleaning and in case of flame cleaning, primary coat shall be applied while the metal is still warm.

All slag from welds shall be removed before painting. Surfaces shall be maintained dry and free from dirt and oil. Work out of doors in frosty or humid weather shall be avoided.

21.6.3 Coatings

Prime coat to be used shall conform to the specification of primers specified hereinafter or in Drawings / Contract and should be approved by the Engineer. Metal coatings shall be regarded as priming coatings. Primer shall be applied to the blast cleaned

surface before any deterioration of the surface is visible. In any case, the surface shall receive one coat of primer within 4 hours of abrasive blast cleaning.

All coats shall be compatible with each other. When metal coatings are used, the undercoat shall be compatible with the metal concerned. The undercoat and finishing coat shall preferably be from the same manufacturer. Successive coats of paints shall be of different shades or colours and each shall be allowed to dry thoroughly before the next is applied. Particular care shall be taken with the priming and painting of edges, corners, welds and rivets. Typical guidelines for epoxy based paints and the conventional painting system for bridge girders as given below may be complied with:

a) Epoxy Based Painting

i) Surface preparation: Remove oil / grease by use of petroleum hydrocarbon solution (IS:745) and Grit blasting to near white metal surface.

ii) Paint system: 2 coats of epoxy zinc phosphate primer = (60 micron; Total 5 coats = 300 micron) to RDSO Specn. No.IC/PCN/103/86. Finished coats approved by --- air less spray of coats of Epoxy zinc phosphate to RDSO Specifications No.M&C/PCN/102/86.

b) Conventional Painting System for areas where corrosion is not severe

Priming Coat:

One coat of ready mixed zinc chrome priming conforming to IS:104 followed by one coat of ready mixed red oxide zinc chrome primer conforming to IS:2074.

Or

Two coats of zinc chromate red oxide primer conforming to IRS P-31.

Finishing Coats

Two cover coats of red oxide paint conforming to IS:123 or any other approved paint shall be applied over the primer coat. One coat shall be applied before the fabricated steel work leaves the shop. After the steel work is erected at site, the second coat shall be given after touching up the primer and the cover coats if damaged in transit.

c) Conventional Painting System for areas where corrosion is severe

Priming Coat:

One coat of ready mixed zinc chrome primer conforming to IS:104 followed by one coat of

red oxide zinc chrome conforming to IS:2074.

Finishing Coats:

Two coats of aluminium paint conforming to IS:2339 shall be applied over the primer coat. One coat shall be applied before the fabricated steel work leaves the shop. After the steel work is erected at site, the second coat shall be given after touching up the primer and the cover coats if damaged in transit.

21.6.4 Painting in the Shop

i) All fabricated steel shall be painted in the shops after inspection and acceptance with at least one priming coat unless the exposed surfaces are subsequently to be cleaned at site or are metal coated. No primer shall be applied to galvanised surfaces.

ii) Shop contact surfaces, if specifically required to be painted, shall be brought together while the paint is still wet.

iii) Field contact surfaces and surfaces to be in contact with cement shall be painted with primer only. Paint shall be completely dried before loading and transporting to site.

iv) Surface not in contact but inaccessible after shop assembly shall receive the fully specified protective treatment before assembly.

v) Where surfaces are to be welded, the steel shall not be painted or metal coated within a suitable distance from any edges to be welded if the specified paint or metal coating would be harmful to welders or is expected to impair the quality of site welds.

vi) Exposed machined surfaces shall be adequately protected.

21.6.5 Painting at Site

i) Surfaces which will be inaccessible after site assembly shall receive the full specified protective treatment before assembly.

ii) Surfaces which will be in contact after site assembly shall receive a coat of paint (in addition to any shop priming) and shall be brought together while the paint is still wet.

iii) Damaged or deteriorated paint surfaces shall be first made good with the same type of coat as the shop coat.

iv) Where steel has received a metal coating in the shop, this coating shall be completed on site so as to be continuous over any welds, bolts and site rivets.

v) Specified protective treatment shall be completed after erection.

21.6.6 Methods of application

The methods of application of all paint coatings shall be in accordance with the manufacturer's written recommendation and approved by the Engineer or as indicated in painting chapter to the extent they are applicable to major steel structures. Spray painting may be permitted provided it will not cause inconvenience to the public and is appropriate to the type of structure being coated. Areas hard to gain access for painting and areas shaded for spray application shall be coated first by brushing.

Oil based red lead primers must be applied by brush only, taking care to work into all corners and crevices.

The primer, intermediate and finishing coats shall all be applied so as to provide smooth coatings of uniform thickness. Wrinkled or blistered coatings or coatings with pinholes, sags, lumps or other blemishes, shall not be accepted. Where the Engineer so directs,

the coating shall be removed by abrasive blast cleaning and replaced at the Contractor's expense.

21.6.7 Guideline of Specifications for Protective Coating System in Different Environments

a) Since the seriousness of the problem of corrosion depends upon atmospheric conditions and these vary enormously, there is no single protective system or method of application that is suitable for every situation.

b) However, as a guide to specifying authorities, broad recommendations in this respect are given in **Table 21.3** for various types of coatings in various environmental conditions, extracted from MOST Specifications for Roads and Bridges. Approximate life to first maintenance is also indicated and can be used as a guide.

TABLE 21.3 RECOMMENDATIONS FOR TYPES OF PROTECTIVE COATINGS

System	Environment
i) Wire brush to remove all loose rust and scale: 2 coats drying oil type primer; 1 under coat alkyd type paint; 1 finishing coat alkyd type. Total dry film thickness = 150 µm	Suitable for mild conditions where appearance is of some importance and where regular maintenance is intended. This system may deteriorate to a marked extent if it is exposed to moderate aggressive atmospheric conditions for lengthy period.
ii) Wire brush to remove all loose rust and scale; 2 coats drying oil type primer; 2 under coats micaceous iron oxide (MXO) pigmented phenolic modified drying oil. Total dry film thickness = 170 µm.	Similar to (i) but where appearance is not very important provides longer life in mild condition. Will provide upto 5 years life to first maintenance in polluted inland environment
iii) Blast clean the surface: 2 coats of quick drying primer; undercoat alkyd type paint; 1 finishing coat alkyd type. Total dry film thickness: 130-150µm.	Compared to (i) this would provide a longer life in mild conditions and could be used in less mild situation e.g. inland polluted, where maintenance could easily be carried out at regular intervals
iv) Blast clean the surface; 2 coats of drying type oil primer; 1 undercoat micaceous iron oxide pigmented drying oil type paint. Total dry film thickness: 165-190µm	Suitable for general structural steel work exposed to ordinary polluted inland environments where appearance is not of primary importance.
v) Blast clean the surface; 2 coats of metallic lead pigmented chlorinated rubber primer. 1 undercoat of high build chlorinated rubber, 1 finishing coat of chlorinated rubber. Total dry film thickness: 200 µm	Suitable for structures in reasonably aggressive conditions e.g. near the coast. Will provide, long term protection than (iv) in non-coastal situations. Also suitable for aggressive interior situations such as industrial areas.
vi) Blast clean the surface: 350-450 µm thickness. Coal tar epoxy.	Suitable for sea water splash zones or for conditions of occurrence of frequent salt sprays
vii) Pickle: hot dip galvanised (Zinc) Total thickness: 85 µm	Suitable for steel work in reasonably mild conditions. Life of 15-20 years before first maintenance could be expected in many

	situation
viii) Grit blast, hot dip galvanised. (Zinc). Total thickness = 140 μm	Provides a longer life than (vii) because of thicker zinc coating
ix) Grit blast; 1 coat of sprayed zinc/ aluminium followed by suitable sealer Total Thickness = 150 μm	Expected to provide long term protection approx 15-20 years in aggressive atmosphere

21.7 TESTS AND STANDARDS OF ACCEPTANCE

The materials shall be tested in accordance with relevant IS specifications and necessary test certificates shall be furnished. Additional tests, if required, shall be got carried out by the Contractor at his own cost.

The fabrication, furnishing, erecting, painting of structural steel work shall be in accordance with these specifications and shall be checked and accepted by the Engineer.

21.8 MEASUREMENTS FOR PAYMENT

a) Measurements of steel work shall be in tonnes based on net weight of metal in fabricated structure computed on the basis of nominal weight of materials, unless otherwise specified. See also Para 21.1.2 (a).

b) The weight of rolled and cast steel and cast iron shall be determined from the dimensions shown on the drawings on the following basis :

Rolled or cast steel : 7.85×10^{-3} kg/cum

Cast Iron 7.21×10^{-3} kg/cum

This will be applicable in areas not covered by condition (e) below:

c) Weight of structural sections shall be nominal weight.

Weight of castings shall be computed from the dimensions shown on the drawings with an addition of 5 per cent for fillets and over runs.

d) No additions shall be made for the weight of protective coating or weld fillets.

Where computed weight forms the basis for payment, the weight shall be calculated for exact cut sizes of members used in the structure, deductions being made for all cuts, except for rivet holes. Additions shall be made for the rivet heads as mentioned above.

When specially agreed upon, the basis for payment may be the bridge weight complete, according to specifications included in special provisions of the Contract.

e) Any steel work, the weight of which differs by more than 2.5% from the calculated weight determined from the nominal weight of the sections shall be liable to rejection.

f) Payment shall be made on the tendered weight to be calculated in accordance with the nominal weight of the sections as specified in the contract drawings. In addition for welds and rivet heads will either be specified in the schedule and if not so so will be

i) 3% in case of riveted

ii) NIL in case of purely welded work.

g) Should the actual weight fall short of the calculated weight by more than 2.5% the material if accepted will be paid for the actual weight.

h) No separate payment shall be made for supply of bolts and nuts and drifts required for erection purposes and any wastages thereof.

i) In the event of a dispute arising as to the weight of a portion of steel work, a weighment shall be made in the presence of Inspecting Officer.

21.9 Rate

The contract unit rate for the completed structural steel work shall include the cost of all materials, labour, tools, plant and equipment, handling and transport required for fabrication, connections, oiling, painting, temporary erection, inspection, tests and complete final erection as shown on the drawings and as specified in these Specifications and specifications given on the drawings and accompanying bid documents. In such cases, latter will prevail unless otherwise directed.

Annexure 21.1

(Refer Para 21.3.6)

Lengths (L) Required for Different Diameters of Rivets

(All dimensions in mm)

Grip Length	(i) Cuphead Rivets						(ii) Countersunk Head Rivets					
	10	12	16	18	20	22	10	12	16	18	20	22
12	$\frac{31}{32}$	$\frac{33}{32}$	$\frac{38}{40}$	$\frac{41}{40}$	..	..	23	..	..	..	..	..
14	$\frac{33}{32}$	36	$\frac{41}{40}$	43	46	..	$\frac{25}{26}$	..	..	..	..	..
16	36	$\frac{38}{40}$	43	46	$\frac{48}{49}$	$\frac{51}{52}$	$\frac{28}{29}$	..	..	..	..	..
18	$\frac{38}{40}$	$\frac{41}{40}$	$\frac{45}{46}$	$\frac{48}{49}$	$\frac{51}{52}$	$\frac{53}{52}$	$\frac{30}{29}$	$\frac{31}{32}$	32	..	..	..
20	$\frac{41}{40}$	43	$\frac{48}{49}$	$\frac{50}{49}$	$\frac{53}{52}$	$\frac{56}{55}$	$\frac{33}{32}$	$\frac{33}{32}$	$\frac{35}{36}$	..	..	..
22	$\frac{44}{43}$	46	$\frac{50}{49}$	$\frac{53}{52}$	55	58	36	36	$\frac{37}{36}$	..	..	..
24	46	$\frac{48}{49}$	$\frac{53}{52}$	55	58	$\frac{60}{61}$	$\frac{38}{40}$	$\frac{38}{40}$	40	40	..	..
26	49	$\frac{51}{52}$	55	$\frac{57}{58}$	$\frac{60}{61}$	$\frac{63}{64}$	$\frac{41}{40}$	$\frac{41}{40}$	$\frac{42}{43}$	$\frac{42}{43}$	43	..
28	$\frac{51}{52}$	$\frac{53}{52}$	$\frac{57}{58}$	$\frac{60}{61}$	$\frac{62}{61}$	$\frac{65}{64}$	43	43	$\frac{44}{43}$	$\frac{45}{46}$	$\frac{45}{46}$	..
30	$\frac{54}{55}$	$\frac{56}{55}$	$\frac{60}{61}$	$\frac{62}{61}$	$\frac{65}{64}$	67	46	46	$\frac{47}{46}$	$\frac{47}{46}$	$\frac{48}{49}$	49
34	..	61	64	67	$\frac{69}{70}$	$\frac{72}{73}$	$\frac{51}{52}$	$\frac{51}{52}$	$\frac{51}{52}$	52	52	$\frac{54}{55}$
38	..	$\frac{66}{67}$	$\frac{69}{70}$	$\frac{71}{70}$	$\frac{74}{73}$	76	..	$\frac{56}{55}$	$\frac{56}{55}$	$\frac{56}{55}$	$\frac{57}{58}$	58
42	..	$\frac{71}{70}$	$\frac{74}{73}$	76	$\frac{78}{80}$	$\frac{81}{80}$	..	61	61	61	61	$\frac{63}{64}$
46	..	76	$\frac{79}{80}$	$\frac{81}{80}$	83	$\frac{85}{86}$	..	$\frac{66}{67}$	$\frac{66}{67}$	$\frac{66}{67}$	$\frac{66}{67}$	67
50	..	$\frac{81}{80}$	83	$\frac{85}{86}$	$\frac{88}{89}$	$\frac{90}{89}$	..	$\frac{71}{70}$	70	70	$\frac{71}{70}$	$\frac{72}{73}$
55	..	$\frac{87}{86}$	89	$\frac{91}{92}$	$\frac{93}{92}$	$\frac{96}{95}$	..	$\frac{77}{76}$	76	76	76	$\frac{78}{80}$
60	..	..	95	$\frac{97}{99}$	99	$\frac{101}{102}$	..	83	$\frac{82}{83}$	$\frac{82}{83}$	$\frac{82}{83}$	83
65	..	..	$\frac{101}{102}$	$\frac{103}{102}$	$\frac{105}{108}$	$\frac{107}{108}$	..	..	$\frac{88}{89}$	$\frac{88}{89}$	$\frac{88}{89}$	89
70	..	..	$\frac{107}{108}$	$\frac{109}{108}$	$\frac{111}{114}$	$\frac{113}{114}$	..	..	$\frac{94}{95}$	$\frac{94}{95}$	$\frac{94}{95}$	95
75	..	..	$\frac{113}{114}$	$\frac{115}{114}$	$\frac{116}{118}$	118	..	..	$\frac{100}{99}$	$\frac{100}{99}$	99	$\frac{100}{99}$
80	..	..	..	$\frac{120}{118}$	$\frac{122}{125}$	$\frac{124}{125}$	..	..	$\frac{106}{108}$	$\frac{105}{108}$	$\frac{105}{108}$	$\frac{106}{108}$
85	..	..	..	..	$\frac{128}{125}$	$\frac{130}{132}$	..	..	$\frac{112}{114}$	$\frac{111}{114}$	$\frac{111}{114}$	$\frac{112}{114}$
90	..	..	..	..	..	135	..	..	..	$\frac{117}{118}$	$\frac{117}{118}$	$\frac{117}{118}$
95	..	..	..	..	..	$\frac{141}{140}$	..	..	..	..	$\frac{122}{125}$	$\frac{123}{125}$
100	..	..	..	..	..	..	..	..	..	..	..	$\frac{129}{132}$

Note : (1) The lengths given above are those required theoretically, except that where two lengths are indicated, the figure in the denominator represents the length to which rivets are generally produced by standard manufacturers.

(2) Interpolate between the theoretical lengths for intermediate grip lengths.

Chapter 22

Bridge Works - Miscellaneous

22. BRIDGE BEARINGS

22.1 Types and General Requirements

a) Types of Bearings can be:-

- i) Steel Plate Bearings
- ii) Pin Bearings
- iii) Rocker and Roller Bearings
- iv) Neoprene Bearings and Elastomeric Pads
- v) PTFE/ POT Bearings

b) Common requirements of different types of bearings are:-

- i) Bearing plates, bars, rockers, assemblies and other expansion or fixed devices shall be constructed in accordance with the details shown on the drawings.
- ii) The bearings may either be procured directly by the Engineer from the manufacturers, and supplied to be installed by the Contractor or the Contractor may be required to supply and install the bearings as part of the contract. In the former case, the manufacturer shall be associated with the installation of the bearings to the full satisfaction of the Engineer, whereas in the latter case, the Contractor shall be solely responsible for the satisfactory supply and installation of the bearing. In the detailed description of the specification, a general reference shall be made to the Contractor or manufacturer and the interpretation shall be as per terms of contract.
- iii) The Contractor shall exercise the utmost care in transporting, setting and fixing all bearings in their correct positions and ensuring that uniformity is obtained on all bearing surfaces.
- iv) Bearings shall be handled with care and stored under cover.
- v) When bearing assemblies or plates are shown on the drawings to be placed (not embedded) directly on concrete, the concrete bearing area shall be constructed slightly above grade (not exceeding 12mm) and shall be finished by grinding.
- vi) It shall be ensured that the bearings are set truly level and in exact position as indicated on the drawings so as to have full and even bearing on the seats. Thin mortar pads (not exceeding 12mm) may even be made to meet with this requirement.

vii) It shall be ensured that the bottoms of girders to be received on the bearings are plane at the locations of these bearings and care shall be taken that the bearings are not displaced while placing the girders.

viii) Unless otherwise specified for sliding plate bearings, stainless steel surface sliding on stainless steel plate with mild steel matrix shall be used. The other option shall be to provide PTFE surface sliding on stainless steel.

ix) These specifications cover the types of bearings which have been successfully used in various bridges in India. For other types of structures (like cable stayed bridges or similar and in special cases, special types of bearings to suit the requirements may have to be provided, for which special specifications may be laid down by designers and approved by the Engineer.

22.2 STEEL BEARINGS

22.2.1 Materials

The material for steel bearings shall conform to the requirements of Chapter 21. Some additional requirements for materials for steel bearings are indicated below:

a) For the purpose of checking the soundness of cast steel components, castings shall be ultrasonically examined following procedures as per IS:7666 with acceptance standard as per IS:9565. The castings may also be checked by any other accepted method of non-destructive testing as specified in IS:1030. Quality level of castings shall be level 3 as per IS:9565.

The grease for bearings shall conform to the requirements of IS:503 (Grade 4).

22.2.2 Fabrication

I. All work shall conform strictly to the drawings and shall be in accordance with the provisions of this section. Care shall be taken to ensure that all parts of an assembly fit accurately together. The workmanship shall satisfy all relevant provisions laid down in Chapter 21.

II. Knuckle pins, rolling surfaces of the rollers and bearing surface of the bearing plates shall be machined and all bolt holes shall be drilled. The whole bearings shall be fitted and finished as required for good

quality machined work to the satisfaction of the Engineer. However, in case of bearings which are to be grouted or bedded on a suitable yielding material on any surface which is to be in permanent contact with the grout or the yielding material may be left unmachined.

III. Fabrication shall be carried out by an organization experienced and qualified to undertake precision engineering of this type and be approved by the Engineer.

IV. Workmanship shall be of good quality, neatly finished and of good appearance.

V. Castings shall be true to the forms and dimensions shown on the drawings and shall be free from pouring faults, sponginess, cracks, blow holes and other defects on position, affecting their appearance or strength. Warped or distorted castings will not be accepted. Exposed surfaces shall be smooth and dense.

VI. All castings shall be cleaned by sand or shot blasting to remove sand or scale and to present a clean uniform surface.

VII. All irregularities, fins or risers shall be ground off flush with the adjacent surface. Castings with visible cracks, blow holes or similar blemishes shall be rejected if the imperfections are located in bearing surfaces or cannot be remedied to the satisfaction of the Engineer.

VIII. Imperfections which are not located in bearing surfaces shall be cleaned out and filled with weld metal of the appropriate composition and ground flush.

IX. All surfaces of major components like top plates, saddle plates, base plates and rollers of the bearings shall be machined all over for correct alignment, interchangeability, proper fitting etc.

22.2.3 Tolerances

Tolerances for its individual components or of the assembled bearings shall be as shown on the drawings or subject to the approval of the Engineer. In all other cases, unless otherwise directed, the following tolerances shall be maintained:

a) Diameter of Rollers, Knuckle Pins and Bores

Tolerances on diameter of rollers and all convex surfaces shall conform to K7 of IS:919.

Tolerances on diameter of all concave surfaces shall conform to D8 of IS : 919.

b) Height of Bearings

Tolerances on height of any component casting shall not exceed + 0.5mm. No minus

tolerance shall be allowed. The edges of all ribs shall be parallel throughout their length.

c) Base Plate

Tolerance on length and width of the base plate shall not exceed + 1.0mm, tolerance on the thickness of the plate shall not exceed + 0.5mm. No minus tolerance shall be allowed. All rocking, rolling and sliding surfaces shall have a machine smooth finish to 20 micron maximum mean deviation as per IS:3073.

d) Castings

No minus tolerance shall be allowed in the thickness of any part of the castings. The edges of all ribs shall be parallel throughout their length.

22.2.4 Installation of Steel Bearings

i) General

a) Bearings shall be placed in the positions as shown on the drawings with all bearing surfaces in full contact and to the tolerances as specified.

b) Roller and rocker bearings shall be placed so that their axes of rotations are horizontal and normal to the direction of movement of the members they support. Upper and lower bearing plates shall be set horizontal in both directions.

c) During installation the bearings shall be pre-set with respect to the bearing axis to account for the movement due to the following:

i) Temperature variation between the average temperature prevailing at the time of installation and the mean design temperature.

ii) Shrinkage, creep and elastic shortening.

d) For bridges in gradient, the bearing plates shall be placed in a horizontal plane.

e) In pre-stressed concrete construction where launching of girders is employed, in order to avoid slipping or jumping of rollers due to vibration or jolts, adequate measures may be taken to ensure that the roller assembly is not disturbed. It is normal practice to provide rocker bearings on the launching end and place the beam on the rocker end slightly in advance of placing on the roller.

f) During concreting of girders, the bearings shall be held in position securely by providing temporary connection between the top and bottom plates in case of fixed bearings and between top plate, base plate and saddle plate in case of roller cum rocker bearing or by any other suitable approved arrangement

which prevents the relative displacement of the components.

g) In pre-stressed precast girders, where recesses are left on the underside of girders to receive the anchor bolts, grout holes extending to the beam sides or to the deck level shall be provided. The cement sand grout shall have a mix of 1:1.

ii) Checking, Cleaning and Lubrication

Before erection, each bearing shall be uncrated, disassembled and checked. Any damaged part shall be made good for approval by the Engineer.

All bearings with sliding surfaces shall be cleaned and lightly lubricated with an approved lubricant immediately before erection.

iii) Testing

Testing of steel Roller and Rocker bearings will be done in accordance with provisions of IRS Specifications B-1-2001.

A) If required, a suitable number of complete bearings as specified by an accepting authority shall be tested to 1.25 times the design load. Recovery should be 100 per cent. Contact surfaces shall be examined by illumination source for any defects, cracks, etc. Segmental roller shall be tested for design movements.

B) For large lots (consisting of 12 sets or more), a quality control report shall be submitted as detailed below:

a) Unless otherwise agreed upon by the Engineer and the manufacturer, the latter shall furnish a complete report on the process of quality control. The Engineer may appoint an authorized inspection agency for inspection purpose on his behalf. Such an inspection agency shall also submit reports to the Engineer regarding various tests performed on the bearing or certify the acceptance of the bearings.

b) Test Certificates of all raw materials shall be submitted. If manufacturer's test certificates are not available for the raw materials, the bearings manufacturer shall perform the necessary confirmatory tests as per relevant codes of practice and shall furnish the test results.

c) A detailed quality control system including stage by stage inspection, starting from raw materials upto the finished bearing shall be submitted by the bearing manufacturer.

d) The Engineer shall reserve the right to witness such inspection at manufacturer's works with or without prior permission of the

manufacturer. For this, the bearing manufacturer shall have in plant testing facilities as far as possible and practicable.

e) The bearing manufacturer shall maintain a list of consumption of raw materials for a period of at least previous one year.

f) Test certificates of bearings manufactured during preceding one year shall be made available at the manufacturer's works.

g) In case the lot size of similar bearings exceeds 12 sets as per the direction of the Engineer, one extra set of bearings for each 24 sets of bearings or part thereof shall be manufactured and the cost of such extra bearings shall be borne by the user.

h) The Engineer shall select the extra bearing (s) at random and shall perform various tests including destructive testing on it at his discretion, either at the manufacturer's works or at any other approved test laboratory, notwithstanding the test reports submitted.

i) In case there is a major discrepancy regarding material, the Engineer shall declare the whole lot of bearings as unacceptable.

j) In case minor defects in fabrication, like welding or machining is found in the test bearing before destructive testing and if the test bearing is found to be acceptable after destructive testing, the minor defects in the test bearings shall not be a bar to the acceptance of the entire lot.

k) The opinion of the Engineer in cases (i) and (j) above shall be binding on the manufacturer.

iv) Placing

a) On supporting structures, pockets shall be provided to receive anchor bolts; one side of the pocket shall project beyond the bearing plate. The pocket shall be filled with mortar of mix 1:1 and the concrete bearing area also shall be finished level by a thin and stiff mortar pad of mix 1:1 (the thickness not exceeding 12mm) just before placing of bearing assemblies or bottom plate on the concrete seat.

b) In case of precast girders a recess of 6mm shall be provided on the underside with a level finish for housing the bearing plate. A thin and stiff mortar pad of mix 1:1 with thickness not exceeding 3mm shall be provided over the top plate before lowering the precast beam in position in order to ensure full and even pressure on the plate surface.

c) It shall be ensured that while placing the girders, the bearings are in their exact positions as indicated on the approved drawing and not displaced therefrom.

d) All concrete surfaces to be in contact with the mortar shall be thoroughly cleaned and kept saturated with water for a period not less than 24 hours before placing mortar and operations are to be carried out when the surface temperatures of the exposed bearings are the minimum practical.

e) No mortar that is more than 30 minutes old after completion of mixing, shall be used.

f) After placing and finishing the mortar, the bearing shall be checked for position and shims or other temporary supports removed and the mortar made good. If the bearing has moved, the bearing or the plate shall be lifted, the mortar removed and the whole procedure repeated.

g) Exposed faces of the mortar shall be cured under damp Hessian for 7 days.

h) Placing of the bearing and mortar shall only be carried out in the presence of the Engineer.

22.3 ELASTOMERIC BEARINGS

Note : The term "bearing" in this case refers to an elastomeric bearing consisting of one or more internal layers of elastomer bonded to internal steel laminates by the process of vulcanisation. The bearing shall cater for translation and / or rotation of the superstructure by elastic deformation.

22.3.1 Raw Material

a) Chloroprene (CR) only shall be used in the manufacture of bearing.

Grades of raw elastomer of proven use in elastomeric bearings, with low crystallization rates and adequate shelf life (e.g. Neoprene WRT, Bayprene 110, Skyprene B-5 and Denka S-40V) shall be used.

b) No reclaimed rubber or vulcanized wastes or natural rubber shall be used.

The raw elastomer content of the compound shall not be lower than 60 per cent by its weight. The ash content shall not exceed 5 per cent (as per tests conducted in accordance with ASTM D-297, sub-section 10)

c) EPDM and other similar elastomers for bridge bearing use shall not be permitted.

d) Properties and Tests

The elastomer shall conform to the properties specified in **Table 22.1**.

Table 22.1 Properties of Elastomer for Bearings

	Property	Unit	Test Method, IS Specification reference	Value of the characteristic specified
1	Physical properties			
1.1	Hardness	IRHD	IS:3400 (Part II)	60+5
1.2	Minimum Tensile Strength	Mpa	IS:3400 (Part I)	17
1.3	Minimum Elongation at break	Per cent	IS:3400 (Part I)	400
2	Maximum Compression Set	Per cent	IS:3400 (Part X) duration (h)	Temperature (deg C)
	CR		+0 to 24.2	100±1
3	Accelerated Ageing		IS:3400 (Part IV) duration (h)	Temperature (deg C)
	CR		70	100±1
3.1	Max. change in Hardness	IRHD		+15
3.2	Max. change in Tensile Strength	Per cent		-15
3.3	Max. change in Elongation	Per cent		-40

Shear modulus of the elastomer bearing shall neither be less than 0.80 MPa nor greater than 1.20 MPa.

e) The adhesion strength of elastomer to steel plates determined according to IS:3400 (Part XIV) method A shall not be less than 7 kN/m.

For elastomeric bearings (CR) used in adverse climatic conditions the following ozone resistance test shall be satisfied:

f) The ozone resistance of elastomer shall be proved satisfactory when assessed by test according to IS:3400 (Part XX). The strain, temperature, duration and ozone concentration of the test shall be 20 per cent, 40 ± 1 degree Celsius, 96h and 50 pphm by volume respectively.

g) No cracking detected by visual observation at the end of the test shall be considered satisfactory. No specific tests for assessment of low temperature resistance may be deemed necessary.

NOTE: For use of elastomer in extreme cold climates, the Engineer may specify special grade of low temperature resistant elastomer in conformity with operating ambient

- i) Identification of polymers : to confirm the usage of Chloroprene (Appendix X-2)
- ii) Ash content test : to determine the percentage (sub-section 34)
- iii) Specific gravity test : (sub-section 15)
- iv) Polymer content test : (sub-section 10)

j) The Engineer shall invariably get the test (a) performed in his presence or in the presence of his authorized representative to satisfy the requirement. In case of any disputes regarding interpretation of results the Engineer may carry out test as per ASTM S-3452-78 (Chromatography test) at the manufacturer's cost in a recognised test house.

k) The elastomer specimen to conduct the test shall be obtained from the bearings selected at random for destructive test. Remaining part of the test bearing shall be preserved by the Engineer for any test to be done in future, if required.

22.3.2 Fabrication

a) Steel plates for laminates shall be sand blasted, clean of all mill scales and shall be free from all contaminants, prior to bonding by vulcanisation. Rusted plates with pitting shall not be used. All edges of plates shall be rounded.

b) Each bearing with steel laminates shall be cast as a single unit in a mould and vulcanised under heat and pressure.

temperature conditions. The specifications of such special grade elastomer including the tests for low temperature resistance shall be mutually agreed to by the Engineer and the producer supplier and are outside the purview of these specifications.

h) Laminates of mild steel conforming to IS:226 shall only be permitted to be used. Use of any other material like fibre glass or similar fabric as laminates shall not be permitted.

i) The manufacturers of elastomeric bearings shall satisfy the Engineer that they have in-house facilities for testing the elastomer for carrying out the following tests in accordance with the relevant provisions of ASTM D-297 as given below :

Casting of elements in separate units and subsequent bonding shall not be permitted, nor shall cutting from large size cast be permitted.

Bearings of similar size to be used in particular bridge project shall be produced by identical process and in one lot as far as practicable. Phased production may only be resorted to when the total number of bearings is large enough.

The moulds used shall have standard surface finish adequate to produce bearings free from any surface blemishes.

c) Spacers used in mould to ensure cover and location of laminates shall be of maximum size and number practicable. Any hole at surface or in edge cover shall be filled in subsequently.

Care shall be taken to ensure uniform vulcanising conditions and homogeneity of elastomer through the surface and body of bearings.

d) The bearings shall be fabricated to comply with the tolerances specified in **Table 22.2**.

TABLE 22.2 TOLERANCES

	ITEMS	TOLERANCES
1.	Overall plan dimensions	-0, + 6mm

2.	Total bearing thickness	-0, + 5mm
3.	Parallelism	
a)	Of top surface of bearing with respect to the bottom surface as datum	in 200
b)	Of one side surface with respect to the other as datum	1 in 100
4a)	Thickness of individual internal layer of elastomer	± 20 per cent (max. of 2mm)
b)	Thickness of individual outer layer	-0, +1mm
5a)	Plan dimensions of laminates	-3mm, +0
b)	Thickness of laminates	± 10 per cent
c)	Parallelism of laminate with respect to bearing base as datum	1 in 100

e) The vulcanising equipment / press shall be such that between the platters of press the pressure and temperature are uniform and capable of being maintained at constant values as required for effecting a uniform vulcanisation of the bearing.

f) The moulding dies utilised for manufacturing the bearings shall be so set inside the platten of the press so that the pressure developed during vulcanisation of the product is evenly distributed and the thickness maintained at all places within acceptable tolerance limits taking into consideration the shrinkage allowance of vulcanizate.

g) The raw compound which has been introduced inside the metal dies for vulcanisation shall be accurately weighed each time and it must be ensured that sufficient quantity has been put inside the die for proper flow of material at every place so that a homogeneous and compact bearing is produced without any sign of sponginess or deficiency of material at any place.

h) Before any vulcanizate of any batch of production is used for producing vulcanised bearings, test pieces in the form of standard slab and buttons shall be prepared in accordance with prescribed standards and salient properties tested and recorded regularly against each batch of production to monitor the quality of the products.

22.3.3 Acceptance Specifications

a) All acceptance and process control tests shall be conducted at the manufacturer's plant. Cost of all materials, equipment and labour shall be borne by the manufacturer unless otherwise specified or specially agreed to between the manufacturer and the Engineer.

The manufacturer shall have all the test facilities required for the process and acceptance control tests installed at his plant to the complete satisfaction of the Engineer. The test facilities and their operation shall be open to inspection by the Engineer on demand.

b) Acceptance testing shall be commenced with the prior submittal of testing programme by the manufacturer to the Engineer and after obtaining his approval. Any acceptance testing delayed beyond 180 days of production shall require special approval of the Engineer and modified acceptance specification, if deemed necessary by him.

All acceptance testing shall be conducted by the Engineer with aid of the personnel having adequate expertise and experience in rubber testing provided by the manufacturer, working under the supervision of the Engineer and to his complete satisfaction.

c) The size and composition of acceptance lot shall be got approved by the Engineer. Acceptance lot shall comprise all bearings including pair of extra bearings, where applicable, of equal or near equal size produced under identical conditions of manufacture to be supplied for the particular project.

d) Testing lots shall be classified as follows:

- i) a lot of size 24 or larger number of bearings shall be defined as a large lot
- ii) a lot of less than 24 bearings shall be defined as a small lot

When production of a number of bearings of equal or near equal size for a large (single) bridge project is permitted to be manufactured in phases, the number of

bearings supplied from each phase shall be treated as a lot and each such lot shall be considered a large lot.

e) Lot by lot inspection and acceptance shall be made.

22.3.4 Levels of Acceptance Inspection and Testing

a) The level of acceptance testing shall generally be graded into the following two levels depending on lot size:

Level 1 acceptance testing

Level 2 acceptance testing

b) Acceptance testing Level 1 is a higher level inspection and shall be applicable to large lots only, unless otherwise specified. This shall involve manufacture of two extra bearings for each lot to be used as test bearing and eventually consumed in destructive testing.

c) Acceptance testing Level 2 shall be applicable to small lots only, (i.e. less than 24 sets) for which one extra bearing shall be manufactured. Out of the lot, one bearing shall be selected at random for carrying out material tests. This bearing shall be excluded from the lot accepted.

d) Acceptance inspection level 1 may be specified at the sole discretion of the Engineer taking into account the special importance of bridge project for small lots also under the purview of special acceptance inspection. The cost of extra bearings, in such cases shall be borne by the user, while the cost of all other materials, equipment and testing shall be borne by the manufacturer.

e) Testing: Acceptance testing shall comprise general inspection, test on specially moulded test pieces and test on complete bearings or sections for measurement of various quality characteristics as detailed in 2005.3.3 to 2005.3.7 of MOST Specifications for Roads and Bridges and IRC 83 Part II – 1996 Appendices 2 and 3, which may be referred to for details.

22.3.5 Certification and Marking

a) Bearings shall be transported to bridge site after final acceptance by the Engineer and shall be accompanied by an authenticated copy of the certificate to that effect.

b) An information card giving the following details for the bearings, duly certified by the manufacturer shall also be appended :

- Name of manufacturer
- Date of manufacture

- Elastomer grade used
- Bearing dimensions
- Production batch no.
- Acceptance lot no.
- Date of testing
- Specific bridge location, if any

c) Explanation of markings used on the bearing

d) All bearings shall have suitable index markings for identifying the information. The markings shall be made in indelible ink or flexible paint and if practicable should be visible after installation. The top of the bearing and direction of installation shall be indicated.

22.3.6 Storage and Handling

Each elastomeric bearing shall be clearly labeled or marked. The bearing shall be wrapped in a cover. They shall be packed in timber crates with suitable arrangement to prevent movement and to protect corners and edges. Care shall be taken to avoid mechanical damage, contamination with oil, grease and dirt, undue exposure to sunlight and weather to the bearings during transport and handling prior to and during installation.

22.3.7 Installation of Elastomeric Bearings

i) Multiple bearings to be installed one behind the other on a single line of support shall be of identical dimensions.

ii) Bearings must be placed between true horizontal surfaces (maximum tolerance 0.2 per cent perpendicular to the load) and at true plan position of their control lines marked on receiving surfaces (maximum tolerance + 3mm.)

iii) Concrete surfaces shall be free from local irregularities (maximum tolerance ± 1 mm in height)

iv) Design shall be checked for the actual inclination in seating if larger inaccuracies than those specified are permitted.

v) For cast-in place concrete construction of superstructure, where bearings are installed prior to its concreting, the forms around the bearings shall be soft enough for easy removal. Forms shall also fit the bearings snugly and prevent any leakage of mortar grout. Any mortar contaminating the bearings during concreting shall be completely removed before setting.

vi) For precast concrete or steel superstructure elements, fixing of bearing to them may be done by application of epoxy resin adhesive to interface, after specified

surface preparation. The specifications for adhesive material, workmanship and control shall be approved by the Engineer. Care shall be taken to guard against faulty application and consequent behaviour of the adhesive layer as a lubricant. The bonding by the adhesive shall be deemed effective only as a device for installation and shall not be deemed to secure bearings against displacement for the purpose of design.

As a measure of ample safety against accidental displacement, the bearings shall be placed in a recess as shown in Fig. 9 of IRC: 83 (Part II).

22.3.8 Seating of Elastomeric Bearings on a Non-Horizontal Plane

Installation of elastomeric bearings on a Non-Horizontal Plane shall be as follows:

Elastomeric bearings shall be delivered with MS backing plate fastened to the bearing from the manufacturer. Template of 6mm M.S. plate and of size same as bearing holding base plate with matching holes for the anchor screws shall be used. Anchors shall be fitted to the templates with the anchor screws but with MS washers in place of elastomer washers. The above template assembly shall be fitted in the form work at its proper location and in a vertical plane. After casting of the pedestal and removal of the form work, the template is to be removed.

A. Installation with Face Plate and without Template in-situ Casting

i) The sub-assembly of elastomeric bearing with the MS backing plate shall be fitted to the embedded anchors with anchor screws and elastomeric washers replacing the steel washer.

ii) A clearance is required between the stainless steel face of the elastomeric bearing and that of the vertical face of the face plate with stainless steel top installed on the projection below the soffit. This shall be achieved by inserting removable steel sheeting of thickness as per the drawing, during preparation of the form work before casting of the superstructure.

iii) The face plate with stainless steel top and pack plate shall be assembled with the anchors with elastomeric washers and anchor screws. The assembly shall be fitted in the form work at its proper location and in a vertical plane. The removable steel shims shall be removed at an appropriate time after the casting of the super-structure.

B. Installation with Face Plate and with Template in-situ Casting

i) Template of 6 mm MS plate and of size same as face plate with stainless steel top and matching holes for the anchor screws shall be used. Anchors shall be fitted to the templates with the anchor screws but with MS washers in place of elastomer washers. Separate screws may be used in case of inconvenience of fixing the washers in the length of original anchor screws. The above template assembly shall be fitted in the form work for the super structure at its proper location and in a vertical plane.

ii) After removal of the superstructure form work, the template shall be removed.

iii) The face plate with the required thickness of pack plate shall be loosely fitted to the anchors embedded in the projection below the superstructure, with elastomer washers and anchor screws.

iv) The sub-assembly of elastomeric bearing with the MS backing plate shall be fitted to the embedded anchors in the pedestal with anchor screws and elastomeric washers replacing the steel washer this time.

v) The required clearance between the stainless steel face of the elastomeric bearing and that of the vertical face plate installed on the projection below the soffit shall be checked. After adjustment of the required working clearance the small gap between the vertical face of the projection below the soffit and the back of the face plate (with pack plates, if any) shall be grouted with epoxy grout.

22.4 POT BEARINGS

22.4.1 General

Pot type bearings shall consist of a metal piston supported by a disc or reinforced elastomer confined within a metal cylinder to take care of rotation. Horizontal movement, if required, shall with a system of sealing rings be provided by sliding surfaces of PTFE pads sliding against stainless steel mating surfaces. The pot bearings shall consist of cast steel assemblies or fabricated structural steel assemblies.

Provisions of IRC-83 (Part I) shall be applicable for all metallic elements. Provisions of IRC:83 (Part II) shall be applicable for all elastomer elements. When any item is not covered by IRC:83 (Parts I and II), the same shall be as per guidelines given hereunder and BS:5400 (Sections 9.1 and 9.2), except that no natural rubber shall be permitted. If there is any conflict between

BS on the one hand and IRC on the other, the provisions of IRC will be guiding.

Combination bearings using any judicious combination and sliding element shall be

permitted. Some examples are shown in **Table 22.3** below.

Table 22.3 : Combination of Elements for POT Bearings

Name	Rotation Element	Sliding Element	Generally for
Pot	Pot	None	Vertical Load
Elastomer	Elastomer	None*	Horizontal Buffer
Pot PTFE	Pot	PTFE-SS**	Vertical Load and Horizontal Load
Spherical Knuckle PTFE	Spherical Knuckle	PTFE-SS**	Vertical Load and Horizontal Load
Elastomer PTFE	Elastomer	PTFE-SS**	Transverse Guide
Elastomer SS**	Elastomer	SS-SS**	Transverse Guide

* Elastomer shall permit movement by shear

** Stainless Steel

For special and innovative bridges, new combinations beyond what is indicated may be required. The same may be used after approval by the Engineer.

22.4.2 Fabrication

i) The surface mating with the PTFE in the sliding pair shall be of corrosion resistant stainless steel. Normally, the stainless steel shall form the upper component. The stainless steel shall overlap the PTFE after full movement on all sides. If stainless steel sheet is used, it should be bonded by continuous welding along the edges. Adhesive or any other bonding can be approved by the Engineer. The surface shall be prepared by thorough cleaning to remove grease, dust or any other foreign substance.

ii) PTFE modular sheets of the sliding pair shall be located by confinement assisted by bonding. Confined PTFE shall be recessed into the metal backing plate. The shoulders of the recess shall be sharp and square to restrict the flow of PTFE.

iii) The thickness of the PTFE shall not be less than 4.5mm with projection above the recess not exceeding 2.0mm. When the piston is subjected to tilting, the seal must slide along the wall and alter its shape according to the angle of tilt. At the same time, it must be sufficiently rigid to bridge the gap between the piston and the wall of the pot. However, the percentage of plan area of the lubrication cavities to the gross area shall not exceed 25 per cent. The depth of the cavity shall not exceed 2.0mm.

iv) The diameter to thickness ratio of the confined elastomer shall not exceed 15. The surface of the confined elastomer shall be smooth.

v) A seal shall be provided to prevent extrusion of the confined elastomer between the piston and the pot wall. The seal should stay functional under the loads and rotations acting on it. Additional seal shall be provided to prevent entry of dust into the pot. Sealing rings for pot bearing shall be fabricated from stainless steel. When the piston is subjected to tilting, the seal must slide along the wall and alter its shape according to the angle of tilt. At the same time, it must be sufficiently rigid to bridge the gap between the piston and the wall of the pot.

vi) The hardness of the piston and pot wall at their contact region shall be minimum 350BHN to reduce wear. The surface finish of the pot base in contact with the confined elastomer shall be very smooth.

vii) All bearings shall be installed with anchor and anchor screws or some similar device such that while replacing, the bearings can be removed with minimum lifting of the superstructure.

viii) The external surfaces of the assemblies shall be completely cleaned by sand blasting. After sand blasting, dust shall be removed from the surface using clean and dry compressed air or a clean brush after which suitable coating shall be applied.

ix) Pot bearings including all parts as shown on the drawings shall be fully shop

assembled at the manufacturer's works to ensure proper fitting of all the parts.

22.4.3 Materials for POT/ PTFE Bearings

a) Steel

i) Structural steel shall conform to IS:226 or IS:2062, as applicable.

ii) Cast steel shall conform to Gr.280-520W of IS:1030 with 0.3 to 0.5 per cent copper added to increase the corrosion resistance properties.

c) Elastomer

The confined elastomer inside pot will have the following properties:

i) Hardness	IRHD	IS:3400 (Part II)	50 + 5
ii) Min. tensile strength	Mpa	IS:3400 (Part I)	15.5
iii) Min. elongation at break		shall be as per Table 22.1 "Properties of Elastomer"	
Max. compression set and Accelerated ageing)			

For other details, refer to Para 22.3.1

22.4.4 Workmanship

22.4.4.1 Welding

All welding shall conform to IS:9595 with electrodes of suitable grade as per IS 814. Preheating and post weld stress relieving shall be done as per IS:9595.

a) Cast Steel assemblies: Cast steel for pot bearing assemblies shall conform to requirements of relevant IS. Castings shall be true to the forms and dimensions shown on the drawings, and shall be free from pouring faults, sponginess, cracks, blow holes and other defects affecting their appearance or their strength. Warped or distorted castings shall not be accepted. Exposed surfaces shall be smooth and dense.

All irregularities, fins or risers shall be ground off flush with the adjacent surface. Castings with visible cracks, blow holes, or similar blemishes shall be rejected if the imperfections are located on bearing surfaces or cannot be remedied to the satisfaction of the Engineer.

Imperfections which are not located on bearing surfaces shall be cleaned out, filled with weld metal of the appropriate

iii) Stainless steel shall conform to AISI:304 or X04Cr 18 Nil) of IS:6911 for ordinary applications. For applications with adverse / corrosive environment, the stainless steel shall conform to AISI:316L or O2Cr17Ni12Mo2 of IS:6911.

b) PTFE

PTFE (poly tetra fluoro ethylene) shall be of unfilled pure virgin quality. It shall be free sintered. The mechanical properties of unfilled PTFE shall comply with Grade A of BS:3784.

composition and ground flush with adjacent surfaces.

b) Structural steel assemblies: Defects arising from the fabrication of the steel shall be inspected by the Engineer, who will decide whether the materials may be repaired by the Contractor or will be rejected. The cost of repairs or replacement shall be borne by the Contractor.

All steel whether fabricated or not, shall be stored on platforms, skids, or other supports above the ground and adequately protected against corrosion. Excessively rusted, bent or damaged steel shall be rejected.

All plates shall be flat, and rolled bars and shapes straight before marking out or being worked. Straightening shall be done by methods which shall not damage the material. Sharp kinks and bends shall be the cause for rejection.

Steel may be flame cut to shape and length so that a regular surface, free from excessive gouges and striation is obtained. Flame cutting by hand shall be done only with the approval of the Engineer. Exposed corners shall be machined or ground.

c) Tolerances

i) Plan dimensions	: -0 to +5mm
ii) Overall height	: -0 to +3mm
iii) Height of elastomer	: $\pm$ 5 percent

- iv) Height of any steel component
 - a) Machined : -0 to + 1mm
 - b) Unmachined : Class of IS :4897
- v) Stainless steel sliding surface
 - a) Flatness : 0.0004L, where L=length in direction of measurement
 - b) Surface Finish : $R_a \leq 0.25 \mu\text{m}$ as per IS:3073

d) Painting

i) All non-working surfaces shall be coated with two coats of epoxy primer and one or more coat each of epoxy intermediate and finish, total thickness $\leq 0.150 \mu\text{m}$ or any other painting scheme as approved by the Engineer.

ii) Silicon grease shall be applied at the PTFE /SS interface after testing.

iii) Anchor sleeves shall be cement coated at the manufacturer's works.

22.4.5 Test

Raw Materials: Necessary test certificates for all raw materials listed in Para 22.4.3 above shall be furnished by the manufacturers. Reference may also be made to Para 22.3.1 for tests on elastomers.

Test on Casting: Tests specified in IS:1030 shall be performed. Castings shall be ultrasonically tested and certificates submitted. Quality level of castings shall be level 3 as per IS:9565.

Test on Welding: All welding shall be tested by Dye Penetration method. Butt welding shall be tested by Ultrasonic method. Soundness of welding shall be certified by the manufacturer.

Acceptance test on Bearing

- i) All bearings shall be checked for overall dimensions.
- ii) All bearings shall be load tested to 1.1 times maximum design capacity including seismic force. Bearing tested at higher loads cannot be used.
- iii) A pair of bearings selected at random will undergo testing in order to determine the coefficient of friction " μ ". The coefficient of friction shall be ≤ 0.05 at the design load.
- iv) Two bearings selected at random shall be tested for permissible rotation.

22.4.6 Installation of POT –cum-PTFE Bearings

a) General

i) Care shall be taken during installation of the bearings to permit their correct functioning in accordance with the design scheme.

ii) To prevent contamination, dismantling of the bearings at site shall not be done.

iii) The load shall be transferred on to the bearings only when the bedding material has developed sufficient strength. The props for the form work shall be removed only after lapse of appropriate time. In special cases, this can be ensured by suitable devices like jacks etc.

iv) Temporary clamps and shims (introduced to maintain working clearance) shall be removed at an appropriate time, before the bearing is required to permit movement.

v) Permitted installation tolerance of the bearing from plane of sliding shall be maintained.

vi) Cement based non-shrink grout with air releasing additive and epoxy based grout, whichever is specified, shall be first tried at the site. For the proprietary grout mixes, appropriate instructions from the manufacturer shall be followed specially with regard to the following:

- a) Preparation → concrete cleaning, roughening, pre-soaking, etc
- b) Forms → sturdiness, leak proofing, shape, header funnel vents, etc.
- c) Bearing Base → cleaning, etc.
- d) Placement → mixing, consistency, time period, finishing etc.
- e) Protection → curing, ambient temperature, etc.

b) In-situ Casting of Superstructure

- i) Form work around the bearing shall be carefully sealed to prevent leakage.
- ii) Sliding plates shall be fully supported and care taken to prevent tilting, displacement or distortion of the bearings under the weight of wet concrete.
- iii) Bearings shall be protected during concreting operation. Any mortar contaminating the bearing shall be completely removed before it sets.

c) Seating of bearing

A. Using Template

i) ___ Template with required rigidity and matching holes corresponding to the base of the bearing shall be used.

ii) All the anchors shall be fitted to the lower face of the template using the anchor screws but with steel washer replacing the elastomer washers. Separate screws may be used in case of inconvenience in the length of the original anchor screws.

iii) The template assembly shall be located with regard to level and alignment. It shall be ensured that the top of the anchors lie in a horizontal plane at the required elevation. The anchors shall be tied / welded to reinforcements to avoid displacement during concreting.

iv) Concreting of the pedestal / pier cap shall be done to a level leaving a gap of 25-50mm below the template.

v) The template and steel washers shall be removed prior to placement of the bearing assembly with temporary clamps. The bearing assembly shall be fitted to the anchors with the help of anchor screws and elastomer washers. Level at the bearing shall be checked.

vi) The gap below the bearing assembly shall be grouted with cement based grout. Reference may be made to Para 22.4.6 (a) (vi)

B. Without Template with Gap

i) Pockets commensurate with the sizes of the anchors shall be kept in pedestals during concreting of the same. The pedestal shall be cast approximately 25mm short of the required finished level.

ii) Anchors shall be fitted to the bearing bottom with elastomer washers and anchor screws. The bearing assembly shall be seated in the location on steel chairs / packs. The anchors fitted below the bearing shall go into pockets in the bed block. Level and alignment of the bearing shall be checked. It shall be ensured that the bearing sits in a horizontal plane.

iii) The gap below the bearing assembly including anchor pockets shall be grouted with cement based grout.

C. Without Template without Gap

Elongated pockets commensurate with the sizes of the anchors shall be kept in pedestals during concreting of the same. The geometry and location of the anchor pockets (with tapered funnel extension, if required) shall be such that after placement of the bearing the pockets can be successfully grouted. The pedestal shall be

cast 5mm to 15mm short of the required finished level. The required level shall be achieved by chipping before placement of the bearing. Careful control shall be exercised to cast at the exact finished level or 1mm to 3mm down from the required finished level.

D. Seating of bearings shall be as per manufacturer's instructions.

22.4.7 Inspection and Testing

Where any patents are used, the manufacturer's certificate with test proofs shall be submitted along with the design and got approved by the Engineer before their use in work

22.4.8 Tests and Standards of Acceptance

The materials shall be tested in accordance with these specifications and shall meet the prescribed criteria.

The work shall conform to these specifications and shall meet the prescribed standards of acceptance.

22.5 MEASUREMENTS AND RATES FOR ALL TYPES OF BEARINGS

22.5.1 Measurements for payment

Bearings shall be measured in numbers, unless otherwise specified in the contract, according to their types, capacities and particular specifications given on the drawings.

The quantity of elastomeric bearings shall be measured in cubic centimetres of finished dimensions.

22.5.2 Rate

The contract unit rate of each type of bearing shall include the cost of supplying and fixing the bearings in position complete as specified on the drawings or as directed by the Engineer. The rate shall also include the cost of samples and their testing when desired by the Engineer.

In case of steel bearings the rates shall include the cost of all nuts, bolts, the cost of all tests prescribed in the specifications and shown on the drawings.

Where the Department supplies the bearings, the rate for fixing them shall include the cost of anchor bolts and grouting materials their fixing, transport of bearings from the place of supply to the site, handling and placing them in position as per direction of the Engineer unless specified otherwise.

22.6 RIVER TRAINING AND PROTECTION WORKS

22.6.1 The following section covers works provided in the rivers / streams for safely guiding flow of water and preventing damage to bridge and approach banks by scour, undermining, outflanking etc. This work shall consist of construction of embankment of guide bund and provision of pitching/rivetment on slopes, apron, toe protection, curtain walls etc., as indicated on the drawing in accordance with these specifications or as approved by the Engineer.. The provisions given hereunder are applicable only to guide bunds for bridges across alluvial rivers. Guide bunds for bridges across sub mountain rivers shall call for supplemental specifications.

22.6.2 Guide Bund

22.6.2.1 Guide bunds shall generally be made of locally available materials from the river bed preferably not cohesionless soil. Trial pits shall be taken in borrow holes to examine suitability of soil for construction and also to decide the types of earth moving machinery to be arranged. The borrow pits should be sufficiently away from the location of any apron. No borrow pits should be dug on the river side of the guide bunds.

Construction of guide bund shall be taken in hand along with the construction of the bridge. Every effort shall be made to complete the work of the guide bund in one working season. Where there is any doubt about completion of the whole guide bund within one working season, suitable measures shall be planned and executed for protection of completed work. In such cases the construction of guide bund shall be started from abutment towards upstream. It shall be built up and compacted in accordance with relevant specifications for construction of a bank as given in Chapter 1 unless otherwise specified.

22.6.2.2 The Contractor shall furnish his proposed methodology and sequencing of works for approval of the Engineer. It should include details regarding transport of stones from the quarries to the site of work taking into account the quantities of stone required to be transported every day, type of transport facility available and labour available for loading and unloading and for laying within the time frame for construction of guide bund. Adequate reserve of stones should be maintained for major works as decided by the Engineer. Stones shall be stacked sufficiently away from the main channel of the river, as instructed by the Engineer.

22.6.2.3 Where the alignment of guide bund or the approach embankment crosses a branch channel of the river, the branch channel may be either diverted to the main channel of the river with the help of spurs, etc., or closed by a properly designed closing dyke or closure bund before taking up construction of guide bund. Such work shall be separately paid for, unless otherwise provided in the contract.

22.6.2.4 Guide bunds shall be provided with a slope pitching with stones laid over a filter media or as shown in the drawing. The toe will be protected with an apron laid horizontal on bed, all as shown in drawing or as directed. Normally stones weighing not less than 35 kg shall be used for pitching, unless otherwise specified. Apron shall be laid at as low level as possible by excavation of bed. Material thus excavated can be used for construction of guide bund, if found suitable and approved by the Engineer. Detailed specifications for Pitching and Apron have been given in subsequent Paras.

22.6.3 Filter Media for Pitching

A filter has to be provided below the layer of pitching stone over the finished earth bank, so that it forms a barrier. Otherwise, the flowing water will tend to suck the soil particles forming the bank through the interstices between stones in the pitching. A graded filter media of specified thickness (one layer preferably 200 to 300 mm thick and not less than 150mm thick) is therefore provided below the stones so as to prevent the flow of finer soil through to the pitching. The filter will not only prevent escape of embankment material through the voids of stone pitching, but also allow free movement of water through it so as to prevent any uplift head developing against the pitching stone. The filter media will be made up of granular material as given below -

The material for filter shall consist of coarse sand, gravel or stone chips. The gradation of material shall satisfy the following requirements. It will be made up of one or two layers of material satisfying the following criteria.

$$\begin{aligned} D15 (\text{Filter}) / D85 (\text{Base}) &< 5 ; \\ 4 < D15 (\text{Filter}) / D15 (\text{Base}) &< 20 ; \text{ and} \\ D50 (\text{Filter}) / D50 (\text{Base}) &< 25 \end{aligned}$$

In the above relationships, D15 means the size of sieve which allows 15% of material to pass through. Similar is the meaning of D 50 and D 85. If filter is provided in two layers, the above mentioned requirement will be followed for each layer.

22.7 STONE OR BLOCK KANKAR PITCHING

Note:- The position, dimensions and slope of the pitching shall be as shown in the drawings or specified by the Engineer. The pitching will be hand packed or roughly deposited as ordered by the Engineer or as shown in the drawing.

22.7.1 Material and Laying

a) Pitching Stone: The pitching stone shall be obtained from sources approved by the Engineer. The stone shall be sound, hard and durable. The stone should weigh between 35 to 60 kg and no stone shall be less than 15 cm in any direction unless otherwise specified, except the smaller stones for filling gaps. Payment for stone supplied shall be made after deduction for voids/ shrinkage is made at 15% of stack measurement, unless otherwise specified.

b) Pitching Methodology. Dry stone pitching shall be of two kinds - dressed stone pitching and rough stone pitching.

i) Rough Stone pitching: The stones for rough stone pitching shall be set in the work as received from the quarry and without any dressing except knocking off weak corners and edges with a mason's hammer. A small proportion of stone chips may be allowed to show in the face work. The face stones must in general weight at least 35 kg and be well bedded and hand set. The ground on which the pitching shall be done will be dressed to the correct profile and joint openings to the underlying fill shall be avoided by carefully arranging the various sizes of stones, and by closing the openings with small stone fragments or smaller size stones. The work shall be done so as to have a reasonably smooth surface and uniform thickness. In roughly deposited pitching, the stone shall be roughly levelled off to the correct section.

c) Precautions to be taken in Laying

i) All earth surfaces that are to be pitched and subsequently exposed to the action of running water, shall be covered with a filter layer of gravel, ballast or quarry chips to a depth of 15 cm to 30 cm as ordered by the Engineer, or with two layers of bricks laid flat before the placing of pitching stone, as mentioned in para 22.7.3. The bricks, when used, shall be laid flat in a diagonal manner with top layer being laid in directly opposite direction to the lower layer. This filter layer prevents the finer material of the bank from being sucked out by the flowing water,

ii) For pitching carried out below water level, the stone shall be thrown carefully so that it may spread as uniformly as possible. This shall be ensured by taking frequent soundings to guide the dumping of stone. For this, necessary arrangement including bamboo poles, plank pathways, floating bridges or boats etc. shall be provided by the contractor and the element of their cost is included in the rate. Pitching under water shall, as far as possible, be carried out when the water level is at its lowest.

iii) Before laying stones, the sides of the bank shall be trimmed to the required slope and template cross walls shall be built to the full height of the intended thickness of slope and apron at intervals of 30m to ensure regular straight work and a uniform slope throughout.

22.8 APRON AND CRATING

22.8.1 Apron pitching

a) Apron pitching stone should only be flung in as it will lie and should be roughly levelled off to the correct section. There is no advantage in hand packing the apron pitching and this should never be done. Size of stone used shall vary between 35 kg and 60 kg and the proportion of different sizes shall be decided by the Engineer, unless otherwise specified in Drawings and Contract Documents.

b) The stones shall not be dressed except knocking of weak edges and corners with a mason's hammer. The face stones must be bigger size stones selected from the lot.

c) For pitching carried out under water the stone will be thrown carefully so that it may spread as uniformly as possible. For this reason, man with poles or sounding leads must be engaged to take frequent soundings to guide the work people where to throw the stone. The cost of bamboo and plank pathway will be borne by the Contractor and if floating bridges are necessary, their erection and maintenance will also be borne by the Contractor.

Pitching under water should where possible shall be carried out when the water level is at its seasonal lowest.

22.8.2 Rate

The rates cover the cost of all labour as well as the supply by the Contractor of all tools and plants required for the execution of the work.

The supply of boulders for protection works shall be as specified in the rate (either by the

contractor or by the Railway). Stones shall be stacked properly, measured and recorded in the measurement book before utilisation in pitching or any other protection works. Payment for stone supplied shall be made after deduction for voids/ shrinkage is made @ 15% of stack measurement, unless otherwise specified.

22.8.3 Sausage and Crated stones

Galvanized iron wire: GI wire used for crating and sausages shall be of mild steel quality conforming to the IS Specification No.280-1978. The wire shall be sound, free from splits, surface flaws, rough jagged and imperfect edges and other harmful surface defects. The minimum tensile strength shall be 32 to 44 kg / mm² and the galvanised coating shall conform to the test given under clause 10 of IS:280.

Stones : Shingle boulder weighing 35 kg. to 60 kg (size between 20 and 40 Cm) as specified in contract or by the Engineer shall be used in filling the sausage crates with stones of smaller size to fill up the gaps in between. For pitching also size of stones used will be of similar size.

Crating

i) Sausage – Standard practice for netting wire sausage is with 4mm dia, (8 SWG) galvd. wire mesh of 15 cm or 10 cm. , double locked and nonslipping type

ii) Sausage Crate – In case of rectangular sausage crate the same quality of materials and procedure for weaving as shown in approved drawings shall to be followed. The sequence of operations for assembling the crate and the process narrated for end binding with illustrations should be followed as in approved drawings. In absence of any drawing following guide lines (extracted from Section 2503.3 of MOST specifications) may be followed.

“ The mesh of the crate shall not be more than 150 mm.

Wire crates for shallow or accessible situations shall be 3 m x 1.5 m x 1.25 m in size. Where they have to be deposited and there is a chance of overturning, the crate shall be divided into 1.5 m compartments by cross netting. For deep and inaccessible situations, wire crates can be made smaller subject to the approval of the Engineer.

Wire crates built in-situ, shall not be larger than 7.5 m x 3.0 m x 0.6 m, nor smaller than 2 m x 1m x 0.3m. Sides of large crates shall be securely stayed at intervals of not more than 1.50 m to prevent bulging.

Wherever possible, crates shall be placed in position before filling with boulders. The crates shall be filled carefully by hand packing of the boulders as tightly as possible and not merely throwing stones or boulders.”

22.9 MEASUREMENTS AND RATE FOR ALL TYPES OF PROTECTION WORKS

22.9.1 Measurements

i) The protection works shall be measured as set forth below. If so directed by the Engineer for measurement, the materials may have to be stacked at site before laying and nothing extra will be paid for this stacking.

ii) The earthwork in construction of embankment for guide bund shall be measured in cubic metres unless otherwise specified. The boulders /cement concrete blocks and wire crates in apron shall be measured in cubic metres.

iii) The filter and stone pitching shall be measured separately in cubic metres unless otherwise specified.

iv) Rubble stone/ cement concrete blocks, flooring and cement concrete bedding shall be measured in cubic metres for each class of work. Preparation of base for laying the flooring shall be deemed incidental to the work.

v) For laying apron, excavation upto an average depth of 150 mm shall be deemed to be included in the main item and shall not be measured separately unless otherwise specified. Excavation more than 150 mm shall be measured in cubic metres as given in Chapter 1 for earthwork. If any of the quantity excavated is used in the guide bund, such quantity will be deducted from such measurement for excavation.

22.9.2 Rate

i) The unit rate for construction of embankment for guide bund shall cover the cost of all materials and labour in setting out, excavation, transportation, laying, compacting, tools, equipment, sampling and testing, supervision and all incidentals necessary for completing the work according to these specifications.

ii) The unit rate for one cubic metre of finished work of apron shall include cost of all materials, labour, tools and plant for completing the work according to above specifications. Excavation upto an average depth of 150 mm shall also be deemed to be included in the rate for dressing of the bed. Excavation beyond this depth shall be paid for separately unless otherwise specified.

iii) The unit rate for one cubic metre of filter or stone/ cement concrete block pitching on slopes shall include the cost of preparing the bases putting to profiles, laying and compacting the filter and stone pitching of dry rubble / cement concrete block revetment for embankment slopes to the specified thickness, lines, curves, slopes and levels and all labour, material, tools and plant for completing the work as per these specifications.

22.10 SPECIFICATIONS OF STEEL WIRE ROPENET FOR ROCKFALL PROTECTION WORKS

High strength steel wire rope nets comprise of galvanized steel wire ropes in both vertical and horizontal directions. At the intersections, vertical and horizontal chords have a tucked joint fixed with special clamps. The nets comprise an upper hang portion with only vertical chords for anchorage and a lower net portion with both vertical and horizontal chords so as to retain the boulders. The appropriate aperture size and length of the hang and net portions are selected to suit site requirements. The product is suitable for rock-fall protection applications requiring high strength and durability.

22.10.1 Specifications of High Strength Steel Wire Ropenets

Property	Specification
Product Types	450mm x 600mm
Properties of the Steel Wire Rope	
Material	Galvanised Steel Wire Rope
Rope Grade	1770 N/mm ²
Nominal Diameter	9 mm
Min. breaking force	4500 Kgf
Construction of wire rope	6 x 19 with fibre (polypropylene) core*
Tensile Strength of wires & zinc coating	IS : 1835 – 1976
Properties of the Ropenet	
Construction of the net	Joints tucked in one direction and clamped
Aperture Size	450mm (horizontal) x 600mm (Vertical)
Tensile Strength of Net	
Vertical Direction :	8500 Kg/m
Horizontal Direction :	6700 Kg/m
Punching strength	7000 Kg
Dimensions of Ropenet	
Length of hang portion	6 m (or as per site requirement)
Length of net portion	10 / 15 / 20 / 25 / 30 / 35m (as per site requirement)
Width	5m (± 5%)

*See Construction of rope

Note : 9mm steel wire rope for Ropenet to be specifically made with pitch of 75± 5mm to suit specific application of fabrication of Ropenets. Hence, BIS Specifications need to be referred for guidelines only.

22.10.2 Construction of Rope

6 x 19 S (9-9-1) with fibre (Polypropylene) core or 6 x 19 M (12/6-1) with fiber (Polypropylene) core as per IS : 2266-2002

a) If it is 9-9-1, diameters of wires in 3 layers may be as follows :

Outer 9 wires of 0.72 mm diameter

Middle layer 9 wires of 0.42 mm diameter.

Centre wire 1 of 0.92 mm diameter.

b) If it is 12/6-1, diameters of wires in 3 layers may be as follows :

Outer layer – 12 wires of 0.60 to 0.63 mm diameter

Middle layer – 6 wires of 0.60 to 0.63 mm diameter

Centre layer – 1 of 0.72 to 0.76 mm diameter.

22.10.3 Tensile Strength of Wire & Zinc Coating

As per IS : 1835-1976

i) Strength of wires : 1770 N/mm²

ii) Zinc Coating AB type as follows :

Diameter of Wires in mm	Zinc Coating in gm/sqm
0.40-0.50	60
0.50-0.60	70
0.60-0.80	85
0.80-1.00	95



22.10.4 Installation Methodology

The installation of High Strength Steel Wire Ropenets and Hexagonal Double twisted wire mesh for rock fall protection involves the following steps :

22.10.4.1 Site Preparation

Remove all surface vegetation including trees & shrubs in the cutting where rope netting has to be done. Loose boulders have to be removed in block condition on slope of rock cutting including removing of loose rock/undulations & dressing side slope to facilitate spreading of Ropenet.

22.10.4.2 Top anchoring

Position of top anchoring should be at a minimum distance of 6 m from the face of cutting. For any deviation from the above mentioned, approval of Engineer-in-Chief is mandatory.

In case of soft soil or moorum present on top of cutting, a top trench of 1.0 m depth & 0.6 m width has to be excavated at a distance of approximately 6.0 m from edge of cutting for

top anchoring of Ropenet. Ropenets are available with eyes or loops in vertical chords for anchoring.

A Precast RCC beam of 0.15 m x 0.15 m x 2 m of M15 concrete is used for top anchoring. RCC beam is inserted through loops of chords & beams are placed inside excavated trench.

Precast beam alongwith anchoring chords is embedded inside trench by M10 concrete of 0.3 m depth. After curing of concrete, the trench is filled with backfill muck with moderate compaction.

22.10.4.3 Lacing of adjacent ropenets and / or Hexagonal wire mesh with Ropenets

After top anchoring of ropenets, adjacent nets are laced so as to form a continuous net. If Hexagonal wire mesh is also specified, mesh is laced beneath ropenet. Specially designed galvanized steel spiral locks are used for lacing. One spiral lock for each mesh of net is used.

22.10.4.4 Spreading

After lacing, the continuous nets / nets and mesh are rolled from top to bottom of cutting so as to cover the cutting.

22.10.4.5 Intermediate anchoring

Nets are anchored on the cutting slope using anchor bolts/fasteners of 10–12 mm diameter and 110mm length. For every 5sqm of surface area, one anchor bolts is fixed with epoxy coated M.S. plate of 200mm x 200mm x 6mm as washer. Intermediate anchoring is required so that nets take the shape of cutting profile and hug the rock surface. Anchor bolts are fixed by drilling a hole for anchors and applying a torque of 65 to 70 Nm after washer plates are placed over the ropenets.

22.10.4.6 Bottom Anchoring

HYSD bolts of 1m depth & 16mm diameter, having a thread of 200mm on top are used for bottom anchoring. Bottom anchoring is done in a staggered manner such that each vertical chord of ropenet is anchored.

A drill hole of 20 mm diameter is made with the help of a jack hammer upto a depth of 1m in a staggered manner. Each hole is filled with 3-4 cement capsules and bolts are

driven to desirable depth. Nuts are tightened on threaded portion of anchor bolts after epoxy coated washer plates of 200 mm x 200 mm x 6 mm are placed over ropenet.

22.11 SPECIFICATIONS OF GEOMAT FOR EROSION CONTROL WORKS

Geomat is a composite mat comprising of a layer of bio-degradable mulching material sandwiched between and mechanically bonded to two layers of polymer netting. The product combines the moisture retention and soil enrichment characteristics of the mulch with tensile strength and durability of polymer netting.

Geomat consisting of three layers shall be held together at every 100mm spacing in a staggered manner with the stitching thread of the same material of Geomat in both directions.

The netting used for fabrication of Geomat shall be depth stretched in autoclave so as to achieve good knot tightness, uniformity of mesh size & good dimensional stability of netting.

22.11 .1 Technical Specifications

Property	Specifications
Top and bottom layers of polymer net	
Material and Structure	Polymer netting comprising of tensile elements of circular cross-section in two orthogonal directions with knotted joints
Aperture size	20 (± 2) mm x 20 (± 2) mm
Tensile strength	
Top net	1.0 kN/m (minimum in both directions)
Bottom net	1.8 kN/m (minimum in both directions)
Combined strength	2.8 kN/m (minimum in both directions)
Type of joint	Knotted
Middle layer of bio-degradable mulch	
Material	Coir fibre
Weight	300 (± 20) gms/m ²
Dimensions of Geomat	
Length	10 / 12 / 15 m (depending on site requirement)
Width	5 m (minimum) without any joints/seams.

Note :

1. Length of Geomat could be varied to suit site requirements.
2. Spacing : Composite mat to be held together at every 100mm. Spacing of stitches in a staggered manner in both direction.



22.11.2 Installation Methodology for Geomat

Installation of Geomat involves following steps :

22.11.2.1 Sub-grade Preparation

An inspection is performed to check up the ground surface for any ridges or major undulations etc. Ridge, undulations if any shall be removed using filling or cutting the same. Existing slope is leveled & gullies formed are properly filled up.

An identified accepted good vegetative soil will be brought to site and stacked.

22.11.2.2 Top Anchoring

Geomat is anchored at top in an anchor trench of size 500mm x 500mm. After anchoring, trench is filled with excavated soil.

22.11.2.3 Laying

A 100mm thick layer of fertile soil is spread on the surface of leveled slope. Geomat is rolled over the slope

22.11.2.4 Overlaps

Overlap on the length of coir mat, if required is minimum 250mm. Adjacent panels of Geomat shall be stitched together using the same twine used in manufacture of product.

22.11.2.5 Intermediate Anchoring

Geomat is anchored on slope surface using U-Pins (MS pins of 6mm diameter and size 100 x 300 x 300 mm) at 1 pin per 2 sqm of Geomat.

22.11.2.6 Vegetation

Once Geomat is properly laid and anchored on the slopes; readymade Grass sods with

minimum 50mm bottom soil are placed over Geomat so as to completely cover it. It is advisable to spray fertilizers on the grass sods atleast once while watering. Watering is done at least for one week. Vegetation will be better if watering is continued for 2 weeks.

In case of any damage found on coir mat while installing, a coir mat patch shall be covered over damaged area extended beyond damaged area a distance of 300mm.

22.12 SPECIFICATIONS OF MECHANICALLY WOVEN DOUBLE TWISTED HEXAGONAL SHAPED WIRE MESH GABIONS

22.12.1 Mechanical Properties

a. Tensile Strength – Tensile strength of wire used for mechanically woven, double-twisted hexagonal shaped mesh, lacing wire and stiffener, when tested shall be in accordance with requirements of specification BS 1052 – (350 to 550 N/mm²) at minimum elongation of 10%.

b. Tensile strength of Mesh Panel – Minimum tensile strength of Mesh panel must be 32 kN/m in the parallel to twist direction.

22.12.2 Physical Properties

a. Zinc Coating – Coating weights shall be **Heavily Galvanized** conforming to requirements of specifications : ASTM A 641.

b. Adhesion of Zinc Coating – No flakes shall be observed while testing for adhesion of Zinc coating as per ASTM A 641.

Mesh Type	10 x 12	Specifications
Mesh Opening 'D' mm	100	EN10223
Mesh Tolerance	+16% to -4%	EN10223
Unit Dimensions	L x W x H	
Tolerances in sizes of units	L & W +/- 5%: H <= 0.3m +/- 10%: H > 0.3m +/- 5%	ASTM A975

Characteristics	Only Zn + PVC Coated	
Mesh Wire Dia mm	2.7/3.7 (I.D/O.D)	EN10223
Tolerance (+/-) mm	0.08	BS1052
Zn Coating Min (gsm)	240	ASTM A 641
Selvedge / Edge Wire Dia mm	3.4/4.4 (I.D/O.D)	EN10223
Tolerance (+/-) mm	0.10	BS1052
Zn Coating Min (gsm)	260	ASTM A 641
Lacing Wire Dia mm	2.2 / 3.2 (I.D/O.D)	
Tolerance (+/-) mm	0.06	BS1052
Zn Coating Min (gsm)	220	ASTM A 641
PVC Coating		
Thickness Nominal (mm)	0.50	ASTM A 975
Thickness Minimum (mm)	0.38	ASTM A 975
Hardness	Between 50-60 Shore D	ASTM D 2240
Colour	Grey RAL 7037	ASTM D 1482
Tensile Strength	Min. 20.6 MPa	ASTM D 412
Specific Gravity	1.3 to 1.35	ASTM D 792



22.12.3 Installation Methodology

22.12.3 .1 Assembly

Gabions are supplied folded flat and packed in bundles. Larger units may be supplied in rolls. Units are assembled individually by erecting the sides, ends and diaphragms, ensuring that all panels are in correct position and tops of all sides are satisfactorily aligned. The four corners shall be connected first, followed by the internal diaphragms to the outside walls. All connections should use lacing wire. Procedure for using lacing wire consists of cutting a sufficient length of wire and first looping and/or twisting the lacing wire to wire mesh. Proceed to lace with alternating double and single loops through every mesh opening approximately every

150mm, pulling each loop tight and finally securing the end of lacing wire to wire mesh by looping and/or twisting.

22.12.3.2 Installation

After initial assembly, gabions are carried to their final position and are securely joined together along the vertical and top edges of their contact surfaces using the same connecting procedure(s) described in the previous section. Whenever a structure requires more than one layer, upper empty baskets shall also be connected to the top of the lower layer along the front and back edges of contact surface using the same connecting procedure(s) described in previous section.

22 12.3.3 Filling

Gabions shall be filled with rock or stone fill. Rock for gabions shall be hard, angular to round, durable and of such quality that they shall not disintegrate on exposure to water or weathering during the life of structure. Gabion rocks shall range between 150mm and 200mm. Range in sizes shall allow for a variation of 5% oversize and/or 5% undersize rock, provided it is not placed on gabion exposed surface. During filling operation, good hand packing & stone placement is required to minimize voids. Exposed faces of vertical structures may be carefully hand placed to give a neat, flat and compact appearance. Care shall be taken when placing fill material to assure that sheathing on PVC coated baskets will not be damaged. Cells shall be filled in stages so that local deformation may be avoided, i.e. at no time shall any cell be filled to a depth exceeding (0.30 m) higher than the adjoining cell. It is also recommended to slightly overfill the baskets to allow for settlement of the rock. Behind gabion walls, compact the backfill material simultaneously to same level as the filled gabions.

22.12.3.4 Internal Connecting Wires

Internal connecting wires should be used when a structure requires layers of gabions to be stacked on top of each other. Internal Connecting Wires shall connect exposed face of a cell to the opposite side of cell. An exposed face is any side of a gabion cell that will be exposed or unsupported after the structure is completed. Lacing wire or prefabricated internal connecting wires may be used.

1m High Gabions

1.0 m high gabions shall be filled in three layers, 0.3m at a time. Connecting wires shall be installed after the placement of each layer, i.e. at 0.3m high and 0.6m high.

0.5m High Gabions

0.5 m high gabions do not require connecting wires unless the baskets are used to build vertical structures. In some cases, these

units shall be filled in two layers; connecting wires shall be installed after the placement of the first layer.

22.12.3.5 Lid Closing

Once the gabion baskets are completely full, the lids will be pulled tight until lid meets the perimeter edges of basket. Lid must then be tightly laced and/or fastened along all edges, ends and tops of diaphragm(s) in the same manner as described in the previous section.

22.12.3.6 Backfilling

Suitable backfill material as per project specifications should be provided after a layer of gabions is erected. Layer wise compaction needs to be done. Ensure a light weight roller is used when compacting upto a distance of 1.0m from the gabion. Adequate care should be taken so that Geotextile is not damaged.

22.13 SPECIFICATIONS OF POLYMER ROPE GABIONS

The polymer ropes shall be manufactured from polypropylene. Polymer Rope Gabions shall be fabricated from polymer rope nets (4 strands - 9 mm dia rope) with woven joints and mesh sizes as mentioned in the specifications. Length of gabions will be decided by ease of handling and site conditions. All gabions shall be supplied in the collapsed form, either folded and bundled or rolled for shipping.

Gabions of length more than 1.5m shall have diaphragms at a spacing of 1.0m. It is suggested to use PP Tarred rope gabions than normal PP rope gabions for its better abrasion resistance and UV resistance.

22.13.1 Specifications

The specifications of PP Tarred Rope Gabions of 9mm Dia. rope, 4 strand, with aperture sizes of 100mm x 100mm and 150mm x 150mm with/without lid and slings are given in Table 1 to 4.

Specifications of 9mm Tarred Rope Gabion, 100mm X 100mm Mesh Size : 4 Strand

Properties	Specifications
Size of body and border rope	9 mm having a weight of 42gm/m with a tolerance of $\pm 8\%$.
Material of rope	PP (with adequate UV stabilizer)
Mesh opening size	100mm X 100mm

Tensile Strength	(a) 9 mm PP Tarred Rope 1560 Kg Breaking Strength (min.) (b) Rope Net 15000 Kg /m width Breaking Strength (c) Punching Shear Strength 6000 Kg.
Structure of the rope	4 strand shroud laid
Construction of net	Woven joint at the intersection of ropes
Abrasion resistance	The rope when tested as per procedure shall have a residual B.S. of at least 90% of the stipulated rope strength at the end of 1000 cycles.
Thermal Stability	The rope when tested as per procedure shall have a residual strength of 90%.
Type approval as per OCIMF 2000 by LRA / ABS / BVQI	Type approval Certificate from LRA / ABS / BVQI to be submitted.
Cyclic Load Fatigue Test (TCLL)	Minimum 60 % of NWBS Certificate from independent Inspection Agency such as LRA / ABS / BVQI to be submitted
Wt. % of Tar	5 to 10 %
Resistance to UV radiation	Material shall be adequately UV stabilized

Note :

1. Testing of Linear Density & Pitch (Length of Lay) of 9 mm 4-Strand PP Rope to be done as per Indian Standard IS 7071: 1992 (Part I to III).
2. Breaking strength of Rope, Rope Net, Abraded rope and Rope subjected to thermal stability to be done as per IS 7071 - Part IV 1986.

**Installation Guidelines**

Profile shall be prepared to the extent shown on the plans or as directed by the engineer. All Loose or unwanted materials shall be removed. All depression shall be carefully backfilled up to desire grade and compacted. Any buried debris protruding from foundation that will impede proper installation and final appearance of gabion or gabion mattress shall also be removed and void carefully backfilled and compacted as specified in the drawing.

Gabions shall be filled with rock or stone fill. The rock for gabions shall be hard, angular to round, durable and of such quality that

they shall not disintegrate on exposure to water or weathering during life of structure. Gabion rocks shall range between 150mm and 200mm. Range in sizes shall allow for a variation of 5% oversize and/or 5% undersize rock, provided it is not placed on the gabion exposed surface.

During the filling operation good hand packing & stone placement is required to minimize voids. The exposed faces of vertical structures may be carefully hand placed to give a neat, flat and compact appearance. Cells shall be filled in stages so that local deformation may be avoided, i.e. at no time shall any cell be filled to a depth

exceeding (0.30 m) higher than the adjoining cell. It is also recommended to slightly overfill the baskets to allow for settlement of rock. 1m high gabions shall be filled in three layers, 0.3m at a time.

Once gabion baskets are completely full, lids will be pulled tight until lid meets the perimeter edges of basket. Lid must then be tightly laced along all edges, ends and tops of diaphragm(s) in the same manner as described in previous section.

22.14 SURFACE PROTECTION OF CONCRETE BRIDGES, CULVERTS AND SIMILAR STRUCTURES

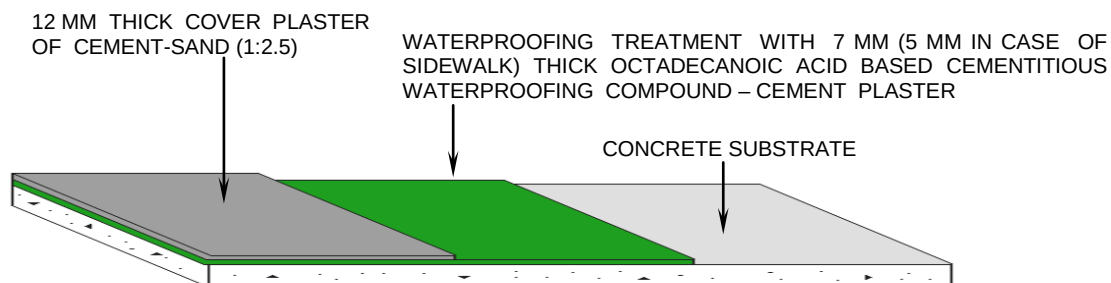
22.14.1 Piers, Substructures and Box Bridges or Culverts in River Beds and Sidewalks (zero permeability when tested for water pressure as in IS 2645:2003)

Specification :

Thorough cleaning of the surface to remove all loose materials, dirt, laitance, etc. : preparing the surface by wetting thoroughly; etching the wet surface with muriatic acid; mopping up excess acid and washing the surface thoroughly; treating the surface by

applying a two-layer plaster; the first layer shall be 7 mm (5 mm in case of sidewalk) thick with cement (OPC or slag), admixed with an octadecanoic acid based cementitious waterproofing compound (bulk density not greater than 0.5 gm/cc, moisture content less than 2.0% and free fatty acid less than 0.2%), conforming to test provisions of IS 2645:2003, but with zero permeability under a waterhead of 20 metres, and having the additional properties of making cement plasticized and less porous, in the weight ratio of 50:3 for cement and waterproofing compound; finally providing the second layer in the form of a protective plaster (12 mm thick) of cement-sand (1:2.5), containing polyester fibre as secondary reinforcement @ 0.25% by weight of cement, before the first plaster will have cracked or dried up; followed by curing for seven days in the case of work with OPC or fourteen days in the case of work with slag cement (Note : Where the velocity of stream or river is expected to cause erosion of the surface protection layer, necessary jacketing of the treated surface with concrete of adequate thickness shall be provided at extra cost).

Other Details :



SCHEMATIC VIEW

1) **MATERIAL** : The material shall be a powder that can be uniformly mixed with cement (OPC or slag) and it must have been in use in projects of Indian Railways for at least 6 years.

2) **TEST** : The two-layer surface protection system shall be tested according to test provisions of IS:2645-2003 under a waterhead of 20 metres. The test shall be conducted at National Test House or at any other laboratory approved by the Engineer-in-charge.

3) **CLEANING THE SURFACE** : Surfaces shall be thoroughly cleaned to remove all growths, plaster, dirt, laitance, any other loose or soft material and all other non-

structural work. Any grease, oil, paint, etc. shall be removed.

4) **PREPARING THE SURFACE** : The concrete surface shall be prepared for the waterproofing treatment by wetting the surface (to prevent absorption of acid) thoroughly and etching the surface by a liberal application of muriatic acid. Should a single application of the acid fail to lead to a rough texture (similar to the texture of a fine grained sand paper), the acid may have to be re-applied. In between applications of acid, the surface should be rubbed with a stiff brush and washed. Excess acid shall be removed when it will stop reacting (formation of gas bubbles) with cement mortar in

concrete, which may take 5-10 minutes. The surface shall be washed. Alternatively, the concrete surface is roughened with a water jet or by sand blasting, or the bond can be improved with the use of a polymer bonding agent

5) **PREPARING THE PASTE OF CEMENT AND WATERPROOFING COMPOUND** : 3 kgs of the waterproofing compound is mixed uniformly with 50 kgs of OPC or slag cement. Water (@ an approximate water/cement ratio of 0.35), small quantities at a time, is added to and mixed with the admixture of cement – waterproofing compound. A paste is thus formed.

6) **PREPARING THE MORTAR FOR COVER PLASTER** : The cement (OPC or slag)-sand mortar in the ratio of 1:2.5 is prepared in the normal way with the addition of water (@ a water-cement ratio of not higher than 0.4). Polyester fibre @ 0.25% by weight of cement is added as secondary reinforcement in making the cement-sand mortar. This mortar for the cover plaster is kept ready before the application of the paste of cement-waterproofing compound.

7) **APPLICATION** : The cleaned and etched surface is properly wetted and the excess water is removed or a polymer bonding agent is applied. A 7 mm (5 mm in the case of sidewalk) thick layer of the plaster of the cement-waterproofing compound is provided on the wet surface, followed by the application of the 12 mm thick cement-sand cover plaster when the first layer plaster of cement-waterproofing compound starts developing surface cracks. The cracks in the first layer plaster are healed with the application of a gentle pressure with a trowel before the application

of the cover plaster and an even finishing of the surface.

8) **CURING** : The treatment is cured with water for at least 7 days in the case of work with OPC and at least 14 days in the case of work with slag cement.

22.14.2 Underside of Bridge Decks, Girders, Inside of Box Girders, Railings, etc. of Bridges and Piers and Substructures which are not in River Bed

(zero permeability when tested for water pressure as in IS 2645:2003)

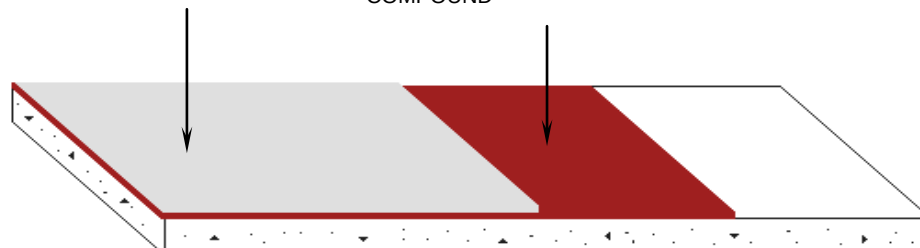
Specification :

Thorough cleaning of the surface to remove all loose materials, dirt, laitance, etc.; drying the surface naturally or mechanically; blowing away dust particles by electrically operated blower or sweeping off by cleaning brush; applying on a dry surface (@ 0.30 litre per square metre) with a brush or spray gun a coat (DFT of 100-150 micron) of a translucent brown coloured modified phenolic resin based single component high performance polymeric waterproofing compound (sp. gr. 0.87, rosin content nil and a solid content of minimum 0.47%), with demonstrable properties of impermeability of treatment under a waterhead of 20 metres, when applied in two coats and tested as in IS 2645-2003, having the additional properties of resistance to acids; applying (@ 0.25 litre per square metre) a coat of a modified phenolic resin based top-coat of grey or other shades, (sp. gr. 0.85), the combined treatment having the property of impermeability when tested under a waterhead of 20 metres as in IS:2645-2003; the top-coat will be applied before the first coat becomes tack-free.

Other Details :

FINISH COAT OF GREY OR OTHER SHADES OF MODIFIED PHENOLIC RESIN BASED SINGLE COMPONENT HIGH PERFORMANCE POLYMERIC WATERPROOFING COMPOUND

FIRST COAT OF TRANSLUCENT BROWN COLOURED MODIFIED PHENOLIC RESIN BASED SINGLE COMPONENT HIGH PERFORMANCE POLYMERIC WATERPROOFING COMPOUND



SCHEMATIC VIEW

1) **MATERIAL** : The phenolic resin based materials of both the first and top coat are miscible with MTO and these must have been in use in projects of Indian Railways for at least 3 years.

2) **TEST** : The base coat material, when applied in two coats, as well as the surface protection system of a base coat and a top coat shall have zero permeability when tested in accordance with test provisions of IS:2645-2003 under a waterhead of 20 metres. The test shall be conducted at National Test House or at any other laboratory approved by the Engineer-in-charge.

3) **CLEANING AND PREPARING THE SURFACE** : The surface is cleaned thoroughly to remove all loose materials, dirt, laitance, any foreign material, etc., and it is permitted to dry naturally or mechanically. Dust particles are removed with an electrically operated blower or sweeping off with a hand brush.

4) **APPLICATION** : Honeycombed areas of the concrete surface are repaired and permitted to dry. A coat of the translucent brown coloured modified phenolic resin based single component polymeric waterproofing compound is applied with a bristle brush or a spray gun. As the coating dries naturally but before it becomes tackfree a coat of the top coat material is applied with a bristle brush or a spray gun. The coating is permitted to dry naturally for at least a day. In the event there will be rain before the application of the top coat, the rain water shall be removed, the surface permitted to dry, and the first coat pressed (not rubbed) with a piece of the finest grain emery cloth before the application of the top coat on the day after the rain or thereafter.

22.14.3 Bridge Deck

(zero permeability when tested for water pressure as in IS 2645:2003)

Specification :

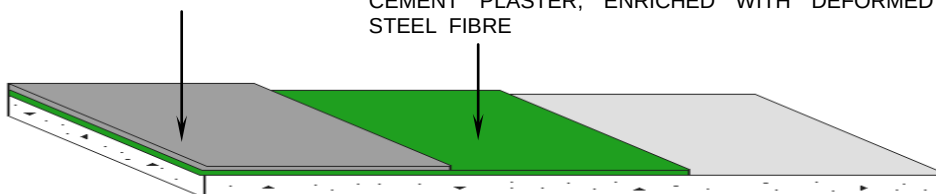
Thorough cleaning of the surface to remove all loose materials, dirt, laitance, etc.; preparing the surface by wetting thoroughly; etching the wet surface with muriatic acid; mopping up excess acid and washing the surface thoroughly; treating the surface by applying a two - layer plaster; the first layer shall be 5 mm thick with cement (OPC or slag), admixed with an octadecanoic acid based cementitious waterproofing compound (bulk density not greater than 0.5 gm/cc, moisture content not greater than 2.0% and free fatty acid not greater than 0.2%), conforming to test provisions of IS:2645-2003, but with zero permeability under a waterhead of 20 metres, and having the additional properties of making cement plasticized and less porous, in the weight ratio of 50:3 for cement and waterproofing compound; further admixed with deformed (sinusoidal form) galvanized steel fibre (150 gm per square metre of surface area), not thicker than 24 gauge and having a UTS of not less than 500 MPa; finally providing the second layer in the form of a protective plaster (12 mm thick) of cement-sand (1:2.5), containing polyester fibre as secondary reinforcement @ 0.25% by weight of cement, before the first plaster will have cracked or dried up; followed by curing for seven days in the case of plastering with OPC or fourteen days in the case of plastering with slag cement and providing a wearing course in the case of bridge decks. (Provide a wearing course at extra cost)

Note : The treatment is to be topped with a wearing course, the cost of which is not included.

Other Details :

12 MM THICK COVER PLASTER
OF CEMENT-SAND (1:2.5)

WATERPROOFING TREATMENT WITH 5 MM THICK OCTADECANOIC
ACID BASED CEMENTITIOUS WATERPROOFING COMPOUND –
CEMENT PLASTER, ENRICHED WITH DEFORMED GALVANIZED
STEEL FIBRE



SCHEMATIC VIEW

1) **WATERPROOFING MATERIAL** : The material shall be a powder that can be uniformly mixed with cement (OPC or slag) and it must have been in use in projects of Indian Railways for at least 6 years.

2) **STEEL FIBRE** : The deformed galvanized steel fibre shall be no longer than 50±5 mm and it shall not be thicker than 24 gauge with a UTS of not less than 550 MPa.

3) **TEST** : The two-layer surface protection system shall be tested according to test provisions of IS:2645-2003 under a waterhead of 20 metres. The test shall be conducted at National Test House or at any other laboratory approved by the Engineer-in-charge.

4) **CLEANING THE SURFACE** : Surfaces shall be thoroughly cleaned to remove all growths, plaster, dirt, laitance, any other loose or soft material and all other non-structural work. Any grease, oil, paint, etc. shall be removed.

5) **PREPARING THE SURFACE** : The concrete surface shall be prepared for the waterproofing treatment by wetting the surface (to prevent absorption of acid) thoroughly and etching the surface by a liberal application of muriatic acid. Should a single application of the acid fail to lead to a rough texture (similar to the texture of a fine grained sand paper), the acid may have to be re-applied. In between applications of acid, the surface should be rubbed with a stiff brush and washed. Excess acid shall be removed when it will stop reacting (formation of gas bubbles) with cement mortar in concrete, which may take 5-10 minutes. The surface shall be washed. Alternatively, the concrete surface is roughened with a water jet or by sand blasting, or the bond can be improved with the use of a polymer bonding agent.

6) **PREPARING THE PASTE OF CEMENT AND WATERPROOFING COMPOUND** : 3 kgs of the waterproofing compound is mixed uniformly with 50 kgs of OPC or slag cement. Water (@ an approximate water/cement ratio of 0.35), small quantities at a time, is added to and mixed with the admixture of cement – waterproofing compound. Deformed steel fibres @ 750 gm per bag of cement are added to the paste of cement-waterproofing compound and the paste is remixed.

7) **PREPARING THE MORTAR FOR COVER PLASTER** : The cement (OPC or slag)-sand mortar in the ratio of 1:2.5 is prepared in the normal way with the addition of water (@ a water-cement ratio not higher

than 0.4). Polyester fibre @ 0.25% by weight of cement is added as secondary reinforcement in making the cement-sand mortar. This mortar for the cover plaster is kept ready before the application of the paste of cement-waterproofing compound, admixed with steel fibres.

8) **APPLICATION** : The cleaned and etched surface is properly wetted and the excess water is removed or a polymer bonding agent is applied. A 5 mm thick layer of the plaster of the cement-waterproofing compound, enriched with steel fibres, is provided on the wet surface, followed by the application of the 12 mm thick cement-sand cover plaster before the first layer plaster of cement-waterproofing compound starts developing surface cracks. The cracks in the first layer plaster are healed with the application of a gentle pressure with a trowel before the application of the cover plaster and an even finishing of the surface.

9) **CURING** : The treatment is cured with water for at least 7 days in the case of work with OPC and for at least 14 days in the case of work with slag cement.

Note : The treatment is to be topped with a wearing course, the cost of which is not included.

Chapter 23

Roads And Platforms

23.1 General

23.1.1 Allowance for Settlement

In the case of new roads and platforms, the sub-grade shall be shaped to suit the content of the finished surface and consolidated to a depth below the proposed finished level, equal to the combined depth of soling and wearing course after providing for an allowance for further settlement of sub-grade that may result during course of the work.

Where the subsoil is of clay or other material, which is not easily drained, a top layer of ashes or sandy material to a depth of not less than 10 cm shall be provided.

23.1.2 Tools & Plant

The Contractor shall provide all tools and plant, including rollers, water carts, mixers etc. at his own cost, unless otherwise specified. He shall also provide at his own expense such barriers, ropes, signals, night lanterns, watchmen, etc. as may be necessary for the protection of the public during construction or maintenance operations.

23.1.3 Safety of Traffic/Public

No alteration or repairs to existing roads or platforms shall be undertaken without leaving free a portion of the width or providing a suitable diversion for the vehicular and other traffic which may be using it, so that its continued use is not denied to them. Further, no excavation, heaps of materials or other obstruction shall be left unprotected at night. It shall be the responsibility of the Contractor to ensure compliance of the above requirements.

23.1.4 Shoulders and Cess

When carrying out repairs to roads, any deficiency in the shoulders (or earth berms) along both edges shall be made up properly, whether by earthwork or by dressing. These will be paid for separately only if the quantum of work involved is considered by the Engineer to be substantial.

In the case of new roads, and platforms, the shoulders and cess shall invariably be cleared of all surplus materials, excess earth or other debris and dressed to the proper profiles, as directed, so as to ensure that

there is no stagnation of water on or alongside the newly laid surface. No extra payment will be admissible for such clearance and dressing, except for any substantial quantity of earthwork involved.

23.1.5 Rolling

~~(a)~~(a) Where the use of a power roller of a certain weight is specified, the Engineer may, at his discretion, permit the use of lighter roller or a hand roller, taking into account the magnitude of the work or other local circumstances, provided he is satisfied that the usefulness or the durability of the work is not affected to any appreciable extent.

~~(b)~~(b) Along kerbs, manholes, etc. and any other place where proper consolidation by rolling is not practicable, alternative means such as steel rammers shall simultaneously be used to secure adequate consolidation.

23.1.6 Rates

Unless otherwise specified, the rates shall be all-inclusive, covering the cost of all materials labour and equipment involved in the respective items of work. Earthwork in formation of new roads or platforms will, however, be paid for separately, as also any special work of improving the subgrade as per sub-para 23.1.5.

23.1.7 Scope

Unless repugnant to the context, the specifications in this Chapter shall be applicable to both roads and platforms, and the term road used here-in-after shall also include platforms, where applicable.

23.2 Earthwork in Road Construction - Earthwork items are covered in EW chapter and relevant specifications may be followed.

23.3 PREPARATION OF SUB-GRADE

23.3.1 Sub-grade : The surface of the formation for width equal to that of the soling (or sub-base where provided) shall first be cut (where necessary) to a depth below the proposed finished level of the road, equal to the combined depth of sub-base (if provided), soling and wearing coat (due allowance being made for consolidation). It shall then be cleaned of all foreign substances.

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Any ruts or soft places that appear due to improper drainage conditions, traffic hauling or any other cause shall be corrected and the sub grade dressed off parallel to the finished profile. The same shall apply to preparation of sub-grade for new platform also.

23.3.2 Consolidation : The sub-grade shall then be consolidated with a road roller. Water shall be applied uniformly to the sub-grade one evening prior to rolling. Any low spots that develop in the sub-grade during rolling shall be brought to grade with the excavated approach earth and re-rolled. Rolling shall be done with a light road roller or sheep foot roller or any vibratory roller as approved by the Engineer. All soft and unsuitable materials and surplus earth shall be removed as directed by the Engineer and the area where it is disposed off shall be dressed, for which nothing extra shall be paid.

23.4 SUB-BASE

23.4.1 Type and Thickness : Where the sub-grade made up of natural soil has poor bearing capacity (less than 11.0 tonnes per sqm), a sub-base consisting of dense granular material shall be provided. This may be of moorum, bajri, shingle, or other easily drainable material. The thickness of the sub-base, where ordered to be used by the Engineer, shall not be less than 15 cm. The sub-base shall preferably be provided over the full formation width and in any case for a width of 60 cm more than the width of the base course. In case of platforms it may be 30 cm more than the width to be paved or surfaced.

23.4.2 Sub-Base or Poor Subgrade : When the sub-grade or formation consists of black cotton soil or other soil subject to capillary action of water, a sub-base of moorum or coarse sand shall be provided below the base course consisting of stone or boulder soling. It will be watered and rolled lightly. It will be for a thickness of 150 mm (minimum), unless otherwise specified.

23.5 SOLING

23.5.1 General :

In the conventional system of road making, soling shall always be provided except where the road is founded on a very hard natural soil such as hard moorum, well compacted

gravel, laterite, hard kankar soil, hard conglomerate or rock. Soling may consist of graded stone ballast or hard stony moorum, or hard laterite, or kankar or well burnt bricks or brick jhama or similar material, as ordered by the Engineer.

23.5.2 Width : The width of soling course shall be 30 cm (i.e. 15 cm on either side) more than that of the wearing coat, unless otherwise ordered by the Engineer.

23.5.3 Thickness:- The thickness of soling shall be as laid down by the Engineer depending upon the material used and sub-grade.

23.5.4 Sizes : The size of the soling materials shall be in the range of thickness in below for various types of materials.

- (a) **Bricks :** Over burnt and jhama bricks.
- (b) **Stone ballast, Kankar :** This may be of the same gauge as for wearing coat (WBM), or if economical and convenient, of slightly bigger size preferably. Brickbats of approved quality and dimensions can be used for soling for minor roads and for patch repairs.

23.5.5 Laying and Consolidation

23.5.5.1 The sub grade prepared as per specification shall be approved by the Engineer before soling work is commenced.

23.5.5.2 If Kankar is used, the laying and consolidation shall be done as specified for kankar roads.

23.5.5.3 If brick bats or stone ballast is used, laying and consolidation shall be done in the same manner as specified for the wearing coat.

23.5.5.4 In case of bricks, the same shall be laid on edge or flat as specified by the Engineer and hand packed in such a manner that no interstices are generally left. The interstices may profitably be filled with locally available sand, not earth.

23.5.5.5 **Cushion :** 25 mm thick layer of moorum (or small kankar or laterite) shall be laid on top of the soling except in case of laterite, kankar or hard moorum soling. This shall be watered and rolled lightly before the wearing coat is laid. For brick soling, the cushioning layer shall be rolled by hand roller.

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23.6 WATER BOUND MACADAM**23.6.1 Scope**

23.6.1.1 This work shall consist of clean, crushed aggregates mechanically interlocked by rolling and bonding together with screening, binding material where necessary and water laid on a properly prepared sub grade/sub-base/base or existing pavement, as the case may be and finished in accordance with the requirements of these specifications and in close conformity with the lines, grades, cross-sections and thickness as per approved plans or as directed by the Engineer.

It is, however, not desirable to lay water bound macadam on an existing thin black topped surface without providing adequate drainage facility for water that would get accumulated at the interface of existing bituminous surface and water bound macadam.

23.6.1.2 General : The wearing surface either receives directly or through the finishing layer, the wheel loads and transmits them to the underlying layers. It must therefore :

(a) be sufficiently hard and tough to resist abrasion and the wearing action of traffic.

(The smoothness of the surface also affects abrasion, hence the surface shall also be made as smooth as possible, if it is the wearing course);

(b) be composed of tough stones which will resist the disruptive action of traffic with a minimum of maintenance and repair work;

(c) be capable of transmitting loads to the base under all weather conditions without undue deformation or creeping occurring. At the same time it shall have sufficient flexibility to adjust itself to the sub-grade without rupture; be non-slippery for traffic under all weather conditions

23.6.2 Thickness : Unless otherwise specified, the thickness of the wearing coat, if laid for the first time over soling course shall be 11.5 cm consolidated. For renewals it shall vary from 7.5 cm to 11.5 cm or as specified or as directed by Engineer.

23.6.3 Camber : The camber shall be 1 in 48 or as directed by the Engineer or otherwise specified.

23.6.4 Materials :

23.6.4.1 Physical requirements of coarse aggregate shall be as in Table 23.1 below :

TABLE 23.1 - PHYSICAL REQUIREMENTS OF COARSE AGGREGATES FOR WATER BOUND MACADAM FOR SUB-BASE/BASE COURSES

Test	Test Method	Requirements
1. *Los Angeles Abrasion value (Part-4) Or *Aggregate Impact value	IS: 2386 IS: 2386(Part-4) or IS: 5640**	40 per cent (Max.) 30 per cent (Max.)
2. Combined Flakiness and Elongation Indices (Total) ***	IS: 2386 (Part-1)	30 per cent (Max.)

• Aggregate may satisfy requirement of either of the two tests.

** Aggregates like brick metal, kankar, laterite etc. which get softened in presence of water shall be tested for impact value under wet conditions in accordance with IS: 5640.

*** The requirement of flakiness index and elongation index shall be enforced only in the case of crushed broken stone

Para 23.6.7 also may be referred to for type of material and other quality requirements.

23.6.4.2 Overburnt (Jhama) brick aggregates : Jhama brick aggregates shall be made from over burnt bricks or brick bats and be free from dust and other objectionable and deleterious materials.

23.6.4.3 Grading requirement of coarse aggregates : The coarse aggregates shall conform to one of the Gradings given in Table 23.2 and as specified, provided, however, the use of Grading No.1 shall be restricted to sub-base courses only.

TABLE 23.2 GRADING REQUIREMENTS OF COARSE AGGREGATES

Grading No.	Size Range	IS Sieve Designation	Per cent by weight passing
1.	90mm to 45mm	125mm	100
		90mm	90 -100
		63mm	25 - 60
		45mm	0 -15
		22.4mm	0 - 5
2.	63mm to 45mm	90mm	100
		63mm	90 -100
		53mm	25 -75
		45mm	0 -15
		22.4mm	0 - 5
3.	53mm to 22.4mm	63mm	100
		53mm	95 -100
		45mm	65 - 90
		22.4mm	0 - 10
		11.2mm	0 - 5

Note : The compacted minimum thickness for a layer with Grading 1 shall be 100 mm while for layer with other Gradings, i.e. 2 & 3, it shall be 75 mm.

23.6.5 Screenings

23.6.5.1 Screenings required to fill voids in the coarse aggregate shall generally consist of the same material as the coarse aggregate. However, where permitted, predominantly non-plastic material such as moorum or gravel (other than rounded river borne material) may be used for this purpose provided liquid limit and plasticity index of such material are below 20 and 6 respectively and fraction passing 75 micron

sieve does not exceed 10 per cent.

Screenings shall conform to the grading set forth in Table 23.3.

The consolidated details of quantity of screenings required for various grades of stone aggregates are given in Table 23.4. The Table 23.4 also gives the quantities of materials (loose) required for 10 m² of sub-base/base with compacted thickness of 100/75 mm.

The use of screenings may be omitted in the case of soft aggregates such as brick metal, kankar, laterites, etc., as they are likely to get crushed to a certain extent under rollers.

TABLE 23.3 GRADING FOR SCREENINGS

Grading Classification	Size of Screenings	IS Sieve Designation	Per cent by weight passing the IS Sieve
A	13.2 mm	13.2 mm	100
		11.2 mm	95-100
		5.6 mm	15-35
		180 micron	0-10
B	11.2 mm	11.2 mm	100
		5.6 mm	90-100
		180 micron	15-35

TABLE 23.4 APPROXIMATE QUANTITIES OF COARSE AGGREGATES AND SCREEINGS REQUIRED FOR 100/75 MM COMPACTED THICKNESS OF WATER BOUND MACADAM (WBM) SUB-BASE/ BASE COURSE FOR 10M² AREA

Classification	Size Range	Compacted thickness	Loose Qty.	Screenings			
				Stone Screening		Crushable Type such as Moorum or Gravel	
				Grading Classification & Size	For WBM Sub-base/base course (Loose quantity)	Grading Classification & Size	Loose Qty.
Grading-1	90mm to 45mm	100 mm	1.21 to 1.43 m ³	Type A 13.2 mm	0.27 to 0.30 m ³	Not uniform	0.30 to 0.32m ³
Grading-2	63mm to 45mm	75 mm	0.91 to 1.07m ³	Type A 13.2 mm	0.12 to 0.15 m ³	- do -	0.22 to 0.23 m ³
- do -	- do -	- do -	- do -	Type B 11.2 mm	0.20 to 0.22 m ³	- do -	- do -
Grading-3	53mm to 22.4 mm	75 mm	- do -	- do -	0.18 to 0.21 m ³	- do -	- do -

Hard kankar nodules 6 mm to 12 mm size are more suitable for this purpose than screenings. In addition to retaining the stones in position, the kankar improves the cementing value and secures a smooth riding surface by resisting the tendency of the wearing coat to unravel.

The amount of screening or kankar nodules required depends on the degree of interlocking and compaction achieved during rolling and this depends largely on the quality of the stone and the efficiency of the rolling operation. With well-compacted stones, 9.5 to 13.5 cum will be sufficient for 1000 sqm of road surface.

23.6.5.2 Screenings : Screenings are the smaller size stones (6-12 mm gauge) of the same type as used for the wearing coat. These are used after full compaction of the loose stone is effected to keep the surface stone in inter- locked position.

23.6.5.3 Where soft stone such as laterite, kankar, etc., is used for the wearing coat, no screenings are required.

24.6.5.4 All screenings shall be clean, free from clay and organic matter, and shall be of the same specifications as the metal of the wearing coat except for the maximum size.

23.6.5.5 If screenings of ordinary stone or kankar are not available, laterite or hard moorum may be used in the same way.

23.6.6 Binding material : Binding material to be used for water bound macadam as a filler material meant for preventing ravelling, shall comprise of a suitable material approved by the Engineer having a Plasticity Index (PI) value of less

than 6 as determined in accordance with IS: 2720 (Part-5).

The quantity of binding material where it is to be used, will depend on the type of screenings, Generally, the quantity required for 75 mm compacted thickness of water bound macadam will be 0.06-0.09 m³ /10 m² and 0.08-0.10 m³/10 m² for 100 mm compacted thickness.

The above mentioned quantities should be taken as a guide only, for estimation of quantities for construction etc.

Application of binding materials may not be necessary when the screenings used are of crushable type such as moorum or gravel.

23.6.7 Stone Meal

23.6.7.1 Collection of stone metal : The stone metal shall be stacked in convenient units clear of the roadway, either on the berm or on level platforms provided for the purpose. No metal in excess to that required for the work shall be stacked at site and all excess quantity shall be removed from the site of work before stack measurements are recorded. The height of a stack shall not be less than 60 cm. The quantity of material required for a particular finished thickness shall make due allowance for the reduction in thickness during consolidation. For payment, the quantity measured in stacks shall be reduced by 15% to allow for looseness and compaction.

23.6.7.2 Choice of Coarse aggregates : Coarse aggregates shall be either crushed or broken stone, crushed slag, over burnt (Jhama) brick aggregates or any other naturally occurring aggregates such as

kankar and laterite of suitable quality. Materials other than crushed or broken stone shall be used in sub-base courses only. If crushed gravel/shingle is used, not less than 90 per cent by weight of the gravel/shingle pieces retained on 4.75 mm sieve shall have at least two fractured faces. The type and size range of aggregate shall be specified in the Contract or shall be as specified by the Engineer. If the water absorption value of the coarse aggregate is greater than 2 per cent, the soundness test shall be carried out on the material delivered to site as per IS: 2386 (Part 5).

23.6.7.3 Crushed or broken stone : The crushed or broken stone shall be hard, durable and free from excess flat, elongated, soft and disintegrated particles, dirt and other deleterious material.

23.6.8 Construction

23.6.8.1 Preparation of base : The surface of the subgrade/sub-base/base to receive the water bound macadam course shall be prepared to the specified lines and cross fall (camber) and made free of dust and other extraneous material. Any ruts or soft yielding places shall be corrected in an approved manner and rolled until firm surface is obtained, if necessary by sprinkling water. Any sub-base/base/surface irregularities, where predominant, shall be made good by providing appropriate type of profile corrective course (leveling course).

As far as possible, laying water bound macadam course over an existing thick bituminous layer may be avoided since it will cause problems of internal drainage of the pavement at the interface of two courses. It is desirable to completely pick out the existing thin bituminous wearing course where water bound macadam is proposed to be laid over it. However, where the intensity of rain is low and the interface drainage facility is efficient, water bound macadam can be laid over the existing thin bituminous surface by cutting 50 mm x 50 mm furrows at an angle of 45 degrees to the centre line of the pavement at one metre intervals in the existing road. The directions and depth of furrows shall be such that they provide adequate bondage and also serve to drain water to the existing granular base course beneath the existing thin bituminous surface.

23.6.8.2 Inverted Choke : If water bound macadam is to be laid directly over the subgrade, without any other intervening pavement course, a 25mm course of screenings (Grading B) or coarse sand shall be spread on the prepared subgrade before

application of the aggregates is taken up. In case of a fine sand or silty or clayey sub grade, it is advisable to lay 100 mm insulating layer of screening or coarse sand on top of fine grained soil, the gradation of which will depend upon whether it is intended to act as a drainage layer as well. As a preferred alternative to inverted choke, appropriate geosynthetics performing functions of separation and drainage may be used over the prepared subgrade as directed by the Engineer.

23.6.8.3 Spreading coarse aggregates :

The coarse aggregates shall be spread uniformly and evenly upon the prepared subgrade/sub-base/base to proper profile by using templates placed across the road about 6 m apart, in such quantities that the thickness of each compacted layer is not more than 100 mm for Grading 1 and 75 mm for Grading 2 and 3. In larger works and wherever possible, approved mechanical devices such as aggregates spreader shall be used to spread the aggregates uniformly so as to minimize the need for manual rectification afterwards. Aggregates placed at locations which are inaccessible to the spreading equipment, may be spread in one or more layers by any approved means so as to achieve the specified results.

The spreading shall be done from stockpiles along the side of the roadway or directly from vehicles. No segregation of large or fine aggregates shall be allowed and the coarse aggregate as spread shall be of uniform gradation with no pockets of fine material.

The surface of the aggregates spread shall be carefully checked with templates and all high or low spots remedied by removing or adding aggregates as may be required. The surface shall be checked frequently with a straight edge / template while spreading and rolling so as to ensure a finished surface as per approved drawings.

The coarse aggregates shall not normally be spread more than 3 days in advance of the subsequent construction operations.

23.6.8.4 Rolling : Immediately following the spreading of the coarse aggregate, rolling shall be started with three wheeled power rollers of 80 to 100 kN capacity or tandem or vibratory rollers of 80 to 100 kN static weight. The type of roller to be used shall be approved by the Engineer based on trial run.

Except on super elevated portions where the rolling shall proceed from inner edge to the outer, rolling shall begin from the edges gradually progressing towards the centre. First the edge/edges shall be compacted

with roller running forward and backward. The roller shall then move inward parallel to the centre line of the road, in successive passes uniformly lapping preceding tracks by at least one half width.

Rolling shall be discontinued when the aggregates are partially compacted with sufficient void space in them to permit application of screenings. However, where screenings are not to be applied, as in the case of crushed aggregates like brick metal, laterite and kankar, compaction shall be continued until the aggregates are thoroughly keyed. During rolling, slight sprinkling of water may be done, if necessary. Rolling shall not be done when the sub-grade is soft or yielding or when it causes a wave-like motion in the sub-grade or sub-base course.

The rolled surface shall be checked transversely and longitudinally with templates and any irregularities corrected by loosening the surface, adding or removing necessary amount of aggregates and re-rolling until the entire surface conforms to desired cross fall (camber) and grade. In no case shall the use of screenings be permitted to make up depressions.

Material which gets crushed excessively during compaction or becomes segregated shall be removed and replaced with suitable aggregates.

It shall be ensured that shoulders are built up simultaneously along with water bound macadam courses.

23.6.8.5 Test for Dry rolling for interlocking and compaction : The metal shall be dry rolled until compaction is completed as judged by the following tests :

- (i) No lines of the roller are left on the surface.
- (i) A loaded cart leaves no indentation when passing over the rolled surface.
- (ii) A piece of 25 mm gauge metal placed on the surface gets crushed under the roller without being driven in. The surface shall then be checked for camber and any inequalities in the surface corrected.

23.6.9 Application of screenings : After the coarse aggregate has been rolled, screenings to completely fill the interstices shall be applied gradually over the surface. These shall not be damp or wet at the time of application. Dry rolling shall be done while the screenings are being spread so that vibrations of the roller cause them to settle into the voids of the coarse aggregate. The screenings shall not be dumped in piles but

be spread uniformly in successive thin layers either by the spreading motions of hand shovels or by mechanical spreaders, or directly from tipper with suitable grit spreading arrangement. Tipper operating for spreading the screenings shall be so driven as not to disturb the coarse aggregate.

The screenings shall be applied at a slow and uniform rate (in three or more applications) so as to ensure filling of all voids. This shall be accompanied by dry rolling and brooming with mechanical brooms, hand-brooms or both. In no case shall the screenings be applied so fast and thick as to form cakes or ridges on the surface in such a manner as would prevent filling of voids or prevent the direct bearing of the roller on the coarse aggregate. These operations shall continue until no more screenings can be forced into the voids of the coarse aggregate.

The spreading, rolling, and brooming of screenings shall be carried out in only such lengths of the road which can be completed within one day's operation.

23.6.10 Wet rolling and spreading of binding material : The surface shall then be copiously watered and rolled. After a few rollings, binding material like moorum or prepared earth shall be spread evenly to a thickness of 6 mm to 12 mm, copiously watered and rolled until a slurry of binder and water begins to flow ahead of the roller. The slurry shall be swept in with hand brooms so as to fill the voids properly and the surface rolled again, water being applied to the wheels in order to wash down the binder that may be sticking to them. The slurry shall be swept up from the haunches to the crown and no part of the slurry shall be allowed to flow off the road surface as this will result in the loss of soil fines, which impart binding properties to the material. The spreading of binder, sprinkling of water, sweeping with brooms and rolling shall continue until the slurry is formed after filling of voids, forms a wave before the wheels of the moving roller. The rolling at all times shall begin at the sides and progress towards the centre thoroughly covering the entire surface with the rear wheels till a hard smooth solid paving is produced.

23.6.11 General precautions during consolidation : Only such lengths shall be taken for consolidation as can be completed in a day. The scarifying and preparing of the surface may, however, be pushed on well in advance by two day's length and metal spreading by one day's length.

23.6.11.1 When the work is done over only half the width of the road at a time, the rolling shall be done over not more than half the width. The marginal 40 cm width in the middle should not be rolled nor should be treated with screenings until the second half width is taken up.

23.6.11.2 No sudden steps should be left, but the junctions of old and new surfaces should be made perfect so that fast moving vehicle do not experience any bumps.

23.6.12 Spreading sand : Next day, sand should be spread to a thickness of 6 mm and the surface lightly rolled.

23.6.13 Curing : In dry weather, the surface shall be kept lightly sprinkled with water for about a week. No traffic shall be allowed on it till the macadam has set. This will be for 2 to 3 days depending on the weather.

23.6.14 Finished surface : There shall be no variation in the finished surface beyond the following limits :

(a) Transversely 8 mm in the camber template

(b) Longitudinally 12 mm in a distance of 3m

23.6.15 (i) Opening the road to traffic : After the macadam has set, the road shall be opened to traffic in sections. For a week after the traffic is let on to the road, attempt should be made to distribute the traffic over the full width of the metalled surface by placing obstacles in any tracks that may be forming in the newly consolidated surface. This is especially necessary where bullock cart traffic is predominant on a newly consolidated road founded on a moorum or similar base course, which may have been softened during the final watering. Nothing extra shall be paid for opening to traffic and distributing the same as specified above.

(ii) The compacted water bound macadam course should be allowed to completely dry and set before the next pavement course is laid over it.

(iii) Surface Finish and Quality Control of Work

The surface finish of construction will meet with the quality standards laid down with following tolerance limits :

Size of coarse aggregates	Longitudinal profile measured with a 3 metre straight edge			Cross profile
	Max. permissible undulations	Maximum no. of undulations permitted in any 300 metre length exceeding		Max. Permissible undulation when measured with a camber template
		12mm	10mm	
63-45 mm and 53-22.4mm	12mm	Nil	30	8mm

The longitudinal profile shall be checked with a three metre long straight edge and graduated wedge at the middle of each traffic lane along a line parallel to the centre line of the road. The transverse profile shall be checked with adjustable templates at intervals of 10 metres.

The water bound macadam work shall not be carried out when the atmospheric temperature is less than 0°C in the shade.

23.6.16 Rectification of Defective Construction : Where the surface irregularity of the W.B.M sub-base course exceeds the tolerances specified in Para 23.6.15 or where the course is otherwise defective due to sub grade soil mixing with the aggregates, the layer to its full thickness shall be scarified over the affected area, reshaped with added material or removed and replaced with fresh materials as

applicable, and re-compacted. The area treated in the aforesaid manner shall not be less than 10 sqm. In no case shall depressions be filled up with screenings and binding materials.

23.6.17 Measurements : The length and breadth shall be taken to the nearest centimeter. The depth of consolidated layer shall be computed to nearest half centimeter by taking average of depths at the centre and at 30 cm from the left and right edges at a cross section taken at 25 metre interval or less as decided by the Engineer by making small pits. The consolidated contents shall be calculated in cum correct to two places of decimals. The cubical contents for each 100 metre length should be compared with the volume of aggregate collected less 7.5% for guidance purpose.

23.6.18 Rate : Unless otherwise specified, the rate shall include the cost of all labour and materials involved in all the operations described above, except cost of stone aggregate, kankar, moorum, screenings and bajri, for which separate payments shall be made. Where W.B.M. is to be laid over an existing road, scarifying and consolidation of the aggregate received from scarifying shall be paid for separately.

23.6.19 Water bound Macadam with Brick Aggregate/Overburnt (Jhama) Brick Aggregate

Quantities of materials : Approximate quantity of brick aggregate (to be paid for separately) required to be stacked for 100 mm average compacted thickness of W.B.M. sub-base for 10 sqm. area shall be 1.60 cum (approximate). The quantity of binding material, if required shall be as specified by the Engineer. Brick aggregate shall be broken from over burnt or well burnt brick bats. It shall be homogeneous in texture, roughly cubical in shape, clean and free from dirt and other foreign matter.

Foundation shall be prepared as specified in para 23.6.8.1.

For spreading aggregate clause 23.6.8.3 shall apply except that the quantities of materials shall be as given above.

The rolling shall be done as specified in 23.6.8.4 except that rolling shall be done with a light power roller. The use of screenings shall also be omitted. Rolling shall be done 3 to 5 times for each layer.

For rolling with Binding material clause 23.6.10 shall apply except that rolling shall be done with a light power roller instead of a heavy road roller and water shall not be used

during rolling. Rolling shall be done 3 to 5 times for each layer.

Surface evenness, rectification of defective construction, Measurements and Rate shall be as specified under 23.6.15 to 23.6.18.

23.7 Bases

23.7.1 General : The base course may consist of any one of the following (with aggregate size 63 mm – 45 mm or 53 mm – 22.4 mm)

(a) Water Bound Macadam (WBM) with stone Aggregate : The stone aggregate of size 63 mm to 45 mm or 53 mm to 22.4 mm as specified shall be used. This is a standard type of base course used in road work. In important roads such as major colony roads, station approach in major towns and cities, goods shed and station circulating areas in major cities, (National Highways and City Roads) this may form the lower part of the base course overlaid by a bitumen bound base. Para 23.6 covers detailed specifications for WBM.

(b) Water Bound Macadam Surfacing / Wearing Course with Stone Aggregate: Water bound Macadam when laid as a surfacing/wearing course needs timely and constant maintenance. This will include patching pot holes, removal of ruts and blinding of surface with blinding material. This course is generally used only in roads of temporary nature and approach roads in wayside stations.

23.7.2 Water Bound Macadam (Base or Surfacing Course)

Quantities of Materials : Quantities of coarse aggregates and screenings required to be stacked for 75 mm (approximate) compacted thickness of W.B.M. base courses for 10 sqm shall be as specified in Table 23.5.

TABLE – 23.5 Quantities for C.A and Screenings for WBM Base Course

Coarse Aggregate			Stone Screening		
Classification	Size Range	Net quantity*	Gradings/ Classification & Size	W.B.M. base course	W.B.M. surface course
Grading-2	63-45mm	0.91 cum to 0.96 cum	Type A 13.2 mm	0.12 cum to 0.15 cum	0.10 cum to 0.12
- do -	63-45mm	0.91 cum to 0.96 cum	Type B 11.2 mm	0.20 cum to 0.22 cum	0.16 cum to 0.18 cum
Grading-3	53-22.4mm	0.91 cum to 0.96 cum	Type B 11.2 mm	0.18 cum to 0.21 cum	0.14 cum to 0.17 cum

The quantity of binding material required for 75 mm (approximate) compacted thickness will be 0.09 cum/10 sqm in the case of W.B.M. base course and 0.13 cum/10 sqm when the W.B.M is to function as a surface course.

***Net quantity means** :The quantity of metal measured in stacks and reduced by 7.5 %

23.8 GRANULAR SUB BASE (GSB)

23.8.1 General : This is done when the sub-grade is of softer nature with low CBR (California Bearing Ratio). This is done in accordance with IRC specification section 401 of MOST Specification for Roads & Bridges, which is given below :

Scope

This work shall consist of laying and compacting well-graded material on prepared sub-grade in accordance with the requirements of these Specifications. The material shall be laid in one or more layers as sub-base or lower sub-base and upper sub-base (termed as sub-base hereinafter) as necessary according to lines, grades and cross-sections shown on the drawings or as directed by the Engineer.

23.8.2 Materials

24.8.2.1 The material to be used for the work shall be natural sand, moorum, gravel,

crushed stone, or combination thereof depending upon the grading required. Materials like crushed concrete, brick metal and kankar may be allowed only with the specific approval of the Engineer. The material shall be free from organic or other deleterious constituents and conform to one of the three gradings given in Table 23.7.

While the gradings in Table 23.7 are in respect of close-graded granular sub-base materials, one each for maximum particle size of 75 mm, 53 mm and 26.5 mm, the corresponding gradings for the coarse-graded materials for each of the three maximum particle sizes are given at Table 23.8. The grading to be adopted for a project shall be as specified in the Contract.

23.8.2.2 Physical Requirements : The material shall have a 10 per cent fines value of 50 kN or more (for sample in soaked condition) when tested in compliance with BS: 812 (Part-III). The water absorption value of the coarse aggregate shall be determined as per IS: 2386 (Part-3); if this value is greater than 2 per cent, the soundness test shall be carried out on the material delivered to site as per IS: 383. For Grading II and III materials, the CBR shall be determined at the density and moisture content likely to be developed in equilibrium conditions which shall be taken as being the density relating to a uniform air voids content of 5 per cent.

TABLE 23.7 GRADING FOR CLOSE-GRADED GRANULAR SUB-BASE MATERIALS

IS Sieve Designation	Per cent by weight passing the IS sieve		
	Grading-I	Grading-II	Grading-III
75.0 mm	100	---	---
53.0 mm	80-100	100	---
26.5 mm	55-90	70-100	100
9.50 mm	35-65	50-80	65-95
4.75 mm	25-55	40-65	50-80
2.36 mm	20-40	30-50	40-65
0.425 mm	10-25	15-25	20-35
0.075 mm	3-10	3-10	3-10
CBR Value (min.)	30	25	20

TABLE – 23.8 GRADING FOR COARSE GRADED GRANULAR SUB-BASE MATERIALS

IS Sieve Designation	Per cent by weight passing the IS sieve		
	Grading-I	Grading-II	Grading-III
75.0 mm	100	---	---
53.0 mm		100	
26.5 mm	55-75	50-80	100
9.50 mm			
4.75 mm	10-30	15-35	25-45
2.36 mm			
0.425 mm			
0.075 mm	<10	<10	<10
CBR Value (Min.)	30	25	20

Note : The material passing 425 micron (0.425 mm) sieve for all the three gradings when tested according to IS: 2720 (Part-5) shall have liquid limit and plasticity index not more than 25 and 6 per cent respectively.

23.8.3 Strength of sub-base

It shall be ensured prior to actual execution that the material to be used in the sub –base satisfies the requirements of CBR and other physical requirements when compacted and finished.

When directed by the Engineer, this shall be verified by performing CBR tests in the laboratory as required on specimens remoulded at field dry density and moisture content and any other tests for the “quality” of materials, as may be necessary.

23.8.4 Construction Operations

23.8.4.1 Preparation of sub-grade : Immediately prior to the laying of sub-base, the surface of sub-grade already finished to requirement of Para 23.3 shall be prepared by removing all vegetation and other elevation and shall commence at the edges and progress towards the centre for portions having crossfall on both sides.

Each pass of the roller shall uniformly overlap not less than one-third of the track made in the preceding pass. During rolling, the grade and crossfall (camber) shall be checked and any high spots or depressions, which become apparent, corrected by removing or adding fresh material. The speed of the roller shall not exceed 5 km per hour.

Rolling shall be continued till the density achieved is at least 98 percent of the maximum dry density for the material determined as per IS: 2720 (Part-8). The surface of any layer of material on completion of compaction shall be well

closed, free from movement under compaction equipment and from compaction planes, ridges, cracks or loose material. All loose, segregated or otherwise defective areas shall be made good to the full thickness of layer and re-compacted.

23.8.4.2 Surface Finish and Quality Control of Work

Control on the quality of materials and works shall be exercised by the Engineer in accordance with Section 900 of MOST Specification for Road and Bridge Works. ۞

23.8.4.3 Arrangements for Traffic

During the period of construction, arrangement of traffic shall be maintained in accordance with directions of Engineer-in-charge.

23.8.4.4 Measurements for Payment

Granular sub-base shall be measured as finished work in position in cubic metres. The length and breadth shall be taken to the nearest centimeter. The depth of consolidated layer shall be computed to nearest half centimeter by taking average of depths at the centre and at 30 cm from the left and right edges at a cross section taken at 25 metre interval or less as decided by the Engineer by making small pits. The consolidated contents shall be calculated in cum correct to two places of decimals.

The protection of edges of granular sub-base extended over the full formation as shown in the drawing shall be considered incidental to the work of providing granular sub-base and as such no extra payment shall be made for the same.

23.8.4.5 Rate

The Contract unit rate for granular sub-base shall be payment in full for carrying out of required operations including full compensation for:

- (i) making arrangements for traffic as instructed by Engineer except for initial treatment to verges, shoulders and construction of diversions; which will be paid for separately.
 - (ii) furnishing all materials to be incorporated in the work including all royalties, fees, rents where necessary and all leads and lifts;
 - (iii) all labour, tools, equipment and incidentals to complete the work to the specifications;
 - (iv) carrying out the work in part widths of road where directed; and
 - (v) carrying out the required tests for quality control
- (d) Surface dressing on new surface with bitumen emulsion : One coat
 - (e) Surface dressing on old surface with bitumen emulsion : One coat
 - (f) Premix carpet with hot bitumen
 - (g) Premix carpet with bitumen emulsion
 - (h) Bituminous Macadam using hot-mix plant and paver equipment
 - (i) Semi-dense Asphaltic concrete using hot-mix plant and paver equipment
 - (j) Dense Asphaltic concrete using hot-mix plant and paver equipment.

23.9.1 Surface Dressing Using Hot Bitumen – Two Coats

23.9.1.0 This consists of the application of two coats of surface dressing each coat consisting of a layer of bituminous binder sprayed on a base prepared previously, followed by a cover of stone chippings properly rolled to form a wearing course. The existing water-bound macadam, kankar or gravel surface shall be cleaned thoroughly before application of bituminous binder. The work shall be carried out only when the atmospheric temperature in shade is 16 deg. C or above. No bituminous material shall normally be applied when the road surface or material is damp, when the weather is foggy or rainy, or during dust storms.

23.9.1.1 Materials : Binder shall be as specified and shall conform to Table 23.9 and stone chippings shall conform to grading as the Table 23.10. Unless otherwise specified or directed by the Engineer the quantities of materials shall be as specified in Table 23.10. A proper record will be kept to ensure that the daily out-turn of work is correlated with the quantity of bitumen used as per proforma given by Engineer or otherwise specified.

23.9 Surface Courses - The main functions of surface course are:

- (a) To provide a dust free wearing course over base course such as water-bound macadam, or bitumen macadam.
- (b) To provide a water-proof surface.
- (c) To protect water-bound macadam by preventing removal of binder between aggregate pieces.
- (d) To prevent disintegration of an old bitumen surface
- (e) To provide a non-skid riding surface. This type of treatment is normally done for roads with medium density, rubber tired traffic.

The surface course may consist of any one of the following :

- (a) Surface dressing using hot bitumen : Two coats
- (b) Surface dressing on new surface with hot bitumen : One coat
- (c) Surface dressing on old surface with hot bitumen : One coat

TABLE-23.9 MAKES AND GRADES OF BITUMEN AND TAR IN GENERAL USE

Make	Grade	Temperature to which heated
Bharat Petroleum	Painting (Surface Dressing)	
	(A) Hot Bitumen	
	(i) Bharat Bitumen 80/100	160° --- 175° C
	(ii) Bharat Bitumen 60/70	165° --- 180° C
Hindustan Petroleum	(iii) Bharat cutback Bitumen 300/400	155° --- 170° C
	(iv) HP paving Asphalt 80/100	177° --- 190° C
Bharat Petroleum	(B) Cold Bitumen	
	(i) Bharat cutback Bitumen RC – 3	Cold application

Shalimar Products Ltd.,	(ii) Cutback MC as per IS 4545	(40 ⁰ – 65 ⁰ C)
	(C) TAR Road TAR Grade RT 2	Cold application 93 ⁰ --- 104 ⁰ C
Bharat Petroleum Hindustan Petroleum Bharat Petroleum	For Premix Work	
	(A) Hot Bitumen	
	(i) Bharat cutback Bitumen 300/400	150 ⁰ --- 165 ⁰ C
	(ii) HP paving Asphalt 80/100	140 ⁰ --- 175 ⁰ C
	(iii) Refinery modified CRMB conforming to IRC:SP 53-1999	
	(B) Cold Bitumen	Cold application
	(i) Bharat cutback Bitumen RC-3	(40 ⁰ --- 65 ⁰ C)

TABLE – 23.10

Stone Chipping				
	Nominal Size	Specification	Quantity	Bitumen * Quantity
First Coat	13.2 mm	100 percent passing through IS: 22.4 mm square mesh and retained on IS: 11.2 mm square mesh	1.5 cum /100 qm.	1.8 kgm per sqm
Second Coat	11.2 mm	100 percent passing through 13.2 mm square mesh and retained on 5.6 mm square mesh	1.0 cum /100 qm.	1.1 kgm per sqm.

* (Preferably Maxphalt 80/100 or stanvac paving asphalt 80/100 or equivalent. In extreme cold weather. Shelspra on stanvac paving asphalt with 3 to 6% socosele or any equivalent).

23.9.1.2 First Coat:

(a) Preparation of Surface :

Repairs: Potholes or patches and ruts in the water bound macadam base or surface course, which is to be surface treated, shall be repaired by removal of all loose and defective material by cutting in rectangular patches and replacement with suitable material.

All pot holes, patches and ruts upto 2.5 cm shall be repaired and brought to level with premix as specified in 23.11 and properly consolidated while those of depths greater than 2.5 cm shall be repaired with similar specifications as adopted originally.

Cleaning : Prior to the application of the binder, all dust, dirt, caked mud, animal dung, loose and foreign material etc., shall be removed 30 cm on either side, beyond the full width to be treated, by means of mechanical sweepers and blowers, if available or otherwise with wire brushes, small picks, brooms etc. The material so removed shall be disposed off as directed by the Engineer-in-charge.

For a water bound macadam surface, the interstices between the road metal shall be exposed upto a depth of about 10 mm by

means of wire brushes. The surface shall then be brushed with soft brooms to remove all loose aggregate. Finally the traces of fine dust, which get accumulated while brushing, shall be thoroughly removed from the surface by blowing with gunny bags.

The prepared surface shall be closed to traffic and maintained fully clean till the binder is applied.

(b) Applying Binder (hot bitumen)

The binder shall be heated in a boiler to a temperature as specified in Table-23.9 for the grade used and maintained at the temperature, the use of a thermometer being essential.

The binder shall be applied evenly to the clean dry surface by means of a pressure sprayer at the rate specified. The binder shall be applied longitudinally along the length of the road and never across it. The edges of the binder surface shall be defined by wire or a rope stretched in position.

Heating in cut out drums and pouring from perforated tins, cans and such other methods shall not be permitted, except in the case of petty works and repairs with the specific approval of the Engineer-in-Charge.

Excessive deposits of binder caused by stopping or starting of the sprayer or through leakage or any other reason shall be suitably corrected before the stone chippings are spread.

(c) Blinding or Spreading Stone Chippings

Immediately after the binder is applied and while it is still hot, stone chippings free from dust and in a dry and clean state shall be spread evenly over the surface at the rate specified above. Spreading shall be done preferably by means of a mechanical gritter, otherwise manually with a twisting motion to avoid segregation which otherwise shall have to be removed by brushing the excess stone chippings over the surface into hungry spots to obtain a uniform surface, free from waviness, depressions and other irregularities. The surface shall be checked by means of a camber board laid across the road and a three metre straight edge laid parallel to the centre line of the road, and undulations if any shall be corrected by addition or removal of blindage till a surface free from undulation is obtained.

If a uniform surface is assured at this stage the completed surface should be normally free from undulations and unevenness.

(d) Consolidation of Blindage

Immediately following the application of the stone chippings and light brooming, the road surface shall be compacted by a power roller of 6 to 8 tonnes, starting at edges and working towards the centre (or to the outside edge in case of super_elevated curve). Each pass of the roller shall uniformly overlap not less than one third of the track made in the preceding pass. The roller shall be worked or started and stopped without jerks and shall not be stopped or reversed each time at the same location to cause displacement of stone and other irregularities. Consolidation shall be considered complete when the stone chippings are firmly embedded.

Generally five to six trips shall be made for thorough compaction of the surface or as may be specified by the Engineer-in-Charge.

Along kerbs, manholes and all places not accessible to the roller, compaction shall be secured by means of steel rammers or hand rollers.

23.9.1.3 Second Coat :

(a) Cleaning the road surface

The surface shall be examined and any loose material and foreign matter shall be removed by brooming or blowing off by

fanning with gunny bags, care being taken not to loosen the blindage already set.

(b) Applying binder (hot Bitumen)

The second coat of binder shall be applied immediately after the blinding has been set and the surface has been cleaned. The binder shall be applied at the specified rate in the manner specified for the first coat.

(c) Blinding or spreading stone chippings.

Immediately after the second application of binder, the stone chippings shall be spread at the specified rate in the manner described.

(d) Consolidation of blindage

The specifications described in Para 23.9.1.2 (c) shall apply. Further the prepared finished surface shall be protected from traffic for 24 hours or such period as may be specified by the Engineer-in-Charge.

23.9.1.4 Surface Finishing : The finished surface shall be uniform and conform to the lines, grades and typical cross-sections shown in the drawings.

23.9.1.5 The finished surface shall be thrown open to traffic on the following day. Controlling traffic shall be done by suitable methods like barricading, posting of watchman etc.

23.9.1.6 Measurements : The length and width of the finished work shall be measured correct to a cm along the finished surface of the road. The area shall be calculated in square metre, correct to two places of decimal.

The measurement for binder and stone chippings shall be taken before they are actually used on the work for guidance. These measurements of materials simply serve as a guide and shall not form the basis for payment.

23.9.1.7 Rate : The rate shall include the cost of materials and labour involved in all the operations described above, except for repairs described under 23.9.1.2 (a).

23.9.2 Surface Dressing on New Surface with Hot Bitumen One Coat

23.9.2.0 This type of treatment shall consist of cleaning the existing water bound macadam, kankar or gravel surfaces, and applying one coat of hot bitumen on the prepared base, blinding it with stone chippings of 12.5 mm nominal size and consolidation with a road roller. This type of treatment is normally done for a road with light density rubber tyred traffic and roads for temporary construction. This treatment is also done on existing water bound macadam

before applying the final surface treatment. In the latter case, after applying a coat of painting the road is thrown open to traffic till the road is consolidated. The final treatment is then given after making good the undulations etc. in the road surface.

23.9.2.1 Preparation of Surface (Repairs and Cleaning) shall be as specified under 23.9.1.2 (a).

23.9.2.2 Applying binder, blinding, consolidation, surface finishing, measurements and rates shall be as specified under 23.9.1 except that binder shall be applied at the rate of 2.25 kg per sqm and stone chippings of size 13.2 mm at 1.65 cum per 100 sqm unless otherwise specified.

23.9.3 Surface Dressing on Old Surface with Hot Bitumen – One Coat

23.9.3.0 This treatment consists of cleaning old painted surfaces and applying a coat of hot bitumen on the prepared base, blinding with stone chippings and consolidation with road roller.

23.9.3.1 Materials : Binder shall be as specified and conform to Table 23.9 Stone chipping shall conform to grading given in Table 23.10 for 11.2mm. Unless otherwise specified or directed by the Engineer-in-Charge stone chippings of 11.2 mm nominal size shall be used @ 1.5 cum per 100 sqm area and bitumen @ 1.95 kg per square metre area. A proper record shall be kept to ensure that the daily out turn of work is correlated with the quantity of bitumen used as per proforma given by Engineer or otherwise specified in the item.

23.9.3.2 Preparation of Surface (Repairs and cleaning) shall be as specified under 23.9.1.2 (a).

23.9.3.3 Applying binder, Blinding, Consolidation, Surface Finishing, Measurement and Rate shall be as specified under 23.9.1 except that the binder and chippings shall be applied at the specified rate as above or otherwise by Engineer.

23.9.4 Surface Dressing on New Surface with Bitumen Emulsion – One Coat

23.9.4.0 This treatment consists of cleaning the existing water bound macadam, kankar gravel or stabilized base and other black top surfaces, applying a coat of bitumen emulsion at atmospheric temperature, blinding it with stone chippings including consolidation with a road roller.

This type of treatment is normally applied under damp conditions and for minor repair

works during rainy season for roads with medium density, rubber tyred traffic such as service roads. This treatment is also done on existing water bound macadam before applying the final surface treatment. In the latter case, the road is consolidated. The final treatment is then given after making good the undulations depressions etc, in the road surface.

23.9.4.1. Materials : Binder shall be as specified and shall conform to RS grade IS: 8837. Stone chipping of 13.2 mm size shall conform to Table 23.11(a). Unless otherwise specified or directed by the Engineer-in-Charge 13.2 mm stone chippings shall be used @ 1.5 cum per 100 sqm area and bitumen @ 1.95 kg/sqm area. A proper record shall be kept to ensure that the daily out turn of work is correlated with the quantity of bitumen used as per proforma given by Engineer or specified otherwise

23.9.4.2 Preparation of Surface : The specification described in 23.9.1.2 (a) shall apply except that the binder used for patch repairs etc., shall be bitumen emulsion.

23.9.4.3 Applying Binder : The specification described in 23.9.1.2 (b) shall apply except that bitumen emulsion is not heated in boilers but it shall be spread at atmospheric temperature at the specified rate. In case the road surface is very dry the surface shall be very lightly sprinkled with water just before applying the binder.

Binding including consolidation, Measurements and Rate shall be as specified under 23.9.1 except that the stone chippings shall be spread at the specified rate immediately after the bitumen emulsion on application breaks i.e. changes colour from brown to black.

23.9.5 Surface Dressing on Old Surface with Bitumen Emulsion – One Coat

This treatment consists of cleaning old painted surfaces and applying a coat of bitumen emulsion on the prepared base, blinding with stone chippings and consolidation with a road roller. This type of treatment is normally done under damp conditions.

23.9.5.1 Materials: Binder shall be as specified and shall conform to RS grade IS: 8837. Unless otherwise specified or directly by the Engineer-in-Charge 11.2 mm stone chippings shall be used @ 1.10 cum per 100 sqm area and bitumen @ 1.22 kg per sqm area. A proper record shall be kept to ensure that the daily out turn of work is correlated with the quantity of bitumen used.

23.9.5.2 Preparation of surface shall be as specified in 23.9.1.2 (a) except that the binder used for patch repairs etc., shall be bitumen emulsion.

23.9.5.3 Applying binder, bitumen emulsion, blinding or spreading it including

consolidation of blindage, measurement etc., shall be as specified under 23.9.1 except for method of preparation of surface and that the binder and stone chippings shall be used at the rates prescribed in 23.9.5.1.

TABLE – 23.11 (a)

SPECIFICATION FOR STONE CHIPPING FOR SURFACE DRESSING USING BITUMEN-EMULSION

SL	Coat	Size of Chippings	Specification
1	First Coat	13.2 mm	Passing 22.4 mm sieve and retained on 11.2 mm sieve
2	Second Coat	6.7 mm	Passing 9.5 sieve and retained on 2.36 mm sieve

TABLE – 23.11 (b)

MATERIALS REQUIRED FOR SURFACE DRESSING 10 SQM AREA USING BITUMEN EMULSION

SL	Materials	First Coat	Second Coat
1	Cationic Bitumen Emulsion	12 to 14 kg	16 to 18 kg.
2	Aggregates	0.10 to 0.12 cum	0.06 to 0.08 cum

23.9.6 PAINTING (SURFACE DRESSING) ONE OR TWO COATS WITH COLD BITUMEN

23.9.6.1 Materials

a) Binder:- This shall be of the grade and make as specified or as in Table 23..9. or as laid down in the item.

b) Blindage (stone grit 12 mm gauge) : Same as for surface dressing in Table 23.9

c) Preparing and cleaning the road surface : Same as under Para for surface dressing. (Para 23.9)

23.9.6.2 Application of binder

In case bitumen emulsion is used after the surface is thoroughly cleaned, it shall be made damp with water, which shall also wash away the dust. While still damp, bitumen emulsion shall be applied evenly, leaving no bare patches, in longitudinal strips at the specified rate, under pressure from a spray machine, or from pouring cans fitted with perforated or baffled mouth pieces. The edges of the painted surface shall be defined before-hand by means of rope or wire stretched and pegged in position.

23.9.6.3 In case cutback bitumen is used as binder, it shall be applied in the same manner as described under Para 23.9.1.2 (b) and the surface shall not be damped with water.

23.9.6.4 Blinding or gritting the surface : This shall be done in the same manner as

under Para 23.7.5, after the application of the binder. In case of bitumen emulsion, blinding shall be done soon after the emulsion breaks i.e. it changes colour from brown to black.

23.9.6.5 Consolidating the blindage : Same as under Para 23.9.1.2 (d). The road can be opened for traffic after 48 hours.

23.9.7 SEAL COAT

23.9.7.1 Materials : The bitumen/tar for seal coat shall be of the grade and make as for "Painting (surface dressing)". The aggregate used for blindage shall be as laid down in the item. The same shall be free from decay, weathering, dust and other foreign matter.

23.9.7.2 Cleaning the road surface : Specifications same as under Para 23.9.1.3(a).

23.9.7.3 Applying binder : When the surface is thoroughly cleaned, bitumen/tar shall be applied as specified under Para 23.9.1.3 (b) at the specified rate.

23.9.7.4 Blinding : Same as under Para 23.9.1.3 (c).

23.9.7.5 Consolidating the blindage : Same as under Para 23.9.1.3 (d)

23.9.7.6 Seal coat with cold bitumen : Seal coat may also be applied with cold bitumen with the corresponding modifications in the process of applying the binder.

23.10 TACK COAT OF HOT STRAIGHT RUN BITUMEN

23.10.1 Materials : Bitumen : This shall be straight-run bitumen of penetration value 80/100 conforming to IS:73 specifications.

23.10.2 Rate of Application : The rate of application of binder which shall be as specified and shall depend on the surface on which the premix carpet is to be laid. Normally 0.40 kg/sqm on W.B.M surface and 0.25 kg/sqm on existing black topped surface.

23.10.3 Preparation of Surface:

Cleaning : Prior to the application of bitumen, all vegetation, loose sealing compound, caked mud, animal dung, dust, dirt and foreign material shall be removed from the entire surface of the pavement and from existing dummy, construction and expansion joints (wherever existing) by means of mechanical sweepers and blowers, otherwise with steel wire brushes, small picks, brooms or other implements as approved by the Engineer-in-Charge. The material so removed shall be disposed off as directed by the Engineer-in-Charge.

23.10.4 Weather and seasonal limitations : The tack coat shall not be applied nor any bitumen work done during rainy weather or when the surface is damp or wet or when the atmospheric temperature in the shade is 16 deg. C or below.

23.10.5 Application of Tack Coat:

23.10.5.1 Heating : Bitumen shall be heated in a boiler to a temperature of 165 deg. C to 175 deg. C and maintained at that temperature. Temperature shall be checked at regular intervals with the help of a thermometer.

23.10.5.2 Application of Bitumen : Hot bitumen shall be applied evenly to the clean, dry surface by means of a pressure sprayer at specified rate. Even and uniform distribution of bitumen shall be ensured. Bitumen shall be applied longitudinally along the length of pavement and never across it.

Excessive deposits of bitumen caused by stopping or starting of the sprayer or through leakage or any other reason shall be suitably rectified

23.10.5.3 Measurements : Length and breadth shall be measured correct to a cm, along and surface or pavement. Area shall be worked out in sqm correct to two places of decimal.

23.10.5.4 Rate : Rate shall include the cost of all materials, equipment, handling, transport and labour involved in all the operations described above.

23.11 PREMIX CARPET WITH HOT BITUMEN

23.11.1 General : This type of treatment is normally applied on roads where the motor traffic is of medium intensity, but bullock cart traffic is fairly heavy. The treatment is suitable for way side station approach roads and for internal and service roads in colonies. The consolidated thickness of this type of treatment shall be 2 cm or 2.5 cm as specified.

This treatment consists of applying a tack coat on the prepared base followed immediately by spreading aggregates pre-coated with specified binder to camber and consolidating.

Premix carpet shall not be laid during rainy weather or when the base course is damp or wet or when the atmospheric temperature in the shade is 16 deg. C or below:

23.11.2 Preparation of Surface : This shall be done as described in 23.9.1.2 (a).

23.11.3 Materials : Quantities of Binder, stone chippings and grading of stone chipping shall be as per Table –23.12. Binder shall be as specified and shall conform to Table–23.9. Stone chippings shall conform to grading as per Table 23.10. Quantities of materials shall be as given in Table-23.12. A proper record shall be kept to ensure that the daily out turn of work is correlated with the quantity of bitumen used.

TABLE-23.12 MATERIAL PROPORTION FOR PREMIX CARPET

Consolidated thickness of premix carpet	Binder hot bitumen	Stone Chippings (in cum/100 sqm)	
		13.2mm size	11.2mm size
2.00 cm.	52 kg/cum of 13.2 mm size and 56 kg per cum of 11.2 mm	1.8	0.90
2.50 cm.	-do-	2.25	1.12

23.11.4 Tack Coat : The rate of application of binder for tack coat shall be as specified. The rate will be depending upon the surface on which the premix carpet is to be laid i.e. water bound macadam surface or existing black topped surface. Tack coat shall be applied as described in 23.10.5.

23.11.5 Preparation of Premix : The aggregate shall be dry and suitably heated to temperature as directed by Engineer-in-Charge before these are placed in the mixer to facilitate mixing with the binder.

Mixers of approved type shall be employed for mixing the aggregates with the bituminous binder.

The binder shall be heated to the temperature appropriate to the grade of bitumen approved by the Engineer-in-Charge, in boilers of suitable design avoiding local overheating and ensuring a continuous supply.

The aggregates shall be dry and suitably heated to a temperature as directed by Engineer-in-Charge before these are placed in the mixer. After about 15 seconds of dry mixing, the heated binder shall be distributed over the aggregates at the rate specified.

The mixing of binder with chippings shall be continued until the chippings are thoroughly coated with the binder. The mix shall be immediately transported from the mixer to the point of use in suitable vehicles or wheel barrows. The vehicles employed for transport shall be cleaned and be covered over in transit if so directed.

23.11.6 Spreading and Rolling : The premixed material shall be spread on the road surface with rakes to the required thickness and camber or distributed evenly with the help of a drag spreader, without any undue loss of time. The camber shall be checked by means of camber boards and inequalities evened out. As soon as sufficient length of bituminous material has

been laid, rolling shall commence with 6 to 9 tonne power rollers, preferably of smooth wheel tandem type, or other approved plant. Rolling shall begin at the edges and progress towards the centre longitudinally. Except on the super elevated portions rolling shall progress from the lower to upper edge, parallel to the centre line of the pavement. The consolidated thickness shall in no place be less than the specified thickness by more than 25%. However, the average shall not be less than that specified for the item in item.

When the roller has passed over the whole area once, any high spots or depressions, which become apparent shall be corrected by removing or adding premixed materials. Rolling shall then be continued until the entire surface has been rolled to compaction and all the roller marks eliminated. In each pass of the roller, preceding track shall be overlapped uniformly by at least 1/3 width. The roller wheels shall be kept damp to prevent the premix from adhering to the wheels and being picked up. In no case shall fuel/lubricating oil be used for this purpose.

Rollers shall not stand on newly laid material as it may get deformed thereby.

The edges along and transverse of the carpet, laid and compacted earlier shall be cut to their full depth so as to expose fresh surface which shall be painted with a thin surface coat of appropriate binder before the new mix is placed against it.

Further, the prepared finished surface shall be protected from traffic for 24 hours or such period as may be specified by the Engineer.

23.11.7 Surface Finishing : The surface regularity both in longitudinal and transverse directions shall be within the tolerances specified in Table 23.13.

TABLE – 23.13 TOLERANCE IN SURFACE FINISHING

Longitudinal profile	Cross profile
Max. permissible undulation when measured with 3 M straight edge	Max. permissible variation from specified profile when measured with a camber template
10 mm	6 mm
The longitudinal profile shall be checked during rolling with a three metres long straight edge and graduated wedge at the middle of each traffic lane along the road. Similarly the transverse profile shall be checked with adjustable templates at intervals of 10 metres.	

23.11.8 Rectification : Where the surface irregularity falls outside the specified tolerances the contractor shall be liable to rectify it to the satisfaction of Engineer by adding fresh material and recompacting to specifications where the surface is low. Where the surface is high the full depth of the layer shall be removed and replaced with fresh material and compacted and finished to specifications.

23.11.9 Measurements : The length and width of the finished work shall be measured correct to a cm along the finished surface of the road. The area shall be calculated in square metre, correct to two places of decimal.

23.11.10 Rate : The rate shall include the cost of materials and labour involved in all the operations described above for the particular item, except for the cost of "Repairs described under Para 23.9.1.2 (a)."

23.12 PREMIX CARPET WITH BITUMEN EMULSION

23.12.1 General : This type of work is not ordinarily recommended but may be done in case of urgent repairs under damp conditions.

23.12.2 Materials : Binder shall be as specified and shall conform to RS grade IS: 8837. Grading of 11.2 mm stone chipping shall be as per Table-23.10. Quantities of bitumen emulsion and stone chippings shall be as specified in Table-23.14. A proper record shall be kept to ensure that the daily out turn of work is correlated with the quantity of bitumen used as per proforma approved by Engineer. It should indicate daily receipts issues and balance quantity of work done and theoretical requirement for same.

TABLE – 23.14

BITUMEN EMULSION AND AGGREGATE FOR PREMIX CARPET

Consolidated thickness of premix Carpet	Bitumen Emulsion	Stone Chippings
	For Carpet in cum of Chippings	Cum per 100 sqm
2 cm	96	2.4 (11.2 mm nominal size)
2.5 cm	96	3.0 (11.2 mm nominal size)

23.12.3 Preparation of Base: Preparation of surface and binder application shall be as specified under 23.9.4 except that the rate of application of bitumen for tack coat shall be 0.75 kg per sqm on water bound macadam surface and 0.5 kg per sqm on black topped surface or as specified in the item.

23.12.4 Construction Operations: Preparation, spreading, consolidating mix, surface finishing, measurements and rate shall be as specified under 23.9.5 except that the bitumen emulsion shall not be heated but it shall be poured over the aggregate at atmospheric temperature at the correct rate before mixing and spreading on the road surface. The rolling shall commence 24 hours after spreading the mixture. The surface shall be protected by a suitable device such as barricading and posting of watchmen for preventing the traffic.

23.13 DENSE GRADED BITUMINOUS MACADAM (DBM)

23.13.1 Scope

This section specifies the construction of *Dense Bituminous Macadam* or Dense Graded Bituminous Macadam, (DBM), for use mainly, but not exclusively, in base/ binder and profile corrective courses. DBM is also intended for use as road base material. This work shall consist of construction in a single or multiple layers of DBM on a previously prepared base or sub-base. The thickness of a single layer shall be 50mm to 100mm.

23.13.2 Materials

23.13.2.1 Bitumen : The bitumen shall be paving bitumen of Penetration Grade complying with Indian Standard Specifications for "Paving Bitumen" IS:73, and of the penetration indicated in Table 23.16 for dense bitumen macadam, or this bitumen as modified by one of the methods specified by the Engineer or as otherwise specified in the Contract. In case of non-availability of the above grades of bitumen, S 90 (80/100) grade may be used with the approval of the Engineer. Guidance on the selection of an appropriate grade of bitumen

is given in the Manual for Construction and Supervision of Bituminous works.

23.13.2.2 Coarse aggregates : The coarse aggregates shall consist of crushed rock, crushed gravel or other hard material retained on the 2.36 mm sieve. They shall be clean, hard, durable, of cubical shape, free from dust and soft or friable matter, organic or other deleterious substances. Where the Contractor's selected source of aggregates have poor affinity for bitumen, as a condition for the approval of that source, the bitumen shall be treated with an approved anti-stripping agent, as per the manufacturer's recommendations, without additional payment. Before approval of the source, the aggregates shall be tested for stripping. The aggregates shall satisfy the physical requirements specified for dense bituminous macadam.

Where crushed gravel is proposed for use as aggregate, not less than 90% by weight of

the crushed material retained on the 4.75mm sieve shall have at least two fractured faces.

23.13.2.3 Fine aggregates : Fine aggregates shall consist of crushed or naturally occurring mineral material, or a combination of the two, passing the 2.36mm sieve and retained on the 75 micron sieve. They shall be clean, hard, durable, dry and free from dust, and soft or friable matter, organic or other deleterious matter.

The fine aggregate shall have a sand equivalent value of not less than 50 when tested in accordance with the requirement of IS:2720 (Part 37).

The plasticity index of the fraction passing the 0.425mm sieve shall not exceed 4 when tested in accordance with IS:2720 (Part 5).

23.13.2.4 Filler : Filler shall consist of finely divided mineral matter such as rock dust, hydrated lime or cement approved by the Engineer. The filler shall be graded within the limits indicated in Table 23.15.

TABLE 23.15 GRADING REQUIREMENTS FOR MINERAL FILLER

IS Sieve (mm)	Cumulative per cent passing by weight of total aggregate
0.6	100
0.3	95-100
0.075	85-100

The filler shall be free from organic impurities and have a Plasticity Index not greater than 4. The Plasticity Index requirement shall not apply if filler is cement or lime. When the coarse aggregate is gravel, 2 per cent by weight of total aggregate, shall be Portland cement or hydrated lime and the percentage of fine aggregate reduced accordingly. Cement or hydrated lime is not required when the limestone aggregate is used. Where the aggregates fail to meet the requirements of the water sensitivity test in Table 500-8, then 2 per cent by total weight

of aggregate, hydrated lime shall be added without additional cost.

23.13.2.5 Aggregate grading and binder content: When tested in accordance with IS:2386 Part 1 (wet sieving method), the combined grading of the coarse and fine aggregates and added filler for the particular mixture shall fall within the limits shown in **Table 23.16**, for dense bituminous macadam grading 1 or 2 as specified in the Contract. The type and quantity of bitumen, and appropriate thickness, are also indicated for each mixture type.

Table 23.16 COMPOSITION OF DENSE GRADED BITUMINOUS MACADAM PAVEMENT LAYERS

Grading	1	2
Nominal aggregate size	40mm	25mm
Layer Thickness	80-100mm	50-75mm
IS Sieve (mm)	Cumulative % by weight of total aggregate passing	
45	100	
37.5	95-100	100
26.5	63-93	90-100
19	--	71-95
13.2	55-75	56-80
9.5	--	--

4.75	38-54	38-54
2.36	28-42	28-42
1.18	--	--
0.6	--	--
0.3	7-21	7-21
0.15	--	--
0.075	2-8	2-8
Bitumen content % by mass of total mix ²	Min 4.0	Min –5.0
Bitumen grade (pen)	65 or 90	65 or 90

Notes : 1. The combined aggregate grading shall not vary from the low limit on one sieve to the high limit on the adjacent sieve, determined by the Marshall method.

23.13.3 Mixture Design

23.13.3.1 Requirement for the mixture : Apart from conformity with the grading and quality requirements for individual ingredients, the mixture shall meet the requirements set out in **Table 23.17**.

TABLE 23.17 REQUIREMENTS FOR DENSE GRADED BITUMINOUS MACADAM

Minimum stability (kN at 60° C)	9.0
Minimum flow (mm)	2
Maximum flow (mm)	4
Compaction level (Number of blows)	75 blows on each of the two faces of the specimen
Per cent air voids	3-6
Per cent voids in mineral aggregate (VMA)	See Table 23.18 below
Per cent voids filled with bitumen (VFB)	65-75

The requirements for minimum per cent voids in mineral aggregate (VMA) are set out in Table 23.18.

TABLE 23.18 MINIMUM PER CENT VOIDS IN MINERAL AGGREGATE (VMA)

Nominal Maximum Particle Size ¹ (mm)	Minimum VMA, Per cent Related to Design Air Voids, Per cent ²		
	3.0	4.0	5.0
9.5	14.0	15.0	16.0
12.5	13.0	14.0	15.0
19.0	12.0	13.0	14.0
25.0	11.0	12.0	13.0
37.5	10.0	11.0	12.0

Notes : The nominal maximum particle size is one size larger than the first sieve to retain more than 10 per cent. Interpolate minimum voids in the mineral aggregate (VMA) for design air voids values between those listed.

23.13.3.2 Binder Content : The binder content shall be optimised to achieve the requirements of the mixture set out in **Table 23.21** and the traffic volume specified in the Contract. The Marshall method for determining the optimum binder content shall be adopted as described in. The Asphalt Institute Manual MS-2, replacing the aggregates retained on the 26.5mm sieve by the aggregates passing the 26.5mm sieve

and retained on the 22.4 mm sieve, where approved by the Engineer.

23.13.3.3 Job mix formula : The Contractor shall inform the Engineer in writing, at least 20 days before the start of the work, of the job mix formula proposed for use in the works, and shall give the following details.

1. Source and location of all materials
2. Proportions of all materials expressed as follows where each is applicable
3. Binder type and percentage by weight of total mixture

4. Coarse aggregate / Fine aggregate / Mineral filler as percentage by weight of total aggregate including mineral filler.
5. A single definite percentage passing each sieve for the mixed aggregate
6. The individual gradings of the individual aggregate fractions and the proportion of each in the combined grading
7. The results of tests as obtained by the Contractor.
8. Where the mixer is a batch mixer, the individual weights of each type of aggregate, and binder per batch.
9. Test results of physical characteristics of aggregates to be used
10. Mixing temperature and compacting temperature.

While establishing the job mix formula, the Contractor shall ensure that it is based on a correct and truly representative sample of the materials that will actually be used in the work and that the mixture and its different ingredients satisfy the physical and strength requirements of these Specifications.

Approval of the job mix formula shall be based on independent testing by the Engineer for which samples of all ingredients of the mix shall be furnished by the Contractor as required by the Engineer.

The approved job mix formula shall remain effective unless and until a revised Job Mix Formula is approved. Should a change in the source of materials to be proposed, a new job mix formula shall be forwarded to the Engineer for approval before the placing of the material.

23.13.3.4 Plant trials – permissible variation in job mix formula :

Once the laboratory job mix formula is approved, the Contractor shall carry out plant trials at the mixer to establish that the plant can be set up to produce a uniform mix conforming to the approved job mix formula. The permissible variations of the individual percentages of the various ingredients in the actual mix from the job mix formula to be used shall be within the limits as specified in Table 23.19. These variations are intended to apply to individual specimens taken for quality control tests.

TABLE 23.19 PERMISSIBLE VARIATIONS FROM THE JOB MIX FORMULA

Description	Permissible variation	
	Base/binder course	Wearing course
Aggregate passing 19mm sieve or larger	± 8%	± 7%
Aggregate passing 13.2mm, 9.5mm	± 7%	± 6%
Aggregate passing 4.75mm	± 6%	± 5%
Aggregate passing 2.36mm, 1.18mm, 0.6mm	± 5%	± 4%
Aggregate passing 0.3mm, 0.15mm	± 4%	± 3%
Aggregate passing 0.075mm	± 2%	± 1.5%
Binder content	± 0.3%	± 0.3%
Mixing temperature	± 10°C	± 10°C

Once the plant trials have demonstrated the capability of the plant, and the trials are approved, the laying operation may commence. Over the period of the first month of production for laying on the works, the Engineer shall require additional testing of the product to establish the reliability and consistency of the plant.

23.13.3.5 Laying Trials

Once the plant trials have been successfully completed and approved, the Contractor shall carry out laying trials, to demonstrate that the proposed mix can be successfully laid, and compacted. The laying trial shall be carried out on a suitable area which is not to form part of the works, unless specifically approved in writing, by the Engineer. The

area of the laying trials shall be a minimum of 100 sqm of construction similar to that of the project road, and it shall be in all respects, particularly compaction, the same as the project construction, on which the bituminous material is to be laid.

23.13.3.6 The Contractor shall previously inform the Engineer of the proposed method for laying and compacting the material. The plant trials shall then establish if the proposed laying plant, compaction plant, and methodology is capable of producing satisfactory results. The density of the finished paving layer shall be determined by taking cores, no sooner than 24 hours after laying, or by other approved method.

Once the laying trials have been approved, the same plant and methodology shall be applied to the laying of the material on the project, and no variation of either shall be acceptable, unless approved in writing by the Engineer, who may at his discretion require further laying trials.

23.13.4 Construction Operations

23.13.4.1 Weather and seasonal limitations: The provisions of Clause 23.13.3.1 shall apply.

23.13.4.2 Preparation of base : The base on which Dense Graded Bituminous Material is to be laid shall be prepared in accordance with Para 23.9.1.2 (a) and (b) as appropriate, or as directed by the Engineer. The surface shall be thoroughly swept clean by a mechanical broom, and the dust removed by compressed air. In locations where mechanical broom cannot access, other approved methods shall be used as directed by the Engineer.

23.13.4.3 Geosynthetics : Where Geosynthetics are specified in the Contract this shall be in accordance with the requirements stated in relevant supplier's specifications or as per Engineer's instructions..

23.13.4.4 Stress absorbing layer : Where a stress absorbing layer is specified in the Contract, this shall be applied in accordance with the requirements stated in relevant specifications or as per Engineer's instructions..

23.13.4.5 Prime Coat : Where the material on which the dense bituminous macadam is to be laid is other than a bitumen bound layer, a prime coat shall be applied, as specified, in accordance with the provisions of Para 23.9.1.2 (b), or as directed by the Engineer.

23.13.4.6 Tack coat : Where the material on which the dense bituminous macadam is to be placed is a bitumen bound surface, a tack coat shall be applied as specified, in accordance with the provisions of Para 23.10, or as directed by the Engineer.

23.13.4.7 Mixing and transportation of the mixture : The provisions as specified in Para 23.13.3.4.

23.13.4.8 Spreading : The provisions of Clause 23.13.3.5 shall apply.

23.13.4.9 Rolling : The general provisions of Clauses 23.13.3.6 shall apply, as modified by the approved laying trials. The

compaction process shall be carried out by the same plant, and using the same method, as approved in the laying trials, which may be varied only with the express approval of the Engineer in writing.

23.13.5 Opening to Traffic

The newly laid surface shall not be open to traffic for at least 24 hours after laying and completion of compaction, without the express approval of the Engineer in writing.

23.13.6 Surface Finish and Quality Control of work

The surface finish of the completed construction shall conform to the requirements of Para 23.13.4.

23.13.7 Arrangements for Traffic

During the period of construction, arrangements for traffic shall be made in accordance with the directions of the Engineer.

23.13.8 Measurement for Payment Dense Graded Bituminous Materials shall be measured as finished work either in cum or by the sqm at a specified thickness as detailed on the Contract drawings, or as directed by the Engineer.

23.13.9 Rate

The contract unit rate for Dense Graded Bituminous Macadam shall be payment in full for carrying out the all required operations as specified, and shall include, but not necessarily limited to all components listed in Para 23.13.8. The rate shall include the provision of bitumen, at the rates specified in the relevant item by weight of the total mixture. The variance in actual percentage of bitumen used will be assessed and the payment adjusted, up or down, accordingly.

23.14 CEMENT CONCRETE PAVEMENT UNDER CONTROLLED CONDITIONS

23.14.1 Generally All specification given in concrete chapter shall be applicable except those given below.

23.14.2 Grading of mixed aggregates : The grading of all ingredients (coarse and fine aggregates) to be used in the work shall be determined in the laboratory. The coarse and fine aggregates shall be mixed in suitable proportions so that the grading of the mixed aggregates shall be in the range indicated in Table-23.20.

TABLE- 23.20

I.S. Sieve Size (IS: 460)	% age passing by weight
45 mm	100
22.4 mm	55-60
11.2 mm	45-50
5.6 mm	35-40
2.8 mm	30-35
1.4 mm	20-25
710 microns	15-20
355 microns	10-14
180 microns	2-5

23.14.3 No concrete shall be laid nor any payment made thereof unless the concrete mix design is obtained by the contractor and got approved from the Engineer in writing. This mix design shall be provisional and subject to obtaining satisfactory results with trial mixes.

23.14.4 Placing of concrete

23.14.4.1 The concrete is to be transported without any delay from place of mixing to the position of laying and any concrete which in the opinion of the Engineer-in-Charge has remained in mixed state more than half an hour before reaching the place of laying is to be rejected and removed from site. In case of RMC, modified instructions shall be issued by the Chief Engineer.

23.14.4.2 The concrete is to be deposited and spread to such a depth that when compacted and finished the slab thickness indicated will be obtained at all points and the surface will not at any point be below the level specified for the finished surface, in order to secure adequate compaction, the concrete is to be spread so as to stand proud of the finished surface level and produce a surcharge. With screed and internal vibrators, slabs of thickness not exceeding 15 cm shall be laid on one layer. Concrete for slabs of greater thickness will be laid in two layers. The second layer will be laid over the unfinished but thoroughly compacted first layer within the initial setting time of cement used in the concrete. Second layer shall also be compacted thoroughly after laying.

23.14.4.3 Concrete shall be deposited in such a manner as to require as little handling as possible. Spreading, compacting and finishing (except final broom/belt finishing) operations shall be completed within a period not exceeding half an hour from the time the mixing starts or as specified otherwise in case of RMC. In case of dry and hot

weather this time shall not exceed 25 minutes.

23.14.5 Finishing of concrete

During compaction, any low or high spots shall be made up by adding or removing concrete. After longitudinal floating has been completed but while concrete is still plastic, the slab surface shall be tested for trueness with a 3 m straight edge. Any depressions or high spots showing departure from the true surface shall be immediately rectified. High spots shall be cut down and refinished. Depressions shall be enlarged to about 8–10 cm and filled up with fresh concrete, compacted and finished.

23.14.5.1 The straight edge testing the re-floating is to continue until the entire surface —

- (a) is free from observable departure from the straight edge.
- (b) Conforms to the required levels and cross section, and
- (c) Shall conform to the specified surface when the concrete has hardened.

23.14.5.2 The foregoing work is to be carried out while the concrete is still plastic and workable.

23.14.6 Belting

Just before concrete becomes non-plastic, the surface shall be belted with a two ply canvas belt not less than 20 cm wide and at least 1 metre longer than the width of the slab. Hand belts shall have suitable handles to permit controlled uniform manipulation. The belt shall be operated with short strokes transverse to the centre line of the pavement and with rapid advance parallel to the centre line.

23.14.7 Brooming

After belting and as soon as the surplus water if any, has risen to the surface, the pavement shall be given a broom finish with

an approved steel or fiber broom not less than 45 cm wide. The broom shall be pulled gently over the surface of the pavement from edge to edge. Adjacent strokes shall be slightly overlapped. Brooming shall be perpendicular to the centre line of the pavement and so executed that the corrugations formed shall be uniform in character and width and not more than 1.5 mm deep.

Brooming shall be completed before the concrete reaches such a stage that the surface is likely to be torn or unduly roughened by the operation. The broomed surface shall be free from porous or rough spots, irregularities, depressions, and small pockets such as may be caused by accidental disturbing of particles of coarse aggregates embodied near the surface. The brooming shall be of uniform pattern all through.

23.14.8 Edging

After belting/brooming has been completed but before the initial setting of concrete, the edges of the slab shall be carefully finished with an edger of 6 mm radius, and the pavement edges shall be left smooth and true to line.

23.14.9 Honey combing

The side forms shall not be removed until 12 hours or such longer period as the Engineer-in-Charge may decide after the laying of concrete. As soon as the side forms are removed, any minor honey combed area shall be filled with mortar composed of one part of cement and two parts of fine aggregate. Major honey combing areas or segregated concrete or other defective work or areas damaged by removal of the forms or concrete damaged by rain or due to any other reason whatsoever shall be considered as defective work and shall be removed and replaced by the contractor at his own expense. The total area of honeycombed surface shall not exceed 4 per cent of the area of the slab side. However, no individual honeycomb patch shall exceed 0.1 sqm. Engineer-in-Charge's decision as to whether the concrete is defective or not shall be final and binding.

23.14.10 Surface Accuracy

23.14.10.1 After the concrete has sufficiently hardened for about 12 hours and not later than 24 hours, the surface shall be tested again for high spots. All high spots shall be marked and those exceeding 3 mm shall be ground down immediately. Care shall be

taken to see that the grinding does not in any way damage the concrete surface.

23.14.10.2 The final surface finish is to be such that when tested with a profilograph / roughness indicator / or a 3 metre long straight edge or an equivalent mechanical unevenness indicator placed anywhere within the same or adjoining slab in any direction on the surface, there shall be no variation greater than 3 mm.

23.14.10.3 If the surface irregularity exceeding 3 mm still remains despite grinding as per Para 23.17.14.1 the concrete shall be removed to its full depth. The area of concrete to be removed shall be complete slab between the nearest joints and where the defective slab is less than 4.5 metres from the expansion joint, the whole area upto the expansion joint shall be removed to the full depth. The concrete so removed shall not be reused in the work. Fresh concrete shall be laid in the manner already described in these specifications and shall again be subject to test for surface accuracy and other quality control measures. Nothing extra shall be paid for the same.

23.14.10.4 Every slab shall bear an impression not exceeding 3 mm in depth comprising the number allotted to the slab and the date on which it is laid. This impression shall be formed by the contractor when the concrete is green so as to leave permanent mark on setting.

23.14.11 Construction Joints

Construction joints shall be provided as shown in the drawing and also at places where concreting is stopped due to unforeseen circumstances. The joints shall be straight and vertical through the full thickness of the slab. While concrete in adjacent bay is still green, flats of suitable size shall be drawn along the edge and a groove of size 10mm x 25 mm deep shall be neatly formed and finished. The edges of the groove shall be full nosed. After curing of concrete is complete, this groove shall be thoroughly cleaned of all sand dust and shall be perfectly dried and filled with hot poured sealing compound conforming to Grade B of IS: 1834. Before filling with sealing compound the faces of concrete of the joint shall be coated with Shalijet primer or equivalent to a depth of 25 mm at the rate of 2.6 litres per 10 square meters.

23.14.12 Dummy Joints

23.14.12.1 The joints shall be 10 mm wide and shall extend vertically from the surface of the slab to be depth equal to $1/3^{\text{rd}}$ of the

thickness of the slab but not less than 4 cm in any case. The joint may be formed by depressing into the soft but compacted concrete, a high tensile M.S. or other approved Tee or flat bar of depth not less than required depth of the joint plus 25 mm. The bar used for forming the groove shall be coated with soft soap or other suitable lubricant to facilitate its removal when the steel Tee or flat is removed. Joints shall be neatly formed with proper tools and mortar material from the slab itself. No additional cement mortar (rich or otherwise) shall be used.

23.14.12.2 Cutting or sawing by a saw mounted on a movable frame and driven mechanically shall also be permitted as a method for making the dummy joint. In this case the width may be reduced to 6 mm. Any other method for making joints can be followed with the prior approval of the Engineer-in-Charge.

23.14.12.3 In all cases, except where cutting is done with saw, the joint edges shall be bullnosed. Care should be taken to see that the edges of the grooves are not damaged.

23.14.12.4 The grooves shall be filled with hot poured sealing compound conforming to Grade B of IS: 1834. Prior to filling with sealing compound, the joints shall be cleaned by compressed air and primed with Shalijet primer or equivalent.

23.14.12.5 All joints shall be sealed as soon as practicable after 28 days of placing of slabs. Joints shall be sealed flush with the adjacent pavement surface in summer and 3-4 mm below finished concrete surface in winter. The pavement shall be opened to traffic only after joint sealing over the entire pavement. To prevent tackiness or pickup under traffic, the exposed surfaces of the sealing compound shall be dusted with hydrated lime, if directed by Engineer, for which nothing extra shall be paid to the contractor.

23.14.12.6 In case of sudden rain or storm, the work can be concluded at the dummy joints but these will then be formed as construction joints.

23.14.12.7 Before sealing of joints, it may be ensured that the groove extends fully across the bay between consecutive longitudinal joints, in the case of transverse joints. Any concrete or other foreign matter must be removed from the groove.

23.14.13 Defects Liability Period

This period shall be reckoned in the case of concrete pavement work as one year from the date of completion of work or as specified otherwise and it shall be the liability of the contractor to repair, strengthen or reconstruct any portion of the work which has shown damage or any defect, arising out of any bad workmanship or defective material used in the work during this period. In the case of this rectification not being commenced by the contractor within 7 days from the date of notice from the Engineer and completed expeditiously the Engineer reserves the right to get the repair work executed at the risk and cost of the contractor.

23.14.14 Measurements

23.14.14.1 For the purpose of ascertaining the quantity of concrete in the pavement, thickness shall be measured by means of a scale correct to the nearest 2 mm. The thickness of the concrete pavement slabs shall be taken on either side of the pavement at each dummy joint at four corners of the slab immediately after removal of the side forms. In case the average thickness of the slab exceeds the specified thickness, payment shall be restricted to the specified thickness. Payment will be made in cum corrected to two decimals unless otherwise specified.

23.14.14.2 The dimensions of each slab of pavement shall be measured as follows to the nearest 5 mm.

(a) Length

- (i) Between the end of a pavement to the centre line of the expansion joints
- (ii) Between the centre lines of consecutive expansion joints.

(b) Width

- (i) Between the edge of a pavement and the centre line of the construction joints.
- (ii) Between the centre lines of construction joints and expansion joints.
- (iii) Between the centre lines of consecutive construction joints.

Note : The quantity of concrete in the pavement slab shall be worked out by multiplying the area of the slab and its average thickness or specified thickness whichever is less. No deduction shall be made for any joints in the concrete slab.

23.14.14.3 Measurements of concrete slabs shall be recorded jointly by the Engineer or his authorized subordinate and the contractor or his authorized agent.

23.14.15 Rate

The rate of the item for concrete in pavement shall include the cost of all materials and labour including charges for form work machinery tools & plants in all the operations described above. Rate includes provision of all joints specified above including infilling. The rate also includes all cost of setting up the laboratory at site and carrying out the quality control measures/tests enumerated above by the contractor at his own cost in the presence of Engineer or his authorized representative and submission of test results on completion of tests to the Engineer thereof.

23.14.16 Expansion Joint (With Non Extruding Filler Pad) in Concrete Pavements

23.14.16.1 Materials

Pre-moulded Joint Filler: It shall conform to IS: 1838 (Pt. I). The thickness shall be 20 mm and shall be of the maximum available standard length.

Joint sealing compound : The joint sealing compound shall be fuel and heat resistant type complying to grade B of IS: 1834. It shall be capable of adhering to the concrete without cracking, spalling and disintegration.

Primer : It shall be Shalijet or Expanjet primer or equivalent. Bituminous emulsions shall not be used as primers.

23.14.16.2 Construction Procedure

Expansion joints shall be provided as shown in the drawing and as per directions of Engineer-in-Charge. All joints shall be constructed true to line with their faces perpendicular to the surface of the pavement. The joint shall be 20 mm wide. The depth of the non-extruding filler pad shall be 25 mm less than the depth of the concrete slab.

Before the provision of expansion joint, the face of the already laid concrete slab shall be painted with primer at the rate of 2.6 liters per 10 square metres. The expansion pad shall be properly cut to shape and shall then be placed in position abutting the painted face of the already laid concrete slab. The adjacent slab shall then be concreted. The face of the pad against which the new concrete slab is to be laid shall also be painted with primer before laying the concrete, while concreting a neat groove 20 mm x 25 mm as per drawing shall be formed on top of the pad taking care that the edges are absolutely straight and that the groove so made does not get filled with any materials like concrete, mortar and other rubbish.

Before the curing process is started, the top of expansion joint shall be filled with bitumen sand mixture in order to ensure that no foreign material used in curing enters into the joint. This filling shall be removed before filling the joints with sealing compound.

For sealing the joints following operations shall be carried out:-

- (a) The joints are cleared of any foreign matter to the full depth upto the top of expansion pad with steel spatula.
- (b) The joints are blown with compressed air.
- (c) Cleaning is done with Kerosene oil.
- (d) Priming is done with spray gun @ 2.6 liters per 10 sqm of the surface to be primed
- (e) The primer is allowed to dry completely before pouring the sealing compound.
- (f) The sealing compound grade 'A' is heated to the required temperature ranging between 155 deg. C to 165 deg. C or to the temperature range specified by the manufacturer. Over heating shall be avoided. Pouring shall be done from vessel with spout in such a manner that the material will not get spilled on the exposed surface of the concrete, any excess filler on the surface of the pavement shall be removed immediately and the pavement surface cleaned.
- (g) The filling shall be worked in to the joints with hot flats to ensure escape of trapped air.
- (h) The filling is then ironed with hot iron. It is recommended that while in summer the joints may be sealed flush with the adjacent pavement surface, in winter the sealing compound may be filled to a depth 3-4 mm below the surface.
- (i) The edges of the joints are then cut and trimmed to ensure neat and straight-line finish.
- (j) To prevent tackiness or pick up under traffic, the exposed surfaces of the sealing compound shall be dusted with hydrated lime, if so directed by Engineer (Nothing extra shall be paid for the same).

23.14.16.3 Measurements

The measurement of the specified depth of joint shall be recorded in metres correct to two places of decimals.

23.14.16.4 Rate

Rate for the item shall include the cost of all materials, plant, machinery and labour

involved in all operations described above, including all cartages and lifts.

23.15 BLACK TOPPED SURFACE ON PLATFORMS (HOT PROCESS)

23.15.1 Base : The base may be made the same way as for cold process except that it should be finished 25 mm below the top level of the finished platform surface.

23.15.2 Priming coat/Tack coat : If the base consists of non-absorbant surfaces such as laterite, kankar or moorum or clay gravel, a priming coat of approved make shall be applied. This shall be allowed to soak into the platform surface for 48 hours.

In case of brick ballast surface (or stone ballast surface), a tack coat shall be applied as detailed in Para 23.10.

23.15.3 Bitumastic Sheet : 25 mm thick carpet of bitumastic sheet (shel-sheet) shall then be laid.

23.15.4 Limitation : Since having a special bitumen mixer of the paddle type is essential for mixing of the aggregates and binder, shell- sheet carpet on platform can be laid only at important and zonal / divisional headquarter stations where the paddle mixer is available. A 6 to 8 tonnes power roller is also preferable though a 3 to 4 tonnes hand roller can serve the purpose, if approved by Engineer.

23.16 PAINTING ROAD/MARKINGS

23.16.1 Materials

23.16.1.1 Special Road marking paint of approved brand and manufacture shall be used. The paint shall conform to IS: 164. Ready mixed paint as received from the manufacturer shall be used without adding any admixture.

23.16.1.2 During work, if the consistency of the paint gets thick and thinning becomes necessary it shall be done by use of thinner of the specific brand of paint recommended by the manufacturer and with the approval of the Engineer.

23.16.1.3 The paint shall be brought to the site of work by the contractor in original sealed containers. The material shall be brought in one lot in adequate quantity to suffice for the entire work. The material shall be kept in the joint custody of the contractor and the Engineer. The empties shall not be removed from the site of work, till the work has been completed and permission obtained from the Engineer-in-Charge.

23.16.2 Preparation of surface

The surface shall be thoroughly cleaned and dusted. All the dirt, scales, oil and grease

shall be thoroughly removed before painting is started. The prepared surface shall be inspected and approved by the Engineer-in-Charge before painting is commenced.

23.16.3 Application

23.16.3.1 Before pouring into smaller containers for use, the paint shall be stirred thoroughly in its original container. During use also, it shall be continuously kept stirred.

23.16.3.2 The painting shall be applied evenly and smoothly by means of crossing and laying off. The crossing and laying off consists of covering the area over with paint, brushing the surface hard for the first time over and then brushing alternately in opposite direction, two or three times and then finally brushing lightly in a direction at right angle to the same. In this process, no brush marks shall be left after the laying off is finished. The full process of crossing and laying off will constitute one coat.

23.16.3.3 Each coat shall be allowed to dry out thoroughly before the next coat is applied.

23.16.3.4 Earlier applied coat shall be cleaned off dust before the next coat is laid.

23.16.3.5 No left over paint shall be put back into the stock tins. When not in use, the containers shall be kept properly closed.

23.16.3.6 No hair marks from the brush or clogging of paint puddles shall be left on the work.

23.16.3.7 The surface shall ordinarily not be painted until it has dried up completely. Trial patches of paint shall be laid at intervals to check if drying is satisfactory.

23.16.3.8 Marking on Roads shall be in accordance with the drawings or specifications prepared based on IRC standards. It should be done using templates, unless otherwise permitted by the Engineer.

23.16.4 Brushes and Containers

23.16.4.1 After work, the brushes shall be completely cleaned of paint by rinsing with turpentine. A brush in which paint has dried up is spoiled and shall on no account be reused for painting work. On no account kerosene oil shall be used for washing the brushes.

23.16.4.2 When the paint has been used, the containers shall be washed with turpentine and wiped dry with soft clean cloth so that they are clean, and can be used again.

23.16.5 Measurement

23.16.5.1 Length and breadth shall be measured correct to a cm. Area shall be

worked out in square metre of painted area, correct to two places of a decimal.

23.16.6 Rate

23.16.6.1 Rate shall include cost of all materials, tools and labour involved in all the operations described above including all cartages, temporary protection and barricading till the paint dries, if required, and all miscellaneous works.

23.17 BAJRI PATHS

23.17.1 Preparation of Sub-Grade

The formation for a width equal to that of the bajri path shall first be cut to a depth, below the proposed finished level, equal to the thickness of the course of brick aggregate (due allowance being made for consolidation) and dressed off level to the finished profile.

In case of made up soil, adequate watering shall be done so that earth settles down as much as possible and the same rolled up with a minimum three tonnes or light power roller or as directed by the Engineer.

23.17.2 Laying and Packing Brick Aggregate

Shall be as specified in 23.6.8.3 except that brick aggregate shall be used instead of stone aggregate and laid to 7.5 cm depth, unless specified otherwise.

23.17.3 Consolidation

Shall be as specified in 23.6.8.4 & 23.6.8.5 except that rolling shall be done by three ☐ones or light power roller instead of by heavy road roller or as directed by the Engineer.

23.17.4 Rolling with Blinding Materials

Shall be as specified in 23.6.10 except that rolling shall be done by three tones or light power roller instead of by heavy road roller as directed by the Engineer.

23.17.5 Measurements

The finished work shall be measured between the kerb or channel stones or brick edging etc., as the case may be. Length and breadth shall be measured correct to a cm. The area shall be calculated in square metres, correct to two places of decimal for each specified thickness.

23.17.6 Rate

The rate shall include the cost of materials and labour tools and plant; transportation involved in all the operations described above.

23.18 SPREADING AND CONSOLIDATING 6 mm THICK RED

BAJRI ON ROADS AND PLATFORMS (WITH ROAD ROLLER)

23.18.1 Preparation of Surface

23.18.1.1 All undulations in the old surface, such as holes or patches and ruts shall be repaired by cutting in square or rectangular shape. These shall be cleaned and hand packed with new stone aggregate of 40 mm nominal size. This shall be well consolidated with heavy iron rammers with sufficient application of water and blinding materials and brought to camber/grade or level.

23.18.1.2 All high humps and depressions shall be levelled by scarifying and re-compaction. Red bajri shall then be spread on the surface to 6 mm thickness. Care shall be taken to avoid thick layers at particular spots. Adequate water shall then be sprinkled on the surface and rolled till the red bajri is formed into a paste before the wheels of the roller. The rolling shall be done for a minimum of three passes. Wet red-bajri, if sticks to wheels shall be removed by brushes and pouring water on it.

23.18.1.3 Finished surface shall give a uniform appearance and necessary obstructions shall be placed on the road/platform to avoid moving of traffic till next day or lapse of 24 hours.

23.21.2 Measurements

The finished work shall be measured between the wall, coping, kerb or channel stones or brick edging etc., as the case may be. Length and breadth shall be measured, correct to a cm. The area shall be calculated in square metres, correct to two places a decimal.

23.18.3 Rate

The rate shall include the cost of all labour and materials involved in all the operations described above excluding cost of supply red bajri unless specified otherwise in the description of the item.

23.19 KERB AND CHANNEL STONES

23.19.1 Laying

23.19.1.1 Trenches shall first be made along the edge of the wearing course of the road to receive the kerb and the channel stones. The bed of the trenches shall be compacted manually with steel rammers to a firm and even surface and then the stones shall be set in cement mortar of specified proportion.

23.19.1.2 The kerb stones with top 20 cm wide shall be laid with their length running parallel to the road edge, true in line and gradient at a distance of 30 cm from the road edge to allow for the channel an shall project

about 12.5 cm above the latter. The channel stones with top 30 cm wide shall be laid in position in camber with finished road surface and with sufficient slope towards the road gully chamber. The joints of kerb and channel stones shall be staggered and shall be not more than 10 mm thick. Wherever specified all joints shall be filled with mortar 1:6 (1 cement: 6 coarse sand) and pointed with mortar 1:2 (1 cement: 2 fine sand) which shall be cured for 7 days.

23.19.1.3 The necessary drainage openings of specified sizes shall be made through the kerb and foot path as per drawings or as directed by the Engineer for connecting to storm water drains.

23.19.1.4 For detailed specifications for Kerb stone, see **Annexure 24.1** which gives extracts from relevant IS codes.

23.19.2 Finishing

Berms and road edges shall be restored and all surplus earth including rubbish etc., disposed off as directed by the Engineer. Nothing extra shall be paid for this.

23.19.3 Measurements

Length of the finished work shall be measured in running metre along the edge of the road correct to a cm.

23.19.4 Rate

The rate shall include the cost of all the materials and labour including stone of specified material involved in all the operations described above.

23.20 BRICK EDGING

23.20.1 Edging

Trenches of specified width and depth shall first, be made along the edges of the wearing course of the road or pathway to receive the bricks. The bed of trenches shall be compacted to a firm and even surface and then the bricks shall be laid with its length at right angle or parallel to the side of the road pathway depending upon the width of edging as specified in the BOQ item or as indicated by Engineer. The bricks shall be abutting against the wearing course, true to line, gradient and in camber with the finished road surface at the edge.

23.20.2 Finishing

Berms and road edges shall be restored with excavated earth and consolidated by hand packing. All surplus earth including rubbish etc. shall be disposed off as directed by the Engineer-in-Charge.

23.20.3 Measurements

Length of the finished work shall be measured in running metres along the edges of the road correct to a cm.

23.21.2 Rate

The rate shall include the cost of materials and labour, tools and plant, handling, transport etc. involved in all the operations described above.

23.21 SCARIFYING METALLED (WATER BOUND) SURFACE

23.21.2 Scarifying

All dirt, dust, checked up mud, slush, animal droppings, vegetation and all other rubbish shall be removed from the water bound macadam surface.

The macadam surface shall be scarified to a depth of approximately 5 cm with such additional picking of high parts of the road as may be necessary to the required camber and gradient as directed by the Engineer. Any hollows that remain after picking shall be filled with new aggregate 50 mm nominal size and well consolidated to bring the surface to template.

23.21.2 Finishing

The scarified aggregate shall be raked to bring smaller stones on the top and surface brought to the required camber and gradient with tolerance of 12 mm longitudinally as well as transversely.

All rubbish etc., shall be disposed off as directed by the Engineer. Scarifying operation will also include consolidation with road roller the aggregate received from scarifying, although this aggregate will be consolidated along with aggregate of new wearing course to be paid for separately.

23.21.3 Measurements

The finished work shall be measured between the kerb or channel stones or brick edging etc., as the case may be. Length and breadth shall be measured correct to a cm. The area shall be calculated in square metres correct to two places of decimal.

23.21.4 Rate

The rate shall include the cost of labour and materials, tools and plants, handling and transport etc. involved in all the operations described above except the cost of stone aggregate which shall be paid for separately.

23.22 CUTTING W.B.M. ROADS AND MAKING GOOD

23.22.1 Cutting

All road crossings shall be cut in half the width at a time and repaired, unless otherwise permitted by the Engineer. Cutting

shall be straight and uniform in width. Soling stone and aggregate obtained from cutting macadam shall be stacked separately, clear of the road surface. Aggregate shall be screened stones of smaller size below 20 mm and with rounded edges discarded and disposed.

23.22.2 Making Good

23.22.2.1 After the trenches have been filled in with excavated earth in layers of 15 cm thickness, watered, well consolidated with heavy iron rammers and brought to sub grade level, soling stone obtained from cutting shall be laid as per existing soling and consolidated with heavy iron rammers. Where the earth consolidation is well done, no settlement need occur subsequently. For this, excess watering should be avoided.

23.22.2.2 New aggregate 50 mm nominal size, as required, shall be added to old aggregate and spread over to a depth of 7.5 cm as specified in 23.6.2. This shall then be consolidated with hand roller or heavy iron rammers, as directed, first with light sprinkling then with sufficient application of water till the aggregate has become adequately consolidated and does not get displaced. All undulations shall be loosened by hand picking, surplus aggregate removed from high spots and depressions filled with surplus and new aggregate and the surface compacted again. When thoroughly consolidated, kankar moorum and red bajri, freshly collected shall be spread over it in 12 mm layer and consolidated with hand roller or heavy iron rammers, with sufficient application of water till a uniform surface is obtained.

23.22.2.3 The finished surface shall be in (camber) and left a little higher than the adjoining road surface to allow for any settlement on drying.

23.22.3 Measurement

Length and width of cutting shall be measured correct to a cm. The area shall be calculated in square metre, correct to two places of decimal.

23.22.4 Rate

The rate shall include the cost of materials and labour, tools and plants, transport handling etc involved in all the operations described above.

23.23 CUTTING BITUMINOUS ROADS AND MAKING GOOD

23.23.1 General

Cutting, making good and measurements shall be as specified in 23.22 except the top

bituminous surface shall be finished as per the existing surface or as directed by the Engineer. The item shall include cutting and restoration of W.B.M. portion as well as Bitumen portion. (by corresponding replacement)

23.23.2 Rate

The rate shall include the cost of materials and labour involved in all the operations described above.

23.24 CUTTING BAJRI PATHS AND MAKING GOOD

23.24.1 Cutting

Cutting shall be straight and uniform in width. Brick aggregate obtained from cutting shall be screened, aggregates of smaller size discarded and disposed off and rest stacked clear off pathway.

23.24.2 Making Good

After the trench has been filled in with excavated earth, consolidated and brought to sub-grade level, brick / stone aggregates obtained from cutting and mixed with new aggregates 50 mm nominal size, as required shall be spread to a depth of 7.5 cm or earlier existing depth as specified in 23.6.8.3. This shall then be consolidated with blinding materials and finished as specified in 23.22.2.1

23.24.3 Measurements

Length and width of cutting shall be measured correct to a cm. The area shall be calculated in square metre correct to two places of decimal.

23.24.4 Rate

The rate shall include the cost of materials and labour, tools and plant, transport, handling etc. involved in all the operations described above.

23.25 Specifications of Reflective Raised Pavement Markers

Raised Pavement Markers made of polycarbonate moulded body and reflective Panels with micro prismatic lens made out of Polycarbonate with abrasion resistant coating capable of providing total internal reflection of the light entering the lens face and conforming to ASTM D 4280 Type H. The length, height and width of the body will not exceed 95mm and 105mm respectively. The lower surface of the RPM will be supported with two nylon shanks, each of length not less than 25mm. The area of each reflective surface will not be less than 15sqcm and the slope to the base shall be 35+/-5 degree. The marker shall support a

load of minimum 18,000 Kg. Fixing will be without nails but by sing twin polymer shanks using bitumen adhesive on bitumen roads or without polymer shanks and epoxy resin

based adhesive on CC Roads as per manufacturer's recommendation including site clearance etc and complete as directed by the engineer.

ANNEXURE 23.1

RELEVANT EXTRACTS FROM B.I.S. CODES (IS: 5758)

A23. SPECIFICATION FOR PRECAST CONCRETE KERBS, CHANNELS,

A23.1 Materials

Coarse aggregate, suitable having regards to strength, durability and freedom from harmful properties, may be used, but such aggregates shall not contain more than on percent of sulphate and shall not absorb more than 10 percent of its own mass of water.

The maximum size of coarse aggregates may be as large as possible within the limits specified but in no case greater than one-fourth of the minimum thickness of the section.

A23.2 Concrete :

The concrete shall be minimum of M 20 grade, with the strength requirements specified in IS: 456-1978. Air entrained concrete may also be used for freezing and thawing conditions.

A23.3 Designation of Sizes

In the designation of the sizes of kerbs, channels, etc., the dimensions of the face which will be horizontal after laying shall be

given first, and the dimensions of the face which will be vertical, second.

A23.4 Dimensions

A23.4.1 The nomenclature of kerbs and channels are shown in Fig. 1.

Dimensions of Straight Kerbs : Unless otherwise specified straight kerbs shall be manufactured to a uniform length of one metre and to the sections shown in Fig. 1A to 1H.

Note : It is recommended that the sections shown in Fig.1D and Fig. 1E should not be used where the footway is immediately adjacent to the carriageway. Their use should be confined to cases where a strip of substantial width, but in no case less than 1500 mm, separates the footway from the carriageway.

A23.4.2 Dimensions of Straight Channels

: Unless otherwise specified, straight channels shall be manufactured to a uniform length of one metre and to the sections shown in Fig. 1A , 1B, 1C (laid flat) and Fig.2.

A23.4.6 Lengths : The straight kerbs shall be manufactured to a maximum length of one metre normally, however, smaller lengths may be permitted for larger sections, so as to make them lighter and facilitate their handling and placement. The typical sections of kerb and gutter are given at Fig.5.

A23.4.7 Tolerances

The following tolerances shall be permitted on the dimensions:

Length (mm)	Width (mm)	Height (mm)
±3	+ 1.5 to - 3	±3

Note : Slope depending on the camber –
heavy rainfall areas – 1 in 60,
moderate to low rainfall areas – 1 in 72 to 1 in 100.

A23.4.8 Finish and Colour

Unless otherwise specified by the purchaser, the kerbs, channels, etc., shall be supplied in natural colour. When these are ordered coloured, the colour shall be as agreed to between the purchaser and the supplier at the time of placing the order. These may be coloured throughout or only in a surface layer as agreed to between the purchaser and the supplier and the surface layer shall be not less than 12.5 mm thick.

Freedom from Defects

All angles of the precast units with the exception of the angles resulting from the splayed or chamfered faces in the sections shown in figures shall be true right angles.

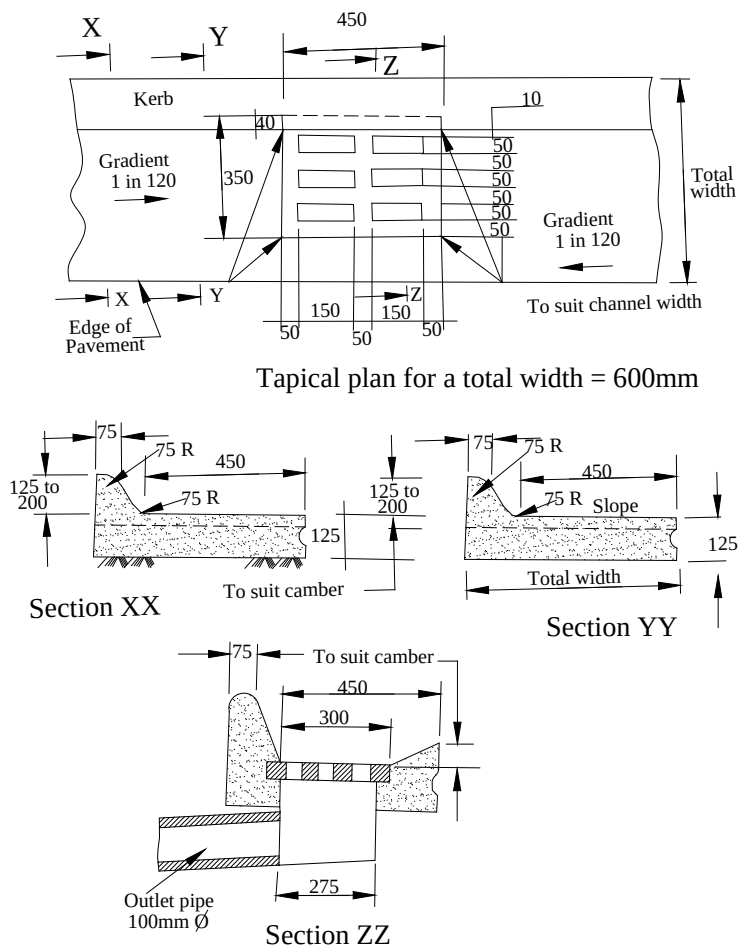
The arises shall be clean and, with the exception of the rounded arrises, sharp. The wearing surfaces shall be true and out of winding. On being fractured, the interior of the products shall present a clean homogeneous appearance.

A23.4.9 Moulding

The kerbs, channels, etc. may be made by any process. Where they are made under hydraulic pressure, the pressure employed shall be not less than 7 MN m² over the entire surface receiving the pressure. The escape of the finer particles of cement during the process of pressing shall be prevented as far as practicable.

Annexure-24.1

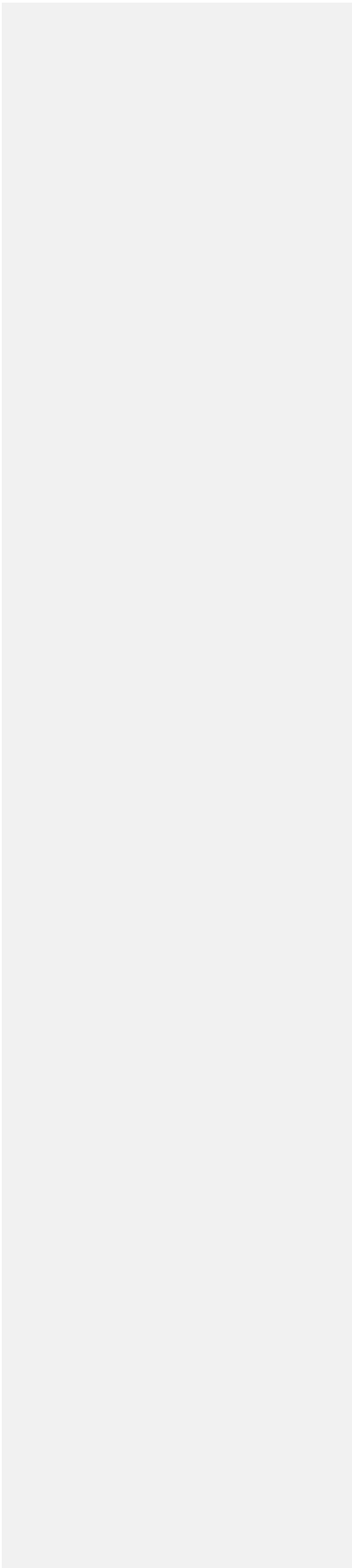
Combined kerb and Gutter



Note : Stop depending on the camber- heavy rainfall areas - 1 in 60 mederrate to low rainfall areas - 1 in 72 to 1 in 100.
To suit width for 600 mm total width, it should be 300 mm.

All dimensions in millimetres.

Fig. 5 : Combined Kerb



Chapter 24

Fencing And Boundary Marks

24.1 FENCING

24.1.1 General

Fencing can be made of wire (plain strand; plain or barbed strands) fixed to Posts or of Posts with railing or with Pales. The posts may be of RCC, scrap rails or of angle iron. These shall be of standard size with the standard length of posts being 1.8m, rails 2.25 m, and pales 1.25 m. Tolerance in length of 12 mm in length and 3mm in other dimensions is permissible. Longer posts and more rows of wires may be used in special cases, if so specified.

Posts ,rails and pales: In case of RCC posts and pales, they shall be precast in concrete mix M15 (or 1:2:4) with stone aggregate 12.5 mm nominal size. Posts shall be with slots as specified in Drawing or by the Engineer and reinforced with 10 mm dia M>S bars in case of posts and pales and 6mm in case of rails. For the whole of their length below the top of the rail the paling shall have a projecting dovetail shape at the back which shall fit into dovetail grooves in each of the rails. The part projecting above the top rail shall be left square to prevent their dropping through the rails. The posts, rails and pales shall be free from cracks, twists and such other defects..

RCC Posts and Struts :

All posts and struts shall be of standard size, the length of posts being 1.8 m or otherwise specified and that of struts being minimum length of 2.0m.. They shall be of RCC precast with concrete mix M15 (1:2:4), finished smooth with cement mortar 1:2; reinforced with 6 mm or higher dia MS bars as per drawing or as directed. Posts and struts shall be free from cracks, twists and such other defects. GI staples on wooden plugs or 6 mm bar nibs will be provided in the posts while casting, as directed by Engineer or as shown in drawing.

24.1.2 Barbed Wire Fencing with RCC Posts

24.1.2.1 Materials: RCC posts and struts shall be as described in 24.1.1 above. Barbed wire used shall be as per IS: 278.

24.1.2.2 Spacing of Posts and Struts: The posts shall be spaced at three metres centres, unless otherwise specified or as

directed by the Engineer, to suit the dimensions of the area to be fenced. Every 15th post, corner posts and last but one end post shall be strutted on both sides and end post shall be strutted on one side (inside) only.

24.1.2.3 Fixing of posts and struts: Pits 450 x 450 mm and 750 mm deep or as directed by the Engineer shall be excavated true to line and level to receive the posts. In case of struts, pits 700 x 450 mm and 750 mm deep or as directed by Engineer shall be excavated to suit the inclination of the strut so that it is surrounded by concrete by not less than 150 mm at any point. The pits shall first be filled with a 150 mm layer of concrete to mix 1:3:6 (C.A to be graded stone aggregate 40 mm nominal size. Posts and struts shall then be placed in the pits in correct position and with 1.2 m or the specified height above ground, true to line and position. If the ground is sloping or undulating the posts shall be placed so that the tops and the positions at which wires are to be fixed are in a predetermined uniform slope or geometric line vertically on selected stretches, in consultation with the Engineer. Cement concrete of 1: 3: 6 proportion mix shall then be filled in the pit around the posts and struts upto a level below ground level of 150 mm for posts and 250 mm for struts, so that the posts are embedded in a concrete block of 450 x 450x 600 mm and the struts are embedded in block of size 700 x 450 x 500 mm. The concrete in foundations shall be watered and cured for at least 7 days. The remaining portion of the pit shall be filled with the excavated earth and well tamped and dressed on top. Surplus earth will be disposed off as directed by the Engineer.

24.1.2.4 Fixing of Barbed wire: The barbed wire shall be stretched and fixed in specified number of rows, and two diagonals in each panel. The bottom row shall be 140 mm above ground and the rest at 125 mm centre to centre, unless otherwise specified in drawing or by the engineer. The diagonals shall be stretched adjacent posts from top wire of one post to the bottom wire of the second post and vice versa. The diagonal wires shall be interwoven with horizontal wires by fixing the odd rows of wires, then the diagonal cross wire and lastly even row

of wires. The barbed wire shall be held to the RCC posts by means of GI staples fixed to wooden plugs or GI binding wire tied to the 6 mm bar nibs fixed to the posts while casting them. Turnbuckles and straining bolts shall be used on end posts or as specified. If the posts are provided with holes at positions of barbed wire, the barbed wire shall be fixed to posts with GI wire of approved gauge and passing through the hole.

24.1.2.5 Measurements: The finished fencing shall be measured in total length from centre to centre of posts, correct upto nearest cm.

2.6 Rates: The rate shall include the costs of all labour and materials, handling and transport, provision of tools and plant involved in all operations described above but excluding the cost of posts, struts, turnbuckle, straining bolts and excavation and concrete in foundations for which separate payments shall be made under respective items. Rate for supply and fixing of the posts and struts include the costs of all labour and materials including cast in fixtures curing, handling, transport and provision of tools and plant thereof.

24.1.3 Barbed Wire Fencing with Angle Iron Posts

24.1.3.1 Materials Alternatively angle iron posts and struts can be used for supports. They will be of mild steel in accordance with specifications in Chapter on Steel work. Barbed wire shall be as per IS: 278. The angle iron shall be 40 x 40 x 6 mm unless otherwise specified

24.1.3.2 Spacing of posts and struts. The posts shall be spaced at three metres centres, unless otherwise specified or as directed by the Engineer, to suit the dimensions of the area to be fenced. Every 15th post, corner posts and last but one end post shall be strutted on both sides and end post shall be strutted on one side (inside) only.

24.1.3.3 Fixing of posts and struts: This shall be as per Para 24.1.2.3. In addition, angle iron post at bottom shall be split and banded at right angle in opposite direction for 100 mm length.

24.1.3.4 Fixing barbed wire: The barbed wire shall be stretched and fixed in specified number of rows and two diagonals. The bottom row shall be 140 mm above ground level and the remaining at 125 mm centre to centre. The diagonal shall be stretched between adjacent posts from top wire of one post to the bottom wire of the second post and vice versa in each panel.

The diagonal wire will be interwoven with horizontal layers as specified in Para 24.1.2.4. The barbed wire shall be held drilling holes of 10 mm in the post and tied with GI wires. Turnbuckles and straining bolts shall be used to tighten the wires at the end posts, if so specified.

24.1.3.5 Fixing posts and struts on top of boundary walls: Barbed wire fencing may be specified for some heights over boundary walls of workshops, depots etc.. In such cases, the posts shall be made of angle iron which shall normally be bent at an angle (30° to 45°) to the plane of the wall. The bottom 300 mm length of the posts struts shall be vertical, of which the bottom most 100 mm length will be split and banded at right angle in opposite direction. This vertical leg of the post and struts will be fixed on top of boundary wall, leaving 75 mm length above the coping and remaining portion embedded in concrete of mix 1:2:4 in preformed holes on top of wall, in such a way that there is a minimum concrete cover of 45 mm allround.

24.1.3.6 Measurements: This shall be same as per Para 24.1.2.5.

24.1.3.7 Rates: This shall be same as per Para 24.1.2.6 except that angle iron posts shall be paid for in weight to nearest kilogram and worked out based on standard tables for gross length of angles used without any deduction for holes and cuts. The rate shall include cutting, splitting, bending etc as per these specifications at no extra cost.

24.1.4 Plain Wire Fencing

24.1.4.1 Plain Wire Fencing will be provided in lieu of barbed wire fencing in some circumstances, if so specified or instructed by Engineer.

24.1.4.2 Materials: Posts and Struts may be of RCC or of angle iron and specifications for same will be as indicated in Paras 24.1.2.1 or 24.1.3.1 respectively. Wire used will be from 1 mm dia strands to IS: 2140

24.1.4.3 Fixing posts and struts will be same as in Paras 24.1.2.3 or 24.1.3.3 respectively

24.1.4.4 Fixing wire: This will be as per Paras 24.1.2.4 or 24.1.3.4, except that the wires will be threaded through the holes preformed in the posts or drilled in angle iron posts. At every 15 posts, corner posts and, they will be secured to the posts by GI wires. At end posts, they will be secured with turnbuckles and straining bolts.

24.1.4.5 Measurements: This will be as per Paras 24.1.2.5 and 24.1.3.6 respectively for RCC post fencing and angle iron post fencing.

24.1.4.6 Rates: This will be as per Paras 24.1.2.6 and 24.1.3.7 respectively for RCC post fencing and angle iron fencing respectively.

24.1.5 Welded Steel Wire Fabric Fencing with RCC Posts

24.1.5.1 Materials: RCC posts and struts shall be as specified in Para 24.1.2.1. Welded steel wire fabric will conform to IS: 4948 and shall be of rectangular mesh 75 x 25 mm size weighing not less than 7.75 kg /sqm.

24.1.5.2 Fixing: of RCC posts and struts shall be as specified in clause 24.1.2.3.

24.1.5.3 Fixing wire mesh: shall be as described in 24.1.2.4 except that instead of barbed wire, steel fabric 900 mm wide will be fixed to the posts by means of GI staple on wooden plugs or tied to 6 mm bar nibs with binding wire. The steel fabric shall be fixed to leave 150 mm clearance at the bottom of and top of the parts.

24.1.5.4 Finishing: The steel wire fabric shall be painted with two or more coats of approved shade of enamel paint over a coat of steel primer as for new work.

24.1.5.5 Chain Link Fencing: Chain link made of GI wires made into meshes of 50 x 50mm size conforming to IS: 4948 shall be fixed to RCC posts and struts, as described in paras 24.1.5.2 and 24.1.5.3. They will not be painted.

24.1.5.6 Measurements and Rates: Measurements and rates shall be as described in Paras 24.1.2.5 and 24.1.2.6 except that the wire mesh fixed shall be measured and paid for in square metre, computed from linear measurements made to nearest cm.

24.2 BOUNDARY MARKS, KM POSTS , CURVE POSTS ETC

24.2.1 Boundary Marks

24.2.1.1 Materials: Boundary stones will be of precast concrete or hard or sound stones of durable quality or precast RCC blocks made in accordance with Standard Drawings. Where no standard drawing exists, following guide lines shall be followed. Dressed stone boundary posts shall be of hard stone like granite, basalt or other approved locally available stones. They shall be sound, free of cracks, fault lines, fissures, holes etc.

24.2.1.2 Dimensions: Precast concrete stones will be at least 900 mm long, of which 450 mm depth will be below ground and 450 mm projecting above ground level and it will be of square cross section of minimum 150 mm sides, unless otherwise specified. The portion above ground may in some cases be made of circular cross section of 150 mm diameter, if so specified. They will be reinforced with four numbers 6mm dia MS bars longitudinally and with 6 mm stirrups at 150 mm spacing and will be made of 1:2:4 mix concrete and finished smooth with cement mortar 1:3 mix. A tolerance of 12.5 mm shall be permitted in the case of specified dimensions. Stones shall be dressed square in cross section of sides 150 mm and be of minimum length 900 mm.

24.2.1.4 Fixing: Boundary stones shall be fixed firmly into the ground to a depth of 450 mm and embedded in foundation concrete of Mix 1:4:8 so as to provide a minimum cover of 150 mm all round and extending for a depth of 100 mm below the bottom of the stone. The pit around should be properly filled, watered and tamped in layers and thus well compacted.

24.2.1.4 Spacing: Boundary stones shall be fixed at the railway boundary at spacing as directed by the Engineer. Spacing should be not less than 200 metres alongside the tracks and all sides of the colony or office boundaries, at every point of change of direction. They will be spaced at closer intervals in important stations and railway colonies and railway property located in vulnerable areas as decided by the Engineer.

24.2.1.5 Measurements for Payment Measurements shall be made in numbers of boundary stones fixed at site.

24.2.1.6 Rate.

The unit rate for boundary stones/ posts shall cover full costs of providing all labour, materials, tools and plant for preparing the boundary stone (in manufacturing PCC or stone including quarrying, cutting and dressing of stone), transport, excavation of pit, concreting for embedment and making good the pits and all incidental charges to complete the work as per these specifications.

24.2.2 Kilometer Posts

24.2.2.1 Location: Kilometer stones and 100 m stones shall be of standard dimensions as given in drawings. They shall be fixed on the cess, clear of ballast sections placed normal to centre line of the track. They shall have the lettering engraved and

painted. Letters will be in black on white background.

24.2.2.2 Materials: Kilometer and other sign posts shall be precast with cement concrete 1:2;4 and finished smooth with cement mortar 1:3. They will be reinforced with a mesh formed of 6mm MS bars or as otherwise directed.

24.2.2.3 Fixing: Trenches 500 mm wide and 450 mm deep shall be excavated to required length to receive the stone, the lower portion of stone shall then be firmly fixed in position in ground and sides filled with earth, watered and rammed and thoroughly consolidated. If so specified, the stones will be fixed in cement concrete 1:4:8 with stone aggregate 40mm nominal size, so that there is 150 mm of concrete in bottom below the stone and 150 mm all round upto formation level. Trenches will, in that case be excavated to required dimensions.

24.2.2.4 Finishing: The exposed surfaces above ground shall be painted with two coats of approved paint in white or as specified over a coat of primer as for new work. The letters (numbers in Roman numerals) will be painted black.

24.2.2.5 Measurements: Kilometer and 100 m stones shall be enumerated as erected.

24.2.2.6 Rates: The rate shall include the cost of materials and labour, tools and plant, handling transport etc involved in all operations, but excluding the costs of excavation, concreting in fixing, painting the surface and numbers for which payment shall be made separately under relevant items of schedule.

24.2.3 Curve posts

Curve posts made in concrete shall be placed at beginning and ends of curves of track on the cess. They will be made in RCC to dimensions given in standard drawings for same. They will be similar to Kilometer posts except that the detailed particulars of curves will be etched and painted on them in English letters and Roman numerals. The lettering shall be in black over yellow background. Specifications will be similar as given in clause 24.2.2 above.

24.3 NAME BOARDS AND SIGN POSTS

24.3.1 Location: Name boards and sign boards shall be of standard dimensions as

given in respective drawings. They shall be fixed on platforms and circulating areas in stations or on sides of roads in colonies at locations and in directions as directed by the Engineer. They shall have the lettering engraved and painted. Letters of specified dimensions will be in black on yellow background.

24.3.2 Materials: Name and sign boards and posts on which they are to be fixed shall be precast with cement concrete 1:2;4 and finished smooth with cement mortar 1:3. Boards will be reinforced with a mesh formed of 6mm MS bars and posts reinforced with appropriate number of MS rods as shown in drawings or as otherwise directed.

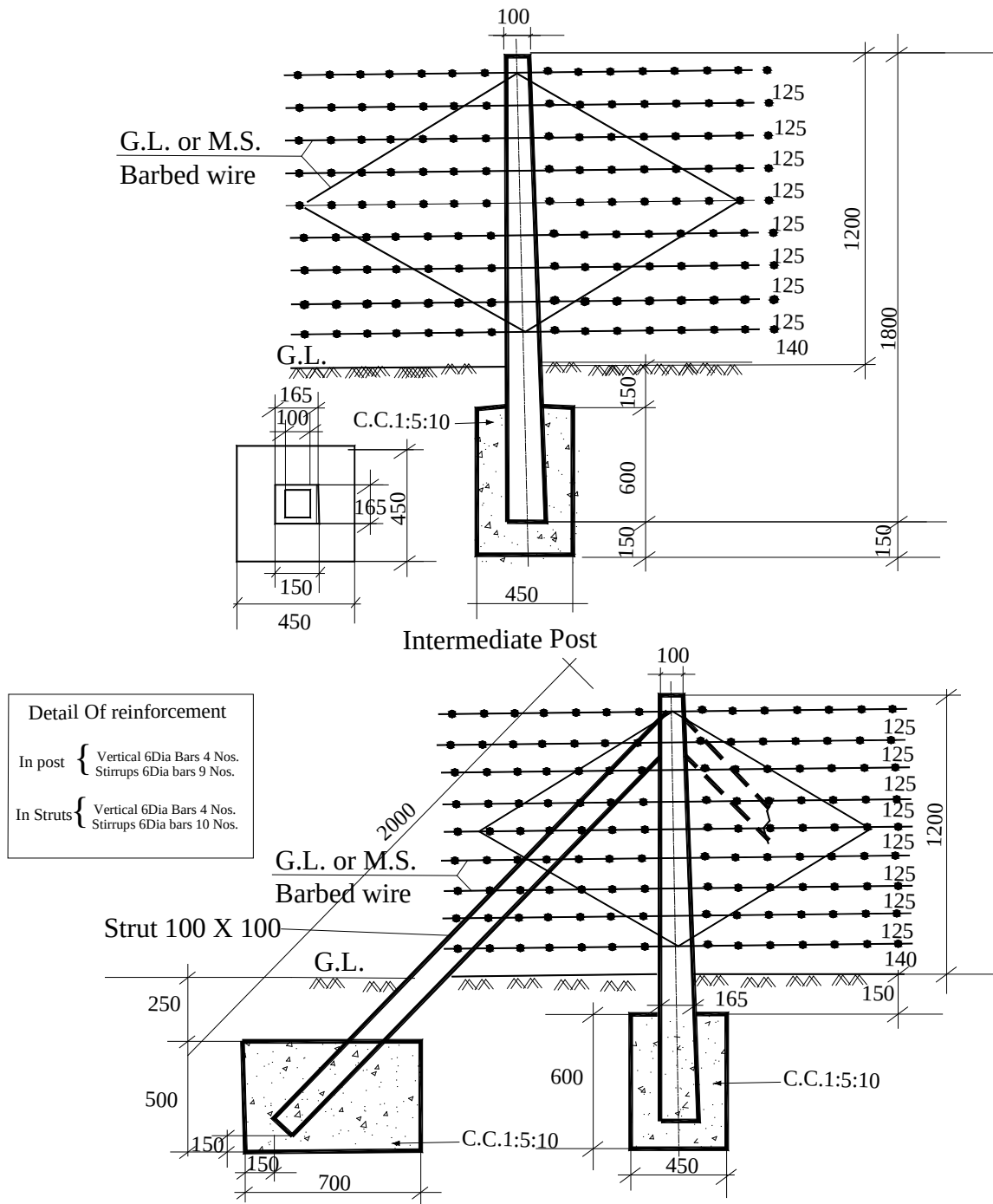
24.3.3 Fixing posts: Pits of size 450 mm x 450 mm and 600 mm deep (or as otherwise directed shall be excavated to receive the posts. The posts shall be fixed in the pits in cement concrete 1:3:6 with stone aggregate 40mm nominal size, so that there is 150 mm of concrete in bottom below the bottom of posts and all round filling the pit upto 100 mm below platform/ road/ ground level.

24.3.4 Fixing Boards: The boards shall be fixed on to the posts by insertion into the grooves or fixed with bolts and nuts in holes provided for same as directed by the Engineer. The gap in the grooves and slots in posts/ slots shall be filled with cement mortar 1:3 and finished flush with surfaces of posts and boards.

24.3.5 Finishing: The exposed surfaces above ground shall be painted with two coats of approved paint in canary yellow or as specified over a coat of primer as for new work. The letters (letters in languages specified and numbers in Roman numerals, unless otherwise directed) will be painted black.

24.3.6 Measurements: Posts and boards shall be enumerated as erected.

24.3.7 Rates.: The rate shall include the cost of materials and labour, tools and plant, handling transport etc involved in all operations, but excluding the costs of excavation, concreting in fixing, painting the surface and numbers for which payment shall be made separately under relevant items of schedule.



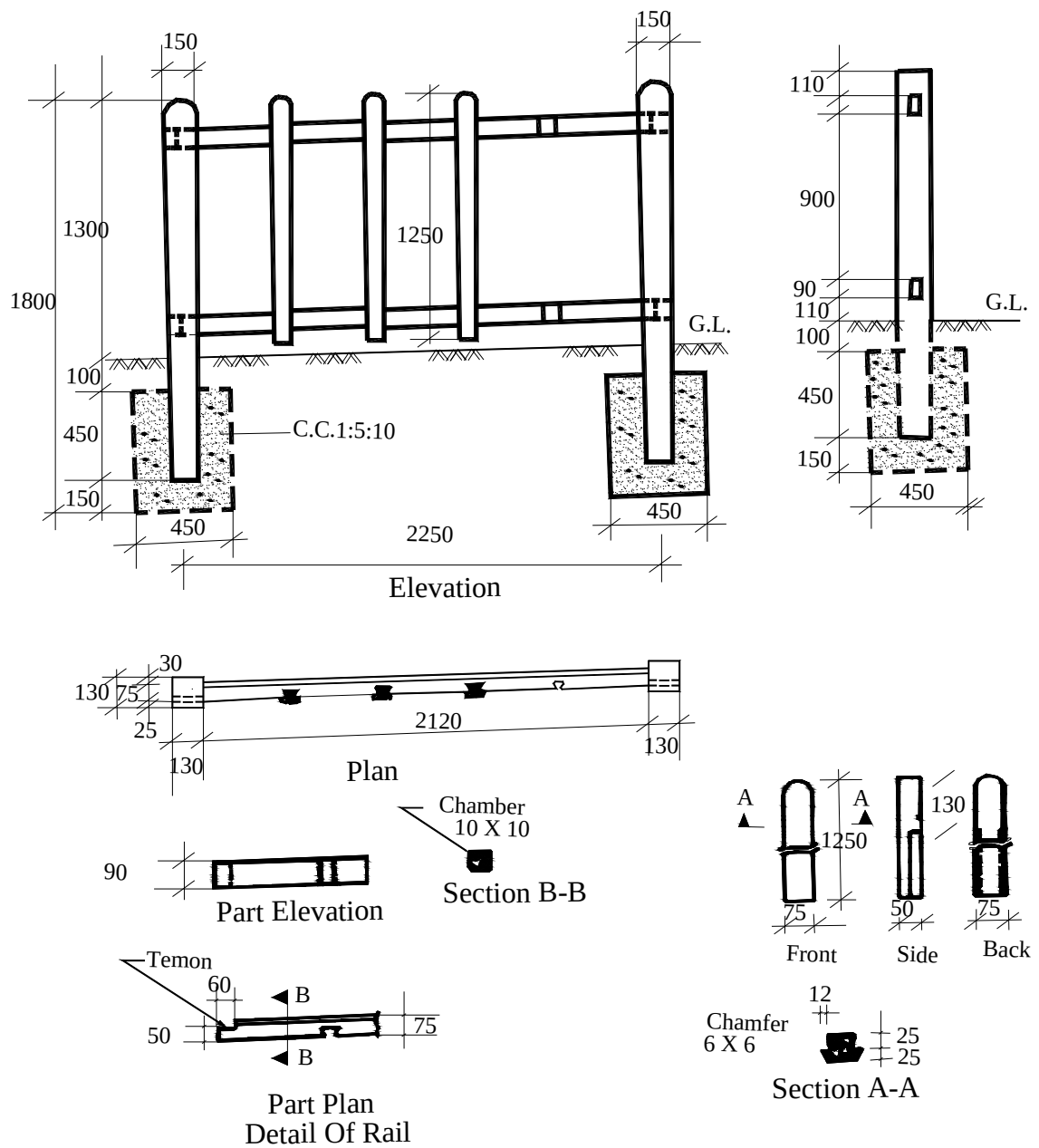
1. In case of end post one Strut shall be omitted.

Drawings are not to scale.

All the dimensions are in MM

End and Intermediate Post with struts

Barbed Wire Fencing (With R.C.C. Post)



Fencing with R.C.C. Post ,Rails,Pales

Chapter 25

Supply Of Materials

25.1 **Specification** : Items of general use required for day to day maintenance by departmental staff have been included in this chapter. Specifications for each item shall be as given in the relevant chapter. Where no specification has been given for any particular item, relevant IS Specification shall apply. List of all relevant IS Codes has been given in Chapter 0.

25.2 **Location Of Supply** : The materials are to be supplied at SSE/SE store in the city. In case, the material is to be supplied at a store located at a far away place or way side station extra

payment for leading shall be made separately as per site conditions. Payment for lead shall be made only for the incremental lead on account of location of the railway store.

25.3 **Rates** : Rates include all the element of cost of material, loading at purchase point, unloading and staking in the railway store but do not include re-handling if required. Deductions in quantity / volume for voids shall be made as per specification of relevant item. Rates shall include all the taxes, royalties, octrai etc.

Chapter 26

Mortars

2.1.26.1 MATERIALS

2.1.26.1.1 Water

26.1.1.1 General - Water used for mixing and curing shall be clean and free from injurious quantities of alkalies, acids, oils, salts, sugar, organic materials, vegetable growth or other substances that may be deleterious to bricks, stone, concrete or steel. Potable water is generally considered satisfactory for mixing. The pH value of water shall be not less than 6. The following concentrations represent the maximum permissible values: (of deleterious materials in water). Reference may be made to Concrete Bridge Code (Revised 1997).

(a) Limits of Acidity: To neutralise 200ml sample of water, using phenolphthalein as an indicator, it should not require more than 2 ml of 0.10 normal NaOH. The details of test shall be as given in IS: 3025 (part 22).

(b) Limits of Alkalinity: To neutralise 200ml sample of water, using mixed indicator, it should not require more than 10 ml of 0.10 normal HCl. The details of tests shall be as given in IS: 3025 (part 23).

(c) Percentage of Solids: Maximum permissible limits of solids when tested in accordance with IS: 3025 shall be as under:

Organic	200 mg/litre
Inorganic	3000 mg/litre
Sulphates (as SO ₄)	500 mg/litre
Chlorides (as Cl)	500 mg/ litre for Prestressed Concrete Work, 1000 mg/ litre for Reinforced Concrete work and 2000 mg/ litre for Plain Concrete Work.
Suspended matter	2000 mg/litre

The physical and chemical properties of water used for mixing and curing should conform to the requirements of IS:456. The contractor has to arrange good quality water for construction indicating the source].

2.1.1.26.1.1.2 Water for Curing

Water found satisfactory for mixing is also suitable for curing. However, water used for curing shall not produce any objectionable stain or unsightly deposit on the surface. The presence of tannic acid or iron

compounds in the water meant for curing is objectionable.

26.1.1.3 Use of Sea Water - Sea water shall not be used for mixing or curing.

26.1.1.4 Frequency of Testing for Quality - Water from each source shall be tested before commencement of the work and thereafter once in every three months till completion of the work or when ordered. In case of ground water, testing shall also be done for different points of draw down. Water from each source shall be got tested during the dry season before monsoon and again after monsoon.

26.1.1.5 Test for Strength - In case of doubt regarding development of strength the suitability of water for making concrete shall be ascertained by the compressive strength and initial setting time tests specified in sub-paras (a) to (c) below.

(a) The sample of water taken for testing should represent the water proposed to be used for concreting due account being paid to seasonal variation. The sample shall not receive any treatment before testing other than that envisaged in the regular supply of water proposed for use in concrete. The sample should be stored in a clean container previously rinsed with similar water.

(b) Average 28 days compressive strength of at least three 15 cm concrete cubes prepared with water proposed to be used shall not be less than 90 percent of the average of strength of three similar concrete cubes prepared with distilled water. The cubes shall be prepared, cured and tested in accordance with the requirements of IS:516.

(c) The initial setting time of test block made with the appropriate cement and the water proposed to be used shall not be less than 30 minutes and shall not differ by ± 30 minutes from the initial setting time of control test block prepared and tested in accordance with the requirements of IS: 4031.

26.1.2 Cement

26.1.2.1 General - The cement used shall be any of the following and the type selected should be appropriate for the intended use.

(a) 33 grade ordinary Portland cement conforming to IS:269

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- (b) 43 grade ordinary Portland cement conforming to IS: 8112
- (c) 53 grade ordinary Portland cement conforming to IS:12269
- (d) Rapid hardening Portland cement conforming to IS:8041
- (e) Portland Slag cement conforming to IS:455
- (f) Portland pozzolona cement (flyash based) conforming to IS:1489 (part 1)
- (g) Portland Pozzolana cement (calcined clay based) conforming to IS:1489 (part 2)
- (h) Hydrophobic cement conforming to IS:8043.
- (i) Low heat Portland cement conforming to IS:12600
- (j) Sulphate resisting Portland cement conforming to IS:12330.

Different types of cement shall not be mixed together. In case more than one type of cement is used in any work, a record shall be kept showing the location and the types of cement used.

26.1.2.2 Caution in use of cement Grade 53 in construction - In case of Grade 33 cement, the gain in strength will continue beyond 28th day. Because, of early gain, gain of strength by other cements will not increase much beyond 28th day. In addition, because of the faster hydration process, the concrete also releases heat of hydration at a much faster rate initially and release of heat is the highest in case of Grade 53. The heat of hydration being higher, the chances of micro cracking of concrete is much greater. Thus, during initial setting period of concrete, the higher heat of hydration can lead to damages by way of micro-cracking within the concrete which may not be visible at surface. This cracking is different from shrinkage

cracks which occur due to faster drying of concrete in windy conditions.

The situation can be worse if the quantity of the cement in concrete is increased with a belief that such increases are better for both strength and durability of concrete. Thus, it is very essential to be forewarned that higher grade cement, specially grade 53, should be used only where such use is warranted for making higher strength concrete and also where good Quality Assurance measures are in place, by which proper precautions are taken to relieve the higher heat of hydration through chilling of aggregates or by proper curing of concrete. Higher grade cement if used for low strength concrete, as mortar or even for plastering can lead to unnecessary cracking of concrete / surfaces.

Another issue to be cautioned against is the tendency of the manufacturers to project grade 53 cement as a stronger cement, whereas grade 33 or 43 is normally enough to produce the concrete of desired characteristic strength. Higher grade cement should hence be used only where there is the need for it on design considerations.

26.1.2.3 Chloride Content - In terms of Correction Slip No.1 dated 26.04.2000 to Concrete Bridge Code (Revised 1997), the total Chloride content by weight in Cement shall not exceed the following values.

- (a) For Prestressed Concrete works
 - (i) Under extreme and very severe environment : 0.06%
 - (ii) Under severe, moderate and mild environment : 0.10%
- (b) For R.C.C. Works : 0.15%

26.1.2.4 Compressive Strength - Compressive strength requirement of ordinary Portland cement of various grades when tested in accordance with IS:4031 (part 6) shall be as under :

Sample	Strength in N/mm ² - not less than for		
Age at testing	Gr.33	Gr.43	Gr.53
72 $\pm$ 1 hr.	16	23	27
168 $\pm$ 2 hrs.	22	33	37
672 $\pm$ 4 hrs.	33	43	53

26.1.2.5 Setting time - Setting time of cement of any type or any grade when tested by Vicat apparatus method described in

IS:4031 shall conform to the following requirement.

- (a) Initial setting time : Not less than 30 minutes

(b) Final setting time: Not more than 600 minutes

26.1.2.6 Supply - The cement shall be packed in jute sacking bags conforming to IS:2580-1982, double hessian bituminised (CRI type) or woven HDPE conforming to IS 11652:1986, woven polypropylene conforming to IS:11653:1986, jute synthetic union conforming to IS:12174:1987, or any other approved composite bags, bearing the manufacturer's name or his registered trade mark if any, and grade and type of cement.

Every delivery of cement shall be accompanied by a producer's certificate confirming that the supplied cement conforms to relevant specifications. These certificates shall be endorsed to the Engineer for his record.

Every consignment of cement must have identification marks on packages indicating date of manufacture and grade and type of cement. Cement when brought to works shall not be more than 6 weeks old from the date of manufacture. In case due to some reasons it is not possible to use the cement within 3 months then it should be ensured that older lot is used in the lean concrete or other unimportant items of work. Effective precautionary measures shall be taken to eliminate dust nuisance during loading or transferring cement.

26.1.2.7 Stacking and Storage - Cement in bags shall be stored and stacked in a shed which is dry, leak proof and as moisture proof as possible. Flooring of the shed shall consist of the two layers of dry bricks laid on well consolidated earth to avoid contact of cement bags with the floor. Stacking shall be done about 150 to 200 mm clear above the floor using wooden planks, old wooden sleepers or scrap GI sheets. Cement bags shall be stacked at least 450mm clear off the walls and in rows of two bags leaving in a space of atleast 600mm between two consecutive rows. In each row the cement bags shall be kept close together so as to reduce air circulation. Stacking shall not be more than 10bags high to avoid lumping under pressure. In stacks more than 8 bags high, the cement bags shall be arranged in header and stretcher fashion, i.e. alternately lengthwise and crosswise so as to tie the stacks together and minimise the danger of toppling over.

A typical arrangement for storing and stacking of cement is shown in **Fig.26.1**. Different types of cement shall be stacked and stored separately. Cement bags shall be stacked in a manner to facilitate their

removal and use in the order in which they are received.

For extra safety during monsoon, or when cement is expected to be stored for an unusually long period, each stack shall be completely enclosed by a water proofing membrane, such as polythylene/ tarpauline, which shall cover the top of the stack. Care shall be taken to see that the water proofing membrane is not damaged at any time during use. Cement which is set or partially set should on no account be used.

Storage of cement at the work site shall be at the contractor's expense and risk. Any damage occurring to cement due to faulty storage in contractor's shed or on account of negligence on his part shall be the liability of the contractor.

2.1.2.8 26.1.2.8 Different types of cements and their properties

(a) 33 Grade Ordinary Portland Cement: IS 269-1989

This ordinary basic Portland cement is in maximum use in the country and is the most suitable cement for all masonry and general concrete works where the members are not to take very high stresses. This cement is not suitable where the member is exposed to sulphates in soil or in ground water.

b. 43 Grade Ordinary Portland Cement: IS 8112-1989 and

c. 53 Grade Ordinary Portland Cement: IS: 12269-1987

Both above types of cements are used where high early strengths in 1 to 28 days range are required. However, the further growth of strength beyond 28 days will be much lower than expected traditionally. These grades of cement are mainly used for RCC works, where a member has to take high tensile stress.

d. Portland Pozzolana Cement: IS: 1489-1991

The pozzolana used in the manufacture of Portland pozzolana cement is burnt clay, shale, or fly ash. The proportion of pozzolana used varies between 10 to 25 per cent by weight of cement as stipulated by Bureau of Indian Standards.

In terms of Correction Slip No.9 dated 27.03.2006 to Concrete Bridge Code (Revised 1997) the use of Portland Pozzolana Cement is subject to the following.

i) "Portland Pozzolana cement shall not be used for PSC Works. When Portland

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Pozzolana Cement is used in plain and reinforced concrete, it is to be ensured that proper damp curing of concrete atleast for 14 days and supporting form work shall not be removed till concrete attains at least 75% of the design strength”.

ii) The rate of development of strength is slow in case of blended cement i.e. Portland Pozzolana cement as compared to ordinary Portland Cement. This aspect should be taken care of while planning to use blended cement. Accordingly stage of prestressing, period of removal of form work and period of curing etc. should be suitably increased.

iii) Compatibility of chemical admixtures and super plasticizers with Portland Pozzolana Cement shall be ensured by trials before use.

iv) Some other properties of concrete such as modulus of elasticity, tensile strength, creep and shrinkage are not likely to be significantly different. For design purposes, it will be sufficiently accurate to take the same value as those used for concrete made with OPC.

(d)e. Portland (Blast Furnace) Slag Cement: IS: 455-1989

This type of cement is manufactured by intergrinding the portland cement clinker and blast furnace slag in the proportion of blast furnace slag not exceeding 65% as per Bureau of Indian Standards. The granular slag possesses latent hydraulic properties which are activated when the slag is inter-ground with the portland cement clinker.

Portland blast furnace slag cement can be used for all purposes for which ordinary portland cement is used and it can also be used with advantage in mass concrete structures such as retaining walls, foundations and bridge abutments in view of its low heat evolution quality.

In terms of Correction Slip No.9 dated 27.03.2006 to Concrete Bridge Code (Revised 1997) the use of Portland Slag Cement is subject to the following:

i) Mixing of 50% blast furnace slag with OPC cement at site shall not normally be permitted. However, in exceptional cases for bridges requiring higher levels of durability using blended cement which is not available from manufacturers, blending at site may be permitted subject to ensuring dedicated facilities and complete mechanized process control to achieve specified quality with the special permission of Chief Engineer/ Chief Bridge Engineer.

ii) The rate of development of strength is slow in case of blended cement i.e. Portland slag cement, as compared to ordinary Portland Cement. This aspect should be taken care while planning to use blended cement. Accordingly stage of prestressing, period of removal of form work and period of curing etc. should be suitably increased.

iii) Compatibility of chemical admixtures and super plasticizers with Portland blast furnace slag cement shall be ensured by trials before use.

iv) Some other properties of concrete such as modulus of elasticity, tensile strength, creep and shrinkage are not likely to be significantly different. For design purposes, it will be sufficiently accurate to take the same value as those used for concrete made with OPC.

(f)f. Rapid Hardening Portland cement: IS 8041-1990

This cement attains greater strengths at early ages and is hence sometimes called as high early strength cement. This cement at the age of 3 days itself develops the strength developed by ordinary portland cement at the age of 7 days with the same water cement ratio. The use of rapid hardening cement enables the removal of forms early in case of both Precast and Cast-in situ concrete works and hence considerable time and money can be saved. In road works especially where it is imperative to open the road to traffic with minimum delay, the use of this cement will be very much helpful.

(g)g. Hydrophobic Portland Cement: IS 8043-1991

This is cement, which repels water, and can be transported even during rains and stored in humid conditions. While manufacturing the above cement, water repellent chemicals are added during the process of grinding. The chemicals thus added form monomolecular coating over each grain of cement, which prevents water or moisture from air from being readily absorbed by the cement. However, when the cement is mixed with aggregates the above chemical coating gets removed due to abrasion and the hydration takes place exactly in the same way as with ordinary portland cement.

(h)h. Low Heat Portland Cement: IS: 12600-1989

In massive structures such as concrete bridge abutments, retaining walls, etc. when concrete is poured it generates considerable heat due to chemical reaction which takes place while cement is setting and hardening,

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and if the rate at which the heat can be lost from the surface is lower, this will build up extra heat in the structure which is dangerous. Tensile stresses are developed in the concrete when the shrinkage occurs during subsequent curing and thus serious cracks would be developed. In ordinary concrete construction this evolution of heat is of little consequence. Hence, to prevent the above damage low heat portland cement can be profitably used. The low heat cement has better resistance to chemical deterioration than the ordinary portland cement. The rate of development of strength with this cement is much lower than the ordinary portland cement. It is only at the age of 3 months that the strength achieved by the use of both types of cements will be equal.

(H)j. Sulphate resisting Portland Cement: IS: 12330-1988

If the soil contains very high quantity of sulphate it percolates through ground waters. In such areas of alkali conditions, for doing works like canal lining, pipe lines, culverts etc. a cement resistant to sulphate attack of very high degree is required. It is essential to conduct tests to confirm actual values of sulphate concentration, when the structure is located near sea coast, chemical factories, agriculture land using chemical fertilizers and sites where there are effluent discharges or where soluble sulphate bearing ground water level is high. In terms of Correction Slip No.1 dated 26.04.2000 to Concrete Bridge Code (Revised 1997), sulphate resisting cement shall be used only in such conditions where the concrete is exposed to the risk of excessive sulphate attack (eg) concrete in contact with soil or ground water containing excessive amount of sulphate. It shall not be used under such conditions where concrete is exposed to risk of excessive chlorides and sulphate attack both.

j. High Alumina Cement: IS 6452-1989

The main characteristic features of high Alumina cements are they attain high early strength, high heat of hydration and have a good resistance to chemical attack. Initial setting time for high Alumina cement is just 3 minutes when compared to 30 to 45 minutes taken by ordinary portland cement. The final time of setting is just 2 hours after initial setting when compared to about 10 hours taken by ordinary portland cement. Also the high alumina cement attains a strength of 300 kgs/cm² after one day and 350 kgs/cm² after 2nd day when compared to the strength achieved by ordinary portland cement as 150 kg/cm² after one day. Considering the

advantage of high heat of hydration and development of high early strength it can be used in some of the cold regions as a structural material.

(H)k. White Portland Cement: IS:8042-1989

On strength and durability the white cement is as durable and strong as ordinary portland cement, but because of its white colour it is mainly used in interior and exterior decorative works such as external renderings of buildings, facing slabs, terrazzo tiles and floorings, ornamental concrete products, swimming pools, etc.

26.1.3 Fine Aggregate

26.1.3.1 General - Aggregate most of which passes through 4.75mm IS sieve is known as fine aggregate. Fine aggregate shall consist of natural sand, crushed stone sand or crushed gravel sand, stone dust or marble dust, fly ash, Surkhi (crushed brick) or cinder conforming to IS:2686. It shall be hard, durable, chemically inert, clean and free from adherent coatings, organic matter etc. and shall not contain any appreciable amount of clay balls or pellets and harmful impurities e.g. iron pyrites, alkalies, salts, coal, mica, shale or similar laminated materials in such form or in such quantities as to cause corrosion of metal or affect adversely the hardening, the strength, the durability or the appearance of mortar, plaster or concrete. The sum of the percentages of all deleterious material shall not exceed 5%. Fine aggregate must be checked for organic impurities such as decayed vegetation humus, coal dust etc. in accordance with the procedure prescribed in **Annexure 26.2**. In terms of Correction Slip No.1 dated 26.04.2000 to Indian Railways Concrete Bridge Code (Revised 1997), in general, marine aggregate shall not be used for Reinforced Concrete and Prestressed Concrete works. However in special cases use of marine aggregate may be permitted by the Engineer subject to the following:

- a) It shall be thoroughly washed.
- b) Generally the limits for Chloride Content and Sulphate content in fine aggregate after washing will be as under – Chloride content. 0.04% by weight acid soluble; Sulphate content 0.40% by weight acid soluble. After washing and drying the aggregate should conform to IS 383.

26.1.3.2 Silt Content - The maximum quantity of silt in sand as determined by the method prescribed in **Annexure 26.3** shall not exceed 8%. Fine aggregate containing

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more than allowable percentage of silt shall be washed so as to bring the silt content within allowable limits for which nothing extra shall be paid.

26.1.3.3 Grading - On the basis of particle size, fine aggregate is graded into four zones. The grading when determined in accordance with the procedure prescribed in **Annexure 26.4** shall be within the limits given in **Table 26.1** below. Where the

grading falls outside the limits of any particular grading zone of sieves, other than 600 micron IS sieve, by a total amount not exceeding 5 per cent, it shall be regarded as falling within that grading zone. The higher the Grading Zone, the finer the sand, with Grading Zone I – coarsest and Grading Zone IV-Finest.

TABLE 26.1

IS Sieve	Percentage passing for			
	Grading Zone I	Grading Zone II	Grading Zone III	Grading Zone IV
10mm	100	100	100	100
4.75 mm	90-100	90-100	90-100	95-100
2.36 mm	60-95	75-100	85-100	95-100
1.18 mm	30-70	55-90	75-100	90-100
600 microns	15-34	35-59	60-79	80-100
300 microns	5-20	8-30	12-40	15-50
150 microns	0-10	0-10	0-10	0-15

Note 1 : For crushed stone sands, the permissible limit on 150 micron sieve is increased to 20 percent. This does not affect the 5 per cent allowance permitted in 26.1.4.3 applying to other sieves.

Note 2 : Allowance of 5% permitted in 26.1.4.3 can be split up, for example, it could be 1% on each of three sieves and 2% on another or 4% on one sieve and 1% on another.

Note 3 : Fine aggregate conforming to Grading Zone IV shall not be used in reinforced cement concrete unless tests have been made to ascertain the suitability of proposed mix proportions.

Note 4 : Sand required for making of mortar for plaster work shall conform to IS:1542-1977 and for masonry work shall conform to IS:2116-1980.

Note 5 : In case marine aggregate is permitted to be used, the grading of fine aggregate should be assessed after thorough washing in water.

26.1.3.4 Type and grading of fine aggregate to be used - These shall be specified in the Contract. It shall be coarse sand, fine sand, stone dust, marble dust, Surkhi or fly ash. Use of sea sand shall not be allowed, unless otherwise specified. Details have been given under items (i) to (iv) below and subparas 26.1.6 and 26.1.7.

(i) Coarse sand shall be either river sand or pit sand or a combination of the two. It shall be clean, sharp, angular, gritty to touch and composed of hard silicious material. Its grading shall fall within the limits of grading Zone I, II, III of Table 26.1. Coarse sand shall have Fineness Modulus not less than 2.5

(ii) Fine sand shall be either river sand or pit sand or a combination of the two. Its grading shall fall within the limits of Grading Zone IV of Table 26.1. Fine sand shall have Fineness Modulus not less than 1.0.

(iii) Stone dust shall be obtained by crushing hard stones or gravel. Its grading shall fall within the limits of Grading Zone I, II or III of Table 26.1.

(iv) Marble dust shall be obtained by crushing marble. Its Grading shall fall within the limits of Grading Zone IV of Table 26.1.

26.1.3.5 Deleterious Material - Sand shall not contain any harmful impurities such as iron, pyrites, alkalis, salts, coal or other organic impurities, mica, shale or similar laminated materials, soft fragments, and sea shale in such form or in such quantities as to affect adversely the hardening, strength or durability of the mortar.

The maximum quantities of clay, fine silt, fine dust and organic impurities in the sand shall not exceed the following limits :

- (1) Clay, fine silt and fine dust when determined in accordance with IS:2386 (Part II)-1963 in natural sand or crushed gravel sand & crushed stone sand Not more than 5% by mass
- (2) Organic impurities when determined in accordance with IS:2386 (Part II) 1963 Colour of the liquid shall be lighter than that indicated by the standard specified in IS:2386 (Part II) 1963.

26.1.3.6 Sand for Masonry Mortar and for Plaster - Sand shall consist of natural sand, crushed stone sand or crushed gravel sand or a combination of any of these. Sand shall be hard, durable, clean and free from adherent coatings and organic matter and shall not contain the amount of clay, silt and

fine dust more than specified under Para 26.1.4.5.

26.1.3.7 Grading of Sand for Masonry Mortar and for Plaster - Grading of sand for use in masonry mortar shall be conforming to IS:2116-1980 (**Table 26.2**). Grading of sand for use in Plaster shall be conforming to IS:1542-1977 (**Table 26.3**).

TABLE 26.2
GRADING OF SAND FOR USE IN MASONRY MORTAR AS PER IS : 2116-1980

IS Sieve Designation	Percentage passing by mass	Ref to method of test
4.75 mm	100	Is: 2386 (Part I) – 1963
2.36 mm	90 to 100	
1.18 mm	70 to 100	
600 micron	40 to 100	
300 micron	5 to 70	
150 micron	0 to 15	

TABLE 26.3
GRADING OF SAND FOR USE IN PLASTER AS PER IS 1542- 1977

IS Sieve Designation	Percentage passing
10mm	100
4.75 mm	95 to 100
2.36 mm	95 to 100
1.18 mm	90 to 100
600 micron	80 to 100
300 micron	20 to 65
150 micron	0-50

Note:- For crushed stone sands, the permissible limit on 150 micron IS Sieve is increased to 20%. This does not affect the 5% allowance under IS:2386 (Part I-1963) also indicated in Para 26.1.4.3 above.

26.1.3.8 Bulking - Fine aggregate, when dry or saturated, has almost the same volume but dampness causes increase in volume. In case fine aggregate is damp at the time of proportioning the ingredients for

mortar or concrete, its quantity shall be increased suitably to allow for bulkage, which shall be determined by the method prescribed in **Annexure 26.5. Table 26.4** gives the relation between moisture content

and percentage of bulking for guidance only. Bulkage % age may be assessed on prorata basis for the different %age of moisture content present at the time of using the fine

aggregate or while making payments at the time of measuring the same in case of supply of materials.

TABLE 26.4

Moisture content %age	Bulking %age (by volume)
1	8
2	15
3	20
4	25
5	30

26.1.3.9 Prior approval and Stacking -

The sand shall be got approved by the Engineer before use and sand which is rejected should be immediately removed from site of work. Fine aggregate shall be so stacked as to prevent dust and foreign matter getting mixed up with it, as far as practically possible.

26.1.3.10 Measurements - As the fine aggregate bulks to a substantial extent when partially wet, measurements shall be taken when the stacks are dry or appropriate allowance made for bulking.

~~2.1.5~~26.1.4 Surkhi - Broken Brick (Burnt Clay) Fine Aggregate**~~2.1.5~~26.1.4.1 General**

Broken Brick (Burnt Clay) Fine aggregate, also known as Surkhi, shall be made by grinding well burnt (but not under or over burnt) broken bricks as specified in IS:3068-1986. It shall not contain any harmful impurities, such as iron pyrites, salts, coal, mica, shale or similar laminated or other materials in such form or quantity as to adversely affect hardening, strength, durability or appearance of the mortar. The maximum quantities of clay, fine silt, fine dust and organic impurities in surkhi (all taken together) shall not exceed five per cent by weight. The particle size grading of surkhi for use in lime mortars shall be within the limits specified in **Table 26.5**. Surkhi shall not be used in situations where there is much salt in the soil.

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TABLE 26.5

IS Sieve Designation	Percentage passing (by wt)
4.75 mm	100
2.36 mm	90-100
1.18 mm	70-100
600 microns	40-100
300 microns	5-70
150 microns	0-15

26.1.4.2 Stacking

Surkhi shall be stacked on a hard surface or platform so as to prevent the admixture of clay, dust, vegetation and other foreign matter. It shall be also protected from rain and dampness and kept under adequate coverings.

26.1.4.3 Measurements

For the purposes of payment. Surkhi shall be measured in regular stacks in cubic metres.

Alternatively it may be measured by weight when supplied in bags. If volumetric measurements are done, 12.50% deduction shall be made towards shrinkage from the gross stack volume.

26.1.5 FLY ASH**~~2.1.6~~26.1.5.1 General**

Fly ash is a finely divided residue resulting from the combustion of pulverised coal in boilers. Fly ash used shall be as per

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IS:3812-1981. It shall be clean and free from any contamination of bottom ash, grit or small pieces of pebbles. Fly ash is meant for use as a part replacement of fine aggregate

in mortar with a view to improve grading and to make use of its pozzolanic properties.

Fly ash shall be supplied in the following grades corresponding to the properties specified in **Annexure 26.6**.

Grade Designation	General use
Grade I	For incorporation in cement mortar and concrete and in lime pozzolana mixtures, and for manufacture of portland pozzolana cement.
Grade II	For incorporation in cement mortar and concrete and lime pozzolana mixture

Note : It is obligatory on the part of supplier/ manufacture to ensure that the fly ash conforms to the requirement mutually agreed upon & shall furnish a certificate to this effect to the purchaser or his representative.

26.1.5.2 Characteristics

The chemical and physical requirements of fly ash shall be as specified in Annexure 26.6.

26.1.5.3 Stacking

Fly ash shall be protected from dirt collecting on it.

26.1.5.4 Measurements: For the purposes of payment Fly ash shall be measured in regular stacks in cubic metres. Alternatively it may also be measured by weight when supplied in bags. If volumetric measurements are done, the extent of shrinkage should be assessed in advance and provided for in the Supply Contract.

26.2 PREPARATION OF MORTARS AND THEIR GRADES AND THEIR APPLICATION IN WORKS

26.2.1 Grade of Masonry Mortar

The grade of masonry mortar will be defined by its compressive strength in N/mm^2 at the age of 28 days as determined by the standard procedure detailed in IS:2250-1981.

For details of grades and criteria for selection of masonry mortar, see **Annexure 26.7**. This Annexure is based on **Appendix G** in CPWD Specifications 1996 updated upto July 2000.

26.2.1.1 Proportioning of the ingredients

For proportioning the ingredients by volume, the conversion of weight into volume shall be made on the following basis:

i) Ordinary brick work and masonry	1:5 or 1:6
ii) Heavily loaded walls and pillars / Bridge Masonry	1:3 or 1:4

(a) Dry hydrated lime	700 kg/cum
(b) Burnt clay pozzolana	860 kg/cum
(c) Lime Pozzolana mixture	770 kg/cum
(d) Coarse Sand (dry)	1280 kg/cum
(e) Fine sand (dry)	1600 kg/cum
(f) Fly Ash	590 kg/cum

One cum of lime putty shall be taken as equivalent to 0.70 Cum. of dry hydrated lime.

26.2.1.2 Classification of Mortars

Mortar strength in general shall not be greater than that of masonry units, nor greater than necessary in any application. The mortar can be broadly classified into Cement mortar, lime mortar and cement-lime mortar. The main characteristics are as under:

a) Cement Mortars

These consist of cement and sand, varying in proportions from 1:8 to 1:3, the strength and workability improving with the increase in proportion of cement.

Mortars richer than 1:3 are not used in masonry because of high shrinkage and no appreciable gain in the strength of masonry.

Mortars leaner than 1:5 tend to become harsh and unworkable.

26.2.1.3 Selection of Mortar for use in Railway Works - Cement Mortar

The mix proportions shall be as specified for each particular class of work as indicated in the Drawings. Under normal conditions, unless otherwise specified, the proportions of cement to sand (by volume) for the different classes of work shall be as under :

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- iii) Walls half brick thick, jack arches and bridge structure other than arches 1:4
- iv) Arches other than jack arch 1:3 or 1:4
- v) Plaster for buildings (inside) 1:6
- vi) Plaster for buildings (outside) 1:4
- vii) Pointing 1:3

In measuring damp sand, allowance shall be made for bulkage as indicated in Para 26.1.4.8.

26.3 Cement Mortar – Preparation and time limit for use

26.3.1 General

This shall be prepared by mixing cement and sand with or without the addition of pozzolana in specified proportions as per **Annexure 26.7**. In terms of provisions in Indian Railways Concrete Bridge Code (Revised 1997), the Engineer may permit the use of admixture for imparting special characteristics to the mortar on satisfactory evidence that the use of such admixtures does not adversely affect the proportion of Mortar, particularly with regard to strength, volume change and durability.

26.3.2 Proportioning

Cement bag weighing 50 kg shall be taken as 0.035 cubic metre. Other ingredients in specified proportion shall be measured using preferably boxes of size 40 x 35 x 25 cm for machine mixing by volume. Sand shall be measured on the basis of its dry volume. In case it is moist then proper allowance for bulkage should be made.

26.3.3 Mixing

The mixing of mortar shall be done in mechanical mixers operated manually or by power as decided by the Engineer. The Engineer may, however, permit hand mixing at his discretion taking into account the nature, magnitude and location of the work and practicability of the use of mechanical mixers or where item involving small quantities are to be done or if in his opinion the use of mechanical mixer is not feasible. In cases, where mechanical mixers are not to be used, the contractor shall take permission of the Engineer in writing before commencement of the work.

(a) Mechanical Mixing : Cement and sand in the specified proportions shall be mixed dry thoroughly in a mixer. Water shall then be added gradually and wet mixing continued for at least three minutes. Only the required quantity of water shall be added which will produce mortar of workable consistency but not stiff paste. Only the quantity of mortar, which can be used within

30 minutes of its mixing shall be prepared at a time. Mixer shall be cleaned with water each time before suspending the work.

(b) Hand Mixing:- The measured quantity of sand shall be levelled on a clean masonry platform and cement bags emptied on top. The cement and sand shall be thoroughly mixed dry by being turned over and over, backwards and forwards, several times till the mixture is of a uniform colour. The quantity of dry mix which can be used within 30 minutes shall then be mixed in a masonry trough with just sufficient quantity of water to bring the mortar to a stiff paste of necessary working consistency, which will permit to be applied without separation of water or segregation of the solid material of the mix.

26.3.4 Precautions

Mortar shall be used as soon as possible after mixing and before it begins to set, and in any case within half hour, after the water is added to the dry mixture.

26.4 Cement Flyash Sand Mortar – Preparation and Time limit for use

~~2.2.5.1~~ 26.4.1 General:

This shall be prepared by mixing cement, ~~flyash~~ fly ash and sand in specified proportions as per **Annexure 26.7**. Mixing shall be done in a mechanical mixer (operated manually or by power) unless otherwise permitted by the Engineer in writing.

26.4.2 Proportioning

Cement bag weighing 50 kg shall be taken as 0.035 cubic metre. Other ingredients in the specified proportions shall be measured using boxes of suitable sizes. Sand and flyash shall be measured on the basis of their dry volume.

26.4.3 Mixing

(a) Mechanical Mixing: Sand and flyash in the specified proportions shall be mixed dry in a mixer and then the specified quantity of cement shall be added and mixed dry thoroughly. Water shall then be added

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gradually and wet mixing continued for atleast one minute. Water shall be just sufficient to bring the mortar to the consistency of a workable paste. Only the quantity of mortar which can be used within 30 minutes of its mixing, shall be prepared at a time.

(b) Hand Mixing: The measured quantity of sand and flyash shall be mixed dry on a clean masonry platform before adding specified quantity of cement to it. The resulting mixture of cement, sand and flyash shall then be mixed thoroughly being turned over and over, backward several times till the mixture is of a uniform colour. The quantity of dry mix which can be used within 30 minutes shall then be mixed in a clean watertight masonry trough with just sufficient quantity of water, to bring the mortar to a stiff paste of necessary working consistency, which will permit supplying it without separation of water or segregation of the solid materials of the mix.

26.4.4 Precautions

Shall be same as specified in 26.3.4.

26.5 Consistency of Masonry Mortar

26.5.1 General

The working consistency of the mortar is a matter of judgement. The water should be enough to maintain workability of the mortar during application but at the same time it shall not be excessive leading to segregation. The quantity of water needed for maintaining consistency or workability will also depend on the masonry for which the mortar is used e.g., thinner joints require greater workability whereas bed joints subject to heavy pressure will require stiffer mortar. Also the mortar should be able to hold the water against absorption by the masonry.

26.5.2 Measurement of consistency

A simple field test for consistency can be carried out by means of a cone penetration apparatus as given in Appendix B of IS: 1625. For various situations of use of

masonry mortar the following values for depth of penetration as measured by the Standard Cone Apparatus are recommended. Specific details have been given under the relevant Chapters on Brick Masonry, Stone Masonry and on Finishing Works including Pointing and Plastering.

- i) For laying walls of solid bricks 9-13 cm
- ii) For laying perforated bricks 7-8 cm
- iii) For filling cavities 13-15 cm
- iv) For pointing and plastering 3-4 cm

26.6 Time Limit in Use of Mortar

Special care should be exercised in ensuring that the mortars of different classes are used within the time limits specified in Paras 26.2.6.2.5, 26.2.3.4, 26.2.4.4. and 26.2.5.4. Mortar remaining unused beyond these periods shall be rejected and removed from site of work.

26.7 Curing of Masonry Works

26.7.1 Curing Period

All masonry using cement mortars, shall be kept wet for a period of seven days after construction.

26.7.2 General

In the case of masonry works in lime mortars, it is desirable that the work, after a height of every 1.5m or less shall be allowed to set for atleast two days before starting further construction over it.

26.8 Strength Development of Masonry Mortar

26.8.1 General

Strength Development is an important requirement before masonry is loaded to the full extent and the rate of construction should synchronize with the development of the strength of masonry particularly in the case of masonry with weak mortars. The following guidance with regard to the strength development of cement mortar and cement lime mortars will be found useful :

Age of mortar in days	3	7	14	28	60	90
Relative strength of mortars as percentage of 28 days strength	25	50	75	100	120	130

26.8.2 Masonry work at low temperature

Extra time shall be allowed for hardening of mortar when the atmospheric temperature

during construction is very low. Period will have to be increased by 100% for the time during which the temperature remains below

5 deg. C and by 50% for the time when temperature is between 5 deg. and 10 deg.C.

ANNEXURE 26.1**BUILDING LIME PHYSICAL REQUIREMENTS**

SL	Characteristics	Class								Method or Test, Ref.to
		A	B		C		D		E	
		Hyd-rated	Quick	Hyd-rated	Quick	Hyd-rated	Quick	Hyd-rated	Hyd-rated	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
I (i)	Fineness: (a) Residue on 2.36mm IS Sieve, percent, Max.	Nil	--	Nil	--	Nil	--	Nil	Nil	IS:6932 (Part 4)-1973*
	(b) Residue on 300 micron IS Sieve, percent, Max.	5	--	5	--	Nil	--	Nil	5	
	(c) Residue on 212 micron IS Sieve, percent, Max.	--	--	--	--	10	--	10	--	
(ii)	Residue on slaking: (a) Residue on 850 micron IS Sieve, percent Max	--	10	--	5	--	5	--	--	IS:6932 (Part 3)-1973 **
	(b) Residue on 300 micron IS Sieve, percent Max	--	--	--	5	--	5	--	--	
(iii)	Setting time: (a) Initial Set, Min, h,	2	--	--	--	--	--	--	2	IS:6932 (Part II)-1984 ***
	(b) Final Set, Max. h	48	--	--	--	--	--	--	48	
(iv)	Compressive strength, Min. N/mm ² (a) at 14 days	1.75	1.25	1.25	--	--	--	--	1.0	IS:6932 (Part 7)
	(b) at 28 days	2.8	1.75	1.75	--	--	--	--	1.75	1973#
(v)	Transverse strength at 28 days, N/mm ² , Min	1.0	0.7	0.7	--	--	--	--	0.7	IS:6932 (Part 7)-1973#
(vi)	Workability bumps, Max	--	--	--	12	10	12	10	--	IS: 6932 (Part 8)-1973###

(vii)	Volume yield ml/g, Min	--	--	--	1.7	--	1.4	--	--	IS:6932 (Part 6)- 1973####
(viii)	Soundness, Le Chaterlier expansion mm, Max	5	--	5	--	--	--	--	10	IS:6932 (Part 9)- 1973\$
(ix)	Popping & pitting	Free from pop and pits	--	Free from pop and pits	—	Free from pop and pits	-	Free from pop and pits	-	IS:6932 (Part-10) 1973\$\$

* Methods of tests for building limes : Part 4 Determination of fineness of hyderated lime

** Methods of tests for building limes : Part 3 Determination of residue on slaking of quicklime.

*** Methods of tests for building limes : Part 11 Determination of setting time of hydrated lime.

Methods of tests for building limes : Part 7 Determination of compressive and transverse strengths

Methods of tests for building limes : Part 8 Determination of workability

Methods of tests for building limes : Part 6 Determination of volume yield of quicklime

\$ Methods of tests for building limes : Part 9 Determination of soundness

\$ Methods of tests for building limes : Part 10 Determination of popping and pitting of hyderated lime

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ANNEXURE 26.2**FINE AGGREGATES
TEST FOR ORGANIC IMPURITIES**

The aggregate must also be checked for organic impurities such as decayed vegetation humus, coal dust etc.

What is called the colour test is reliable indicator of the presence of harmful organic matter in aggregate, except in the area where there are deposits of lignite.

Fill a 350 ml clear glass medicine bottle upto 70 ml mark with a 3% solution of caustic soda or sodium hydroxide. The sand is next added gradually until the volume measured by the sandy layer is 125 ml. The volume is then made upto 200 ml by addition of more of solution. The bottle is then stoppered and shaken vigorously and allowed to stand for 24 hours. At the end of this period, the colour of the liquid will indicate whether the sand contains a dangerous amount of matter. A colourless liquid indicates a clean

sand free from organic matter. A straw coloured solution indicates some organic matter but not enough to be seriously objectionable. Darker colour means that the sand contains injurious amounts and should not be used unless it is washed, and a retest shows that it is satisfactory.

Add 2.5 ml of two per cent solution of tannic acid in 10 per cent alcohol, to 97.5 ml of three per cent -- hydroxide solution. Place in a 350 ml bottle, fix the stopper, shake vigorously and allow to stand for 24 hours before comparison with the solution above the sand.

Note: A three per cent solution of caustic soda is made by dissolving 3 g of sodium hydroxide in 100 ml of water, preferably distilled. The solution should be kept in a glass of bottle tightly closed with a rubber stopper. Handling sodium hydroxide with moist hands may result in serious burns. Care should be taken not to spill the solution for it is highly injurious to clothing, leather, and other materials.

ANNEXURE 26.3**TEST FOR SILT CONTENT IN SAND**

The sand shall not contain more than 8% of silt as determined by field test with measuring cylinder. The method of determining silt contents by field test is given below :

A sample of sand to be tested shall be placed without drying in a 200ml measuring cylinder. The volume of the sample shall be such that it fills the cylinder upto 100ml mark.

Clean water shall be added upto 150 ml mark. Dissolve a little salt in the water in the proportion one tea spoon to half a litre. The mixture shall be shaken vigorously, the last few shakes being sidewise direction to level off the sand and the contents allowed to settle for three hours.

The height of the silt visible as settled layer above the sand shall be expressed as a percentage of the height of sand below. The sand containing more than the above allowable percentage of silt, shall be washed so as to bring the silt contents within allowable limits.

ANNEXURE 26.4**GRADING OF FINE AGGREGATE
TEST FOR PARTICLE SIZE (SIEVE
ANALYSIS)**

Apparatus: Perforated plate sieves of designation 10mm, 4.75mm and fine mesh

sieve of designation 2.36mm, 1.18 mm, 600 micron, 300 micron and 150 micron should be used.

The balance or scale shall be such that it is readable and accurate to 0.1 percent of the weight of the test sample.

Sample: The weight of sample available shall not be less than the weight given in the table below. The sample of sieving shall be

prepared from the larger sample either by quartering or by means of a sample divider.

TABLE SHOWING MINIMUM WEIGHTS FOR SAMPLING

Maximum size present in substantial proportions (mm)	Minimum weight of sample for sieving (kg)
10	0.5
4.75	0.2
2.36	0.1

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Test Procedure

The sample shall be brought to an air-dry condition before weighing and sieving. This may be achieved either by drying at room temperature or by heating at a temperature of 100 degree to 110 degree centigrade. The air dry sample shall be weighed and sieved successively on the appropriate sieves starting with the largest. Care shall be taken to ensure that the sieves are clean before use.

Each sieve shall be shaken separately over a clean tray until not more than a trace passes, but in any case for a period of not less than two minutes. The shaking shall be done with a varied motion, backwards and forwards, left to right, circular clockwise and anti-clockwise, and with frequent jarring, so that the material is kept moving over the sieve surface in frequently changing directions. Materials shall not be forced through the sieve by hand pressure, but on sieves coarser than 20mm, placing of particles is permitted. Lumps of fine material, if present may be broken by gentle pressure with fingers against the side of the sieve. Light brushing of under side of the sieve with a soft

brush may be used to clear the sieve openings.

Light brushing with a fine camel hair brush may be used on the 150 micron IS sieve to prevent segregation of powder and blinding of apertures. Stiff or worn out brushes shall not be used for this purpose and pressure shall not be applied to the surface of the sieve to force particles through the mesh.

On completion of sieving the material retained on each sieve, together with any material cleaned from the mesh, shall be weighed.

Reporting of Results

The results shall be calculated and reported as :

- (a) The cumulative percentage by weight of the total sample passing each of the sieves, to the nearest whole number. or
- (b) The percentage by weight of the total sample passing one sieve and retained on the next smaller sieve, to the nearest 0.1 percent.

ANNEXURE 26.5

BULKING OF FINE AGGREGATES / SAND (FIELD METHODS)

Two methods are suggested for determining the bulking of sand / fine aggregate. The procedure may be suitably varied, if necessary. Both depend on the fact that the volume of inundated sand / fine aggregate is the same if the sand/ fine aggregate were dry.

Method 1: Put sufficient quantity of wet sand loosely into a container until it is about two-

third full. Level off the top of the sand and push a steel rule vertically down through the sand at the middle to bottom, measure the height. Suppose this is 'X' cm.

Empty the sand out of the container into another container where none of it is lost. Half fill the first container with water. Put back about half the sand and rod it with a steel rod, about 6mm in diameter, so that its volume is reduced to a minimum. Then add the remainder and level the top surface of the inundated sand. Measure its depth at the middle with the steel rule. Suppose this is 'Y' cm.

The percentage of bulking of the sand due to moisture shall be calculated from the formula:

Percentage bulking $(X/Y-1) \times 100$

Method 2: In a 250 ml measuring cylinder, pour the damp sand, consolidate it by stacking until it reaches the 200 ml mark.

Then fill the cylinder with the water and stir the sand well (the water shall be sufficient to submerge the sand completely). It will be seen that the sand surface is now below its original level. Suppose the surface is at the mark of Y ml. The percentage of bulking of sand due to moisture shall be calculated from the formula.

Percentage bulking $= (200/Y-1) \times 100$

ANNEXURE 26.6

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FLY ASH : PHYSICAL REQUIREMENTS

SL	Characteristic	Requirement Grade of Fly Ash	
		I	II
(1)	(2)	(3)	(4)
(i)	Fineness – Specific surface in m^2 / kg by Blaine's permeability method, Min	320	250
(ii)	Lime reactivity – average compressive strength in N/mm^2 Min	4.0	3.0
(iii)	Compressive strength at 28 days in N/mm^2	Not less than 80 percent of the strength of corresponding plain cement mortar cubes	
(iv)	Drying Shrinkage, per cent, Max	0.15	0.10
(v)	Soundness of autoclave test expansion of specimens, per cent, Max	0.8	0.8

CHEMICAL REQUIREMENTS

SL	Characteristic	Requirement
(1)	(2)	(3)
(i)	Silicon dioxide (SiO_2) plus aluminium oxide ($Al_2 O_3$) plus iron oxide ($Fe_2 O_3$) per cent by mass, Min	70.00
(ii)	Silicon dioxide (SiO_2) per cent by mass Min	35.0
(iii)	Magnesium Oxide (MGO) per cent by mass Max	5.0
(iv)	Total sulphur as sulphur trioxide (SO_3) per cent by mass, Max	2.75
(v)	Available alkalis as sodium oxide (Na_2O) per cent by mass, Max (see Note 1)	1.50
(vi)	Loss of ignition, percent by mass, Max	12.0

Note 1 : Applicable only when reactive aggregates are used in concrete and are specially requested by the purchaser.

Note 2 : For determination of available alkalis IS: 4032-1985 "Method of chemical analysis of hydraulic cement" shall be referred to.

ANNEXURE 26.7**CRITERIA FOR SELECTION OF
MASONRY MORTARS**

- (a) The selection of masonry mortars from durability consideration will have to cover both the loading and exposure conditions of the masonry. The masonry mortar shall generally be as specified in (b) to (g).
- (b) In case of masonry exposed frequently to rain and where there is further protection by way of plastering or rendering or other finishes, the grade of mortar shall not be less than MM 0.7 but shall preferably be of grade MM2. Where no protection is provided, the grade of mortar for external walls shall not be less than MM2.
- (c) In case of load bearing internal walls, the grade of mortar shall preferably be MM 0.7 or more for high durability but in no case less than MM 0.5.
- (d) In the case of masonry work in foundations laid below damp proof course, the grade of mortar for use in masonry shall be as specified below:
- (i) Where soil has little moisture, masonry mortar of grade not less than MM 0.7 shall be used.
- (ii) Where soil is very damp, masonry mortar of grade preferably MM2 or more shall be used. But in no case shall the grade of mortar be less than MM2.
- (e) For masonry in building subject to vibration of machinery, the grade of mortar shall not be less than MM 3.
- (f) For parapets, where the height is greater than thrice the thickness, the grade of masonry mortar shall not be less than MM3. In case of low parapets the grade of mortar shall be the same as used in the wall masonry.
- (g) The grade of mortar for bedding joints in masonry with large concrete blocks shall not be less than MM3.

GRADE OF MASONRY MORTARS

SL	Grade	Mortar Mix (By Loose Volume)				Compressive Strength At 28 days
		Cement	Lime	Pozzolana	Sand	
(1)	(2)	(3)	(4)	(5)	(6)	(7)
1	MM 0.5	0	1 B or E	0	3	0.5 to 0.7
2		0	1 C or D	1	2	
3	MM 0.7	1	3 C or D	0	12	0.7 to 1.5
4		1	0	0	8	
5		1	0	0.4	10	
6	MM 1.5	1	0	0	7	1.5 to 2
7		1	0	0.4	8.75	
8		0	1A	0	3	
9	MM 2	0	1A	0	2	2 to 3
10		0	1C or D	3	0	
11		1	2C or D	0	9	
12	MM 3	0	1C or D	2	0	3 to 5
13		1	1C or D	0	0	
14		1	0	0	6	
15		0	1A	0	1	
16		1	0	0.21	4.2	
17		1	0	0.4	7.5	
18	MM 5	1	0 To 1/4B, C, D OR E	0	4	5 to 7.5
19		1	0	0	5	
20		1	0	0.4	6.25	
21		1	0	0.4	5	
22	MM 7.5	1	1/4 C or D	0	3	7.5 and above
23		1	1/2 C or D	0	4.5	
24		1	0	0	4	
25		1	0	0.2	2.1	
26		1	0	0	3	
27		1	0	0.4	3.75	

Note :

- 1) A,B,C,D and E denote the classes of limes to be used (see IS:712-1984 specification for building limes) (refer Para 26.1.3.1)
- 2) The strength values of lime mortar given in the table are after wet grinding of the mortar ingredients.
- 3) The compressive strength shall be determined in accordance with the procedure given in IS 2250-1981.

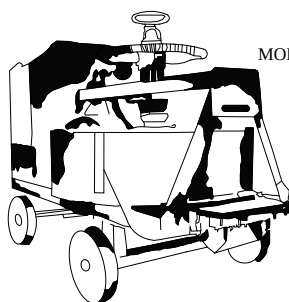
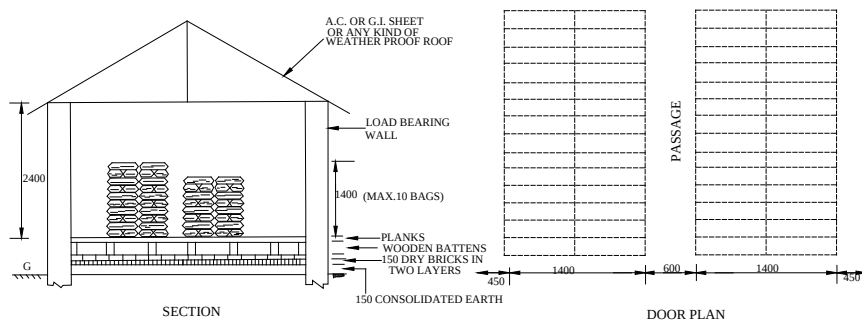
- 4) Pozzolana to be of minimum lime reactivity of 4N/MM²
- 5) When using plain Cement Mortar, it is desirable to include a plasticizer in the mix to improve workability. If sand used is too coarse and graded.
- 6) Strength of mortar may vary appreciably, depending on angularity grading and fineness of sand. Quantity of sand in the mix may therefore be varied where found necessary to attain the desired strength.
- 7) Other mortar mixes may also be permitted where necessary as in block work.

LIST OF RECOMMENDED TESTS ON MATERIALS

Material	Para	Test	Field / Laboratory	Test Procedure	Minimum quantity of Material for carrying out test	Frequency of testing
Water	26.1.1	i) pH Value ii) Limits of Acidity iii) Limits of Alkalinity iv) Percentage of solids (a) Chlorides (b) Suspended matter (c) Sulphates (d) Inorganic solids (e) Organic solids	Lab " " "	IS:3025		Water from each source shall be got tested before the commencement of work and thereafter once in every three months till the completion of the work. Water from municipal source need be tested only once in six months. Number of Tests for each source shall be 3.
Cement	26.1.2	Physical Requirement (i) Fineness (ii) Soundness (iii) Setting time (Initial & Final) (iv) Compressive Strength (v) Consistency of standard cement paste	Lab " " " "	(i) IS:4031 (Part II) (ii) IS:4031 (Part III) (iii) IS:4031 (Part V) (iv) IS: 4031 (Part VI)	Each lot	Every 50 tonnes or part thereof
Lime	26.1.3	Chemical and physical properties of lime	Lab	Physical Properties (I to IX) of Annexure 26.1 (IS 6932) Chemical properties (I to VI) Annexure 26.1 (IS 6932) (VII & VIII) of Annexure 26.1 (IS 1514)	5MT	10 MT or part thereof as desired by Engineer

Sand	26.1.4.1	Organic impurities	Field	Annexure 26.2	20 cum	Every 20 cum or part thereof or more frequently as decided by the Engineer
	26.1.4.2	Silt content	Field	Annexure 26.3	20 cum	-do-
	26.1.4.4	Particle size distribution a, b, c, d & e	Field or Lab as decided by the Engineer	Annexure 26.4	40 cum	40 cum or part thereof
	26.1.4.8	Bulking of sand	Field	Annexure 26.5	20 cum	Every 20 cum or part thereof or more frequently as decided by the Engineer.

TYPICAL SKETCH FOR CEMENT GODOWN
FIGURE 26.1



MOBILE ROLLER PAN MIXER (HEAVY DUTY LIME MORTAR MILL)
FIGURE 26.2

(Para 2.2.2.4)