INDIAN RAILWAYS
CONSTRUCTION MANUAL

December 2023

सत्यमेव जयते

Ministry of Railways
Government of India

Chenab Bridge, USBRL

Anji Khad Bridge, USBRL

Dugga Yard Ballastless Track, USBRL

Rani Kamalapati Station, W C Rly.

INDIAN RAILWAYS
CONSTRUCTION MANUAL

December 2023

सत्यमेव जयते

Ministry of Railways
Government of India

अश्विनी वैष्णव
Ashwini Vaishnaw

सत्यमेव जयते

Azadi Ka Amrit Mahotsav

रेल, संचार एवं इलेक्ट्रॉनिकी और
सूचना प्रौद्योगिकी मंत्री
भारत सरकार
Minister of Railways
Communications & Electronics and
Information Technology
Government of India

Message

Bharat is one of the fastest growing economies. Railways, being the most efficient means of transport, will play a pivotal role in this journey of growth for which it needs to augment its capabilities and resources to achieve quantum jump in execution of construction projects of new lines, multitracking, yard works, constructions of Rail flyovers, bye pass lines etc to carry about 3000 MT of traffic and improve modal share from present about 27% to 35% by year 2031.

Construction projects in Railways need to be executed within targeted time conforming to the best specifications and matching with best international standards to meet this challenge. The "Indian Railway Construction Manual" incorporates all essential prerequisites for good quality fast construction along with all latest instructions and methodologies/guidelines.

This comprehensive manual covering all aspects of construction activities – from planning to commissioning has been prepared associating both young & experienced construction officials. It will enhance the institutional strengths and capabilities of Indian Railways for the efficient implementation of infrastructure projects.

I believe that this manual will be of great value to the Railway officials and other professionals engaged in the construction projects.

अश्विनी
1.12.23

Ashwini Vaishnaw

Room No.: 341, Rail Bhawan Raisina Road, New Delhi-110001
Tel.: +91-11-23386645, 23381213 Fax : +91-11-23387333

जया वर्मा सिन्हा
JAYA VARMA SINHA

सत्यमेव जयते

अध्यक्ष एवं मुख्य कार्यकारी अधिकारी,
रेलवे बोर्ड
पदेन प्रमुख सचिव, भारत सरकार
रेल मंत्रालय
CHAIRMAN & CHIEF EXECUTIVE OFFICER,
RAILWAY BOARD
EX-OFFICIO PRINCIPAL SECRETARY
GOVERNMENT OF INDIA
MINISTRY OF RAILWAYS

18th October, 2023

MESSAGE

Indian Railway Institute of Civil Engineering (IRICEN) and the team of the construction officers of different Zonal Railways have prepared **"Indian Railways Construction Manual, 2023".** This manual is an important milestone in the efforts of Indian Railways to equip the construction officials with the required knowledge for execution of construction projects at a faster pace.

As per the National Rail Plan, Indian Railways has to develop capacity by year 2030 that will cater to the growing demand up to year 2050. To achieve this, Indian Railways has to increase its pace of building its infrastructure i.e. commissioning of supercritical and critical projects, construction of new lines; completion of gauge conversions, multi-tracking, automatic signaling and traffic facility works etc.

To guide construction officials, a need was therefore felt to have a manual covering various aspects of construction. This manual covers different aspect of project like project planning, land acquisition, tendering & contract handling including EPC contracts, bridge construction, execution of signaling, electrical TRD works and non-interlocking works. The manual has been prepared in a simple language which can be understood easily by field officials.

I convey my heartfelt congratulations to the IRICEN and the team of officers involved in the preparation of this manual.

I look forward that construction officials across Indian Railways will make best use of this manual.

New Delhi

(Jaya Varma Sinha)

Rail Bhawan, Raisina Road, New Delhi-110 001.
Tel.: 011-23384010, Fax : 011-23381453, Email : crb@rb.railnet.gov.in

रूप नारायण सुनकर
ROOP NARAYAN SUNKAR

सत्यमेव जयते

सदस्य इन्फ्रास्ट्रक्चर, रेलवे बोर्ड
एवं पदेन सचिव, भारत सरकार
रेल मंत्रालय
MEMBER INFRASTRUCTURE, RAILWAY BOARD
& EX-OFFICIO SECRETARY
GOVERNMENT OF INDIA
MINISTRY OF RAILWAYS

FOREWARD TO INDIAN RAILWAYS CONSTRUCTION MANUAL

In recent past, there has been complete change in construction project execution on Indian Railways. With availability of adequate fund for construction projects there is need to strengthen the construction organisation so as to build the infrastructure assets at the fastest rate.

For smooth execution of projects many instruction, guidelines, drawings etc. have been issued by Railway Board and RDSO. However, if these instructions are made available to construction officer as one document it will help them in expeditious execution of works. In view of this, during the Chintan Shivir held on 1st& 2nd June 2023 at New Delhi, it was agreed to have a manual for this purpose. This manual will be called as "Indian Railways Construction Manual".

The manual has been prepared by construction officers and IRICEN faculty. While preparing the manual, the difficulties faced by the officers when they join the construction project work is given special attention.

In this manual EPC contracts, advance surveying techniques, Project management services (PMS),Project supervision services (PSS) which are quiet new to Indian Railways are covered. Relevant topics for on project planning, feasibility study, DPR preparation, land acquisition, tenders & contracts, bridge planning and execution, track laying, Signalling & Telecommunication, electrical TRD works and commissioning of project are covered.

It is hoped that "Indian Railways Construction Manual" will be of immense use to the construction officials. Thus, helping Indian Railways in building the logistic infrastructure at fastest pace with highest standard of quality and safety.

(Roop Narayan Sunkar)

Room No. 223, Rail Bhawan, New Delhi-110 001
Tel.: 011-23383879, Fax : 011-23385114, Email : mi@rb.railnet.gov.in

PREFACE TO INDIAN RAILWAYS CONSTRUCTION MANUAL

Railway Board vide letter no. 2023/W-I/Genl/Construction manual dated. 23.06.2023 instructed IRICEN to draft a "Construction Manual" containing various instructions, guidelines, drawings, good construction practices etc. It was also envisage that the young officers shall be associated while drafting "Construction Manual"

Accordingly, a team under guidance of Director General/IRICEN (Convener) was formed by IRICEN. This team comprised of IRICEN faculties, Construction field officers including young officers. Team details are as under -

SN	Faculty from IRICEN	SN	RDSO & Field Officials
1	Satya Prakash ADG/IRICEN	1	B P Awasthi PED (Infra-II)/RDSO
2	C M Gupta Dean/IRICEN	2	Sujat Hashmi CPM/Prayagraj/NCR
3	R K Shekhawat Sr. Professor/Projects	3	Rajkumar Wankhede CE/C/WR
4	Anil Choudhary Sr. Professor/Track machines	4	M. V. S. Ramaraju CE/C/III/SCR
5	Anil Kalra Sr. Professor/Track -2	5	R K Shrivastava ED/B&S/RDSO
6	D N Kate Sr. Professor/Works	6	Suresh Pakhare CE/C/South/CR
7	R N Gupta Sr. Professor/Bridge-1	7	Mohit Verma Director/B&S-I/RDSO
8	Anil Kumar Sr. Professor/Track -2	8	V Suresh Dy. CEE/C/CR
9	Anurag Rastogi Sr. Professor/Track machines	9	Sudhir N Singh Dy. CSTE/C-I/CCG/WR
10	Avinash Kumar Sr. Professor/Bridge - 2	10	Archana Meena Dy. CE/Works/NWR
11	S K Agarwal Professor/Bridge	11	Narendra Kumar Meena Dy. CE/CN/II/RTM/WR
12	B K Kushwaha Professor/Procurement	12	Kanaka Sailesh Vankana Dy. CE/C-II/SC/SCR
13	A Sivakumar Professor/Works	13	Badda Rama Rao Dy. CE/C-III/SC/SCR
14	N K Mishra Professor/Track -1	14	Rajendra Dhaka Dy. CE/C/V/Maliagaon/NFR
		15	Sagar Choudhary Dy. CE/CN/STR/CR
		16	Balaji Gadre DEE/CN/DR/CR

Salient features of the "Indian Railways Construction Manual" (IRCM) are as under–

1. The topic on pre-investment studies is included under name "Alignment and survey". In this topic, the new concept of feasibility study, preparation of Detailed Project report (DPR) are explained in detail. The mandatory provision of checking the new project alignment through (BISAG-N) has been mentioned.
2. In Project Planning- the standard of Construction, Planning and execution strategy including tender planning, quality control & quality assurance are discussed.
3. The land acquisition using i) Special Railway project ii) The Right to Fair Compensation and Transparency in Land Acquisition, Rehabilitation and Resettlement Act- 2013 iii) "Direct purchase" etc. are detailed.
4. A chapter on tenders and contract covers item rate contracts, EPC contracts. It also covers provisions of PMS, PSS, GC for project design, supervision, monitoring etc.
5. Design of railway formation and earthwork in construction covered with quality control & quality assurance measures.
6. Chapters explaining complete bridge planning, design and execution have been included. These topics covers bridge foundations, substructure, bridge bearings, launching of superstructure.
7. It covers building planning, design covering green buildings etc. Brief on Passenger amenities at stations including those required for Divyangjans are included.
8. Various aspect of track laying – planning, execution with mechanised means are covered.
9. S&T chapter covers EI, RRI, track circuiting, S&T utility shifting, precautions in cable laying, use of universal fail safe block interface, signalling requirement for compatibility with RE standard 25KV AC.
10. Electrical and TRD chapter covers Railway electrification, principles of layout plans & sectioning diagram of 25 KV AC traction, anti-theft charging of OHE, methods of power line crossings etc.
11. A separate chapter on Pre-NI and NI working and commissioning of Railway projects has been included. This will be very useful while taking up the yard modification / multi-tracking etc.

Valuable inputs/suggestions received from Gati Shakti Directorate of Railway Board are incorporated in the manual, it helped in making document more refined.

While preparing this manual all provisions of various codes, manuals, guidelines etc. as well as practical aspects of work execution are considered. However, the Chief Administrative Officers (Construction) of Zonal Railways may supplement, where necessary for expeditious work execution.

Any errors or omissions found in this edition may be brought to the notice of IRICEN.

Pune
October, 2023

(Ram Karan Yadav)
Director General
IRICEN

IMPORTANT INSTRUCTIONS ABOUT USE & VALIDITY OF THIS MANUAL

The "Indian Railways Construction Manual" is prepared by taking content of various letters, guidelines, codes & manuals. Purpose of this manual is to make the relevant information about construction project planning, execution & monitoring available to the officials involved in construction of a project in single document.

In case of any conflict with the provisions with relevant codes, manuals and guidelines etc. shall prevail the provisions of this manual.

This manual will be updated periodically. The first updating will be done in July 2024. However, to have updated information the user should see provisions of relevant manual, codes, guidelines, correction slips etc.

In various paragraphs of this manual specific reference of other codes, guidelines, Railway Board instructions have been mentioned. Since there are number of references and content of same is running in hundreds and their content is available on various Indian Railway websites, it has been considered prudent to compile and place them on IRICEN website instead of keeping them in this manual. In order to have ease in accessing these reference document, all these reference documents are made available on IRICEN's website www.iricen.gov.in at Home page ➔ "Codes & Manual" ➔"Work Related" ➔ "IRCM Reference Documents".

e.g. In chapter – 2, under para 201(1) there is reference to Railway Board letter. It is written as "Railway Board's letter No. 2015/W-1/Gen/Corr./GM Pt dated 06.12.2018, **Ref. 2.01**". This means the letter referred as 2.01 is relevant to the para 201(1) and the complete content of letter is made available on IRICEN's website as Ref. 2.01 under chapter 2 and not in the Manual. At end of each chapter, a summary of referenced document along with the paras in which these references is provided. Also, at the end of this manual a complete summary of all referenced document is provided at one place.

ABBREVIATIONS

ACTM	–	AC Traction Manual
ADECO-RS	–	Analysis of Controlled Deformation in Rocks and Soils
API	–	Application Programming Interface
ASP	–	Accumulated Sliding Path
BEE	–	Bureau of Energy Efficiency
BISAG-N	–	Bhaskaracharya National Institute for Space Applications & Geoinformatics
BLT	–	Ballastless Track
BSG	–	Bow String Arch Steel Girder
BWA	–	Balanced Weight Assembly
CBC	–	Concrete Bridge Code
CHUM	–	Cross Hole Ultrasonic method
CNC	–	Computerised Numerical Control
CNS	–	Cohesive Non-Swelling Soil
CRS	–	Commissioner of railway Safety
CRZ	–	Costal Regulation Zone
CSL	–	Clear Standing Length
CSR	–	Clear Standing Room
CTL	–	Continuous Track lifter
DAB	–	Dispute Adjudication Board
DBR	–	Design Basis Report
DDC	–	Detailed Design Consultant
DEC	–	Digital Encryption Certificate
DEM	–	Digital Elevation Model
DFT	–	Dry Film Thickness
DGPS	–	Differential Global Positional System
DI	–	Dimension Inspection
DLP	–	Defect Liability Period
DOC	–	Date of Completion
DPR	–	Detailed Project Report
DSC	–	Digital Signature Certificate
DT	–	Destructive Testing
DTI	–	Direct Tension Indicators
EC	–	Environment Clearance
ECBC	–	Energy Conservation Building Code
EIA	–	Environmental Impact Assessment
EIG	–	Electrical Inspector General

EIRR	–	Economic Internal Rate of Return
EMP	–	Environment al management Plan
EPC	–	Engineering Procurement Construction
ERC	–	Elastic Rail Clip
ESP	–	Engineering Scale Plan
ETP	–	Effluent Treatment plant
EUR	–	End Unloading Rake
FAR	–	Floor Area Ratio
FBW	–	Flash Butt Welding
FC	–	Forest Clearance
FIRR	–	Financial Internal Rate of Return
FIU	–	Fabrication Inspection Unit
GAD	–	General Arrangement Drawing
GC	–	General Consultant
GeM	–	Government e Marketplace
GMAW	–	Gas Metal Arc Welding
GNSS	–	Global Navigation Satellite System
GPS	–	Global positioning System
GRIHA	–	Green Rating Integrated Habitat Assessment
GSI	–	Geological Survey of India
GSI	–	Geological Survey of India
HDPE	–	High Density Polyethylene
HFL	–	High Flood Level
HG	–	halt Group
HPC	–	High Performance Concrete
HRWR	–	High Range Water Reducer
HSFG	–	High Strength Friction Grip
IGBC	–	Indian Green Building Council
IRBM	–	Indian Railway Bridge Manual
IRPWM	–	Indian Railway Permanent Way Manual
IRS	–	Indian Railway Standard
IRSEM	–	Indian Railway Signal Engineering Manual
IRTMM	–	Indian Railway Track Machine Manual
IR-WCMS	–	Indian Railway Works and Contract management System
LAR	–	Last Accepted Rate
LEED	–	Leadership in Energy and Environmental Design
LiDAR	–	Light Detection and Ranging

LoA	–	Letter of Acceptance
LOP	–	layout Plan
LUP	–	Land Use Planning
LWR	–	Long Welded Rails
MDD	–	Maximum Dry Density
MEA	–	minimum Essential Amenities
MMAW	–	Manual Metal Arc Welding
MOEFCC	–	Ministry of Environment, Forest and Climate Change
MTC	–	Manufacturer's Test Certificate
NABCB	–	National Accreditation Board for Certification Bodies
NABL	–	National Accreditation Board for Testing and Calibration Laboratories
NATM	–	New Austrian Tunnelling Method
NBSS	–	National Bureau of Soil Survey
NDT	–	Non Destructive Testing
NI	–	Non Interlocking
NMC	–	Natural Moisture Control
NMT	–	Norwegian Method of Tunnelling
NSG	–	Non Suburban Group
NTC	–	New Track Construction
O-D Study	–	Origin - Destination Study
ODC	–	Over Dimensional Consignment
OEM	–	Original Equipment Manufacturer
OMC	–	Optimum Moisture Control
OMS	–	Oscillation Monitoring System
PG	–	Performance Guarantee
PIT	–	Pile Integrity Test
PMS	–	Project Management Services
PSC	–	Pre-stressed Concrete
PSSA	–	Project Supervision Services Agency
PTFE	–	Polytetrafluoroethylene
PwDs	–	Persons with Disabilities
QA	–	Quality Assurance
QAP	–	Quality Assurance Plan
QC	–	Quality Control
RCC	–	Route Control Chart
RFCTLARR	–	The Right to Fair Compensation and Transparency in Land Acquisition, Rehabilitation and Resettlement
RFO	–	Rail Flyover

RFP	–	Request For Proposal
RMR	–	Rock Mass Rating
ROB	–	Road Over Bridge
ROW	–	Right of Way
RQD	–	Rock Quality Designation
RUB	–	Road Under Bridge
RVNL	–	Rail Vikas Nigam Limited
RWH	–	Rain Water Harvesting
SAT	–	Standing Arbitral Tribunal
SAW	–	Submerged Arc Welding
SCC	–	Self Compacting Concrete
SD	–	Security Deposit
SEJ	–	Switch Expansion Joint
SFRS	–	Steel Fibre Reinforced Shotcrete
SG	–	Suburban Group
SIA	–	Social Impact Assessment
SIP	–	Signal Interlocking Plan
SMAW	–	Shielded Metal Arc Welding
SOI	–	Survey of India
SP	–	Switching Post
SQ	–	Soil Quality
SRH	–	Stress Release Holes
STP	–	Sewage Treatment Plant
SWL	–	Safe Working Load
SWRD	–	Station Working Rule Diagram
TAC	–	Technical Advisory Committee
TAD	–	Temporary Arrangement Drawing
TAG	–	Technical Advisory Group
TBM	–	Tunnel Boring Machine
TC	–	Tender Committee
TILOS	–	Time Location System
TOC	–	Table of Control
TRR	–	Through Rail Renewal
TSP	–	Tunnel Seismic Prediction
TSR	–	Through Sleeper Renewal
TSS	–	Traction Sub Station
USFD	–	Ultrasonic Flaw Detection

UTS	–	Ultimate Tensile Strength
VDU	–	Visual Display Unit
VMA	–	Viscosity Modifying Agent
WC	–	Wildlife Clearance
WPQR	–	Welding Procedure Qualification Record
WPSS	–	Welding Procedure Specification Sheet
WQT	–	Welder Qualification Test
WRP	–	Water Recycling Plant

CONTENTS

CHAPTER 1

ALIGNMENT AND SURVEY

101 General 1
102 Feasibility Study..... 2
103 Approval of Feasibility Report 11
104 Final Location Survey 11
105 Modern Surveying 19
106 Design of Alignment 20
107 National Master Plan & Utilization of BISAG-N Portal 21
108 Proforma for submission of Detailed Project Report 22

CHAPTER 2

PROJECT PLANNING

201 Standards of Construction – Points for Consideration 25
202 Good Practices to be Followed During Project Planning and Execution 28
203 Planning and Execution Strategy - Points for Consideration..... 29
204 Quality Control and Assurance 32
205 Project Monitoring and Control 33
206 Contractor Management 34
207 Important Ingredients of a Successful Project Execution Scheme 35

CHAPTER 3

LAND ACQUISITION AND FOREST CLEARANCE

301 Background 43
302 Governing Provisions for Acquisition of Land For Railway Projects 43
303 Applicability of Land Acquisition Provisions 43
304 Application for Land Acquisition 44
305 Responsibility of Railway Administration While Acquiring Land 45
306 Classification of Railway Land 45
307 Extent of Land to Be Acquired 46
308 Land Plans and Schedules 47
309 Market Value of Land to Be Acquired 47
310 Procedure Flow for Acquisition Under Railway Act-1989 48
311 Procedure Flow for Land Acquisition as Per RFCTLARR Act-2013 51
312 Land Acquisition by Direct Purchase through Private Negotiations 57
313 Withdrawal from Acquisition 58
314 Management of Land 58
315 The Award Statement 60

316 Transfer of Land and Buildings Between Union and State Government 61
317 Transfer of Defence Land 61
318 Diversion of Forest Land 62

CHAPTER 4

DRAWING APPROVALS

401 General 67
402 Drawings prepared by the Civil Engineering Department 67
403 Approval of Civil Engineering Drawings 68
404 Standard Procedure order for ESP & GAD approval 70
405 Approval of bridge designs and drawings for works being executed by RVNL 72
406 Drawings prepared by S & T Engineering Department 73
407 Approval - Signalling and Telecommunication Engineering Drawings 78
408 Standard Procedure order for SIP approval 80
409 Drawings prepared by Electrical Department 81
410 Sanction of Grade Condonation 82
411 Sanctioning or approving authority for laying various track items 82

CHAPTER 5

TENDER, CONTRACT & CONTRACT MANAGEMENT

501 Tender and Contract 111
502 Tender Planning 111
503 Tender Invitation & Formulation of Tender Document 113
504 Finalisation of Tender and Issue of Letter of Acceptance 119
505 Dos and Don'ts on Tender Handling 122
506 Contract Management 122
507 Dos and Don'ts on Contract Management 129
508 Dos and Don'ts in EPC Contract 129
509 Resolution of Disputes 130
510 Dos and Don'ts in Arbitration 132
511 Standard Conditions of Tender and Contract 133
512 Indian Railway Standard General Conditions of Contract 133
513 Indian Railway Standard RFP (Request For Proposal) Document and Agreement for Railway Projects on EPC Mode/ Indian Railway Standard RFP (Request For Proposal) Document and Agreement for Station Development on EPC Mode 134
514 Indian Railway Standard RFP and Form of Agreement for Appointment of Project Supervision Services Agency (PSSA) for Providing Project Supervision / for Appointment of Authority Engineer for Providing Project Management Services For EPC Contract / for Appointment of General Consultant 136

CHAPTER 6

FORMATION DESIGN AND BLANKETING

601 Design of Formation 139
602 Soil Exploration and Survey 139
603 Suitability of Subsoil and Ground Improvement 141
604 Formation Width 142
605 Cross Slope of Formation 142
606 Minimum Track Centre Distance on Straight Track 142
607 Minimum Height of Embankment 142
608 Side Slopes of Embankment 143
609 Side Slopes in Cuttings 143
610 Unsuitable Soil for Construction Of Embankment 144
611 Single Layer and Two Layer System of Construction 145
612 Soil Quality Class 145
613 Filter Criteria 146
614 Details of Various Layers in Formation 146
615 Approval of Design of Formation 150
616 Uniform Total Thickness of Formation Layers 150
617 Drainage Arrangements in Embankments and Cuttings 150
618 Erosion Control of Slopes 151
619 Use of Geosynthetics in Railway Formation Construction 151

CHAPTER 7

EARTHWORK IN CONSTRUCTION PROJECTS

701 Execution of Earthwork In Formation 153
702 Checks on Construction Materials 154
703 Compaction of Earthwork 155
704 Field Compaction Trial 156
705 Compaction of/Near Side Slopes 159
706 Backfill on Bridge Approaches and Similar Locations 159
707 Sandwich Construction of Embankment With Cohesive Soils 160
708 Methods for In-Situ Dry Density Measurement 161
709 Quality Control Measures For Earthwork 162
710 Quality Control Records 163
711 Certification for Quality of Earthwork 163
712 Special Design/Construction Problems 163
713 Permanent Records 163

CHAPTER 8

PLANNING FOR BALLAST PROCUREMENT

801 Introduction 173
802 Minimum depth of ballast cushion 173
803 Calculation of Quantity of Ballast per meter in track 174
804 Specification of track ballast 174
805 Method of sieve analysis 176
806 Conditions for submission of Tender 176
807 Collection and Training out of ballast 177
808 Measurement 179
809 Sampling Frequency 180
810 Supply of ballast in Stacks 180
811 Supply of ballast in Heaps for loading directly in Wagons 181
812 Checklists for Ballast Supply 182

CHAPTER 9

PLANNING OF BRIDGES

901 Introduction 185
902 Minor, Major and Important Railway Bridges 185
903 Bridge Planning 185
904 Investigations and Survey 186
905 Geographical Surveys 187
906 Surveys of Rivers in connection with the location of an Important Bridge 187
907 Plan and Cross Section of Rivers 188
908 Hydrological Investigations 188
909 Factors governing the selection of a Bridge site 190
910 Sub-Surface Investigation 190
911 Seismic Surveys 191
912 Utility Survey 192
913 Overall Length of Bridge 193
914 Bridge Foundations 196
915 Substructures 200
916 Bridge Superstructures 202
917 Bridge Bearings 208
918 River Training Works 212
919 Provision of OHE arrangements 212
920 Provision for Inspection Arrangements for New Bridges 212
921 Preparation and Approval of Drawings 212

922 Preparation of Design Basis Report (DBR) 212
923 Approval of Structural Drawing 216
924 Codes, Manual and Specifications Referred 217

CHAPTER 10

EXECUTION OF BRIDGE WORKS

PART A GENERAL

1001 Introduction 219
1002 Setting out a bridge 219
1003 Setting out a bridge without a base line 219
1004 Setting out a bridge with the help of a base line 219
1005 Utilities Shifting 220
1006 Selection of Material Source 220

PART B REINFORCED CEMENT CONCRETE

1007 Cement 221
1008 Aggregates 221
1009 Water (Natural or Treated) 222
1010 Admixture 222
1011 Steel Reinforcement 225
1012 Concrete 226
1013 Concreting Under Special Conditions 229
1014 Tremie 230
1015 Strength of Concrete 230
1016 Workability of Concrete 231
1017 Durability of Concrete 232
1018 Clear cover to reinforcement 232
1019 Type and quality of constituent materials 233
1020 Concrete Mix proportioning 235
1021 Reinforcement Splicing 237
1022 Lap lengths 237
1023 Reinforcement Placing 238
1024 Formwork and Shuttering 238
1025 Stripping time 239
1026 Sampling, Strength Testing and Acceptance Criteria of Concrete 240
1027 Frequency of sampling 241
1028 Test strength of sample 242
1029 Quality control for concrete work 242
1030 Pumpable Concrete 243
1031 Ready Mixed Concrete 244

1032 High Performance Concrete 245
1033 Self-compacting Concrete 245
1034 Tests for Cement, Aggregates and Concrete 245
1035 Checklist for RCC Work 250

PART C BRIDGE FOUNDATION AND SUBSTRUCTURE

1036 Foundation 253

OPEN FOUNDATION

1037 General 254
1038 Excavation 254
1039 Founding in soft soil 255
1040 Founding in Rock 255

PILE FOUNDATIONS

1041 General 255
1042 Sub-Surface Investigations 255
1043 Classification of pile foundations 256
1044 Selection of type of piles 256
1045 Spacing of piles 257
1046 Test piles 257
1047 Load carrying capacity of a pile / group of piles 257
1048 Construction of pile foundation 258
1049 Socketing length in Rock 259
1050 Permissible tolerance while driving piles 260
1051 Sequence of piling 260
1052 Concrete in Piles 260
1053 Tremie Concreting 261
1054 Recording of Data 262
1055 Defective piles 262
1056 Load test on piles 263
1057 Standard test method for Low Strain Pile Integrity Testing 263
1058 Pile Cap 264

WELL FOUNDATIONS

1059 Types of well 265
1060 Components of wells 265
1061 Equipment for construction of well foundation 267
1062 Pitching of the cutting edge and well curb 267
1063 Concreting of steining 267
1064 Sinking of wells in water 267

1065 Floating Caissons 268
1066 Process of open sinking of wells 268
1067 Tilt and Shift of the well 268
1068 Pneumatic sinking of well 269
1069 Founding the well 270
1070 Bottom plugging of the well 270
1071 Sand hearting 270
1072 Construction of the top plug 271
1073 Setting out of the piers on the top of well 271

SUBSTRUCTURE

1074 General 271
1075 Abutments 272
1076 Piers 272
1077 Wing Walls 272
1078 Bed Blocks for Abutments and Piers 272

PART D BRIDGE SUPERSTRUCTURE

1079 Components of PSC Structure 273
1080 Construction sequence with timeline 273
1081 Quality Assurance Plan (QAP) for material for PSC structures 273
1082 Construction records for PSC structures 273
1083 Construction material for PSC 274
1084 Prestressing Steel 277
1085 Sheathing 279
1086 Anchorages 281
1087 Grout 283
1088 Stage-wise construction activities in PSC Work 284
1089 Steel Superstructure..... 287
1090 Load Test 287

PART E BRIDGE BEARINGS

1091 Bridge bearings 289

PART F LAUNCHING OF SUPERSTRUCTURE

1092 Launching/Erection of superstructures 293
1093 Launching with the help of Derricks 297
1094 Launching by side slewing method 297
1095 Launching by use of crane 298
1096 Launching by gantries 301
1097 End launching without/with launching nose 302
1098 Erection by cantilever method 304
1099 Safety precautions in electrified area 310

CHAPTER 11
GRADE SEPARATOR

1101 Introduction 333
1102 Planning and Design 333
1103 Selection criteria for ROB/RUB 334
1104 Planning of road over bridges and road under bridges 334
1105 Innovative Designs 342
1106 Launching of Girders for Road Over Bridge (ROB) 343
1107 Erection by use of cranes 345
1108 Bow String Arch Steel Girders (BSG) 346

CHAPTER 12
STEEL GIRDER FABRICATION

1201 Introduction 349
1202 Authority for Inspection of Newly fabricated steel girders..... 350
1203 Fabrication Workshop..... 352
1204 Quality assurance Plan (QAP) for Fabrication 352
1205 Raw Material Inspection 354
1206 Inspection of Consumables 358
1207 Fabrication Records 359
1208 Layout and Templating 362
1209 Flattening and Straightening 363
1210 Planning, Shearing and Cutting 363
1211 Edge Preparation/Scalloping, Grinding & Finishing 364
1212 Drilling 364
1213 Tack Assembly 365
1214 Welding 366
1215 High Strength Friction Grip (HSFG) Bolts 378
1216 Initial Assembly 380
1217 Inspection of Trial Assembly 381
1218 Final Inspection 386
1219 Surface Protection 386
1220 Dispatch 388
1221 Assembly at Site 388
1222 Codes, Manuals and Specifications Referred 390

CHAPTER 13

TUNNELS

1301 Difference between Rock material and Rock mass 395
1302 Geotechnical Investigations for Tunnels 396
1303 Rock Mass Classification systems..... 398
1304 Tunnel System and Cross Section of Tunnels 400
1305 Tunnel Portals 403
1306 Tunnel Supports 405
1307 Tunnel Support Design..... 406
1308 Tunnel Excavation Methods..... 406
1309 Tunnelling Methods / Philosophies..... 407
1310 Safety aspects during Tunnel Construction..... 409
1311 Instrumentation and monitoring of Tunnels..... 409
1312 Drainage and Waterproofing in Tunnels..... 411
1313 Tunneling in weak /Soft grounds..... 413
1314 Ventilation of Tunnels..... 416
1315 Other Safety Features for Train operation in Tunnels..... 418

CHAPTER 14

BUILDINGS AND PASSENGER AMENITIES

PART A BUILDNGS

1401 Architecture..... 419
1402 Development Control Norms..... 420
1403 Relevant Instructions / Circulars on Construction of Buildings on Railway Land..... 422
1404 Conceptualization & Planning of the Project..... 423
1405 Other Important Aspects..... 423
1406 Clearances/NOCs from Local Authorities/Bodies..... 425
1407 Amenities to be provided in Buildings..... 425
1408 Fire Protection..... 426

PART B PASSENGER AMENITIES

1409 General..... 427
1410 Categorization of Stations..... 427
1411 Minimum Essential Amenities (MEA)..... 428
1412 Recommended Amenities..... 434
1413 Desirable Amenities..... 434
1414 Important Aspects..... 435
1415 Facilities for Persons with Disabilities (Divyangjan)..... 438
1416 Tactile Pavers: Guiding and Warning blocks..... 442

1417 Functional Requirements and Technical Specifications For Materials, workmanship and finishes etc. 443
1418 Amrit Bharat Station Scheme..... 445

CHAPTER 15

TRACK LAYING AND ALLIED WORKS

PART A- TRACK LAYING,PLANNING AND EXECUTION

1501 Sanctioned Provisions and Initial Planning..... 457
1502 Unloading and Stacking of P. Way material..... 459
1503 Formation and Fixing of reference pegs..... 461
1504 Ballast works, Laying of Sleepers and Linking of Normal Track..... 462
1505 Manual packing & tamping by machines..... 465
1506 Laying of Points and Crossings in yards..... 466
1507 Long Welded Rails (LWR)..... 468
1508 Level Crossings..... 471
1509 Track Structure on Bridges..... 474
1510 Alumino Thermic (AT) Welding..... 475
1511 Flash Butt (FB) Welding..... 478
1512 In-situ Glued Insulated Rail Joints..... 479
1513 Rail Painting..... 480
1514 P-Way Registers and other records..... 481

PART B MECHANISATION IN TRACK LINKING IN CONSTRUCTION

1515 Introduction..... 484
1516 Machines for Miscellaneous work and Ballast spreading..... 484
1517 Machines for Laying of Plain Track..... 486
1518 Machines for Laying of Points and Crossing..... 488
1519 Other Useful Machines for Track Linking Work..... 490
1520 Small Track Machines useful for Track Linking..... 492
1521 On Track Machines..... 494

CHAPTER 16

SIGNALLING WORKS

1601 Utility shifting involving S&T in construction Projects 501
1602 Power Supply..... 501
1603 Cable laying work..... 503
1604 Automatic Signalling works on Indian Railways 506
1605 Electronic Interlocking..... 506
1606 Lightning and surge protection for signalling equipment..... 511
1607 Data Logger..... 511
1608 Fire alarm and smoke detector system..... 512
1609 Automatic fire detection and suppression system..... 512
1610 General Arrangements..... 512

1611a	Proposal for Works	513
1611b	Planning, preparation & execution of works	513
1612	Joint inspection/handing over of new assets	520
1613	Do's & Don'ts for work execution	520
1614	Signalling Gears Description Writing	527
1615	Miscellaneous	527
1616	Latest version of All Guidelines/ Specifications/ Directions of Reference made in this Chapter may be followed	527

CHAPTER 17

ELECTRICAL AND TRACTION DISTRIBUTION WORK

1701	Definition	531
1702	Scope	531
1703	Works to be executed by the Railway	532
1704	Method of crossing	532
1705	Important aspects for Railway Electrification	535
1706	Principles for Layout Plans & Sectioning Diagrams for 25KV AC Traction	542
1707	General Guidelines for Anti-Theft Charging of OHE	549
1708	High Rise OHE	551

CHAPTER 18

Pre-NI AND NI WORKS AND COMMISSIONING FOR RAILWAY PROJECTS

1801	Planning for Pre-NI & NI Works	555
1802	NI Working in any Project	555
1803	Precautions for safe and smooth NI working	556
1804	Speed Restriction during NI Working	560
1805	CRS Inspection for Opening of Sections	560
1806	Statutory Provisions for Opening	560
1807	Planning for CRS Inspection	561
1808	Preparation for CRS Inspection	564
1809	Procedure for CRS Inspection	568
1810	Actions post inspections	569
1811	Handing over and taking over of newly commissioned assets	569
	Summary of Reference Documents	571

CHAPTER 1
ALIGNMENT AND SURVEY

101 GENERAL

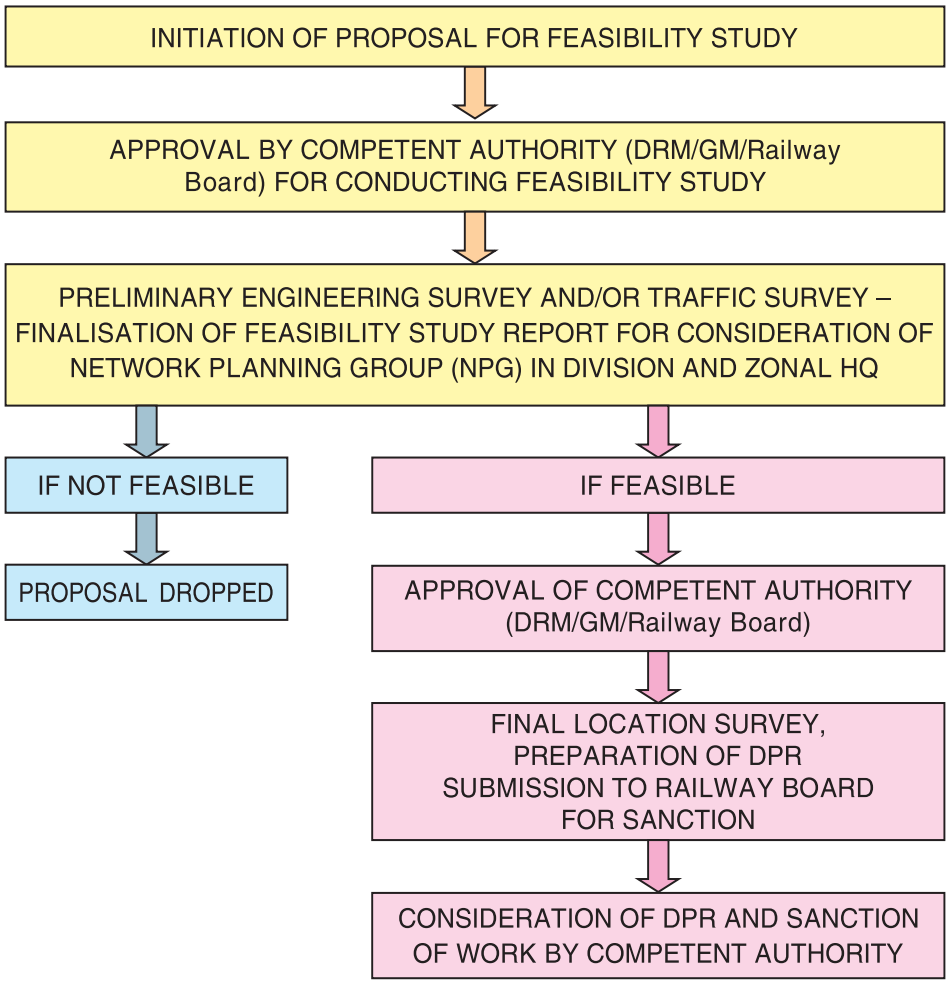
This chapter provides insight into feasibility study, final location survey and few details about modern survey techniques. As per Indian Railways Code for the Engineering Department, Project Development Process consists of:

(1) **Feasibility Study:** As per Railway Board's Letter No. 2021/W-I/Gen/Gati Shakti dated: 27.07.2022 **(Ref. 1.01)**, RECT (Reconnaissance Engineering cum Traffic) and PECT (Preliminary Engineering cum Traffic) Surveys will be called as feasibility study. Traffic survey is conducted in conjunction with feasibility study.

(2) **Final Location Survey:** Final Location Survey shall be done for the routes so chosen, on the basis of Feasibility study and only after the approval of competent authority.

A flow chart showing project development process is as follows:

Sequence of Activities



Note: The procedure as detailed in Railway Board's L. No. 2021/W-I/Genl./Gati Shakti Dated 28.10.2022 (Ref. 1.02) may be followed.

102 FEASIBILITY STUDY

In Preliminary Surveys detailed investigation is not carried out and only an approximate cost estimation is done. Investigation of this nature is termed as "Feasibility Study" which include Preliminary investigation, Traffic survey, Techno economic study, approximate cost and preparation of a feasibility study report. Preferably BISAG-N platforms be used for selecting the optimal alignment and later confirmed with ground data.

(1) Objective: The main objective of the feasibility study is to examine the general characteristics of the area to determine the most feasible route or routes for further detailed investigation. It is a rough, quick investigation of an area to determine the technical feasibility and approximate cost of one or more routes for a proposed Railway line with the help of contour maps and other available material without very detailed investigation in the field. It is done to get approximate distances and heights, using basic instruments. Where suitable arial photographs/ terrain models are available, field investigation by instruments can be considerably reduced with stereoscopic studies of the photographs and fewer site visits may be required. Adequate data should however be collected to examine the feasibility of all possible routes in question and also to furnish approximate estimates of quantities and costs so as to decide on the most suitable alternative(s). The investigation should also help in determining any deviation(s) required in basic geometric standards.

(2) Terms of Reference: The project Investigator should be supplied with approved terms of reference of the Railway by the Railway Administration. It should broadly indicate the category of line, ruling gradient to be adopted, gauge, loading standard, track structure, track centre, traction, traffic facilities etc. The terms of reference should include instructions regarding the scope and nature of the investigations to be carried out, particulars of railway lines already projected in the area and what undertakings or interests, if any, are involved in the proposal. The terms of reference should also include instructions to the officer-in-charge of the survey to visit the headquarters of the Railway Administration at suitable interval both during the progress of work in the field and during the period of recess to consult the Railway Administration and where necessary, have the original terms of reference modified from time to time.

(3) Sequence of Feasibility study: It should be conducted in the following sequence; Assessment of existing and future needs/requirements; Project formulation, which is to determine the various options to meet the demand; Project investigation, which is to examine some selected alternative routes as defined in the terms of reference to the Project Investigator and detailed examination of the selected scheme by conducting a Preliminary survey; Preparation of Feasibility Reports i.e. Techno-Economic study reports; Project evaluation which may involve economic analysis or Social Profitability Analysis, in addition to financial appraisal and selection of a scheme based on such an appraisal, considering existing facilities.

a) Assessment of existing and Future needs/requirements:

A traffic survey including Origin-Destination (O-D) study needs to be conducted to study the existing trade needs and make a forecast of the traffic prospects regarding the setting up of specific industries and consequent growth of traffic requirements for the movement of raw materials to and finished products from such industries and to facilitate the projection of the most promising route and the category of line to be constructed in the case of new lines and to assess the quantum of traffic to determine

the traffic facilities to be provided on an existing line. While collecting information traffic surveyor should visit all trade centers in the area, consult local authorities and prominent citizens freely, both as regards to trade and industry and the most suitable alignment for the proposed Railway line and study the area from the following perspective i.e. Human resources; Agricultural resources; Mineral resources; Industries located and projected; The pattern of trade and commerce; Existing transport facilities; Tourism and tourist prospects; Banking facilities; National Income; and Planning for the economic development of the area by the local Government or by the Central Government. The alternatives should also be get checked through BISAG-N portal for different reports like, intersection report, multimodal report and economic nodes in the zone of influence etc., details about using BISAG-N portal are elaborated in Para 107 [Railway Board's L. No. 2021/W-I/Genl./Gati Shakti Dated 28.10.2022 **(Ref 1.02)**].

Methodology to be adopted in the "Assessment of Traffic Prospects and Traffic Forecasting and Earnings" is covered under IR Engineering Code. Guidelines for items to be included in the Traffic Survey Report are covered in the IR Engineering Code.

b) Project formulation and Investigation:

Based on the needs assessed above, various options are to be explored duly considering technical features. First of all, the study of survey sheets and maps is conducted to mark suitable alignments on toposheets. These alignments are further studied in detail to recommend the most suitable alignment.

(i) Study of Survey Sheets, Maps etc.: Study of the project area through available maps. The details available from maps currently available in the country are as below:

i. Survey of India (SOI) Maps.

- The most useful maps are the topographical sheets available on the scale of 1:25,000, 1:50,000 and 1:2,50,000. Maps of 1:50,000 and 1:2,50,000 scale are available for the whole of India but map coverage of 1:25,000 is presently available for about half of the country's territory.
- State maps on a scale varying from 1:5,00,000 to 1:10,00,000 for different states. These are useful as index maps or to indicate an overview of the project location and are available for most of the States.
- Plastic Relief Maps on scale a 1: 1,50,00,000: Plastic relief maps are also available for a few regions in the country. These three-dimensional maps delineating ridges, valleys, peaks, etc. with contour information, may be useful for alignment planning in very difficult areas.
- **SOI maps procurement:** list of SOI offices (from where SOI maps can be procured) and unit price of different maps can be seen and procured at http://www.surveyofindia.gov.in. The SOI maps can also be procured from SOI head office at Dehradun i.e. Map Archive and Dissemination Center (MADC), Survey of India, Hathibarkala, Dehradun.

ii. The SOI topographical maps are divided into two types.

- Restricted (area of strategic importance).
- Unrestricted (rest of the country).

For procurement of SOI sheets, indent on form No. O.57 (to be downloaded from SOI website http://www.surveyofindia.gov.in/), is required to be submitted, with approval from Engineer-in-charge. After acceptance of Indent by SOI and communication from SOI about details of the availability of maps, payment for available topographical maps is required to be ensured. After receiving the payment, SOI will supply the maps to the Indenting officer.

SOI has now launched the Open Series Map portal (http://soinakshe.uk.gov.in/). Unrestricted topographical maps of 1:50,000 can be downloaded from this portal after registration. Paid digital data in other formats (DGN, DEM, ARC, SHAPEFILE, and GEOTIFF) can also be bought online through this website.

iii. Apart from SOI maps, there are special purpose maps, like Forest Survey of India and Vegetation Maps on a scale 1:2,50,00,000 showing orchards, reserve forests, clusters of social forestry areas etc. which may be helpful in special cases in the selection of alignment. Nowadays, many State Govts have digitized their forest maps which can be acquired from respective DFOs/Head offices.

iv. Maps prepared by National Bureau of Soil Survey and Land Use Planning (NBSS & LUP) indicating information about soil, wasteland, etc. and Geological Survey of India (GSI) Maps (on a scale 1:2,50,000 or smaller) with information on geology, geomorphology and changes in drainage, river courses, etc. are available for many areas. GSI has now launched their web portal http://bhukosh.gsi.gov.in/, geological maps of 1:250k and 1:50k can be downloaded in digital format from this website, free of cost.

v. Data of Google Earth, Aster DEM, CartoSat -1 & 2 imageries and DEM, LISS etc. can be accessed free of cost. Carto DEM data can be downloaded free of cost, from NRSC's Bhuvan Portal i.e. https://bhuvan-app3. nrsc.gov.in /data/download/index.php. A list of few open-source digital data websites is as under:

- Indian Railways: https://indianrailways.gov.in/index/index.html
- Google Earth: https://earth.google.com/web/
- Bing Maps: https://www.bing.com/maps
- Open Street Map: https://www.openstreetmap.org/
- Wikimapia: https://wikimapia.org
- https://www.mosdac.gov.in/
- https://earthexplorer.usgs.gov/ - paid data site

After a study of topographical features on the maps, economic/commercial details and details from adjoining existing Railway lines, options are prepared to meet the needs assessed in the first step.

(ii) Marking of alignment: After the study of topographical features on the maps, a number of feasible alignment options are selected and marked on topo sheets after considering approved terms of reference. The following points should be kept in

mind while marking alignment on topo sheets:

i. The alignment should take into account all the control points and should be the shortest and most economical, compatible with the requirement of gradient and curvature.

ii. Shape of the alignment.

iii. Avoidance, as far as possible, of marshy ground, steep terrain, unstable hill features and areas subject to severe climatic conditions, floods and inundation.

iv. Need to connect important villages and towns.

v. Bridging cross drainage and drainage problems.

vi. Proper location and orientation of cross drainage structures is an important factor in selection of alignment. For bridges having linear waterways more than 300m i.e. for important bridges, siting of bridge will be the primary guiding factor in route selection.

vii. Need to preserve the environment and maintain ecological balance.

viii. Minimum disturbance to habitation and structures

(iii) Field Survey:

i. After the paper alignment is finalized, the alignment is marked in the field with the help of instruments such as total station, GNSS/DGPS, RTK Survey etc. Walkie-talkie sets, mobile phones etc. are useful for communication, particularly in difficult terrain.

ii. The survey starts with the running of a traverse along the selected route, adhering as far as possible to the probable final centre line of the proposed railway alignment. In difficult situations, a secondary traverse connected to the primary one at either end may also be run. In hilly areas, a trace cut 1.0 to 1.2 m side, if required may be made during the survey.

iii. The traverse consists of a series of straight lines with their lengths and intermediate angles measured very carefully. In difficult terrains, the alignment may have to be negotiated through a series of short chords, preferably the traverse should be done with Electronic Distance Measurement (EDM) like total station and all angles measured with the double reversal method.

iv. Traversing procedure by Total Station for stacking the alignment: The process of fixing Alignment Centre-line points on the ground using its coordinates is known as staking. The following procedure may be applied during traversing, for staking the co-ordinates in the field:

- Set up the total station on a known Ground control point.
- Then go to the survey option in the instrument's control panel and set up the total station by any one of two methods i.e. "known back side" or "resection".
- Set up the instrument by giving the coordinates of known point used as station, then the feed input of 2nd point coordinates used as the back site. Then setup total station.
- Next go in menu option, search for stakeout function. Select stakeout and

enter the coordinates of the points to be stake out.

- As the coordinates of the point to be staked, are entered, the total station will give the direction and distance of the point.
- Rotate the total station to the staking direction. Bring the reflector (prism-pole) in the line of sight. Measure the point.
- Total station will display deviations in the present reflector position and the position of the point to be staked.
- Shift the reflector to the display deviation. Again, measure the point. Repeat the procedure until the desired accuracy of 5-10 mm is achieved.

The same procedure may be followed for further completion of the survey.

v. Distance between two consecutive transit stations, depends upon directional changes in the alignment, terrain conditions and visibility. The transit stations should be marked by means of stakes and numbered in sequence and if possible, co-ordinates of permanent structures should also be recorded. These should be protected and preserved till the final location survey.

vi. Physical features such as buildings, monuments, burial grounds, cremation grounds, places of worship, posts, pipelines, existing roads and electric lines, stream/river/canal crossings, cross drainage structures etc. that are likely to affect the project proposals should be located by means of offsets measured from the traverse line. Where the survey is for doubling an existing railway line, measurements should also be made for the existing railway line, railway land boundary and location and radii of horizontal curves. In the case of railway alignment in rolling and hilly terrain, the nature and extent of grades, ridges valleys and vertical curves should necessarily be covered. The width of land to be surveyed will depend on the terrain and other related factors.

vii. Generally, the survey should cover the entire proposed corridor with adequate provision for possible shifting of the centre line from the traverse line.

viii. Levelling work during a feasibility study is usually kept to a minimum. Generally, fly levels are taken along the traverse line at 50m intervals and at all intermediate breaks in the ground. To draw contours of the strip of land surveyed, cross sections should be taken at suitable intervals, generally 100 to 250m in plain terrain, up to 50m in rolling terrain and up to 20m in hilly terrain. To facilitate the levelling work, benchmarks, either temporary or permanent, should be established at intervals of 250 to 500m. The levels should be connected to the GTS datum. The fly level can be taken with the help of Total Station.

ix. Field notes of the survey should be clear and concise, yet comprehensive enough for easy and accurate plotting.

x. Apart from traverse survey, general information about soil and drainage should be collected while the traverse is being run.

xi. DGPS (Differential Global Positioning System) using GNSS (Global Navigational Satellite System) is also very useful and appropriate for a feasibility study. The DGPS will give location coordinates at all necessary points on the traverse. DGPS is very fast, reasonably accurate equipment for feasibility study and is

computer-friendly for data transfer. Control pillars in cement concrete should be fixed at suitable intervals (ranging from 500m to 2kms) to have control on accuracy. It also helps in repeating the survey, if required, within the control pillars.

(iv) Advanced techniques in Survey

Digital Terrain Model (DTM) may be prepared, by digitizing 1:25,000 or 1:50,000 scale toposheets for various features viz. contours, roads, rivers, streams etc. Readymade digital formats are available these days free of cost.

Since toposheets supplied by Survey of India may be quite old, these are required to be updated for various ground features. This updation is done through satellite imageries/ DEM available with NRSC, Hyderabad. Digital Elevation Model (DEM) from CARTOSAT is available free of cost at the BHUVAN website.

Study of the project area should preferably be done on the digital interface instead of paper maps. This can be done by visualizing the project area in Google Earth, Terra Explorer etc. As per approved TOR, three or more tentative feasible alignments are marked on Google Earth, without providing engineering parameters at this stage. These alignments are then transferred to Auto-CAD or Bentley Open Rail Designer, where engineering parameters to these alignments are provided on the surface/ contours generated from the available DEM of the project area (DEM may be opened as a base layer while performing the job). Most of the alignment softwares are able to open Google Earth in the background for better visualization.

Generally, three alternatives are first marked and with the help of available software, detailed analysis is carried out to find out the best economical, feasible option. The best alignment option is finally selected based on various technical & commercial criteria. The alignment file can also be superimposed on the vector maps of the area where layers of Road river, streams, structures etc. are available. Open-source vector maps can be obtained from https://www. Openstreetmap.org. These vector maps along with DEM are very useful in finalizing the planning of structures like ROB/RUB, Bridges etc. during the development of alignment and further estimating the cost of construction. The quantity of earthwork, list of gradients, curves, viaducts, tunnels and other relevant data can directly be extracted from this software.

The set of co-ordinates (X,Y, Z) or KMZ file of the alignments is extracted and verified in the field using GNSS or Total Station. The co-ordinates are required to be checked at all important locations like crossing of roads, major/important bridges and every 500m apart in an accessible area. Efforts should be made to fix permanent benchmarks/ control points in the field at every 5 KM using GNSS.

(v) Final Details for alignment

After confirmation and suggestions from the field, the alignment is rectified and finalized. The final report as described below has to be prepared.

General description of Area, Topography, Climate indices (viz. Humidity, Temperature, Wind) etc. Alignment & L-section in Scale of 1:50,000 for horizontal and 1:1,000 for vertical.

Index Map in Scale of 1:2,50,000 and General Map in Scale of 1:25,00,000.

The proposed route or routes is marked on them in red, and all towns and places referred to in the report are clearly shown therein. Other details finalised are:

i. Conceptual Yard Plan/Line Diagram
ii. List of Gradients
iii. List of Curves
iv. List of ROBs/RUBs/LHS
v. List of Stations
vi. List of Quarters
vii. Land details showing the area of land to be acquired, and the type of land (Rural/Urban, Agriculture/Forest etc.).
viii. Estimate for Earthwork/Blanket
ix. List of Electric & Telephone Crossings
x. List of Bridges indicating size, waterway, height and type of foundation.
xi. List of Major Bridges
xii. List of Tunnels
xiii. List of RAW (Railway Affecting Works) if any
xiv. List of SSP (Sub Sectioning and Parralleting Post)
xv. Standard of Interlocking/PI/SSI.

(vi) Preparation of Detailed Engineering Estimate

Project cost is then prepared which includes the cost of Civil Engineering, Electrical, TRD and S&T works required in the project. The unit rates for cost estimation of civil engineering works are obtained from the latest LARs or rates circulated by Zonal headquarter. Detailed Project Estimate is framed by compiling sub-estimates of all concerned departments, in formats available in IR code for Engineering Department.

c) Preparation of Feasibility Reports i.e. Techno-Economic study reports:

Feasibility Study Reports based on Preliminary Engineering-cum-Traffic Surveys for new lines and traffic facilities etc. may be compiled under chapters as indicated below as per provisions of the IR code for Engineering Department:

Chapter No.	Title
-	Executive summary (Synopsis)
I.	Introduction
II.	Characteristics of Project Area
III.	Standards of Construction
IV.	Route Selection/Project Description
V.	Project Engineering and Construction Schedule
VI.	Estimation of cost, phasing and investment schedules
VII.	Traffic Projection
VIII.	Map
IX.	Analysis of Alternatives

X. Environment and Rehabilitation assessment

XI. Financial and Economic Appraisal

XII. Recommendation

(i) Executive Summary: A synopsis of the salient features of the project along with clear recommendations should be provided in the Executive Summary. The following information is to be included:

i. Alignment and Length of the line

ii. Number of stations and important cities connected.

iii. Area covered state-wise and district-wise.

iv. Principal items of goods traffic.

v. Quantum of goods traffic year-wise projections in tonnes.

vi. Coaching traffic year-wise projection of passengers with the break-up of local and interchange figures.

vii. Number of trains (Goods, Coaching)

viii. Gross earnings per year.

- Goods
- Coaching

ix. Working expenses (Operation and maintenance).

x. Net earnings.

xi. Economic benefit due to network effect

xii. Cost of the project.

- Civil Engineering.
- Signal and Telecommunication.
- Electrical.
- Rolling Stock.

xiii. Financial result.

xiv. Working capital.

xv. Investment schedule.

xvi. Ruling gradient adopted.

xvii. Standard of construction.

xviii. Maximum degree of curvature.

xix. Speed potential of the line.

xx. Cost per Kilometre.

(ii) Estimation of cost, phasing and investment schedules: The Feasibility Study Report should also be accompanied by the Project features including the following items as per the provisions of IR Engineering Code.

i. Curve Abstract

ii. Gradient Abstract

iii. Bridge Abstract

iv. Important Bridges

v. Station Machinery

vi. Stations and Station Sites

Estimation of Cost- The methodology adopted in the computation of quantities for earthwork, bridges and buildings may be indicated. For estimation of cost, construction estimates as per IR Engineering Code together with Abstract Cost of Project and Abstract Estimate of Junction Arrangements in the case of projects relating to construction of New Line, Gauge conversion, doubling etc. should be prepared and appended to the Report. Estimation should be detailed in the format (Similar to Final Location Survey) based on the preliminary engineering survey.

Similar estimation for Signal and Telecommunication, Electrical and Rolling stock is to be made and added to the cost. Working capital if any should also be added to the project cost.

Investment Schedule- In addition to the project abstract cost, an investment schedule for the various years of the construction programme should be furnished.

If any phasing of work is required, the extent of such phasing with reasons thereof and the investment levels for such phasing may be indicated.

(iii) Maps: The reports and estimate should be accompanied by a map of the area on a scale of 25 Km to 1 cm, an index map on a scale of 2.5 Km to 1 cm and an index plan & section on a scale of 0.5 Km to 1 cm horizontal and 10 m to 1 cm vertical, the proposed route or routes being marked on them in red, and all towns and places referred to in the report clearly shown therein.

(iv) Analysis of alternatives: The Analysis must indicate the alternative schemes, their approximate cost, the time required for their execution, the additional capacity they will create, and their merits and demerits. Financial returns must be worked out for the important alternatives and the one giving the best return may be generally adopted except when there are other overriding reasons in favour of the costlier alternative. The alternatives should also be checked through BISAG-N (Bhaskaracharya National Institute for Space Applications and Geo-informatics) portal for different reports like, intersection report, multimodal report, economic nodes in the zone of influence etc.

(v) Environment and Rehabilitation Assessment: Climatic conditions, rainfall characteristics, the existence of air pollution which may cause corrosion etc. may be brought out. Details of communications facilities available like access roads, availability of water, human activity in the area and human settlements (townships squatter settlements etc.) may be furnished. This aspect is of considerable importance since the location of terminal facilities or yard facilities close to squatter settlement with attendant problems like pilferage etc., has to be borne in mind in the choice of selection of alternative sites. Environmental Impact Assessment (EIA) and Resettlement and Rehabilitation Action Plan (RAP) should normally be prepared wherever required.

(vi) Financial and Economic Appraisal:

i Financial Internal Rate of Return (FIRR) of the project is to be calculated based on various inputs like traffic, earnings etc. For calculation of FIRR Railway Board's latest Circular No.2023/Gatishakti/TF/02 dated 14.09.2023 **(Ref. 1.03)** is to be followed.

ii. Economic Internal Rate of Return (EIRR) of the project is to be calculated based on economic cost and economic benefits. For calculation of EIRR Railway Board's latest Circular No.2022/Gatishakti/EU/49 dated 19.08.2022 **(Ref. 1.04)** is to be followed.

(vii) Selection of most preferred alignment: A detailed techno-commercial analysis is done to select the most technically feasible and economically viable alignment from among the alternatives. A multi-criteria analysis is done for the purpose of selecting of most preferred alignment. A weightage is decided for all the factors which are taken into consideration and a rating is given to each factor for every alignment. A combined score is calculated for all the alternatives and the best alternative is finalized. The main factors which are taken into consideration are the following:

i. Cost Consideration.

ii. Ease of Construction Consideration.

iii. Serviceability Consideration.

iv. Geological Consideration.

v. Environmental and Social Impact Consideration.

Further studies like geological mapping, geophysical & geotechnical survey, hydrological studies, design of structures etc. are done on the selected alignment and further refinement of alignment is done based on these studies. After getting the most appropriate alignment, required investigations such as detailed geological survey, and geotechnical investigations are planned which may further cause the change of alignment depending upon the output of various investigation

(viii) Recommendation: A clear recommendation should be made by an officer in charge of Feasibility Survey as regards to the feasibility and best possible alternative for the proposal.

103 APPROVAL OF FEASIBILITY REPORT

The Feasibility report prepared as above will be examined by the zonal railway and submitted to Competent Authority for approval i.e. DRM/GM/Railway Board as applicable [Railway Board's Letter No. 2021/W-I/Gen/Gati Shakti dated: 27.07.2022 **(Ref. 1.01)]**.

104 FINAL LOCATION SURVEY

After approval of the feasibility report of the work by the competent authority, FLS and preparation of DPR will be initiated. Final Location Survey (FLS) for improving mobility/improving throughput/improving loading/coal connectivity/port connectivity/cargo loading/new line / doubling/ Gauge Conversion works is done by the concerned executing unit as decided by Railway administration [Railway Board's L. No. 2021/W-I/Genl./Gati Shakti Dated 28.10.2022 **(Ref. 1.02)**].

For DPR preparation works of New Line, Doubling and GC work, concerned Chief Engineer shall be the convener of the team consisting of CTPM/COM(Survey), CEE/C, CSTE/C & FA&CAO/C. A professional team of sector experts shall be engaged for an integrated survey, preferably a single agency to avoid repetition of activities.

The proposal of FLS shall include details as laid down by guidelines issued by Railway Board vide letterno. 2021/W-I/Genl./GatishaktiPt.3 dt.31.07.2023 (Ref. 1.05).

(1) Objective: The purpose of FLS is to lay down and mark the center line of alignment in the field based on the alignment selected in the design office, after the feasibility study to collect necessary data for the preparation of working drawings. The completeness and accuracy of the project drawings and estimates of quantities depend a great deal on the precision with which this survey is carried out. The accuracy of the survey should be scrutinized by senior Railway officers. This will also help in assessing precise land acquisition requirements.

FLS is generally a post-sanction decision for investigation & preparation of accurate working details. The principal difference between FLS and feasibility study is that the alignment finally selected during FLS is fully staked on the ground with an Electronic Distance Measuring Instrument (Total stations etc.). In addition to the above, Satellite Imagery, Drone photogrammetry and LiDAR technology may be used. Detailed plans and sections are developed after FLS. This also includes the preparation of Site plans marking loco sheds/ EMU car sheds, maintenance depots, control offices, repeater stations, staff quarters, land acquisition plans etc.

(2) Terms of Reference: The project Investigator should be supplied by the Railway Administration with approved terms of reference of the Railway, and should indicate broadly the category of line, ruling gradient to be adopted, Gauge, Loading Standard, Track Structure, Track Centre, Traction, Traffic facilities etc. The terms of reference should include instructions regarding the scope and nature of the investigations to be carried out, particulars of any railway lines already projected in the area and what undertakings or interests, if any, are involved in the proposal. The terms of reference should also include instructions to the officer-in-charge of the survey to visit the headquarters of the Railway Administration at suitable intervals both during the progress of work in the field and during the period of recess in order to consult the Railway Administration and where necessary have the original terms of reference modified from time to time.

(3) Sequence of activities: Main activities in FLS are the staking out of the final center line of the proposed Railway alignment by means of a continuous survey and detailed leveling, preparation of a detailed plan and L-section of alignment, preliminary design & drawings of structures and assessment of nearly accurate project cost and preparation of Detailed Project Report. FLS is basically a Pre-construction Survey. The alignment should be mapped on BISAG-N portal and validated on various layers such as road network, railway network, geographical constraints, forest, national park, wildlife, CRZ, river & water bodies, transmission lines, various mines, soil, land etc. FLS should be conducted as per the following sequence:-

- **Step I: Traffic Study –** At first, the origin – destination study of likely incremental freight traffic and passenger traffic study should be carried out. It may be based on field surveys, DPRs of other zonal railways, other Ministries/ State Govt./Niti Aayog etc. The aim is to first establish the need of the project.
- **Step II: Alignment –** In case sufficient traffic is available, best & optimal alignment should

be chosen so as to attract the traffic. The obligatory points should also be considered while finalizing the alignment.

- **Step III: Design –** Once the alignment is final, the design of the project i.e. geo-tech study, location of stations, bridges, tunnels, ROB/RUB etc. should be completed so as to have an integrated planning after getting inputs from stakeholders. The phasing of the project should be part of the design.
- **Step IV: Estimation –** Based on the design, the estimation of quantity should be worked out. The costing should be based on the latest rates of USSOR/DSR etc. so as to minimize any cost variation.
- **Step V: Optimization –** Once all the above steps are completed, the FIRR/EIRR of the project should be worked out based on the model issued by the Railway Board. In case the FIRR/EIRR is lower than the hurdle rates, the project should be reviewed so as to optimize the cost based on alternate alignment/ design along with exploring other revenue streams such as non-fare revenue and parcels etc.

a) Staking Out Final Center Line:

(i) The center line of the proposed Railway alignment, as determined in the design office, after a feasibility study, is transferred on the ground by means of continuous transit survey and staking of the center line as the survey proceeds. The double reversal method should be adopted at all horizontal intersection points (HIP) and intermediate points of transit (POT) on long tangents. The horizontal intersection points should be fixed on hubs driven flush with the ground and suitably referenced so that they may be readily located. Usually, these should be serially numbered for easy identification and shall be defined by coordinates. On long tangents, the intermediate transit points should also be fixed on hubs in the case of new roads with proper referencing.

(ii) The reference points should be so located that these will not be disturbed during construction. Description and location by coordinate of the reference points should be noted for reproduction on the final plan drawings.

(iii) All the curve points, namely the beginning of transition curves (TTP), beginning of circular curve (TP), end of the circular curve (TP) and the end of transition (TTP) should be fixed and referenced in the same manner as for POTs described earlier.

(iv) The final center line of the proposed Railway alignment should be suitably staked. Stakes should be fixed at 50m intervals in plain and rolling terrain, and 20m intervals in hilly terrain. The stakes are intended only for a short period for taking levels of the ground along the center line and cross section with reference thereto.

(v) Distance measurements along the final center line should be continuous following the horizontal curves where these occur.

(vi) The traverse in the case of proposed Railway alignment would be open and should be controlled by establishing control points to be established by GNSS/DGPS survey or by astronomical observations or Total Station or by running cut- off lines between intermediate stations.

(vii) At road crossings, the angles that the intersecting roads make with the final center line should be measured.

b) Establishment of Permanent Control Points / Bench Marks:

The permanent control points or Benchmarks are established along the final alignment for the purpose of construction. These permanent control points are also called Ground Control Points (GCP) and should be established in a pair of two RCC pillars (minimum) at one location preferably 100m to 300m apart because any new point to be established during the construction stage with the help of total station needs at least two known points. The X & Y coordinates of GCPs can be established with the help of GNSS/DGPS or Total Station by taking reference from known Survey of India (SOI) GCPs. The Z coordinate of the GCP is derived by carrying out levelling survey using Auto level/Total station from known SOI GTS benchmarks. Reference points for POTs and HIPs, could also be used as benchmarks. It is particularly important that a single datum, preferably WGS-84 & GTS/ MSL datum, should be used to tie up all the points. For benchmark levelling, check levels should be run over the entire line back to the first benchmark.

c) Longitudinal Sections and Cross-Sections

(i) Levels along the final center line should be taken at all staked stations and at all breaks in the ground.

(ii) Cross-sections should be generally taken at 50-100m intervals in plain terrain and 50-75m in rolling terrain depending on the nature of the work.

(iii) Centerline profile should normally be continued at least 200m beyond the limits of the project.

d) Proper Protection of Points of Reference

(i) FLS is considered complete when all the necessary information is available and ready for the designer to be able to plot the final proposed Railway alignment profile and prepare the project drawings.

(ii) At the time of execution, all construction lines will be set out and checked with reference to the final center line established during the final location survey. It is therefore important, that not only all the points referencing the center line should be protected and preserved but these are so fixed at site that there is little possibility of their being disturbed or removed till the construction is completed.

e) Soil and Material Surveys:

Soil investigation and other materials survey is carried out with respect to sources and availability/suitability of materials. Additional investigations in respect of landslide or avalanche-prone locations may also be carried out at this stage. Detailed investigation at important locations viz. high embankments, deep cuttings, major/important bridges, tunnels, weak subsoil, marshy land etc. may also be conducted. RDSO's, "Comprehensive Guidelines and Specifications for Railway formation", No. RDSO/2020/GE: IRS-0004(D), September-2020" should be referred for conducting soil survey. The design of formation should be finalized after a comprehensive study of all related technical reports/ specifications issued by RDSO (with the latest amendments) regarding earthwork, blanketing, sub-grade, slope stabilization, geosynthetics, drainage etc.

Soil and materials survey is required:

(i) to determine the nature and physical characteristics of soil and soil profile for design of the embankment.

(ii) to determine the salt content in the soil in areas known to have problems or where the composition of the design crust requires such testing.

(iii) to determine proper method(s) of handling soils

(iv) to classify earthwork involved into various categories such as rock excavation, earthwork in hard soil etc.

(v) to gather general information regarding sub-soil water level and flooding.

(vi) to locate sources for aggregate required for ballast and concrete and to ascertain their suitability for use.

(vii) To locate a source of good quality water suitable for use in construction.

f) Study of Available Information

(i) Soil and materials survey should include the study of all available information such as geological maps, data published by various authorities regarding the availability of suitable construction materials and information available with groundwater authorities regarding the depth of the water table. Soil maps prepared by the local agricultural department and records of existing highways may also provide useful information. A study of these data, if available, will be of great help in the planning and conduct of further surveys and investigations. This information should be perused in conjunction with general information gathered during the feasibility study.

(ii) After studying the available information, a detailed programme of survey can be drawn up. Points needing attention during a detailed soil survey are highlighted further on.

g) Soil Investigations for Low Embankments

(i) The first operation in the detailed soil survey is to demarcate the possible borrow areas.

(ii) The general character of material excavated from test pits should be recorded and tests conducted on it in the laboratory for required properties. Where the type of material varies in a single pit, the tests should be conducted on each type of soil separately and the horizon of occurrence noted. Similar tests as listed below should be carried out on material from cuts for ascertaining the suitability of its use in the embankment.

i. Gradation test (IS: 2720 Part IV)

ii. Liquid limit and Plastic limit (IS: 2720 Part V)

iii. Density and optimum moisture content (IS:2720 Part VII or Part VIII as relevant)

iv. Deleterious constituents (only in salt-infested areas or where presence of salt is suspected) (IS: 2720 Part XXVII).

However, in the case of highly plastic, poorly draining and unstable soils, some additional soil tests (e.g. shrinkage limit test) may also need to be performed before accepting the borrow.

h) Special Investigations for High Embankments

The basic objective of investigations in such cases is to obtain engineering data for soil and

rock necessary for a quantitative design of embankment at the chosen sites. Generally, for checking stability against slip failures, the basic properties to be investigated are shear parameters, unit weight and moisture conditions.

i) Soil Investigations for Cuttings

In the same manner as described in the preceding paras for embankment material, soil in cut sections along the center line of the proposed Railway alignment at an elevation corresponding to the design subgrade level should be tested for the following general properties:

(i) Gradation

(ii) Atterberg limits

(iii) Field density and moisture content

(iv) Proctor density.

j) Special Investigations in Landslide-Prone Areas

Information collected during the feasibility study would normally identify the landslide prone areas along the alignment and every effort would have been made to avoid these while fixing the center line of the proposed Railway alignment. However, in cases where the same is not feasible, further investigations would be required to study the extent of the problem and plan appropriate remedial measures. For this purpose, the services of a geologist or soil specialist may often be needed.

k) Geological Investigations

Before starting the work, particularly in hilly terrain, geological investigations are required to find out the location of various thrusts/faults if any, coming in the proposed alignment. Such surveys are being done by the Geological Survey of India (GSI) and other Govt/Pvt agencies. The study of underground sub-structures is most important for the design & construction of tunnels. Avalanche prone areas are also required to be identified in snow-clad mountains. Snow & Avalanche Study Establishment (SASE), Chandigarh/Manali conducts avalanche studies.

l) Hydrological Studies for Important Rivers

Hydrological studies may also be conducted to find out the design discharge, highest flood level (HFL), lowest water level (LWL), afflux, free board, scour depth and waterway requirement for important rivers that are required to be passed by alignment. RDSO guidelines should be followed for conducting hydrological studies.

m) Other Relevant Legislation

These should be also considered during the survey

(i) Environmental (protection) Act, 1986

(ii) Wildlife (Protection) Act, 1972

(iii) Forest (Conservation) Act, 1980

(iv) Water (Prevention and control of pollution) Act, 1981 (amended 1987)

(v) Air (Prevention and control of pollution) Act, 1981 (amended 1987)

(vi) Coastal Zone Regulation

n) Preparation of Maps & Drawings

After collecting all details from the site, the following detailed drawings are prepared as per provisions of IR code for Engineering Department.

(i) General Map of the country traversed by project scale about 25 Km to 1 cm.

(ii) Index Map, scale about 2.5 Km to 1 cm.

(iii) Index Plan and Sections.

(iv) Detailed Plans and Sections.

(v) Plans and Cross Section.

(vi) Plans of Station Yards.

(vii) Detailed Drawings of Structures.

(viii) Plans of Junction Arrangements.

(ix) OHE and substation plan in electrified territory.

o) Engineering Annexures

Engineering Annexures as described below are prepared in formats prescribed in IR Engineering Code:

(i) List of Gradient

(ii) List of Curves

(iii) List of ROBs/RUBs/LHS

(iv) List of Stations and Station sites

(v) List of Station Machinery

(vi) List of quarters

(vii) Land details showing the area of land to be acquired, the type of land Rural/Urban/ Agriculture/ Forest land etc.

(viii) Estimate for Earthwork/Blanket

(ix) List of Electric & telephone crossings

(x) List of Bridges indicating their size, waterway, depth and type of foundation.

(xi) List of major Bridges

(xii) List of tunnels

p) Preparation of Detailed Engineering Estimate

Project cost is prepared as per formats available in the IR Code for Engineering Department. This includes the cost of Civil Engineering, Electrical, TRD and S&T works required in the project.

q) Financial and Economic Appraisal:

(i) Financial Internal Rate of Return (FIRR) of the project is to be calculated based on various inputs like traffic, earnings etc. For calculation of FIRR, Railway Board's Circular No.2023/Gatishakti /TF/02 Dated 14.09.2023 **(Ref. 1.03)** or any revised guidelines issued subsequently has to be followed.

(ii) Economic Internal Rate of Return (EIRR) of the project is to be calculated based on economic cost and economic benefits. For calculation of EIRR Railway Board's

Circular No.2022/Gatishakti/EU/49 Dated 19.08.2022 **(Ref. 1.04)** or any revised guidelines issued subsequently has to be followed.

r) Detailed Project Report (DPR)

A Detailed Project Report is prepared after the Final Location Survey as per the Railway Board's Letter No. 2022/W-I/Gen/DPR proforma dated 02.09.2022 **(Ref. 1.06)** or as per any revised guidelines. The DPR has to be prepared in two volumes:

(i) Volume-I of DPR should contain:

Chapter-1	Executive summary
Chapter-2	Traffic Survey
Chapter-3	Engineering Survey
Chapter-4	Land Requirement
Chapter-5	Permanent way
Chapter-6	Formation, Tunnels & Bridges
Chapter-7	Station & Yards
Chapter-8	Service Buildings
Chapter-9	Residential Buildings
Chapter-10	Shifting of Utilities
Chapter-11	Electrical Traction & General
Chapter-12	Signal & Telecommunication
Chapter-13	Environmental Assessment & Social Impact Assessment
Chapter-14	Statutory Clearances
Chapter-15	Cost Estimates
Chapter-16	Traffic Earning Projections
Chapter-17	Non Fare Revenue
Chapter-18	Financial Analysis
Chapter-19	Economic Analysis
Chapter-20	Risk Analysis

(ii) Volume-II should contain a detailed estimate of project as the per IR Engineering code.

Detailed Project Report (DPR) is submitted to the Railway Board with a covering letter signed by SAG and the above officer. The covering letter should contain the following details, brief details and justification of the project; Pink book reference/ FLS reference; table showing total cost and department wise cost; basis of rates and certification about estimated cost at current price level; validation of alignment on BISAG-N portal; completion period; summary of projected freight and passenger traffic, projected earning, FIRR & EIRR and mention about finance concurrence and approval of GM.

(iii) A short video film of the project alignment & salient features, documentation/ presentation on area approach based on PM Gatishakti framework [Rly. Board letter No. 2021/W-I/Genl/Gatishakti (E-3378115) dt. 24.08.2023 **(Ref. 1.07)**].

105 MODERN SURVEYING

Revolutionary changes have taken place in the last few years in the field of topographical surveying. With rapid advancement in technology like GNSS (Global Navigation Satellite System), LiDAR (Light Detection and Ranging), and Aerial Photogrammetry from aircraft/ UAV (Unmanned Aerial Vehicle) etc., there has been drastic improvement in the manner of determining dimensions and contour of the Earth's surface. Sophisticated equipment like the total station & digital auto level has made the traversing & levelling much faster & more accurate. The use of seismic & electromagnetic waves (geophysical survey) to interpret the lithology of the area has vastly increased the pace & reduced the cost of survey & design works by reducing the need for geotechnical investigation.

Similarly, there are a lot of Modern Surveying advancements and a few of them are listed below for guidance purpose:

SN	Modern Surveying Advancements
1.	Digital Elevation Model (DEM) and High-Resolution Satellite Imagery: Ground control Points are identified qualitatively on raw satellite images. Which is further used in the GNSS survey.
2	GNSS (Global Navigational Satellite System) Survey: This is done to measure X&Y coordinates very precisely.
3	Remote sensing studies: These studies help to interpret vegetation type, lithology, alluvial plains etc. Moreover, 3D stereo features reflect the features of terrain, lineaments/ fractures, slope, aspect, drainage pattern, geohazards etc. and this data is very helpful for selection of railway route. Remote sensing analysis is done in GIS software like ERDAS LPS, ARCGIS, QGIS, PCI Geomatica etc.
4	LiDAR (Light Detection and Ranging): LiDAR uses light in the form of a pulsed laser/ point cloud to measure distance to the Earth from LiDAR equipment. These light pulses combined with other GPS data recorded by the airborne/terrestrial system generate precise, three-dimensional information about the shape of the Earth and its surface characteristics.
5	Unmanned Aerial Vehicle (UAV)/ Drone survey: Drone surveys have a number of applications these days like surveillance, Forestry management and planning, Flood modeling, Pollution modeling, Urban planning, Coastline management, Oil and gas exploration, Archaeology etc.
6	Pre-Assessment of the geology using GIS maps and the Bhukosh website.
7	Geophysical Survey: This is a non-destructive, indirect, cheap and quick technique carried out to measure physical properties of medium for subsurface characterization, groundwater conditions, geological structures etc. The results of geophysical survey can later be verified by doing geotechnical investigations.
8	Hydraulic studies:
a)	Modelling by HEC-RAS (Hydrological Engineering Center – River Analysis System) for hydraulic modeling of the river reach to estimate water surface profiles for various return periods.
b)	Graphic Modeler Software for Assessment of Catchment Area Properties: For calculating "Design Discharge" for any Bridge location, can be utilized for assessment of catchment area properties using GIS techniques.

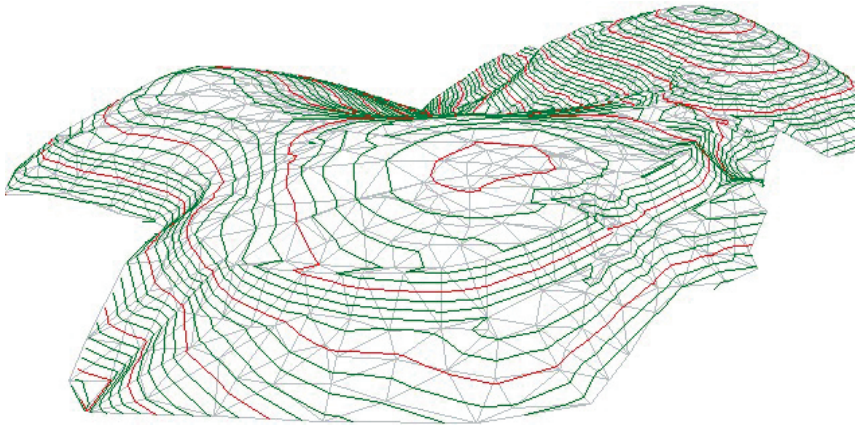
c)	Design Discharge Calculation using Flood Estimation Reports of CWC: The catchment area properties obtained above through GIS techniques have to be utilized for feeding in Excel Sheets for Calculating "Design Discharge", for all the hydrometeorological Zones of India. For details visit IRICEN's website.

106 DESIGN OF ALIGNMENT

The design of alignment is the most important output of all survey procedures. It is the most preferable route between two obligatory points considering all the terms of reference. The shortest path is the direct straight connection, but due to topographical, strategic, commercial and geological constraints, alignment deviation is done with the help of the introduction of curves. The first step while designing the alignment is the marking of all the obligatory points (locations which are mandatory to connect) on Google Earth or Orthophotos. The minimum distance requirement between two obligatory points (stations) is calculated based on their elevation difference & ruling the gradient on the section. If the crow fly distance is more than the calculated distance based on gradient requirement, then crow fly distance is the minimum distance between two stations. On the basis of varying terrain, it can be divided into a number of sections if needed. The obstructions in the form of natural & manmade features are avoided by the introduction of permissible curves. The viaducts & tunnels are introduced at the required locations. All possible efforts should be made to design the alignment along the contours to have a minimum cut/fill along the alignment. Large viaducts, long tunnels and geologically unstable areas/ geohazards should be avoided as far as possible. A minimum three alignments should be studied before the finalization of route based on the technical parameters such as Gradient, Degree of Curve etc. and later most appropriate alignment is decided. The important items to keep in mind while designing of alignments are the following:

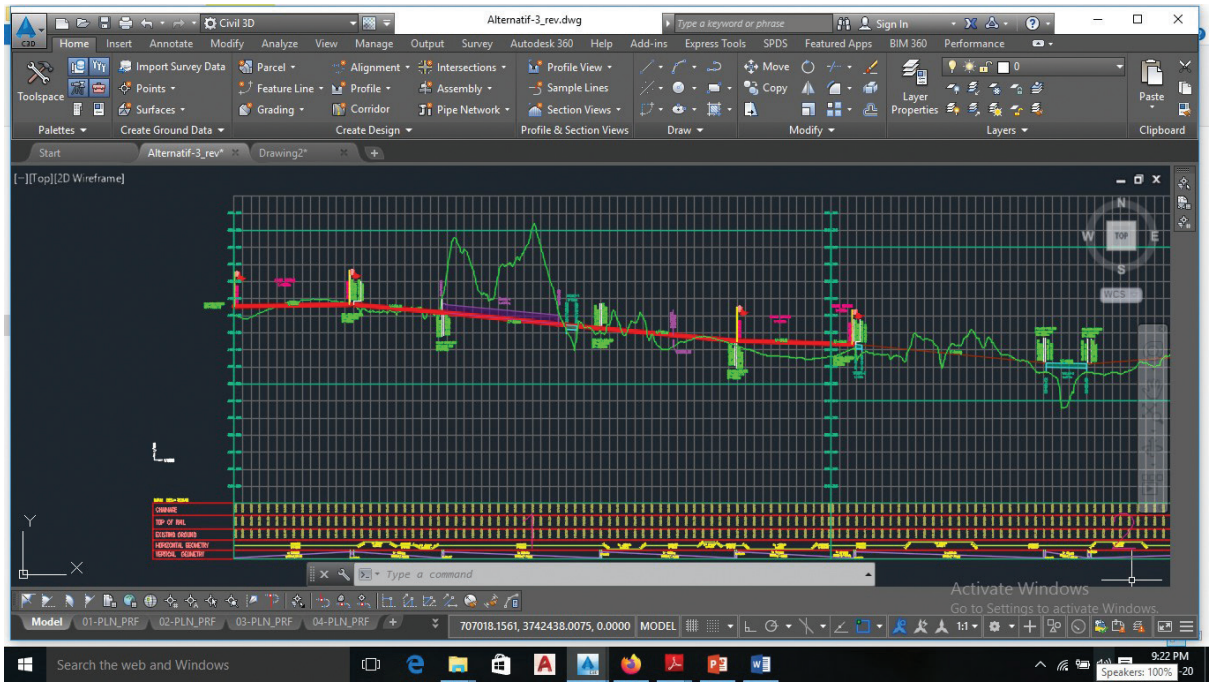
(1) Minimum Cut and Fill
(2) Tunnel Length (in case of Hilly Terrain)
(3) Habitation
(4) Bridge Length and Height
(5) Safety and Comfort
(6) Accessibility for ease of construction
(7) Geological Constraints
(8) Environmental Impact

All the different alignment alternatives are designed in software like, AutoCAD Civil 3D, Bentley Open Rail etc. Horizontal curvatures are first set at required locations by keeping orthophotos/ Google Earth in the background. Thereafter profile is created by generating 3D surface in software with the help of Contour data or DEM or directly through the topographical survey data. The alignment is modified accordingly to minimize the cut/fill, tunnel length, bridge length/height and suitable locations of station yards.



Surface Image created in AutoCAD

The final grade lines are then marked for all alignment alternatives and cross-sections are generated at the required interval. Earthwork quantity is also calculated directly through the software.



Profile View

107 NATIONAL MASTER PLAN & UTILIZATION OF BISAG-N PORTAL

PM Gati Shakti National Master Plan has been developed as a Digital Master Planning tool by BISAG-N (Bhaskaracharya National Institute for Space Applications and Geoinformatics) and has been prepared in dynamic Geographic Information System (GIS) platform wherein data on specific action plans of all the Ministries/Departments have been incorporated within a comprehensive database. Dynamic mapping of all infrastructure projects with real-time updation will be provided by way of a map developed by BISAG-N. The map will be built on open-source technologies and hosted securely on Meghraj i.e. GOI cloud. It will use Satellite imagery available from ISRO and base maps from the Survey of India.

The digital system is a software where individual Ministries will be given separate user identification (login ids) to update their data on a periodic basis. The data of all the individual Ministries will be integrated into one platform which will be available for planning, review and monitoring. The Logistics Division of Ministry of Commerce will further assist all the stakeholders through BISAG-N in creating and updating their required layers in the system and updating their database through Application Programming Interface (APIs).

The portal developed by BISAG-N will help during the project development process as follows:

(1) **Comprehensiveness:** By including all the existing/ planned initiatives of various Ministries/ Departments covering various Infrastructure Ministries and Ministries involved in the development of Economic Zones with 200+ layers with 01 centralized portal providing visibility to all the stakeholders. For example, the implementation agency of Railways may not know the upcoming projects of other Departments like irrigation, roads, economic zones, industrial clusters etc. Through this plan, each & every Department will now have visibility of each other's activities providing critical data while planning & executing of projects in a comprehensive manner.

(2) **Prioritization:** By enabling different departments to prioritize their projects through cross – sectoral interactions. This prioritization will help industries of these zones to get better connectivity for sourcing the raw material/labour and evacuation of their final product. Similarly, whenever any economic zone is established in the future, infrastructure connectivity projects can be prioritized by respective departments with the help of this plan to provide timely connectivity.

(3) **Optimization:** By assisting different ministries in planning for modification/ expansion/ new projects after identification of critical gaps. For example, if coal has to be transported from Jabalpur to Mundra Port, the most cost-effective and less time-consuming route of the rail network can now be identified through this plan which will lead to a reduction in the overall logistic cost. This plan will help the Rail Ministries to identify the critical routes for modification, expansion etc. to achieve better efficiencies.

(4) **Analysis:** By providing the entire data in one place with GIS based spatial planning and analytical tools having 200+ layers like land use, existing structures (e.g. bridge, railway crossing, culvert), soil quality, infrastructure (Road, Rail, Waterway etc.), elevation data/3D (contour and gradient), habitation sprawl etc. enabling better visibility to the executing agency. For example, many infrastructure contracts go into litigation as the Detailed Project Report (DPR) of the project does not have complete information about the structures and the likely hindrances etc. in and around the project area. Contractors meet with uncertainties while executing, which delays execution and leads to litigation. This plan provides visibility to users like contractors/agencies to avoide such situations.

108 PROFORMA FOR SUBMISSION OF DETAILED PROJECT REPORT

(i) **Covering letter:** It should contain brief details and justification of the project, Pink Book reference (if included in Pink Book), FLS reference, table showing total cost and department wise cost, basis of rates and certification about estimated cost at current price level, completion period, existing & projected freight and passenger traffic, projected earnings, FIRR & EIRR. Covering letter should also mention about finance concurrence and approval of GM. It should be signed by an officer not

below the SAG level officer;

(ii) **DPR (Vol-I):** The volume I of DPR should contain on Executive summary and chapters on various components as per the Format attached as Annexure-A;

(iii) **DPR (Vol-II):** The Volume-II of DPR should contain a Detailed Estimate of the Project as per Engineering code.

A checklist on Cash Outflows (Construction cost, Working expenses) and Cash Inflow (Traffic earnings and residual value) is also required to be submitted.

Documents related to Internal correspondence and vetting of associate finance of Zonal Railways are not required to be made part of DPR.

Reference Documents

SN	Para No	Ref. document details	
1	101(1), 103	1.01	Setting up of Gati Shakti Units in Divisions Railway Board's Letter No. 2021/W-I/Gen/Gati Shakti dated: 27.07.2022
2	101(2), 102(3)(a), 104	1.02	Fast-tracking the sanction & execution of Projects - Railway Board's L. No. 2021/W-I/Genl./Gati Shakti Dated 28.10.2022
3	102(3)(C)(vi), 104(3)(q)(i)	1.03	Financial Appraisal framework for evaluation of Railway Project - Railway Board's latest Circular No.2023/Gatishakti/TF/02 Dated 14.09.2023
4	102(3)(C)(vi), 104(3)(q)(ii)	1.04	Economic appraisal framework for evaluation of Railway Projects - Railway Board's latest Circular No.2022/Gatishakti/EU/49 Dated 19.08.2022
5	104	1.05	Proposals for sanction of Final Location Survey (FLS) 2021/W-I/Genl./Gatishakti Pt. 3 dt.31.07.2023
6	104(3)(r)	1.06	Proforma for preparation and submission for DPR for NL/MT/GC - Railway Board's Letter No. 2022/W-I/Gen/DPR Proforma dated 02.09.2022
7	104(3)(r)(iii)	1.07	Development of a short video by project Proponent on the Proposed Project 2021/W-I/Genl./Gatishakti (E-3378115) dt. 24.08.2023
8	…….	1.08	CAO Conference on the subject "Efficient Project Management" on 22.04.2023 2023/Gatishakti/Genl./CAO/Conf. dt.29.05.2023
9	……	1.09	Fast-tracking the execution of Projects No.2023/W-I/Genl./CAO/C/Conference.Pt.7 dt. 16.03.2023

***

CHAPTER 2
PROJECT PLANNING

Since Indian Railway is planning to execute large number of construction projects for capacity augmentation, it is essential to adopt appropriate project management structure, execution methodology, project financing and disputes resolution mechanism to ensure commissioning of projects without cost and time overrun. Like other infrastructure sectors in India, IR's projects also suffer from cost and time overruns, improper project planning being one of the contributory factors.

201 STANDARDS OF CONSTRUCTION - POINTS FOR CONSIDERATION

(1) Speed Potential

Degree of the curvature should be provided as per latest Railway Board guidelines, speed policy framework of Indian Railways satisfying IRSOD provisions.

As per the current policy on Indian Railways, except for hilly terrain, for all new line construction the track geometry should be planned for the speed of 160 kmph with limiting degree of curvature of 1 degree and Maximum Permissible Speed (MPS) on opening should be 130 kmph; without any new level crossings. For the Gauge Conversion/multi tracking projects, the minimum MPS should be 130 kmph, with no unmanned level crossings. In hilly regions, decision must be taken on case-to-case basis [Railway Boards letter Nos. 2013/W-1/Genl/0/30 Pt-II dated 04.05.2018 & dated 28.05.2018 **(Ref. 2.01)**; and Railway Board's letter Nos. 2017/Mobility/2/3 dated 12.06.2018 & 2015/W-I/Genl/Corr.GM/Pt.I dated 06.12.2018 **(Ref. 2.02)**].

Any departure from this speed policy framework of Indian Railways, may be done at the level of CAO/C on case to case basis, with a reasoned decision. However, as per Para 405(50 of IRPWM, in case of Doubling and New lines, if a curve is not possible to be designed for 160 Kmph for Group 'A' and 130 Kmph for Group 'B' routes, approval of PCE shall be obtained. Clearance of Plans and Estimates should not be delayed once a decision has been taken in this regard. [Railway Board's letter No. 2015/W-1/Gen/Corr./GM Pt dated 06.12.2018, **(Ref. 2.02)**].

(2) Axle Load

The choice of axle load shall govern the planning for formation, bridge and track as well as rolling stock. The choice should offer better flexibility for running trains with higher axle load and higher pay to tare ratio.

The axle load to be considered for construction of formation in New Line/Doubling and Gauge Conversion projects is 25 T, except for the formation of doubling on the DFC feeder routes where the axle load of 32.5 T has to be considered **[Railway Board's letter No. 2013-W/Genl./0/30/Pt-II dated 18.12.2019 (Ref. 2.03)]**.

(3) Formation and Blanketing

Design of formation and the thickness of the blanketing and other layers should be as per the provision of specification for Railway formation issued by RDSO (Specification No. RDSO/2020/GE:IRS-0004, September'2020) for the given axle load. Soil source(s) shall be explored during

the survey. As formation design will primarily depend upon the type of the soil being used in construction, it is essential that soil classification and assessment of requisite properties is done during soil exploration.

In the areas having weak sub-soil, as per the criteria given in the RDSO Specification No. RDSO/2020/GE:IRS-0004, September'2020, then suitably designed Ground Improvement should be implemented as part of embankment work, before starting the track works. The time required for the ground improvement should be accounted for in the construction scheduling.

Integration with existing Railway network is also an important requirement. Therefore, whatever axle load is adopted after due consideration, it should be uniform for the entire corridor i.e. formation, bridges, rolling stock etc.

(4) Bridges

While deciding GAD of the bridges being planned for doubling/3rd line etc., the following may be ensured in order to avoid excessive scour:

(i) The piers of new abridge are in alignment of the piers of the existing bridge. The span arrangement should be decided in such a way that there is free flow of water through spans of old bridge and there is no staggering of piers in water flow area.

(ii) There should be adequate distance between new bridge and old bridge.

[Railway Board letter no. 2017/29/CE-III/BR/Br 588/ECoR dated 03.08.2017**(Ref. 2.04)]**.

Formation with high embankment shall normally be avoided. In case of very high embankment say 15-20m height, a techno-economical study shall be carried out to decide whether a viaduct or high embankment is to be provided.

(5) Over-head Structures

The overhead structures are to be designed, keeping in view the double stack container traffic movement as per the IRSOD on indentified routs

In case of electrification of single line or 3rd line in case of three lines, provision of additional line should be kept in mind while executing the electrification project. Thus, alignment of future doubling and yard plans for this should be prepared and approved in advance. Further layout of OHE for electrification project should be decided based on these approved plans and alignment [Railway Board's letter No. 2017/W/-I/Genl./NL-RE dated 27.01.2017, **(Ref.2.05)**].

(6) Level Crossings and ROB/RUB works:

Railway Boards Ltr. no. 2021/W-I/Genl/Gatishakti (e-3378115) dt. 18.08.2023 **(Ref 2.06)** shall be followed. The details of letter are as under -

i. New Line Project:- No Level crossing shall be planned in a New Line Project.

ii. Doubling/Multi-tracking Project:- Existing LCs may be planned for elimination with ROB/RUB if project viability is not affected i.e. FIRR remains above hurdle rate of 10%. Otherwise, elimination of balance LCs should be planned under PH-30 (ROB/RUB works).

iii. Gauge Conversion Project:- As these projects are sanctioned under Uni-gauge policy, all LCs may be planned for elimination with ROB/RUB. However, RUBs shall be planned only when no substantial increase in earthwork is involved. Otherwise, ROBs can be planned based on cost benefit analysis.

iv. **For ongoing projects:** ROB/RUB can be provided to eliminate level crossings by revising the estimate of the ongoing project, if the formation level permits its construction without any substantial raising or lowering, else these ROB/RUBs can be sanctioned separately under PH-30. Such revision in estimate shall not be treated as material modification.

v. Elimination of Level Crossing shall not be linked with commissioning of doubling/ multi tracking.

vi. For level crossing already located within busy station yards affecting Railway operations and causing heavy detention to the road traffic, efforts should be made to replace them by Road Over/Under Bridges as per extant rules or shift them outside the outermost facing point.

vii. Problem of drainage and construction methodology for LHS/RUBs should be properly studied and addressed at planning stage.

In order to improve train operations and increase mobility, it is envisaged to eliminate LC on Indian Railways. In this reference, Railway Board has issued a policy for Road Crossing Works (ROB/RUB/LHS/FOB/Subway) to eliminated LCs. Reference Railway Board letter no. 2017/CE-IV/LX/Misc./244 (LCs) Pt. Dt. 02.03.2023 **(Ref. 2.14)**

The detailed project reports (DPR) of projects should be prepared accordingly.

(7) Track Center and Geometry of Track

Minimum distance between the tracks should be as per the latest instructions issued by Railway Board, keeping in view provisions of Indian Railways Schedule of Dimensions (IRSOD). It should be ensured that reverse curves are avoided in the vicinity of bridges (at least up to 100m on either side of bridges).

The Centre line distance between the tracks is directly linked to extent of land acquisition and has direct bearing on the cost of the project as well the time frame for the completion of the project. In case of Doubling or 3rd/4th line projects, existing utilities (OHE masts/portals etc.) also guide the decision of track distance for additional tracks. Existing ROBs, FOBs, OHE installations, existing major bridges or abandoned substructure of major bridges and many other obligatory points have to be considered with due diligence to arrive at most optimum track center distance in case of Doubling/Tripling/Quadrupling projects.

(8) Distance between Stations

It will be desirable if stations are located at a distance as per operational requirement, in New Line project. Innovative solutions for relief during emergencies and totally mechanized maintenance practices may have to be examined in detail before deciding the distance. In doubling, Intermediate Block Station (IBS)/ Intermediate Block Hut (IBH) may be planned to reduce block section if passenger's requirement or provision of loop lines are not foremost considerations.

In 3rd/4th line projects, integration with existing network should be planned after 3-4 stations (i.e. 30-40 km apart), to avoid large scale yard remodeling. Any exception to this may require approval of Railway Board [Railway Board's letter nos. 2013/PL/19/1 (Policy) dated 05.07.2018 and 2018/W-I/Genl/Policy dated 04.09.2018 and Railway Board letter no. letter no. 2023/W-I/Gel/CAO/C/Conference.Pt.7 dt. 16.03.2023 **(Ref. 2.07)]**.

(a) Permanent Structures, Platforms and Passenger Amenities

Platform and other passenger amenities to be provided while executing NL, DL or GC project should be as per the norms of the minimum essential passenger amenities. High level platforms and FOBs are now part of Minimum Essential Amenities (MEAs) on all categories of stations, as per the comprehensive instructions for provision of Passenger Amenities and user facilities at Stations issued through Railway Board's letter no. 2018/ LM(PA) 03/06 dated 09.04.2018 **(Ref. 2.08)**.

For new lines, gauge conversion and multi-tracking projects, high level platforms should be restricted to the length of longest stopping coaching train at that station and remaining portion of platform should be at rail level to accommodate 26 coach train. All loop lines should be of full length of required Clear Standing Room (CSR) and the rail level platform provided for 26 coach length should have the required technical clearance ie. OHE mart for upgradation as high level as and when required. [Railway Board's letter No. 2013/W-I/Genl./0/30/Pt-II dated 25.02.2020 **(Ref. 2.09)]**.

All the fixed structures such as gate lodges, station buildings or other permanent structures should be planned keeping provision for future doubling/quadrupling, yard remodeling etc. in view to avoid dismantling of any of these structures in future. Gate lodges should be provided in staggered manner keeping the sufficient setback distance wherever new gate lodges are being constructed while executing Doubling projects. Wherever it is not possible to adhere to the above instructions, approval of PCE or CAO(C) shall be obtained [Railway Board's letter no. 2013/W-1/Genl/0/30 Pt.-II dated 12.05.2017 **(Ref. 2.10)**].

(9) Rail Section and Sleepers

It will be as per the route classification, axle load and latest instruction of Railway Board. However, 60 kg UIC 90 UTS Rails and wider base PSC sleeper with sleeper density of 1660 PSC is the minimum requirement presently.

(10) Ruling Gradient: In view of heavy haul trains, as far as possible the ruling gradient of 1 in 150 shall be provided. However, the terrain through which alignment is passing will be the deciding factor.

(11) Mode of Traction

As per extant instructions, all New Line, Doubling and Gauge Conversion Projects are to be executed with electrification, with 2x25 kV AC OHE system [Railway Board letter No. 2022/ RE/161/4 dt. 27.05.2022 **(Ref. 2.11)**].

202 GOOD PRACTICES TO BE FOLLOWED DURING PROJECT PLANNING AND EXECUTION

(1) Alignment of New line and gauge conversion projects shall be finalized keeping in view of the future line (2nd and 3rd line) i.e. optimal use of available land to be done.

(2) In new line/Gauge conversion projects, important bridges shall be constructed with foundation and substructure for two lines.

(3) In new line/Gauge conversion projects, major bridges shall be constructed with foundation and substructure for two lines.

(4) In new line project/ Gauge conversion, Limited height Subways (LHS)/RUBs/RCC Boxes shall

be constructed for two lines. In case of slab or girder are used for superstructure, substructure shall be constructed for two lines.

(5) While planning & executing multi-tracking project, shifting of OHE portal shall be avoided since it is very critical and time taking process. The track alignment shall be finalized keeping in view this crucial aspect.

(6) Doubling work shall be carried out in phases. In first phase, station yards shall be connected at every 3rd or 4th stations and doubling shall be commissioned. In the second phase remaining stations yards may be commissioned.

(7) In all EPC tender suitable clause may be provided for using superstructure of all bridges as well as RCC boxes as per RDSO standard drawings. This will avoid unnecessary delay in design approval. Standard superstructures will help in maintenance of superstructure.

(8) As far as possible the reverse curves due to change in track centres shall be avoided. The track centre shall be planned such that the alignment can be merged with the nearest normal curve. However, such decision shall be taken considering overall economy of the project i.e. such high track centre can be for small stretches only and not for kilometer together.

(9) OHE portals shall be planned in such way that the isolation of individual lines is possible. This will help in carrying out various maintenance activities for individual lines instead of taking block for all lines which are supported over OHE portals.

(10) As far as possible standard layouts of yards as per Railway Board letter no. 2015/Sig/WG/ Standard layout dt. 12.07.2017 **(Ref. 2.12)** shall be used.

203 PLANNING AND EXECUTION STRATEGY - POINTS FOR CONSIDERATION

(1) Magnitude of work involved viz.:

a) Land acquisition
b) Formation and Blanketing material Requirement
c) Ballast Requirement
d) Rails
e) Sleepers
f) No. of level crossings and ROBs/RUBs/LHSs
g) Number of Bridges/Linear waterway
h) Value of contracts excluding cost of Rails

(2) Project Strategy

Project completion period should be meticulously decided, keeping in view the quantum of work, availability of construction agencies and other administrative requirements.

(3) Detailed Project Planning

Planning is the most critical activity for any project. It is said that “well begun is half done”. Considerable importance should be attached to this aspect. Planning comprises of many aspects as elaborated below:

(A) Creation of Organisation Railway Board issues yardstick for Gazetted staff on yearly basis. Based on this yardstick, the organisation shall be decided.

Manpower has to be decided based on the size of the project. More emphasis will be put

on laying down systems and documentation rather than round the clock supervision.

In view of shortage of departmental manpower, various types of consultancy services can be engaged as per Railway Board's letter No. 2023/CE-I/CT/1/Policy dated 15.03.2023 **(Ref. 2.13)**.

- **Project Management Services (PMS)** can be deployed for supervision of EPC contracts.
- **Project Supervision services (PSS)** can be employed for supervision of non-EPC contracts and for hiring manpower for other technical services like site supervisors, draftsmen etc.
- **General Consultants (GC)** can be used for office support where manpower of adequate skills is not available with the project unit. GC is not project specific and GC can be used for activities like examination of DPRs by other consultants, preparation of estimates & tender schedules, assistance in pre-bid meetings & their responses, preparation of brief for the tender committee, examination of contract agreements, assistance in giving response to references by contractors/consultants, assistance in arbitrations, preparation of periodical reports & presentations, progress review & suggesting necessary interventions, assistance in various compliances, suggesting economy measures etc.
- **Detailed Design Consultants (DDC)** can be employed for design support wherever sufficient manpower with design/drawing skills is not available. DDCs may also be engaged by a project unit for a specific project requiring special design competence.
- Retired personnel can be re-engaged and technical personnel can be engaged on contract basis for sites not covered by any PMS/PSS or in office if GC/DDC is not available. They may also be used as a back-up whenever there is a sudden failure of PMS/PSS/GC/DDC.
- While engaging any of these agencies, care must be taken to avoid conflict of interest between various agencies and overall cost should be contained within the D&G charges available on the Railway.

(B) Survey

This aspect has been covered in detail in the chapter on Survey. However, following aspects should be kept in mind at the time of survey:

(i) Identification of the source(s) for ballast, blanketing material and material for other layers in formation.

(ii) Identification of utilities and structures that need to be shifted or dismantled.

(iii) Rate Analysis for various items of execution regarding their source(s).

(iv) Geotechnical studies at bridge, high embankment locations, tunnels, deep cuttings etc.

(C) Experience of NHAI, State PWD etc.

NHAI, State PWD etc. are executing almost similar works with similar spread and quantum nowadays. Their experience in acquisition of land, fixing of various types of contracts with high value, its success/failures, experience with the consultants, disputes likely to arise during execution, availability of construction material and agencies, should

be collected as this can serve the best benchmark for optimizing our performance in planning and execution and avoiding the pit-falls they have faced.

(D) Acquisition of Land, Forest and wild life clearances

This is the most critical and time-consuming activity as land acquisition is spread over many states/districts and involves action by multiple authorities. This should be first activity which should be immediately taken up after the project is sanctioned and put on fast track for completion in planning stage. Procedure for Land acquisition has been dealt with, in detail, in the chapter on Land Acquisition.

(E) Detailed Geotechnical/ Seismic/ Hydrological/ Geological studies

These confirmatory studies, to the extent required for all the components of a project, shall be carried out for economic and reliable design of all the components of the project and for realistic estimation of various items of work required during execution of the project.

(F) Design and Drawings

In-house design may or may not be possible for all items. Hence, engaging a consultant can be a better option. However, developing in-house expertise is essential to interact with various consultants to select best available solution. Standard drawings should be followed as far as possible, to expedite pace of execution. All GADs must be finalized in advance and should be available before calling of tenders. GADs of minor and major bridges other than canal and road crossings can be included in EPC tender.

(G) Tender Packaging

Tender Packaging is decided on the basis of the policy instructions in vogue, type of the work, time required for completion, cost, in-house experience and expertise availability besides availability of the contractors for the job to be executed.

Tenders can be of two types:

(i) EPC Contracts

EPC (Engineering, Procurement and Construction) contract, is a design and built contract where the lump sum project cost is indicated and the payment is scheduled on the pro-rata basis according to the predefined milestones to be achieved. The risk of construction and drawings largely shifts to the contractor from Railways whereas Railways guarantees the availability of right of way, forest and other statutory clearances before undertaking the project.

As per the current instructions of Railway Board, all new line, doubling, important colonies work, important bridges etc. should be undertaken through EPC mode only and any deviation from this requires the personal approval of GM.

(ii) Item Rate Contracts

In these types of contracts, detailed design and drawings are prepared in advance and contractors are asked to quote the rates. The rates may be quoted as % age above or below the base rate for the schedule as a whole or alternatively, the rates may be asked for each item of the work.

(H) Breaking down of project in workable units/fixing of Zone length

The Zone length/value should be fixed keeping in mind the type of work, availability of

reliable, competent & experienced contractors having expertise of site management, supervision and other logistics. It will be desirable to decide length/reach in such a manner that normally all works in that reach are executed by the same contractor. The value and scope of contract must be fixed very judiciously for achieving the objective of getting reliable, competent contractors who can complete the job in time.

If there is likelihood of participation from competent contractual agencies, composite contracts can be planned, for a judiciously decided section length, for all the works required to commission the section (i.e., earthwork, bridge works, buildings, passenger amenities works, ballast, track works, general electrical works, electrical TRD works, S & T works etc.). Otherwise, item-rate contracts can be planned for various items of works as under:

(i) One package for combined work of earthwork, bridges/ROB/RUBs, blanketing, all buildings (station buildings, relay huts, level crossing structures etc.).

(ii) One contract to be planned for P. Way work covering linking of track, welding of rails, putting of ballast and bringing track to the final geometry etc.

(iii) One contract for supply of ballast.

(iv) One contract each for S&T and another for Electrical (General) and Electrical (TRD).

Alternatively, P. Way works and ballast supply can be part of formation works at Sl. No. (i) above.

(I) Fixing of Contracts

(i) Eligibility / qualification criteria

(ii) Defining work of similar nature

(iii) Availability of experienced and reliable agencies in that field

(iv) Time for completion

(v) Two packet System

The aspects detailed above, regarding tenders and contracts, are discussed in detail in the chapter on Tenders and Contracts.

204 QUALITY CONTROL AND ASSURANCE

Quality control and assurance means execution of each specific component of the project (i.e. earthwork, blanketing, ballast, track laying, RCC, building work etc.) in time bound and recursive manner, complying with laid down quality standards and identifying ways to eliminate cause(s) of unsatisfactory performance.

Contract document must mention clear, complete, and accurate description of the standards and specifications to be followed for each component of the project, facilities to be developed by agencies either in the project area or through the third party and the documentation to be ensured and preserved while undertaking the inspections and tests for each component.

For having an effective and well-documented quality control and assurance plan, following basic elements of a Quality Control and Assurance Plan must be adhered to:

(1) Quality Control Organization

There must be a well-structured organizational set-up, both from the Railways and the agency

side, to undertake various inspections and conduct tests. Personnel engaged by the agency for undertaking the quality control should be qualified (such qualification should be part of the tender document). Duties and responsibilities of such personnel should be well-defined in QAP. Training may be imparted to engineers of various stakeholders to ensure the quality of construction.

(2) Quality Assurance Plan

Onus for proving quality work done rests with the contractor i.e. contractor will be required to prove and establish with the help of the documentation of various tests, procedures etc. that quality work has been done. There should be a well-documented quality audit plan comprising of:

(a) Standards, Specifications and Method Statement for each component of the Project.

(b) Inspection and Test Plan for all test/inspections to be done.

(c) Check lists to undertake Inspections and Tests duly mentioning the limits and tolerances for each parameter.

(d) Undertaking Field inspections and Tests: Series of inspections on each component of the project should be undertaken as per the protocol mentioned in QAP duly following the relevant codes and specifications. For undertaking each inspection, check list should be prepared as part of QAP.

(e) Quality Documentation and Audit: Each test carried out as per QAP should be audited to ensure that non-compliance is ruled out. Each test should be well documented to create and audit trail for future references.

(f) Availability of all relevant codes and manuals.

(g) Training of all officers and staff associated with the Project.

205 PROJECT MONITORING AND CONTROL

Project Monitoring includes observing and checking the progress of the project to ensure compliance with project scope, timeline, and deliverables and schedules whereas Project Control is measuring such progress by comparing actual progress with project plans and schedules and taking corrective action as required. Each project involves many uncertainties viz. availability of labour, machinery, monsoon, right of way, budget etc. Project Monitoring and Control thus becomes an important aspect of construction management. For ensuring the effective project monitoring and control, following aspects are important:

(1) Objective of the project and each component of the project defining specific and measurable goals.

(2) Schedule for the start and the end of each goal to be defined for every component of the project.

(3) Sequencing: Each component of the project should have a defined sequence of execution correlating it with previous, forthcoming or parallel activities.

(4) Size and Nature of Task: Clearly defining the task in terms of the measurable units like cum, m, days etc.

(5) Resources: Requirement of resources in terms of Money, Manpower and machinery for successful execution of each goal.

(6) Controlling Cash flow: Controlling the cash flow for the execution including maintaining a healthy billing cycle.

(7) Information and Control Systems: Well-established system should be in place to relay the information of progress in terms of the measurable units, expenditure incurred, constraints faced etc.

Nowadays, various softwares are available for project monitoring and control which help Project Manager to take a balanced view based on the data provided in terms of aforementioned seven points. Most of these tools analyze the project in terms of CPM or PERT and produce GANTT or BAR chart for easy appreciation and monitoring of the project. These software help in developing a proper project scheduling and monitoring thus guiding on resource deployment schedule and optimization to achieve the desired task. Use of the project monitoring tools also helps in avoiding the clash between various activities and helps the manager to take balanced decisions. Such tools thus prove cost effective by avoiding rework and optimizing the available resources.

Project Monitoring also involves preparation of Cash Flow chart, details of interfacing requirements of drawing, design, interaction with other departments/division, fixing and ensuring bill cycle in consultation with contractor, monthly presentation on project execution by top management of the contractor, availability and scheduling of resources viz., men, machinery & material and prompt decision on technical/design issues cropping up during execution.

GANTT and BAR charts: are basically two-dimensional charts depicting activity on Y axis and time on X axis, thus giving a most simplistic overview of the progress of each activity vs stipulated progress. Based on these charts, resource planning and augmentation can be done to achieve the stipulated progress of various activities.

TILOS (Time Location System) is a linear scheduling software. It has project management functions like structuring construction activities, schedule costs and resources, import and export data from one project management system to other system. It also has time -distance functions like display site plans & graphics on distance axis, cost and resource histogram, making mass haulage diagram etc.

Microsoft Project: It is file based project management software. It supports maximum 11 baselines. It is used to create schedules, project plans, assign resources to tasks, tracking the progress, managing the budget. It helps in report generation, resource tracking and management. Multiple users cannot use it on real-time basis.

Oracle Primavera: It is a web-based project management software. It supports unlimited baselines. It is used to create schedules, project plans, assign resources to tasks, tracking the progress, managing the budget. It helps in report generation, resource tracking and management. Multiple users can use it on real-time basis.

206 CONTRACTOR MANAGEMENT

(1) Success and timely completion of Project depends upon team-work. Contractor is an important part of team.

(2) Identify bottlenecks in advance which contractor is likely to face ahead of problems not behind.

(3) Cash flow problems with the contractor and its solutions.

(4) Optimization of methodologies and procedures for better out- put.

(5) Decisions to be given to the contractor as early as possible for better management of problems.

(6) Regular meetings with consultants, contractors for corrective inputs at right time.

207 IMPORTANT INGREDIENTS OF A SUCCESSFUL PROJECT EXECUTION SCHEME

(1) Availability of Land

(2) Availability of Fund

(3) Prompt Decision-making, use of standard details

(4) Endeavour to make the contractor successful

(5) Proper documentation for Safety, Quality and Payment

Instructions for smooth execution for doubling projects, in the form of Dos & Don'ts for doubling works, as issued by Northern Railway are given in **Table 2.01** below. This is presented as example only and every Railway may prepare their own Do and Don'ts, based on the instructions in vogue on various aspects and the prevailing site conditions.

Table 2.01
DO's and Don'ts

SN	Activity	DO's	DONT's
1	Survey	1. Fix reference points and benchmarks before start of work. 2. Mark all such points in the field, duly numbered. 3. Ensure indication of such reference benchmark/ points on all the drawings being prepared for the work (Index plan, L-section & Bridge GADs etc.). These shall be noted in diaries/ book of field staff also for ready reference. 4. Carryout survey of area including centre line of all existing tracks, footprint of all structures along with their height using these points. 5. All instruments shall be calibrated at start of work and further got calibrated periodically during the progress of work. 6. Note down all track data including curve data (TP, Super elevation, Degree, Versines etc.), gradient, turnout layout parameters etc. 7. Pick up data of all road/ river/ canals/ drain/ lines etc. crossing the track up to required distance on either side of existing railway track. 8. For existing ROBs, pickup location & size of all piers within railway land and soffit level of spans (with reference to existing tracks).	1. Commence survey work until reference points and bench marks have been established in the field. 2. Disturb reference marks during course of work

		9. For existing RUBs, check availability of span/box provided for future line. If available, note down its location w.r.t. existing track as it will be obligatory point. 10. Note down all utilities crossing the track/ running parallel to track along with their depth (Reduced Level) 11. Collect data of all signals, electrical cables running parallel/ across the track. 12. Note down feasibility of rising/ lowering of track at each such crossing. 13. Carryout survey of all bridges. Note down minimum track centre at which new bridge can be made considering infringement to existing foundations and feasibility. 14. Collect hydraulic data for all bridges from existing records, marking on bridge etc. canal data can be taken from state authorities. 15. Carryout discharge calculation for those bridges for which discharge is not available. 16. Collect data of all bridges in upstream and downstream for all major streams. 17. Prepare detailed survey plan showing all above noted details. 18. Wherever, ROBs have not been proposed/ sanctioned, survey shall be carried out for elimination of level crossings by diversion/ LHS/ RUB. 19. Up gradation of level crossing, whenever justified on TVU, may be planned where RUB/ LHS is not feasible and ROB not sanctioned. 20. Minimum SAG level officer should verify the alignment on site.	
2	Fixing of Alignment	1. Mark all obligatory points on survey plan. 2. Plan new track on side where railway land is available. Attempt to keep track on same side of existing track in long patches to minimize cut connections. 3. Mark location of cut connections. 4. Mark new line at minimum track centre as per schedule of dimensions/ IRPWM/ Engineering code from neatest existing track.	1. Raise the track w.r.t. existing track unless unavoidable. 2. Provide reverse curve unless unavoidable. 3. Provide excess length of loop lines.

		5. Mark proposed track at minimum track centre line on all bridges. Highlight locations where deviation from minimum track centre is unavoidable as per available site data. 6. Reconfirm data for all such locations. 7. Mapping on PM Gatishakti National Master plan- Alignment to be done on PM Gatishakti portal to see if the alignment infringes with any avoidable sectors/locations viz. forest, mines, eco sensitive zones etc., and to make necessary adjustment in alignment, if required. 8. Plan work with sheet pile, if required to avoid reverse curves. 9. Attempt should be made to fix proposed alignment at locations of deviation in alignment without providing reverse curve by shifting curve. 10. Reverse curve, if unavoidable, shall be provided after personal approval of CAO/C, submitting detailed justification and options exercised to avoid the reverse curve. 11. Calculate curve data for all curves along with speed potential. Speed potential shall not be less than proposed sectional speed. 12. Attempt to ease existing curves during doubling work should be made without involving land acquisition, if possible, while fixing new alignment. 13. Mark all turnouts on survey plan. 14. Carryout layout calculations for each layout. 15. In case of Major bridges, if well foundation is planned, minimum distance between centre lines of existing and proposed track shall be D1+D2 (D1 dia. of exists well & D2 dia. of proposed well).	4. Provide turnout in transition of curve.
3	Fixing of Gradient	1. Proposed track shall be planned mostly at same level as for existing track, especially at all level crossings. 2. Deviation may be made at bridges where clearance is less. 3. Deviation in level from existing track, if required and unavoidable, should be done with personal approval of CAO/C submitting full justification	1. Provide turnout in steep gradient / change of gradient violating the SOD

		4. Mark all turnouts in section also to ensure that there is no change of gradient within turnout zone. 5. Whenever, crossovers are provided in curve, speed potential for all lines shall be workout to ensure speed potential of section.	2. Provide crossover in lines at level difference without detailed layout calculations both for layout and gradients.
4	Marking of Alignment	1. Prepare Index plan and L-section Mark all reference points in the drawing. 2. Establish secondary reference points from primary reference points for actual working. 3. Regularly check the working bench mark with reference bench mark as work progresses. 4. Check secondary reference points periodically w.r.t. primary reference point. 5. Arrange safety of survey bench marks & alignment control points by barricading or any other suitable means. 6. Mark layout of centre line of new track with pegs. 7. Carryout foot by foot survey after marking of centre line. 8. Note all infringements/ impediments in the work. 9. Check layout of curves. 10. Revise drawings if required at this stage. 11. Record final feasibility of index plan and L-section at this stage. 12. Proceed with final approved drawings only for marking of layout on ground by providing c/l Pegs. Apex points of curves shall also be marked with permanent pegs.	1. Work from primary reference points for long distances. 2. Start the work before unless foot-by- foot survey has been carried out after marking of centre line.
5	Embankment/ Cutting	1. Survey area for importing of earth for embankment and its quantity and quality. 2. Use good soil in embankment (SQ-2 or SQ-3) 3. Provide turfing of local fast-growing grass/ shrubs/ sarkandas etc. having deep root for protection of embankment against soil erosion. Protection shall be carried out along with progress of earthwork.	1. Use SQ-1 soil in embankment without approval of CAO/C 2. Provide drain walls without approved drawing of HQ

		4. Breast wall shall be provided in cutting in place of retaining wall being economical. 5. Avoid drain between tracks by providing proper cross slope in formation. In curves, attempt shall be made to continue existing cross slope in bank to ensure proper drainage of both tracks. 6. Drain size, wherever provided, shall be finalized based on rainfall and catchment calculations. Drawing of drain (preferably using lining only) shall be prepared and got approved from HQ before execution. 7. Blanketing should be provided to minimum after studying the behavior of existing formation. 8. If SQ1 soil is encountered in formation in cutting, top 300 mm SQ1 soil layer shall be replaced with good earth.	
6	Bridges	1. Bearing capacity shall be assessed in the beginning for economic planning and informed decision making. 2. For bridges smaller than 1.0m span, provide minimum1.0 m span 3. While deciding span of major streams due consideration shall be given to development since construction of existing bridge, e.g. taking out of canal/ construction of barrage/ dam etc. in upstream, change in habitation pattern, change in land use etc. 4. Data of all bridges constructed in upstream and downstream of major bridges shall be given due consideration while finalizing the span configuration. As far as possible, provide same span type and height as in existing bridge. Subject to satisfaction of Provision of IRS Substructure and Foundation Code. 5. Check clearance and free Board of existing bridge and workout raising, if required. 6. Provide flexible pitching for abutment/ guide bund protection up to freeboard (1.0 m) above HFL. 7. New bridges up to 24.4 m span shall be planned with ballasted deck unless unavoidable.	1. Provide box only to avoid raising of track due to clearance requirement. 2. Provide box in downstream of existing bridge. 3. Provide box on river streams. 4. Provide box on filled up earth. 5. Provide grouted rigid pitching.

		8. Open foundation shall preferably be at same level as existing bridge. Subject to satisfying scour depth and bearing capacity requirement as per IRS Substructure and Foundation Code. 9. For providing deep foundation approval of CAO/C shall be obtained as per Railway Board letter.	
7	Structures	1. Carry out condition assessment of all affected structures. 2. Existing structures in good condition (building FOBs etc.) shall be utilized to the extent possible. Suitable alterations may be carried out. 3. If new structures are to be provided, it shall be as per approved type plan if no type plan is available, new plan may be prepared with facility level as per norms.	1. Provide facilities beyond estimate and norms.

Reference Documents

SN	Para No	Ref. document details	
1	201(1)	2.01	Degree of curvature for new projects of New Line, Gauge conversion and Doubling and Level Crossing in New Line. [Railway Board's letter Nos. 2013/W-I/Genl./0/30 Pt-II dated 04.05.2018 & 28.05.2018]
2	201(1)	2.02	Speed Policy framework for Indian Railways. [Railway Board's letter no. 2017/Mobility/2/3 dated 08/12.06.2018 and 2015/W-1/Genl./Corr.GM/pt. dated 06.12.2018]
3	201(2)	2.03	Construction of formation for Doubling on DFC feeder routes. [Railway Board's letter no. 2013/W-1/Genl./0/30 Pt-II dated 18.12.2019]
4	201(4)	2.04	Construction of bridges during doubling. [Railway Board's letter no. 2017/29/CE-III/BR/Br.588/ECoR dated 03.08.2017]
5	201(5)	2.05	Planning of OHE Layout While Executing Electrification work on single line sections. [Railway Board's letter no. 2017 /W-I/Genl./NL-RE dated 27.01.2017]
6	201(6)	2.06	Level Crossings on New Line/Gauge Conversion/Doubling/Multi Tracking projects. 2021/W-I/Genl./Gatishakti (e-3378115) dt. 18.08.2023
7	201(8)	2.07	Policy guidelines-Execution and Alignment of 3rd line projects. [Railway Board's letter nos. 2013/PL/19/1 (Policy) dated 05.07.2018, letter no. 2018/W-I/Genl./Policy dated 04.09.2018 and letter no. 2023/W-I/Genl/ CAO/C/ Conference. Pt.7 dt.16.03.2023]

8	201(8)(a)	2.08	Comprehensive instructions for provision of passenger Amenities and user facilities at station. [Railway Board's letter no. 2018/ LM(PA)/03/06 dated 09.04.2018]
9	201(8)(a)	2.09	Platform length at Railway stations for new line, gauge conversion and doubling projects. [Railway Board's letter no. 2013/W-I/ Genl./0/30/Pt-II dated 25.02.2020]
10	201(8)(a)	2.10	Provision of Fixed structures in New Line/Gauge conversion projects and setting of Gate lodges, station buildings etc. alongside the existing track. [Railway Board's letter no. 2013NV-I/Genl./0/30 Pt. II dated 12.05.2017]
11	201(11)	2.11	Up-gradation of electric traction system [Railway Board letter no. 2022/RE/161/4 dt. 27.05.2022]
12	202(10)	2.12	Standard yard layouts [Railway Board letter no.2015/Sig/WG/ Standard layout dt. 12.07.2017
13	202(3)(A)	2.13	Provision of different type of services/consultancies for project implementation in Indian Railways. [Railway Board's letter no. 2023/CE-I/CT/1/Policy dated 15.03.2023]
14	201(6)	2.14	Policy for Road Crossing Works (ROB/RUB/LHS/FOBs/Subway) to eliminate level crossing and Tresspassing areas under PH-30 issued vide Rly. Bd. Letter no. 2017/CE-IV/LX-Misc./244 (LCs) Pt. dt. 02-03-2023.

***

CHAPTER 3
LAND ACQUISITION AND FOREST CLEARANCE

301 BACKGROUND

Earlier, land acquisition was being done through the Land Acquisition Act, 1894. Further, for speedy dealing with the land acquisition cases for Special Projects, provisions have been made in various Acts like "The Railways Act, 1989", "The National Highways Act, 1956", "The Metro Railways (Construction of Works) Act, 1978" etc. ''The Railways Act, 1989'' was amended by ''Railways (Amendment) Act, 2008'' and a new Chapter-IV A was added to deal with land acquisition cases for Special Projects on a fast track basis. It came into force on 31st day of January, 2008.

In 2013, the Land Acquisition Act, 1894 was repealed, and "The Right to Fair Compensation and Transparency in Land Acquisition, Rehabilitation and Resettlement Act, 2013" was enacted, which came into effect on 1st Jan, 2014.

302 GOVERNING PROVISIONS FOR ACQUISITION OF LAND FOR RAILWAY PROJECTS

Whenever non-government land is required for railway purposes, it should be acquired by any of the following Acts, as per the existing policy prescribed by Railway Board -

(1) Land Acquisition for notified "Special Railway Projects" can be done as per the Indian Railway Act-1989 (as per Chapter IV A as inserted by Railway Amendment Act-2008).

(2) Land acquisition can be done as per the provisions of "The Right to Fair Compensation and Transparency in Land Acquisition, Rehabilitation and Resettlement (RFCTLARR) Act-2013".

(3) Land can be acquired by "direct purchase through private negotiations with land owners" as per the policy formulated by State Governments under Section 108 of RFCTLARR Act-2013.

(4) Government Land which is already public property and in which no interests of private persons exist, should not ordinarily form the subject of proceedings under these Acts. Such land should be transferred to the Railways as per Rule-310 of General Financial Rules-2017 as indicated in para 811 of Engineering Code.

303 APPLICABILITY OF LAND ACQUISITION PROVISIONS

(1) Land Acquisition under Railway Act - 1989

(a) Land acquisition under "Indian Railway Act-1989" is preferable for railway projects. For this purpose, Chapter IVA has been inserted in Indian Railway Act-1989 through Railway Amendment Act-2008. For acquiring land under this act, that project has to be declared "Special Railway Project".

(b) As per Section 2(37A) of Indian Railway Act-1989, "Special Railway Project" means a project notified as such by the Central Government time to time, for providing national infrastructure for a public purpose in a specified time frame, covering one or more States or the Union Territories. On behalf of Central Government, Railway Board vide letter no 2010/LML/12/8 dated 19.12.2014 **(Ref. 3.01)** has authorized CAO(C)/CE(C)-Coord with the approval of GM to declare any railway project as "Special Railway Project".

(c) Railway Board vide letter No. 2018/W-1/Genl/Land Acquisition dated 25.11.2022 has laid down that all Doubling, Gauge Conversion & only important New Line projects should be declared as "Special Railway Projects" and land acquisition should be done as per Railway Amendment Act-2008 by opening a joint account **(Ref.3.02)**.

Railway Board vide letter No. 2010/LML/12/8 dated 21.02.2020 has laid down that for all such Railway infrastructure projects which have to be completed in a specified time frame, the land should invariably be acquired through the provisions of Railway Act,1989 by declaring them "Special Railway Projects" **(Ref. 3.03)**.

(d) In this land acquisition process, land owner is given opportunity to submit his objections, however, final decision rests with the "Competent Authority". A declaration made by the Central Government shall not be called in question in any court or by any other authority as provided in Section 20E(4) of the Act. For dispute resolution, "Arbitrator" is appointed u/s 20F(6) by General Manager and CAO(C) of the project.

(e) This method is faster but there are chances of disputes regarding compensation amount. Disputes are referred to Arbitrator.

(2) Land Acquisition under RFCTLARR ACT-2013 – This is the general act applicable for all types of land acquisition cases. Land can be acquired through this process also. This process is lengthy and generally takes more time in acquisition.

(3) Land Acquisition under Direct Purchase Policy

(a) Railway Board vide letter no 2015/W-2/SCR/NL/22 dated 20.10.2016 **(Ref. 3.04)** has issued instructions that for doubling, traffic facility, passenger amenities works and for left over provision of land in other projects where land requirement is minimal, land acquisition can be done through "direct negotiations" if the State Government has formulated policy/guidelines u/s 108 of RFCTLARR Act-2013.

(b) Some state governments have enacted policies u/s 108 where this method can be used. State governments act as a facilitator between land owner and Railways.

(c) In this process, land is acquired with the consent of land owner through direct purchase, hence, chances of disputes are less and land acquisition is faster.

(d) The compensation in this process, is either equal or more than the other two methods. So, under this method, compensation value may be higher.

304 APPLICATION FOR LAND ACQUISITION

(1) Whenever land is required for Railway purposes, an application should first be made to the Revenue Officer in-charge of the district in which the land is situated, for a statement of the value of the land.

(2) When the work of acquisition extends to more than one district but lies within one division, application should be made to the Commissioner and when in more than one division, to the Chief Revenue Authority of the State. If state governments require applications district wise, the same should be followed.

(3) The application should set forth clearly the purpose for which the land is required, and should be accompanied by the following documents specifying the extent of the land and such other particulars necessary for its identification-

(a) The name of the railway.

(b) The copy of sanction of project for which land is being acquired.

(c) A brief general description of the route to be followed by the railway with the names of the important villages or towns through or near which the railway should pass.

(d) A list of civil districts in which the land will be required for the purposes of the railway with the approximate area of the land required in each district.

(e) A general index plan to a scale of 0.5 km to 1cm, showing the route to be followed by the railway.

(f) A complete set of land plans and schedules prepared in accordance with the provisions given in Para 837 of Engineerig Code or in such other forms as may be prescribed by the State Government or administration concerned.

(4) Every endeavor should be made to avoid interference with religious edifices, burial grounds or other places or objects which may be considered as sacred. If the land applied for, contains religious edifices etc., the fact must be specifically brought out in the application.

(5) Reference of provision should be made under which Railway intends to acquire the land.

(6) Requirement of forest land diversion and wildlife clearance shall be identified in the beginning of the project. Forest land diversion and wildlife clearance is a long drawn process and shall be planned sufficiently in advance so as not to delay the projects.

305 RESPONSIBILITY OF RAILWAY ADMINISTRATION WHILE ACQUIRING LAND

In acquiring land for railway purposes, it should be ensured that-

(a) There is a necessity to acquire the land. As a general rule land may not be acquired except in connection with a duly sanctioned work but this rule does not debar the acquisition of land for bonafide railway purposes, such as sanitary zones which are unconnected with any particular work. Where any third party's right of way in the form of a path or road is permanently obstructed by the railway, either by the land having been acquired or otherwise, the acquisition of land to restore the right of way on another site, can be done with the approval of General Manager

(b) The sanction of competent authority exists for the land acquisition

(c) The purchase price of land is reasonable. For this purpose, accurate estimation of land price should be obtained from revenue authorities.

(d) The land is utilized to the best advantage.

306 CLASSIFICATION OF RAILWAY LAND

(1) Permanent land

Permanent land is the land which will be required permanently after the railway is open for traffic and the work of construction is complete.

(2) Temporary land

Temporary land is land which is acquired for temporary purposes during construction only, such as for making approach road for working, for spoil-banks, side-cuttings, quarries, stacking and preparation of material, temporary offices, workshops etc., and which is disposed of, after the work of construction is completed.

307 EXTENT OF LAND TO BE ACQUIRED

For extent of land to be acquired, provisions contained in Chapter-VIII and Appendix-III of the Indian Railway Code for the Engineering Department need to be followed. Some important points to be observed are as under-

(1) For lines on which the traffic cannot reasonably be expected to grow beyond the carrying capacity of a single line within 15 years of opening, the widths of land to be acquired should be those for a single line.

(2) For lines over which traffic is likely to develop beyond the carrying capacity of a single line within 15 years after opening, the widths of land to be taken up should be those for a double line. The orders of the Railway Board should be obtained before reckoning widths on this basis.

(3) The widths of land to be taken up for a single/Double line should be, under ordinary circumstances, as shown in the tables in Appendix-III of Engineering Code. In specific cases, the Railway Administration can modify the requirement of land.

(4) For new lines and doublings, the acquisition of agricultural lands should be limited to the bare minimum area to be acquired and it need not conform to the arrangement given in Appendix-III of Engineering Code.

(5) Care should be taken to leave sufficient space for arrangements for drainage and for catch-water drains, where required, to prevent surface water from the adjacent land running down the slope of the cutting. Land required for catch-water drains will be additional to that shown in the table in Appendix-III of Engineering Code.

(6) In arranging the side-widths, there should be continued straight in portions as long as practicable. These lines should follow the average variation in height of bank or depth of cutting over considerable lengths and not be made to zig-zag to suit the local variation at each chain e. g. where there is minor variation in side-widths, it will often be advisable to neglect such local variations entirely, and take up the land in a parallel strip for some distance.

(7) Special care should be taken to ensure that sufficient land is taken up at stations. This land should be provided for any reasonable extensions of the yard which may be expected in the future.

(8) **Tunnels -** As per Railway Board's letter no. 2018/W-I/Genl./Land Acquisition/ Pt I dt. 06.09.2018 **(Ref. 3.05)**, no land to be acquired over tunnels except at the entrances to the tunnels i.e. portals and for any adits/shafts which may be required for facilitation of increase in rate of construction or for provision of safety features. For geologically unstable regions, where there are chances of cave-ins during tunneling/excavations and also at locations of low overburdens, the land acquisition may be resorted to, based on practical considerations.

(9) **Viaduct -** The land should be acquired for minimum width along the span and pier locations.

(10) **Cut & Cover -** The land required in this case is though temporary, however if required, minimum land shall be acquired for construction affected zone, also covering requirement for portal, ventilation and access for maintenance etc.

(11) In special circumstances, where land is needed for temporary purposes as mentioned in earlier Para, and where there is little likelihood of the land on the expiration of the term of temporary occupation being rendered unfit to be used for the purpose for which it had been utilized immediately before such occupation, temporary acquisition may be undertaken as per Chapter- XI of RFCTLARR Act-2013, provided that such procedure would result in economy.

If land is required for temporary occupation, a separate application to be made under Section 81(1), Chapter XI of RFCTLARR Act-2013, in which the fact that permanent acquisition is not required should be clearly stated.

308 LAND PLANS AND SCHEDULES

(1) Land Acquisition Plans normally to be prepared on 50m to 1cm scale. However, to introduce sufficient detailing for clarity and for congested areas, large scales such as 10m to 1cm and 5m to 1cm may be used.

(2) Where the State Governments have prescribed separate scales for plans and sections in respect of acquisition of land for railway projects, such scales should be adopted.

(3) The data for the preparation of land plans should generally be obtained during the progress of final location survey of the line. Initially all land is acquired as Permanent Land only and it should be shown in Pink color by outer boundary. However, for Railway's records, a separate plan showing Permanent and Temporary land are to be distinguished by colour as follows:

   (a) Permanent Land - Pink.

   (b) Temporary Land - Yellow.

(4) The names of villages to which the land belongs, should in each case, be written on the plan alongside of the line indicating the village boundary. If the boundary line crosses the railway line, the names should be repeated on the other side of the railway line and the chainage of the crossing point to be mentioned.

(5) When boundary marks have been erected for the demarcation of railway land, the position and corresponding number of every detached mark should be inserted in the land plans.

(6) The plans should show all existing roads and buildings, and when the latter are known to be used for public purposes or by special departments, their purposes and ownership should be stated.

(7) The schedules showing details of the land required may be drawn up as required by each State Government or Administration, showing location wise land area proposed for acquisition and other relevant details.

(8) Minimum two sets of land plans and schedules are required; one for the revenue authorities and one for the Railway.

309 MARKET VALUE OF LAND TO BE ACQUIRED

The market value of land to be acquired under any provision, shall be determined by Collector/Competent Revenue Authority as per "The Right to Fair Compensation and Transparency in Land Acquisition, Rehabilitation and Resettlement Act - 2013'' (Section 26, Chapter IV of the Act), which is as under -

(1) The market value, specified for the registration of sale deeds in the area or the average sale price for similar type of land situated in the nearest village or nearest vicinity area; whichever is higher. Date for determination of market value shall be the date on which the notification has been issued u/s - 11 of RFCTLARR Act or u/s 20A(1) of Railway Act as the case may be.

(2) The average sale price shall be determined taking into account the sale deeds during immediately preceding three years of the year in which such acquisition of land is proposed to be made.

For determining the average sale price, one-half of the total number of sale deeds in which the highest sale price has been mentioned shall be taken into account.

310 PROCEDURE FLOW FOR ACQUISITION UNDER RAILWAY ACT-1989

Land Acquisition of notified Special Railway Projects can be taken up under Indian Railway act-1989 (As amended by Railway Amendment Act-2008) and The Land Acquisition (Special Railway Projects) Rules-2016.

(1) Gazette notification is issued u/s 2(37A) of Indian Railway Act-1989, by General Managers or CAO(C)/CE(C)-Coords with the approval of General Manager to declare the project as "Special Railway Project". [Sample copy of gazette notification u/s 2(37A) **(Ref. 3.07)**].

(2) As per Section 2(7A) of Indian Railway Act-1989, Central Government shall notify a person as "Competent Authority for Land Acquisition (CALA)" and appoint an Arbitrator u/s 20F(6). For this, General Managers and CAO/Cs have been authorized vide Railway Board's letter No. 2008/LML/12/2 dated 13.02.2008 **(Ref. 3.06)** to issue Gazette notification. An officer of Revenue Deptt is nominated as "Competent Authority for Land Acquisition (CALA)" and some other Gazetted rank officer of State Government as Arbitrator in consultation with the State Govt.[Samplecopy of gazette notification u/s 2(7A) **(Ref. 3.08)**].

(3) Notification for intention to acquire land u/s - 20A (1)

(a) As per Section 20A (1) of Indian Railway Act-1989, Central Government to issue Notification to declare its intention to acquire land giving a brief description of such land and of the special railway project for which the land is intended to be acquired. For this, General Managers and CAO/Cs have been authorized vide Railway Board's letter No. 2008/LML/12/2 dated 13.02.2008 **(Ref. 3.06)** to issue Gazette notification. [Sample copy of Gazette notification u/s 20 A (1)**(Ref. 3.09)**].

(b) In the notification, objections to the acquisition of land and use of such land for the said purpose from interested persons are invited within 30 days of publication of notification.

(c) Substance of this Notification should be published in two local newspapers by Competent Authority as per Section 20A (4) of this Act.

(4) Power to enter for Survey u/s - 20B

(a) On issue of Notification as per Section 20A (1), Competent Authority may authorize any official to enter on subject land for survey, measurement, marking, valuation, enquiry, taking Levels, digging bore hole etc.

(b) Damages during survey, digging, boring, marking etc. should be evaluated and paid within a period of 6 months from the completion of the said works.

(5) Hearing of objections u/s - 20D

Any person interested in the land may, within a period of thirty days from the date of publication of the Notification u/s - 20A (1), object to the acquisition of land for the purpose. After hearing of objections of interested persons, if any, Competent Authority will pass the order of allowing/ disallowing the objections as per Section 20D (2) and submit the report to Central Government.

(6) Declaration of Acquisition u/s - 20E

(a) On the basis of the report of Competent Authority, Central Government issues Declaration of land acquisition by notification u/s - 20E (1). For this, General Managers and CAO/Cs

have been authorized vide Railway Board's letter No. 2008/LML/12/2 dated 13.02.2008 **(Ref. 3.06)** to issue Gazette notification. (Sample copy of Gazette notification u/s 20 E (1)–**(Ref. 3.10)**

(b) On the publication of the Declaration u/s - 20E (1), the land shall vest absolutely in the Central Government free from all encumbrances.

(c) The notification u/s - 20A shall cease to have any effect if no declaration u/s 20E has been published within one year from notification.

(d) This Declaration shall not be called in question in any court or by any authority.

(7) Award of compensation u/s - 20 F

(a) The competent Authority will make compensation award u/s 20F (2) within one year of date of declaration. If no award is declared within one year, the entire land acquisition proceedings shall lapse.

(b) If competent authority is satisfied that the delay has been caused due to unavoidable circumstances, and for the reasons to be recorded in writing, he may make the award within an extended period of six months. In this case, entitled person shall be paid an additional compensation every month for the period so extended, at the rate of not less than 5% of the value of the award.

(c) Determination of compensation to be paid under this Act shall be subjected to Section 105(3) of the RFCTLARR Act-2013. As per Section 105(3) of RFCTLARR Act-2013, provisions related to determination of compensation in accordance with the First schedule, rehabilitation and resettlement in accordance with the Second Schedule and Infrastructure amenities in accordance with the Third Schedule of the RFCTLARR Act-2013 will be applicable to Railway Act also. Therefore, compensation amount under Railway Act should also be determined similar to the provisions of RFCTLARR Act-2013.

(d) To determine the market value of building and other immovable property or assets and trees, plants and standing crop, Competent Authority may use the services of experienced persons/engineer/specialist.

(e) Before proceeding to determine the compensation amount, the competent authority shall give a public notice published in two local newspapers, one of which shall be in a vernacular language inviting claims from all persons interested in the land to be acquired by appearing in person or by an agent or by a legal practitioner u/s 20(F)(4)(5).

(8) Appointment of Arbitrator

(a) An Officer of the rank of Gazetted officer of State Government is appointed as "Arbitrator" by General Manager or CAO/C, with the consultation of State Government, to determine the compensation amount in case of dispute by either party as per Section 20F (6).

(b) If the amount determined by the competent authority is not acceptable to either of the parties, the amount shall, on an application by either of the parties, be determined by the arbitrator.

(c) Subject to the provisions of this Act, the provisions of the Arbitration and Conciliation Act, 1996 shall apply to every arbitration under this Act.

(9) Deposit and Payment of Amount u/s - 20H

(a) Railway shall deposit the amount determined as payable under compensation with

competent authority as per Section 20H(1) of the Act which shall deposit the amount in an account opened by the competent authority in a nationalized bank for acquisition of land under the Act as per Rule 4(2) of the "Land Acquisition (Special Railways Projects) Rules, 2016" **(Ref. 3.11)**, Rly Board's letter No. 2018/W-I/Genl./Land Acquisition dated 05.02.2020 **(Ref. 3.12)** and letter No 2023/ACII/9/2/e 342205 dated 27.02.2023. **(Ref. 3.13)**. The fund shall be under the control of competent authority and shall be operated by the competent authority jointly with the account officer nominated by the Railway for this purpose.

(b) The Competent Authority shall on behalf of the Central Government pay the amount to the person or persons entitled thereto as per Section 20H(2) of the Act.

(c) Where several persons claim for compensation, the competent authority shall determine the persons who in its opinion are entitled to receive the amount. In case of dispute, the competent authority shall refer the dispute to the principal civil court, within the limits of whose jurisdiction the land is situated.

(d) Where the amount determined by the arbitrator is in excess of the amount determined by the competent authority, the arbitrator may award interest at 9% per annum on such excess amount from the date of taking possession u/s 20 I till the date of actual deposit thereof.

(e) Land compensation amount should be expeditiously paid by Railway to avoid interest on award amount. Railway Board has issued instructions vide letter no 2021/W-1/377/SR/7 dated 06.02.2023 to monitor court cases related to enhancement of compensation for land on regular basis and to ensure timely payment/deposition of money in court without delay. Railways may however, decide to go for appeal in higher court on merit of case only **(Ref. 3.14)**.

(10) Power to take possession u/s - 20 I

After Declaration as per Section 20E (1) and deposit of compensation amount, the competent authority may, by notice in writing, direct the owner as well as any other person who may be in possession of such land to surrender or deliver possession thereof to the competent authority or any person duly authorised by it in his behalf within a period of sixty days of the service of the notice.

(11) Right to enter into land u/s - 20 J

Where the land has vested in the Central Govt u/s - 20E, it shall be lawful for any person authorized by the Central Govt in this behalf, to enter and to do other act necessary upon the land for carrying out the building, maintenance, management or operation of the Special Railway Project or part thereof or any other work connected.

(12) Utilisation of land for the purpose u/s - 20 L

(a) The land acquired under this Act shall not be transferred to any other purpose except for a public purpose, and after obtaining the prior approval of the Central Government.

(b) When any land or part thereof, acquired under this Act remains un-utilised for a period of five years from the date of taking over the possession, the same shall return to the Central Government by reversion.

Anticipated Time Frame for Land Acquisition as per Railway Act

SN	Activity	Tentative Time consumed
1	-Application for Land Acquisition to Collector. -Nomination of Competent Authority for land acquisition u/s- 2(7A), - Issue of Notification u/s - 20A -Appointment of Arbitrator u/s -20F(6)	1-2 Months
2	-Survey, marking etc. u/s 20B -Hearing Objections etc. u/s 20D -Declaration u/s - 20E	2-4 Months
3	- From Declaration u/s 20E to Award u/s 20F	1-2 Months
4	- Payment of compensation u/s 20H - Possession of land u/s 20 I	2-4 Months
	Total	**6-12 Months**

311 PROCEDURE FLOW FOR LAND ACQUISITION AS PER RFCTLARR ACT-2013

Under this Act, Land Acquisition Authority is "Appropriate Government" who acquires land for public purposes. Normally, State Government or Collector of the District acts as "Appropriate Government" for land acquisition cases as defined in Section-3(e) of the Act.

(1) On receiving the request for land acquisition from Railway, respective Govt shall notify the officers who shall work as "Collector" for land acquisition (Land Acquisition Officer), "Administrator" for Rehabilitation and Resettlement (R&R) and "Commissioner/Rehabilitation and Resettlement (R&R)". Requiring Body (i.e. Railway) shall request "Collector for land acquisition" under intimation to "Commissioner/R&R".

(2) Evaluation of land and asset value

(a) As per land acquisition application submitted by Railway, Collector may constitute a committee of Revenue, Forest, Agriculture, Water Resources and Railway officers for preliminary enquiry about land proposed for acquisition, its nature, crop, building on it etc.

(b) On the basis of report, a Preliminary Estimate of the cost of acquisition, administrative expenses etc. are assessed. Railway may be asked to deposit the amount or part thereof as decided by Collector.

(3) Social Impact Assessment Study u/s - 4

(a) At first, Social Impact Assessment (SIA) Study has to be conducted for the land under consideration for acquisition. Appropriate government (normally Collector), shall issue Notification for SIA Study which is to be completed in six months' time as per Section 4(2) of the Act.

(b) Notification for SIA Study shall be made available in the office of Collector/SDM/Tehsil/ Gram Sabha and shall be published in affected areas in local language.

(c) SIA unit of State Government will finalise terms of reference for SIA Study and will appoint an agency for this. Railway will bear the cost of SIA unit and SIA study.

(d) SIA Study team will prepare SIA Report and Social Impact Management Plan (SIM Plan) listing the ameliorative measures required to address the impact of land acquisition in consultation with the Panchayat or Municipal Corporation and by making field visits. Public hearings are conducted in affected areas for collecting objections and suggestions from affected persons by giving usual notice of 3 weeks (Section-5).

(e) SIA Report and SIM Plan shall be made available in the office of Collector/SDM/Tehsil/ Gram Sabha and shall be published in affected areas in local language (Section-6).

(f) On receiving SIA report, Appropriate Government will constitute an independent multi-disciplinary Expert Group for evaluation of SIA study report (Section-7).

(g) SIA Study Report to be evaluated by Expert Group. It shall make a recommendation within two months from the date of its constitution. The recommendations of expert group shall be made available in the office of Collector/SDM/Tehsil/Gram Sabha and shall be published in affected areas in local language.

(h) The appropriate Government shall examine the report of the Collector, if any, and the report of the Expert Group on the SIA study and after considering all the reports, recommend such area for acquisition which would ensure minimum displacement of people, minimum disturbance to the infrastructure, ecology and minimum adverse impact on the individuals affected. Decision of State Govt. shall be made available in the office of Collector/SDM/Tehsil/Gram Sabha and shall be published in affected areas in local language (Section-8).

(4) Special provisions to safeguard food security u/s-10, Chapter-III of RFCTLARR Act shall not apply to Railways.

(5) Preliminary Notification for land acquisition

(a) On the basis of its decision, the Appropriate Government shall issue Preliminary Notification for acquisition of land u/s-11.

(b) Preliminary Notification u/s-11 is to be issued within 12 months from the date of submission of appraisal report by Expert Group, otherwise such report shall be deemed to have lapsed and a fresh SIA study shall have to be conducted. Appropriate Government can extend this 12-month period by recording reasons and publishing it.

(c) Preliminary Notification for acquisition of land u/s-11 shall be published in Official Gazette, Govt Website, in the office of Collector/SDM/Tehsil/Gram Sabha and shall be published in affected areas in two local language daily newspapers of the locality.

(d) Collector shall ensure updating of land records within 2 months from the date of publication of Preliminary Notification (Section 11(5) of the act).

(6) On issue of Preliminary Notification, the Appropriate Government may authorize concerned officials to enter on subject land for survey, level, bore holes measurement, marking, valuation and enquiry. These activities are to be done in presence of owner or his representative. In case of absence, a prior notice of minimum 60 days to be served (Section - 12).

Payment of damage during preliminary survey has to be tendered by Railway (Section-13).

(7) Hearing objections u/s - 15

Any person interested in subject land may submit his objections to Collector within 60 days of issue of Preliminary Notification. Decision of Appropriate Government on such objections

shall be final (Section 15(3) of the Act).

(8) Rehabilitation and Resettlement Scheme u/s - 16

(a) Appointment of Administrator: Appropriate Government has to appoint an officer as Administrator for Rehabilitation and Resettlement (R&R) u/s - 43(1) of the Act, who, after issue of Preliminary Notification, shall conduct a survey and census of affected families and submit a draft scheme for R&R as per Section-16 of the Act within 2 months of issue of Preliminary Notification u/s - 11.

(b) Draft R&R Scheme: Administrator or the officer authorized by him, shall conduct public hearing in affected area by giving notice of date, time & place usually 3 weeks in advance. Representatives of Requiring Body, members of SIA team may remain present to respond to queries.

The Administrator shall, on completion of public hearing submit the draft Scheme for R&R along with a specific report on the claims and objections raised in the public hearing to the Collector.

(c) Review of R&R Scheme by Collector: The Collector shall review the draft Scheme submitted by the Administrator with the R&R Committee at the project level constituted u/s - 45, if any, and shall submit the draft R&R Scheme with his suggestions to the Commissioner/R&R for approval.

Where land proposed to be acquired is equal to or more than one hundred acres, the appropriate Government shall constitute a Committee under the chairmanship of the Collector to be called "the Rehabilitation and Resettlement Committee" u/s - 45, to monitor and review the progress of implementation of the R&R scheme.

(d) Approval of R&R Scheme by Commissioner: The State Government shall appoint an officer of the rank of Commissioner or Secretary as Commissioner/R&R u/s – 44 of the Act for rehabilitation and resettlement of affected families, who shall be responsible for supervising the formulation of R&R schemes or plans and proper implementation of such schemes or plans.

After approval of Draft R&R Scheme by Commissioner, it is given wide publicity in the affected area in the same way as Preliminary Notification.

(9) Declaration of acquisition u/s - 19

On approval of R&R scheme, Appropriate Government shall make a Declaration u/s-19 of the Act that any particular land is needed for public purpose. Such Declaration should be made within 12 months of publication of Preliminary Notification u/s -11.

Before making such Declaration u/s -19, Railway shall have to deposit an amount, in full or part, towards the cost of land acquisition as prescribed by the Appropriate Govt.

(10) Survey u/s - 20

After the publication of the Declaration u/s 19, the Collector shall cause the land, to be marked out and measured unless it has been already marked out and if no plan has been made thereof, a plan is to be made of the same.

(11) Notice to take possession of land u/s - 21

(a) The Collector u/s - 21(1) of the Act, shall publish the public notice on his website and at convenient places on or near the land to be taken, stating that the government intends

to take possession of land and that claims to compensation and rehabilitation and resettlement for all interests in such land may be made to him.

(b) The public notice referred above shall state the particulars of the land, and require all persons interested in the land to appear personally or by agent or advocate before the Collector at a time and place mentioned in the public notice and to state the nature of their respective interests in the land and the amount and particulars of their claims to compensation for such interests, along with their objections, if any, to the measurements made.

(c) Land Acquisition Officer during inquiry and award, will give notice to the Railway Administration or their local representative for their views and will take into consideration any representation of Railway Administration or their local representative.

(d) Also, before finally making the award, the Land Acquisition Officer will allow the Railway Authorities an opportunity of appearing in person or by agent and of producing evidence as to the value of the land.

(12) Land Acquisition Award u/s - 23

Collector will declare land acquisition Award as per Section-23 of the Act duly enquiring into the objections. This Award shall be made within 12 months of publication of Declaration u/s-19. Appropriate Government may extend the period of 12 months, if, in its opinion, circumstances exist justifying the same. (Section – 25)

(13) Compensation Value

(a) Market value of land shall be determined by Collector as per Section-26 of the Act. Market value, thus determined, shall be multiplied by a factor as specified by Appropriate Government as per the First Schedule of the Act. This factor has been specified by respective State Governments for different land banks in rural and urban areas.

(b) Collector shall calculate total amount of compensation to be paid tothe land owner by adding the value of all assets attached to the land (on the basis of Section 27, 28 & 29 of the Act) with the market value of land.

(14) Award of Compensation u/s - 30

(a) The Collector shall issue individual awards detailing the particulars of compensation payable and the details of payment of the compensation as specified in the First Schedule of Act.

(b) To arrive at final award, Solatium amount equivalent to 100% of the compensation amount as calculated above, is added.

(c) Railway Board vide letter no. E(NG)II/2010/RC-5/1 dated 11.11.2019 **(Ref. 3.15)** has issued modalities for implementation of Sr. No 4 of the Second Schedule of the Act where provision of Lump sum payment of Rs. 5 lakhs has been provided to the affected families. Now, there is no provision of employment to the affected land losers.

(d) In addition, the Collector shall, in every case, award an amount calculated at the rate of 12% per annum on market value of land, for the period from the date of the publication of the Notification of Social Impact Assessment study till the date of the Award of the Collector or the date of taking possession of the land, whichever is earlier

(e) On making an Award, the Collector shall tender payment of the compensation to the persons entitled thereto in their bank accounts and take receipt as per the prevailing system in revenue department containing a reference to the payee and award statement.

(f) When the compensation amount is not paid or deposited on or before taking possession of the land, an interest at the rate of 9% per annum from the time of taking possession until it shall have been so paid or deposited up to one year and at the rate of 15% per annum from one year onwards (Section-80).

(g) If the person entitled to compensation does not receive it, or not available, or in case of dispute to the title land or its share, the Collector shall deposit the amount of the compensation with the Authority to which a reference u/s - 64 would be submitted.

(15) Land Acquisition and Rehabilitation Authority u/s - 51

The Appropriate Government shall establish "the Land Acquisition and rehabilitation Authority" under Section-51 of the Act who shall have original jurisdiction to adjudicate upon every reference made to it u/s - 64 and shall have same powers as are vested in a Civil Court under the Code of Civil Procedure-1908 (Section-51 & 60 of the RFCTLARR Act-2013).

(16) Reference to Authority u/s - 64

Any interested person who has not accepted the award may, by written application to the Collector, require that the matter be referred by the Collector for the determination of the Authority as per Section-73(3) of the Act. Collector then shall refer the matter to the Authority.

(17) Determination of Award by Authority

(a) The Award of authority shall deemed to be a 'Decree' within the meaning of clause (2) of Section-2 of Code of Civil Procedure, 1908 and the statement of the grounds of every such award shall be deemed a 'Judgment' within the meaning of clause (9) of Section-2 of the Code of Civil Procedure, 1908. The compensation amount to be re-determined on the basis of Award by Authority u/s -70(2) of the Act.

(b) Authority during hearing of objections u/s - 66 of the Act, provides opportunity to Railway to submit their interests. Railway Administration should take advantage of these opportunities for representing their views and protecting their interests.

(c) The award determined by authority shall be paid to the interested persons. Railway shall deposit the amount of award to the Collector.

(d) Land compensation amount should be expeditiously paid by Railway to avoid interest on award amount as discussed in Para 310(9)(e) and as per Railway Board's instructions vide letter no 2021/W-1/377/SR/7 dated 06.02.2023 **(Ref. 3.14)**.

(e) The Requiring Body or any person aggrieved by the Award passed by an authority u/s - 69 may file an appeal to the High Court within 60 days from the date of Award. (Section-74)

(18) Jurisdiction of Civil Courts barred u/s - 63

No civil court (other than High Court under Article 226 or Article 227 of the Constitution) shall have the jurisdiction to entertain any dispute relating to land acquisition in respect of which the Collector or the Authority is empowered by or under this Act.

(19) Acquisition of part of house or building –

The provisions of this Act shall not be put in force for the purpose of acquiring a part only of any house, manufactory or other building, if the owner desires that the whole of such house,

manufactory or building shall be so acquired. If any question arise as to whether any land proposed to be taken under this Act does or does not form part of a house, manufactory or building within the meaning of this section, the Collector shall refer the determination of such question to the Authority concerned & shall not be taking possession of such land till the question has been determined (Section-94).

(20) Possession of Land u/s - 38

(a) The Collector shall take possession of land after ensuring that full payment of compensation as well as rehabilitation and resettlement entitlements are paid or tendered to the entitled persons as per Section-38(1) of the Act.

(b) Person duly authorised by Competent Authority or Collector shall take the possession of land from the owner as per Section-38(1) of the Act after ensuring payment of full amount of compensation (within 3 months), Monetary part of R&R entitlements (within 6 months) and Infrastructural R & R entitlements (within 18 months) from the date of award u/s - 30.

(c) Collector shall be responsible for ensuring that the R&R process is completed in all aspects before displacing the affected families.

(d) Possession of the Land then will be handed over by the local revenue Authority or his representative, and will be taken over by a representative, not lower in status than a Senior Section Engineer/Junior Engineer of the Engineering Department of the Railway. The area on the ground should be carefully checked with that on the Plan and, if found correct, the permanent boundary marks should be affixed as soon as possible thereafter.

(e) Mutation of the land in favour of Railway in Revenue records should be ensured.

(21) No change from the purpose or related purposes for which the land was originally acquired, shall be allowed. No change of ownership without specific permission from the Appropriate Government shall be allowed (Section-99).

(22) Return of Un-utilized land u/s - 101

When any land acquired under this Act remains un-utilised for a period of five years from the date of taking over the possession, the same shall be returned to the original owner or owners or their legal heirs, as the case may be, or to the Land Bank of the appropriate Government by reversion in the manner as may be prescribed by the Appropriate Government.

(23) No income tax or stamp duty shall be levied on any award or agreement made under this Act (Section-96).

Anticipated Time Frame for Land Acquisition as per RFCTLARR Act:-

SN	Activity	Time (months)	Reference
1	-Application for Land Acquisition submitted to Collector -Collector will constitute Evaluation Committee and SIA study team and Issue notification for SIA study.	2-4	Section 4, 5
2	Submission of Report by SIA team, its publication and Constitution of Expert Group.	4-6	Section 6, 7
3	Appraisal by Expert Group	1-2	Section 7
4	SIA report is accepted by Government and issue of Preliminary Notification u/s-11	3-4	Section-8 & 11
5	-Survey of land, marking, measurement etc. -Hearing Objection of land owners by collector	4-6	Section-12 13
	-Appointment of R&R Administrator u/s – 43(1) and R&R Commissioner u/s – 44(1)		Section-15
	-Submission of R&R report by administrator, Collector's remarks and acceptance by Commissioner		Section-16, 17 & 18
6	Declaration u/s 19 and deposit of money by Railway	2-4	Section- 19
7	-Measurement, marking and Evaluation, hearing objections of land owners	4-8	Section-20
	-Notice for Claims & compensation u/s 21		Section 21, 22
	-Declaration of acquisition award u/s 23		Section 23
8	Compensation award u/s – 30 and Possession of Land u/s 38	4-8	Section- 26, 27, 28, 29,30 & 38
Total		**2 year to 3 years 6 months**	

312 LAND ACQUISITION BY DIRECT PURCHASE THROUGH PRIVATE NEGOTIATIONS

(1) Direct purchase through private negotiations is to be done as per policy formulated by State Governments u/s- 108 of the RFCTLARR Act-2013, if any.

(2) As per Section 106(1) of the RFCTLARR Act-2013, Compensation or Rehabilitation and Resettlement provisions under the Act are not to be diluted by Central Government. However, as per Section 108(1) of the Act, State Governments may formulate a policy which provide higher compensation than calculated under this Act. Affected persons may, at their will, opt to avail such higher compensation provisions. Many State Governments have made the policy under this section where compensation provisions are higher.

(3) Application for land acquisition under this process is made to the Collector as provided in the policy of State Government. Land Acquisition Officer appointed by the State Government facilitates the land acquisition under this policy. Land Acquisition Charges as fixed by the State Governments have to be paid by the Railway.

(4) Flow Chart of activities for Land Acquisition through Direct Negotiations:-

(a) Final Location Survey of the project and marking centre line on ground.

(b) Joint survey of alignment with Revenue officials.

(c) Marking of alignment on Revenue maps by the revenue official/Patwari.

(d) Calculation of Khasra-wise area and preparation of land plans by Revenue staff.

(e) Checking and verification of land plans by Railways.

(f) Placing indent of land to be acquired to Land Acquisition Officer (LAO) nominated by State Govt.

(g) Constitution of Negotiation Committee by State Government associating Railway representative in Committee.

(h) Joint inspection of alignment with all concerned departments & landowners.

(i) Negotiation with landowners for fixing rate of the land.

(j) Recommendation by Committee and approval by State Government (Collector).

(k) Award by LAO

(l) Agreement with Land Owner and Deposit of requisite amount by Railway with State Government.

(m) Payment to land owners through State Government.

(n) Possession of land.

313 WITHDRAWAL FROM ACQUISITION

(1) When possession is taken, the acquisition is completed and the land then vests absolutely with the Government. Up to the moment of taking possession under the Act, Government is at liberty to withdraw from the acquisition but not afterwards. It should be noted that withdrawal from acquisition entails liability for payment of compensation for any damage suffered by the owner(s) in consequence of the notice or any proceedings thereunder.

(2) When it is decided to make reduction in the extent of the land which the State Government has already been asked to arrange to acquire, prompt intimation should be given to them to take steps to modify the declaration already issued, or to make necessary withdrawal from acquisition.

314 MANAGEMENT OF LAND

(1) Title to Land

The Engineering Department is responsible for—

(i) preparation of the necessary plans and estimates,

(ii) taking possession of the land when required from the revenue authorities,

(iii) verifying and demarcating its boundaries and plotting them on the plans and

(iv) obtaining the ownership title (mutation etc.) of land including getting it updated in revenue records.

Railway Board vide letter no 2019/W-1/Genl/Land-LC (E-3280805) dated 08.06.2023 has issued instructions to scrupulously complete all the formalities related to land acquisition i.e.

mutation of land and completion of land records for the acquired land for railway projects **(Ref. 3.16)**.

(2) After land acquisition, its proper demarcation and protection from encroachments is of paramount importance. For this, following action as stipulated in Para 808 to 811 of Indian Railways Works Manual (IRWM) should be taken-

(a) All land permanently occupied for the purposes of Railway, shall have its boundaries defined on the ground in such a manner as to enable such boundaries to be readily ascertained and identified. For this purpose, the boundary of the Railway land may be defined by a continuous wall, fence or ditch or by detached marks, posts or pillars.

(b) Where the boundary mark is continuous, the boundary of the railway land is to be on the outer edge of the wall, fence or ditch, that is to say, the wall, fence or ditch will be situated wholly on railway land.

(c) Where detached marks, such as isolated posts or pillars are used, the boundary of the railway land will pass along the outside of such posts and pillars. Between marks, the boundary shall in each case be taken in a straight line from the outside of one mark to the outside of the next mark.

Detached marks should, in no case, be at a greater distance apart (centre to centre) than 50m. They should be of a substantial character, not easily destroyed or moved by accident or mischief, and of such size and form as can be readily found and recognized. Where there is a change in land boundary line or possibility of displacement of boundary post by mischief, additional boundary posts may be installed.

Each detached boundary mark should bear a number. The position and number of each detached boundary mark should be shown on the land plan.

(d) Where a fence, wall or ditch is situated at some distance within the boundary and does not mark the actual limit of the railway land, it will be necessary (in addition to such fence, wall or ditch) to have the actual boundary of the railway land properly marked and defined in accordance with these rules.

(e) The boundary stones to be used for this purpose should be as per para 809 of IRWM.

(f) High boundary pillars on each bank of river of important waterways crossed by Railway bridges should be erected so as to prevent and control encroachments.

(3) Construction of Boundary Wall

In areas having habitation bordering railway land and also where habitation is likely in near future, boundary wall should be provided so that potential encroachments are prevented and outsiders do not develop any right of entry on railway land. Boundary walls are an operational necessity in such situations, so as to prevent trespassing, cattle being run over by trains, use of railway tracks for easing etc. and theft of P.Way fittings and other railway materials. It is also necessary for boundary walls to be extended right from the station outwards along the tracks of vulnerable locations within towns so that outsiders do not find an easy access to the stations.

(4) Fencing

Fencing as a rule should be provided at the following locations-

(a) In municipal limits and notified area limits.

(b) Around busy station yards.

(c) On either side of level crossings.

(d) For protection of railway land from encroachments.

(e) On high-speed routes.

(5) Handing over of Land Records

After land acquisition proceedings are completed, following records should be handed over to Open Line in original in bound registers as per para 807(f) of IRWM and Railway Board's letter No. 2014/LML-11/13/7 dated 09.07.2014 **(Ref. 3.17)**

(a) Indent for acquisition of land for Railways as submitted to Revenue authority

(b) Land plan duly verified by the Revenue authorities showing details of Mutation

(c) Attested copy of Mutation

(d) Shajra/Khasra duly verified

(e) Copy of Awards

(f) Taking/handing over note for land possession **(Ref. 3.18)**

These documents must be handed over duly pasted in machine numbered registers. Each register should have index in beginning, showing the details of documents pasted in the register. The first register containing land documents for a project should be numbered as land - 1/x and subsequent registers may be numbered as land - 2/x land - 3/x etc. where x is the total number of registers.

Above documents should be prepared in five copies (1 original + 4 copies), to be distributed as under-

(i) Original to Open Line HQ

(ii) One copy to Divisional HQ

(iii) One copy to SSE(Works) Open Line

(iv) One copy to Construction HQ

(v) One copy to be retained by Construction Field Unit

315 THE AWARD STATEMENT

(1) When an award is made u/s - 23 of RFCTLARR Act or Section 20F of Indian Railway Act (as amended by Railway Amendment Act 2008), the officer will have a statement of Award prepared as per the format given in Forms of Appendix-V of Engineering Code, showing the amounts payable to each person under the award and will forward a copy of the statement to the Railway Accounts Officer.

(2) In cases where an award is modified by Land Acquisition, Rehabilitation and Resettlement Authority u/s - 70 of the RFCTLARR Act, a second award statement should be prepared by the officer as soon as the decision of the Authority is ascertained and a copy thereof forwarded to the Railway Accounts Officer. On receipt of this statement, the Railway Accounts Officer will check and verify the entries with the original award by the Land Acquisition Officer. Similar action shall be taken in case of land acquisition as per Indian Railway Act, if award amount is modified by Arbitrator.

316 TRANSFER OF LAND AND BUILDINGS BETWEEN UNION AND STATE GOVERNMENT

(1) The transfer of land between Union and State Governments shall be regulated by mutual agreements. Such land should be transferred to the Railways as per Rule-310 of General Financial Rules-2017 as indicated in para 811 of Engineering Code.

(2) The amount payable by the Union Government will ordinarily be the market value of the land and buildings, if any, thereon. The amount payable may include the capitalised value of land revenue when the transfer causes actual loss of land revenue to the State Governments. Solatium payable under the Land Acquisition Act will not apply to such transfer.

317 TRANSFER OF DEFENCE LAND

(1) Defence land can be transferred for railway use as per Ministry of defence's letter no 11015/2/2012/D (Lands) dated 11.03.2015 (**Ref. 3.22**). The important points of the letter are as under-

(i) No defence land is normally permitted to be transferred for non-defence use. However, as an exception, transfer of defence land may be permitted to Central Government departments, State Governments and local bodies for execution of projects related to creation/upgradation of public infrastructure/utilities.

(ii) Such transfers are normally considered on the basis of exchange of equal value land to be provided by the Indenting Authority (Railways). Where the Indenting Authority is neither a land owning authority nor does it have an arrangement with the State/ UT governments for providing land for the project and is therefore unable to provide equal value land, transfer is considered on payment of current market value. Land is also given on lease/license with premium and rent being fixed on the basis of nature of the project.

(iii) All Indenting Authorities (IAs) seeking transfer of Defence land for public infrastructure/ utilities will carry out prior consultation with the Ministry of Defence through their administrative ministries/ respective State Governments. The IAs will submit proposals containing information as mentioned in the format annexed to the letter, to the Ministry of Defence at the preliminary/planning stage for 'in principle' approval with a copy to concerned Land Managing Authority (viz Army, Navy, Air Force, DGDE etc). Once approved 'in principle', a detailed proposal will have to be sent again for final approval for working permission or transfer of land, as the case may be. In principle' approval shall specify the mode of transfer of defence land.

(iv) After issue of 'in principle' approval, the indenting agency to send a firm proposal for working permission or transfer of land, as the case may be, within 6 months of the grant of 'in-principle' approval to the concerned Joint Secretary in the Ministry of Defence i.e. the Joint Secretary dealing with the land managing agency concerned with a copy to concerned Land Managing Authority (viz Army, Navy, Air Force, DGDE etc) for further processing the case, failing which the approval would be deemed to have been cancelled. MoD shall accord working permission/final approval expeditiously but not later than 08 months of receipt of the formal proposal from the Indenting Authority, after issue of 'in principle' approval.

(v) Proposals for transfer of defence land to be sent by the indenting Central Ministry /Department / State Government to the concerned Joint Secretary in the Ministry of Defence i.e. the Joint Secretary dealing with the land managing agency concerned.

(vi) For all cases in which defence land is proposed to be transferred or alienated, formal approval of cabinet is to be sought. After Cabinet approval, formal orders for transfer/exchange of land will be issued by MoD and formal handing over/taking over and correction of records will be undertaken

The procedure for dealing with the land transfer cases have been detailed in Ministry of defence's letter no 11015/2/2012/D (Lands) dated 02.02.2016 **(Ref. 3.23)**.

(2) In the case of privately owned land in cantonments the provisions of appropriate act for land acquisition should be applied, but it will be necessary to obtain the sanction of the Central Government in the Ministry of Defence to the occupation of such land.

(3) Rules Relating to Restrictions on the use of Military Land - The construction of buildings etc. on land in the charge of Military Authorities or of Civil Departments, lying within the authorized zones of works of Defence will be dealt with in accordance with the Works of Defence Act, 1903.

Such zones will be prescribed and clearly demarcated in the vicinity of all the works of Defence which are enumerated in Army Regulations, and such other fortifications or places as the Central Government may decide.

318 DIVERSION OF FOREST LAND

(1) The land required for construction of new Railway line can be divided into two parts:

(a) The land on which the railway line is to be actually laid; and

(b) The land required by the Railway for other purposes

All forest trees in area indicated in clause (a) above have to be clear felled but it may not be immediately necessary to fell the tree growth in area indicated in clause (b) above. The trees falling on land required by the Railway for other purposes in future, will remain the property of the Forest Department, though the land on which these trees will be standing will remain with the Railway.

(2) While diversion of forest land, suitable agreement should be made with the Forest Department covering the following aspects:

(a) If in future the removal of any tree or trees is considered necessary by the Railway in connection with train operation, the Railway should notify to the Forest Department about it and the Forest Department would fell and remove these trees quickly;

(b) If for any future construction on the land diverted to the Railway, trees have to be felled, the Railway will notify the same to the Forest Department, and the Forest Department will fell and remove them quickly;

(c) If in emergency the Railway has to fell any tree, the Forest Department will be notified of this being done and the Railway will be paying the compensation thereof; and

(d) That for trees felled by the Forest Department according to sub-para (i) and (ii) above, no payment will be made by the Railway to the Forest Department unless the felling of trees is done by the Railway, in which case the Railways will pay for the trees felled to the Forest Department.

(e) As clarified vide Ministry of Environment, Forest and Climate Change (MoEFCC)'s letters dated 10.03.2022 & 22.02.2023, for execution or maintaining of railway works within

the limits of Railway owned land in forest area, where right of way (RoW) is with Railway and land is already under non-forest use before October 25, 1980, then the Forest Conservation Act, 1980 and Wild life Protection Act, 1972 will not be applicable **(Ref. 3.19 & 3.20)**.

(3) Forest & Environmental issues while planning and executing projects

Issues related to forests and environment are important while planning and executing the project. The protection and management of forests and wildlife, irrespective of their presence in a notified/reserved forests, sanctuary or in a National Park are governed by various central and states' laws with stringent provisions.

Therefore, it is important that before planning or execution of the rail projects, it must be ensured that whether the project is passing through any forest area, wildlife area or eco-sensitive area or coastal zone area for which permissions under The Forest (Conservation) Act, 1980, Wildlife (Protection) Act, 1972, The Environment (Protection) Act, 1986 or under any other provisions are required or not.

In case a project is falling or passing through a forest area, the clearance under Forest (Conservation) Act, 1980 is required, which is generally called Forest Clearance (FC). Similarly, Wildlife Clearance (WC) from Standing Committee for National Board for Wildlife (SC NBWL) is required under Wildlife (Protection) Act, 1972, if a proposal falls or passes through a sanctuary or national park. If the proposal passes through a tiger corridor, which may or may not be a forested area, the wildlife clearance of SC NBWL is required. Although, Environment Clearance (EC) is not required for laying of railway lines, however, there may be components which may attract provisions of EC, for which sufficient precautions have to be taken to get approvals incase required. Similarly, in coastal zone area, all the developmental proposals require Coastal Regulation Zone approvals, which is called CRZ clearance. In Maharashtra, if the proposal falls in Mangrove Areas, the approval of Hon'ble High Court of Maharashtra becomes indispensable.

It is important to mention that certain exemptions have been given to the Railways specially in Forest Clearance (FC) and Environment Clearance (EC), including of non-applicability of FC in certain cases, however, it is always advisable to know about the locations of the project before planning and execution and applicability of FC, EC, Wildlife Clearance (WC) or Coastal Regulation Zone (CRZ) clearances in the project, for which authorities must consult the local forest and wildlife officials and know the nuances of clearances required. Since the approval of these clearance are processed through Parivesh Portal (PARIVESH 2.0), the authorities can assess the requirements of these clearances by putting the KML file in Decision Support System based module of "Know Your Proposal", devised to ease out the planning and avoiding the delay due to requirements of FC, EC or WC.

All these clearances may involve technicalities, compliance of legal provisions, time and money. In FC proposals, the User Agency has to pay money for compensatory Afforestation (CA) and Net Present Value (NPV). Similarly, plans such as Wildlife Plans or Mitigation Plans require time and additional costs. Therefore, it is important that enough heed must be paid before planning or execution of projects in forests and wildlife areas and sufficient factoring in of cost and time be made in planning and execution, to avoid any delay, cost or time overrun.

(4) CRZ Clearance

As clarified vide Ministry of Environment, Forest and Climate Change (MoEFCC)'s letter no F.No.IA3-12/3/2023-IA.III (E-220190), dated 06.10.2023, Railway Projects covered under Railway Act, 1989 shall not attract CRZ clearance. However other statutory clearances, as applicable, need to be obtained **(Ref. 3.21)**.

(5) Steps for Forest Land Diversion and Wildlife clearance-

(i) Identification of forest land through DGPS.

ii) Complete process of forest land diversion and wildlife clearance is to be done through PARIVESH portal of Ministry of Environment, Forest and Climate Change (MoEFCC). Many times during approval process EDS (Essential Details Sought) are raised by different authorities through PARIVESH portal. All such queries shall be appropriately replied in time in consultation with concerned forest officials to avoid delays.

iii) Mitigation Measures for wildlife conservation shall be planned through Wildlife Institute of India (WII) Dehradun or any other institutes approved by MoEFCC for this purpose. Cost of mitigation measures in wildlife areas is generally higher and shall be got timely sanctioned from competent authority.

iv) Stage-I approval (In principle approval) for forest land diversion is valid only for one year. Complete process for obtaining Stage-II approval along with payment for NPV (Net Present Value), CA (Compensatory Afforestation), Avenue Plantation and SSWLCP (Site Specific Wildlife Conservation Plan) etc., shall be expeditiously done.

v) After obtaining all clearances, demarcation of land at site shall be done jointly with forest authorities and marked.

Reference Documents

SN	Para No	Ref. document details	
1	303(1)(b)	3.01	Railway Board's letter no 2010/LML/12/8 dated 19.12.2014 authorising General Managers of Railways to notify any project as "Special Railway Project."
2	303(1)(c)	3.02	Railway Board's letter No. 2018/W-1/Genl/Land Acquisition dated 25.11.2022 to declare projects as "Special Rly Project".
3	303(1)(c)	3.03	Railway Board's letter No. 2010/LML/12/8 dated 21.02.2020 to declare projects as "Special Rly Project"
4	303(3)(a)	3.04	Railway Board's letter no 2015/W-2/SCR/NL/22 dated 20.10.2016 listing cases where land acquisition can be done under Direct Purchase Policy
5	307(8)	3.05	As per Railway Board's letter no. 2018/W-I/Genl./Land Acquisition/ Pt I dt. 06.09.2018 regarding land acquisition for tunnels.
6	310(2), 310(3)(a), 310(6)(a)	3.06	Rly Board's letter No. 2008/LML/12/2 dated 13.02.2008 authorising CAO/C and GM to notify Competent Authority for land acquisition under Rly Act.
7	310(1)	3.07	Sample Gazette Notification to notify Special Railway Project u/s 2(37A) of Railway Act
8	310(2)	3.08	Sample Gazette Notification to notify "Competent Authority for Land Acquisition" u/s 2(7A) of Railway Act
9	310(3)(a)	3.09	Sample Gazette Notification to declare intention to acquire land u/s 20A(1)
10	310(6)(a)	3.10	Sample Gazette Notification for declaration of land acquisition u/s 20E(1)
11	310(9)(a)	3.11	Land Acquisition (Special Railways Projects) Rules, 2016
12	310(9)(a)	3.12	Rly Bd. letter No. 2018/W-I/Genl./Land Acquisition dated 05.02.2020 reg. opening of joint account for payment under Rly Act
13	310 (9) (a)	3.13	Railway Board's letter No 2023/ACII/9/2/e 342205 dated 27.02.2023 reg. opening of joint account for payment under Rly Act
14	311 (17) (d)	3.14	Railway Board's instructions vide letter no 2021/W-1/377/SR/7 dated 06.02.2023, reg. expeditious payment of compensation amount.
15	311(14) (c)	3.15	Railway Board's letter no. E(NG)II/2010/RC-5/1 dated 11.11.2019 reg. Lump sum payment of Rs. 5 lakh and no employment to the affected families
16	314(1)	3.16	Railway Board vide letter no 2019/W-1/Genl/Land-LC (E-3280805) dated 08.06.2023, reg. mutation and completing land records.
17	314(5)	3.17	Railway Board's letter No. 2014/LML-11/13/7 dated 09.07.2014 reg. handing over of land records to open line
18	314(5)(f)	3.18	Sample Copy of Land Taking/handing over note with Railway and Revenue officials

19	318(2)(e)	3.19	MoEF's letter dated 10.03.2022 reg. non applicability of Forest Conservation Act, 1980 and Wild life Protection Act, 1972 for Rly land in forest area.
20	318(2)(e)	3.20	MoEF's letter dated 22.02.2023 reg. non applicability of Forest Conservation Act, 1980 and Wild life Protection Act, 1972 for Rly land in forest area.
21	318(4)	3.21	Ministry of Environment, Forest and Climate Change's letter no. F.No.IA3-12/3/2023-IA.III (E-220190), dated 06.10.2023, reg CRZ clearance.
22	317(1)	3.22	Ministry of defence's letter no. 11015/2/2012/D (Lands) dated 11.03.2015 regarding transfer of defence land
23	317(1)(vi)	3.23	Ministry of defence's letter no. 11015/2/2012/D (Lands) dated 02.02.2016 regarding transfer of defence land

***

CHAPTER 4
DRAWING APPROVALS

401 GENERAL

In the construction project, various types of drawings are prepared for the execution of work by Civil, Electrical and S&T Engineering departments. All plans and system design documents are to be carefully prepared and approved.

402 DRAWINGS PREPARED BY THE CIVIL ENGINEERING DEPARTMENT

Some of the important drawings prepared for project execution are as follows:

(1) General Arrangement drawings (Buildings, Railway bridges, FOB/ ROB/ RUB/RFO):

The General Arrangement Drawing (GAD) shows the overall shape and size of the structure, detailing the specific dimensions and specifications of materials and work. This will normally include the following:

- Key plan of the work site in a box.
- Chainages of the center line of structure and its elements and elevations as Reduced Levels.
- Overall dimensions of structure, distances of structure from outer reference points or outer boundaries. The plan and elevation along with sections at specific locations, should be drawn wherever required to leave no ambiguity in the arrangement of the structure.
- Ground level, Rail level, HFL, bed level in case of bridges, formation level of the embankment, or plinth level with reference to the bench mark
- Plinth area of building, total height of building, type of structure.
- Scale to which drawing is drawn.
- Place/Box of all required signatures of officers of concerned departments, alteration box, for future amendments to be issued.
- Authority for the approval/sanction of work.
- The codes, manuals and specifications on which the work has to be executed.
- Soil bore log details and the bearing capacity of soil at founding levels.
- In case of a building, a floor plan of the building with the roof removed at various floors.
- If there are more than one distinct structure in the work, separate sets of GAD's and detail drawings should be prepared for each, e.g., there might be a residential complex, a power substation, and a gymnasium constituting the work. Then three sets of GADs and corresponding detail drawings should be made.

  (a) Checklist for preparation of General Arrangement Drawing (GAD) for Railway bridges issued by RDSO vide letter no. CBS/DBR/IMP/Policy dt. 04.02.2022. The same is placed as **Table 4.03** at the end of this chapter.

  (b) Check list for examination of GAD of ROB is placed as **Table 4.04** at the end of the chapter.

(c) Check list for examination of GAD of RUB is placed as Table 4.05 at the end of the chapter.

(2) Engineering Scale plan for yard, junction arrangements:

An Engineering drawing made to scale is basically an Engineering Scale Plan (e.g. yard plans, LC plans). However, the terminology- Engineering Scale Plan is primarily used for yard plans.

ESP shall be prepared on a scale of 10m to 1 cm. The plan shall show all lines, sidings, platforms, buildings, wells, tanks, watercranes, ashpits, turntables, traversers, weighbridges, signals, etc. within the boundary of the station yard; also any roads, buildings, etc., lying outside the station yard but immediately adjacent there to-The name of each work or structure should be entered against it on the plan, with such notes and dimensions as may be necessary to define its size, position and purpose for which intended.

ESP shall be prepared as per Engineering code para 468 to 472. The checklist for preparation of Engineering Scale Plan is placed as **Table 4.06, 4.06A & 4.06B** at the end of the chapter.

(3) Index plan and Index section: shall be prepared as per Engineering code para 449 to 451.

(4) Detailed plan and section (L-section) or project sheets: shall be prepared as per Engineering code para 452 to 466.

(5) Completion Drawings

The completion drawing should be submitted by Assistant Divisional Engineer to the Divisional/Dy. Chief Engineer for works completed as per the approved drawings. The drawing should indicate the work as actually carried out; special care to be taken that the work below ground is correctly shown, and the nature of the soils met should be recorded in the drawing. Alterations or modifications that may have been made to the working plans should be marked in red ink. When several structures are erected at the same time in the same locality and to the same drawings, one completion drawing may be submitted. If the structures or buildings differ only in foundations, the completion drawing should show the superstructure common to all, and separately, the foundations of each building, designated with separate foundation drawings, can be prepared

(6) Temporary Arrangement Drawing (TAD)

The Temporary Arrangement Drawing shows the scope of temporary works required to be done for the completion of work as proposed in GAD. In bridge works, separate temporary arrangement drawing is prepared to show the methodology of temporary work along with phase working with details of minute to minute activities to be completed in block hours. Details of cranes working in a phased manner with pictorial diagrams are also to be included in the case of launching of girders, slabs, R-H girders, etc. A temporary supporting arrangement to support the span by C.C. Crib or Trestles as per standard RDSO drawings is also to be shown in TAD. The TAD along with launching scheme for bridge works, is approved by CBE, and this becomes part of the documents to be submitted to CRS.

403 APPROVAL OF CIVIL ENGINEERING DRAWINGS

The approval of engineering drawings takes a lot of time, which also delays the execution of work. To expedite approval of engineering drawings, the Board (ME, CRB) has issued instructions vide Rly Board's Letter No. 2017/CE-I/CT/13/Procedure Simplification, dated 20.10.2017 **(Ref. 4.01)**.

Further, vide advance correction slips no. 36 dt. 27.03.2018 **(Ref. 4.02)** and no. 38 dt. 14.01.2020 **(Ref. 4.03)** of Indian Railways Bridge Manual modification to certain existing provisions have been made. The present provisions are as follows:

- All GADs, except drawings involving construction/modification of yards and bridges (including ROB, RUB, FOB, RFO flyover etc.) shall be approved at the level of division. The structural design and drawing shall be carried out by open line or construction organisation who is the executing agency for the work.
- GADs involving the construction/modification of yards, where the open line is the executing agency, after clearance by all concerned divisional branch officers and DRM, shall be examined by CTPM in HQ and approved by CPDE.
- GADs involving construction/modification of yards, where the construction organisation is the executing agency, after clearance by all concerned divisional branch officers and DRM, shall be examined by CTPM in HQ and approved by CPDE.
- In case of new lines/doublings/gauge conversions, the General Arrangement Drawing (GAD) for Railway bridges where linear waterways are being reduced or vertical clearances are inadequate and where construction is likely to affect any of the existing bridges (during construction or during service), after clearance by the concerned divisional branch officers and Divisional Railway Manager (DRM), shall be approved by the Chief Bridge Engineer (CBE) of the concerned zonal Railway. GADs of other Railway bridges shall be approved by concerned Chief Engineer/Construction.
- GADs for all Railway bridges on open line shall require the approval of the Chief Bridge Engineer of the concerned Zonal Railway.
- GADs and Launching schemes of all ROBs/RUBs/FOBs/Rail Flyovers, which shall affect the existing lines after clearance by the concerned divisional branch officers and DRM, shall require the approval of CBE of the concerned zonal Railway. GADs and launching schemes of all other ROBs/RUBs/FOBs/Rail flyovers shall be approved by the concerned Chief Engineer/ Construction.
- The structural design and drawing work for the bridge works (Railway bridges/ ROBs/RUBs/ FOBs/Rail flyovers etc.) being executed by Open line organisation shall be carried out by Bridge branch at HQ level of the concerned zonal Railway.
- The structural design and drawing work for the bridge works (Railway bridges/ ROBs/RUBs/ FOBs/Rail flyovers etc.) being executed by Construction organisation shall be carried out and approved by the Construction organisation.
- ADRM/Infra shall be responsible to ensure that GADs are approved/ cleared by all concerned branch officers in division within a period not exceeding 15 days. ADRM/Infra. shall get GADs signed at Divisional level in a meeting to be conducted for this purpose.
- Similarly, AGM shall be responsible in HQ. to ensure that GADs are approved/cleared by concerned HOD within a period not exceeding 7 days. AGM shall personally ensure adherence to the time limit by CTPM, CPDE, & CBE (Bridge GADs). There shall be no other signatures on the GADs in the HQ.

404 STANDARD PROCEDURE ORDER FOR ESP & GAD APPROVAL

In addition to the instructions mentioned in the above para, letter No.2017/CE-I/CT/13/Procedure simplification dated 22.04.2022 **(Ref. 4.04)** have issued Standard Procedure order for ESP, SIP & GAD approval, which is as under -

(1) Approval of ESP:

a) ESP should be signed by JAG officers of the originating department, DRM of Division and HQ officers (CE/Con, CEE/Con, CSTE/Plg, CSTE/Con, CTPM & CE/Planning for ESPs of Construction Organisation & CTPM, and CSTE/Plg & CE/Planning for ESPs of Open Line/RVNL/RITES/IRCON/Other Units). ESP signed by JAG/SG/Equivalent officers of the originating department should be circulated by concerned JAG/SG/Equivalent officer to divisional branch officers (Sr DOM, Sr DEN, Sr DEN Co, Sr DSTE, Sr DCM & Sr DEE TRD) and ADRM. DRM/ADRM should resolve conflicting observations, if any, in consultation with originating department and ESP should be cleared within 15 days from the division.

b) ESP should be prepared as per the concept plans given in the DPRs in the normal course unless the extra facilities which are minor in nature are approved by the DRM and major modifications/additions are approved by the GM.

c) While finalizing the Concept Plan during DPR/DE, standard layout & instructions issued vide Railway Board's letter No 2017/CE-I/CT/13/Procedure simplification, dated 20.10.2017 & 2015/Sig/WG/Standardize layout, dated 12.07.2017, may be followed.

i) The Concept plan for remodeling of yard included in the DPR should be revalidated by CTPM, CE Planning, CSTE/Planning, & concerned SAG Officers of the originating department before the initiation of approval of the ESP to avoid changes in ESP at approval stage, and the same should be put in writing.

ii) Revision of ESP should be divided into following two broad categories:

- **Major Revision:** resulting in changes of yard layout. Provision of additional line, additional cross over, addition/deletion of slip/catch siding etc. shall qualify for major yard remodeling. ESP, once approved, should not be taken up for major revision without the approval of the General Manager. If revision of the ESP is inescapable due to any reason, the onus of taking approval of the GM within 15 days shall lie with the Department asking for revision of the ESP. The phasing of work to be indicated department wise.
- **Minor Revision:** This does not result in a change in the layout of the yard but is required to rectify the minor defects or deficiencies detected after approval of ESP, at the time of preparation of SIP, or due to any other reason. In case of a minor alteration in ESP, the approval of ESP should be only given by the oncerned JAG/SG & SAG Officers of Originating Department & CSTE/Planning. Change of turnout from 1 in 12 to 1 in 8 ½ or vice versa, classification of line, change in location of gradient post, change in chainage, closure of LC gate, change in classification of LC gates, & updation to match actuals at site shall be treated as minor alterations.

  Categorization of Planning/alteration into minor or major categories apart from the above defined-categories may be done jointly by CE /planning and CSTE Planning or CSTE/Project.

In case of any difference of opinion regarding categorization of alteration into minor and major, decision of the AGM shall be final.

Note: Concerned branch officers of open line and construction officials shall inspect the site, if possible as a joint inspection, before finalization of the ESP.

(2) Sanction of grade condonation: The sanction should be processed as per the provisions of IRSOD 2022, CH II Item no. 2. Proposal for grade condonation is based on approved ESP and infringement table in the approved ESP should be made. Once the ESP along with infringement table is approved, there is no need to involve Divisional officers in the approval of the grade condonation proposal. The grade condonation proposal signed by the concerned JAG/SG & SAG officers of Originating Department should be submitted to CPDE for further processing for approval and signature of concerned PHODs (PCOM, PCSTE, PCEE, and PCE) and GM and submission to CRS for sanction.

(3) Approval of project sheet (L-section and Plan) - Project sheet shall continue to be approved by Planning Cell of HQ. Planning Cell should broadly check the project sheet for violations of Terms of References to the project, if any. The executing agency should furnish a certificate that the level of bridges as shown in the approved GAD has been adopted in Project Sheet. Any discrepancy in the levels shown in the ESP, GAD of projects, and project sheet shall be reconciled by Executing Agency and rectified in the completion drawing.

(4) Approval of ESP should not be linked with the approval of the project sheet.

(5) Checklist for approval of ESP, GAD of major and minor bridges, project sheet, and other drawings should be signed by JAG/SG officer of the concerned department.

(6) ADRM/Infra (or nominated ADRM) shall ensure that GADs are approved/cleared by all concerned branch officers in the division within a period not exceeding 15 days. ADRM/Infra shall get GADs signed at the divisional level in a meeting to be conducted for this purpose.

(7) Similarly, AGM shall monitor in HQ to ensure that GADs are approved/cleared by concerned HOD within a period not exceeding 7 days and time limit is adhered to by CTPM, CPDE, & CBE (for bridge GADs). There shall be no other signatures on the GADs in the HQ.

(8) Timelines in working days for comments / approval shall be as follows:

	DRM & Divisional Officers	**CAO/C**	**CTPM**	**CSTE/Plg / CSTE (Proj) / CSTE (Con)**	**CE(P&D)/ CBE**	**Total**
ESPs						
Up to 5 lines	15	7	3	3 (Parallel)	7	32
More than 5 lines & major junctions	18	10	5	5 (Parallel to CTPM)	10	43
GADs						
Minor Bridges	7	7	--	--	7	21
Major Bridges	10	10	--	--	10	30

The timeline given above is reckoned since submission/re-submission after compliance of the observations/clarifications.

(9) It may be noted that the time line given in para (8) above shall be followed strictly. However, if in the tender documents the timeline given for approval of the above-mentioned drawings is stricter then the same shall be followed for that specific contract work.

10) Based on the above, all Zonal Railways/Other Units should make a detailed procedure order to expedite approval of ESP & GAD.

405 APPROVAL OF BRIDGE DESIGNS AND DRAWINGS FOR WORKS BEING EXECUTED BY RVNL

[As per Rly. Bd. letter no. 2021/2/CE-III/BR/1/Bridge Policy dated 28.10.2021 **(Ref. 4.05)]**

- GADs of all important, major, minor railway bridges affecting existing bridges during doubling/tripling/quadrupling works, all important bridges on NL/GC works, and all ROBs/RUBs/FOBs/RORs shall be prepared by RVNL and approved by CBE.
- GADs of all minor and major railway bridges not affecting existing bridges during doubling/tripling/quadrupling works and on NL/GC works shall be prepared by RVNL and approved by the Chief Engineer/Construction.
- To the extent possible and wherever applicable, standard RDSO drawings shall be used. Existing instructions in this regard need to be followed in letter and spirit.
- A centralized design cell shall be created in corporate office of RVNL, headed by ED/GGM and assisted by an experienced design team to scrutinize and approve structural designs prepared by field units of RVNL. This design cell shall also assist field units in the preparation of GADs for important bridges and other typical bridges, the preparing design basis reports, and launching schemes for various structures. The structural design of important, major, and other typical bridges approved by this design cell shall be submitted to zonal Railways and may be suitably considered for approval by CBE and Chief Engineer/Construction for further certifications during the submission of opening documents to the Commissioner of Railway Safety (CRS).
- The completion plans of various bridges/structures shall be approved by the Chief Project Mangers (CPMs) of RVNL. A countersignature of the concerned Executive Engineer or Divisional Engineer (not below the level of DEN) shall be done on the completion plan.
- The design of launching schemes for all ROBs/RUBs/FOBs/RORs and Railway bridge girders affecting running lines shall be checked by the ED/GGM incharge of the design cell of corporate office, RVNL, and approved by CBE before submission of documents for CRS sanction through the nodal Chief Engineer/Construction.
- CRS sanction for construction of bridges by RVNL adjacent to existing bridges and affecting the structural safety of existing bridges shall be processed by nodal Chief Engineer/Construction as per the approved GAD.

  Note 1: A brief on competent authority for approval of Railway bridges, ROB/RUB etc. for zonal Railways and other than zonal Railway is given in Annexure 4A (at the end of this chapter).

  Note: As per the Gazette notification for the Railways (opening for public carriage of passengers) Amendment Rule, 2023, following matters shall be referred to the Principal Chief Engineer or the Principal Chief Electrical Engineer or the Principal Chief Signal and Telecommunication Engineer:

- Construction, rebuilding, modification and strengthening of foot over bridges and road over bridges;
- Construction, rebuilding, re-girdering and strengthening of minor bridges;
- Re-girdering and strengthening of all existing bridges, other than minor bridges;
- Elimination of manned level crossing;
- Up-gradation of level crossing including interlocking outside station limits;
- Introduction to electric traction
- Work related to the Dedicated Freight Corridor

406 DRAWINGS PREPARED BY S & T ENGINEERING DEPARTMENT

All All signaling works are required to be carried out in accordance with the approved plans, standard drawings, and specifications and should conform to the provisions of the Signal Engineering Manual, where applicable.

The Railway board has issued standard scheme for the preparation of SIP vide its letter no. 2018/Sig/36-SD/1 date 26.11.2019 **(Ref. 4.06)** and has instructed to implement the standardization scheme.

The Railway Board vide letter No. 2020/Sig/Drawings dated 02.03.2022 has issued guidelines for the use of standard layouts of double-line sections **(Ref. 4.07)**.

The following plans and system design documents are to be carefully prepared and approved.

(1) Signal Interlocking Plan (SIP):

A Signal Interlocking plan is prepared on the basis of Engineering Scale Plan. It shall be prepared as per the Indian Railways Signalling Engineering manual (IRSEM para 8.1.5). It contains information regarding type of Signalling & Interlocking arrangement, the method of operation of points, signals etc. Various inter-signal distances, overlaps and line capacities are also detailed in it. It also gives information regarding the type of block working and telecommunication facilities provided at a station. Signal Interlocking Plan should be drawn to scale in metric dimensions. The Signal Interlocking plan is approved by the Chief Signal and Telecommunication Engineer (CSTE) and the Chief Transportation Planning Manager (CTPM).

Information to be shown in Signal Interlocking Plan

- Standard of interlocking and class of station, chainage of station building.
- Name of the station in full.
- Names of adjacent stations and their distances.
- Holding capacity of all running lines and sidings (CSL).
- Direction of reception and dispatch on running lines and description of sidings.
- Restriction on dead-end sidings (e.g. no stabling), if any.
- All gradients within the station limits and up to 2.5 kilometers in rear of the first stop signal.
- Kilometer and class of level crossings within the station limits, whether interlocked or not.
- Type of Block Working with adjacent stations and location of block Instruments.

- Up and Down directions and names of important junctions on either side.
- Reference to condonation of gradient infringements and CRS dispensation for deviations from GR / IRSEM, if any.
- Reference to the approved Engineering Scale Plan on which the Signal Interlocking plan is based.
- In case of an interlocked level crossing gate within the station limits, mention the KM No., distance, width, class, type of barrier, method of operation and control on signals, Telephone communication provided and the place to which it is connected. Bell / warning, and road signals provided are to be indicated. Indicate whether it is operated electrically or mechanically, and from where?
- Inter-signal distances and lengths of overlaps.
- Note regarding telephone communication provided between ASM/Cabin man and level crossings within and outside station limits.
- Aspect sequence chart for color light signals.
- Whether turnout is 1 in 8-1/2 or 1 in 12 or 1 in 16 or symmetrical split or thick web switch etc.
- Details of of the Detection Table etc., which are not apparent in the plan.
- Details of Track Circuits / Axle Counters.
- SM's slide control for individual signals & routes.
- Type of signalling, standard of Interlocking, method of operation of various points, detection table of points for various signals to be given.
- Gradient and level posts.
- Signals, inter-signal distances and distance between Warning Boards and Signals.
- Details of open bridges/RUB/ROB/LHS.
- List all Main routes with all overlaps, Calling On routes & Shunt routes.
- Fouling point/Track circuits.
- Custody of spare keys.
- Emergency Key Box.
- Date of all previous references of commissioning the installation with their sanction numbers and deviations (if any) and date of commissioning.
- Present Version Number.

A sample checklist for the Signal Interlocking plan approval is placed as **Table 4.05** at the end of the chapter. The list is not exhaustive, zonal railways may add/delete the items as per site requirement.

(2) Selection Table or Route Control Chart (RCC):

A selection table is a set of interdependencies/relationships/requirements with applicable conditions among various signaling functions/equipment at a station/yard, presented in a logical way in a tabular format with all possible combinations of routes for all the signals to achieve safety and to provide for operational requirements. It is also called a Selection Table/Route Control Chart. Locking table is used in Mechanical Interlocking, while Selection Table/Control Table/Route Control Chart is used in Electro-mechanical/Relay and Electronic

Interlocking.

It is the basis on which detailed circuit design is undertaken for implementing Interlocking requirements. The control table should be read in conjunction with the scheme plan or Signal Interlocking plan.

IRSEM Drg.No.8-D2 (Sheets 1 of 4, 2 of 4, 3 of 4, and 4 of 4) of CONTROL TABLE FOR DOUBLE LINE STATION may be referred **(Ref. 4.08)**.

(3) Track Circuit Bonding Plan:

The Track Bonding Diagram consists of a complete layout of yard and diagrams of individual track circuits showing location of insulation joints, jumpers, relay and feed ends, polarity, length, traction, bonds, etc. Track relays shall be located at the entry end of the track circuits wherever possible. (IRSEM para 17.2.1). Maximum positive rail connectivity is to be ensured.

IRSEM Drg.No.17-D2 for TRACK CIRCUIT BONDING DIAGRAM FOR a 4-ROAD STATION (DOUBLE LINE) may be referred **(Ref. 4.09).**

(4) Station Working Rule Diagram (SWRD):

As per details in Operating Manual Chapter STATION WORKING RULES (SWRs) AND TEMPORARY WORKING ORDER regarding SWRD **(Ref. 4.10)**.

The SWR Diagram is based on Signal Interlocking Plan and should show the complete layout of the Yard, Points, Signals, gradients, and interlocking arrangements of the Station, including the non-interlocked sidings, exact and actual holding capacity of all the individual lines in metres, actual inter-signal (demarcation point) distances, names of the adjacent stations and IBH signals, where provided, on either side of the station with their respective distances from the centre line of the station building to the centre line of the adjacent Stations, and any other information necessary in the day to day operation of trains.

The particulars of the date up to which it was corrected should also be mentioned. The SWR diagram should show actual distances and not the minimum prescribed.

It should be signed by the Divisional Operations Manager, Divisional Signal & Telecom. Engineer and Divisional Engineer.

The Station Working Rule Diagram (SWRD) shall be prepared by the concerned Construction/ Project Officer or Rly PSUs Officer and signed by the Divisional S&T and Operating Officers.

(5) Interface Circuit and Logic Circuit Diagram:

CHAPTER 4 of Electronic Interlocking notes of IRISET S-18 regarding INSTALLATION OF ELECTRONIC INTERLOCKING SYSTEM may be referred **(Ref. 4.11)**.

These are the interconnection wiring diagrams of Interlocking equipment such as Signals, Points, Crank handles, LC Gate, Siding point, Block Instrument, Axle Counters, etc. These circuit diagrams are prepared on the basis of:

- Approved Signal Interlocking Plan
- Approved Panel Diagram.
- Approved Control Table
- Details of any additional Interlocking equipment to be interlocked with the EI/RRI system.

(6) Contact booking/allotment and contact Analysis Chart:

As per SEM para 21.2.2 -

A contact analysis chart shows the contacts used circuit-wise, with reference and spare contacts available, a wire count for each contact, and the relay position in the rack. This avoids duplication of contacts in circuits during design stage and helps in identification of spare contacts for assigning them during circuit alterations.

IRSEM Drg.No.21-d5 (Sheet 1 of 2 and 2 of 2) for CONTACT ANALYSIS FORMAT may be referred **(Ref. 4.12)**.

(7) Visual display Unit (VDU)/Panel Diagram:

As per IRSEM para 8.1.8 (v)

A panel diagram is required for developing and manufacturing an operating panel or VDU kept in the station master room for operating the signals. The VDU diagram shall be submitted to the actual size or in proportionately reduced size of the VDU for approval. It shall indicate:

- Track Layout as per the approved signaling interlocking plan with a symbol for the direction of traffic for each line of the layout.
- Nomenclature of each line/siding.
- Boards for BSLB/GWB/STOP.
- SM's key in/Out indications
- SI cancellation Key-In indication;
- Provision of all un-blocking;
- List of all emergency counters;
- Relevant signaling details such as track section numbers with route set-clear/set-occupied or occupied lit indications in different colour.
- Main/calling-on/shunt signal numbers with timer, locked indication, & each aspect's indications
- Point numbers with 'Normal' & 'Reverse' indication slits, locking indications, subroute cancellation symbol in blue colour with white dot.
- Each signal route initiation & signal overlap set/release timer indications
- Block instrument status; LCPR/SR/Block release indication;
- Crank handle Key-In/Key-Out indications for each crossover;
- status of active/standby VDU;
- Link status, health status, OC/CIU status, CRC/Checksum
- Date/Time, colour scroll for flashing indication, etc.
- These are the least, but not limited, to be shown.An approved Typical VDU layout may be referred.

IRSEM Drg.No.8-D3 VDU LAYOUT PLAN FOR ELECTRONIC INTERLOCKING (EI) may be referred **(Ref. 4.13)**.

(8) Cable Route Plan:

As per IRSEM para 15.1.2(e &f)

The Cable Route Plan shall show disposition of underground cables at OHE mast/regular intervals with respect to nearest track centre for each yard.

- The cable route plan should be got approved from the division before undertaking the

work of trenching & cable laying [IRSEM Annexure: 9-A7] **(Ref. 4.14)**.

- The route shall be shown clearly on a cable route plan, showing the actual alignment of the track, giving offsets from permanent way or permanent structures. The diagram should indicate the various road and track crossings, crossings with power cables, water and sewage mains and other points of importance. It is preferable to chart the route on a route plan on which the existing routes of power cables, etc. are shown. Changes, if any, should be incorporated into the chart/plan. [SEM Para15.1.2. (e)].
- The Cable route plan shall also be approved by Engineering and Electrical departments. Approval of S&T open line is also required wherever it is prepared by someone other than open line. In the case of Construction works cable, the route plan shall be signed by Engineering and Electrical departments of executing agencies as well. [SEM Para 15.1.2(f)]
- Ducting at least up to the home signal is to be shown.

(9) Cable Core Chart:

The Cable Core plan shows the distribution of various outdoor signalling cables, including power cables. Cable core plans are necessary for:

- Commissioning and testing.
- Producing other design details (circuit diagram termination sheets, power supply wiring, etc.)
- Updating for record purposes.
- Routine and incidents testing.
- Facilitating preventive and corrective maintenance.
- Correlation of site wiring and records.
- Alterations to show proposed signaling works.

Note: Whenever any alteration is undertaken, the cable core chart is required to be altered and updated, duly approved by Sr. DSTE/Dy. CSTE.

The cable core plan should contain the following information:

IRSEM Drg. No. 15-D9 (Sheet 1 of 3, 2 of 3 and 3 of 3) i.e. CABLE CORE PLAN may be referred **(Ref. 4.15)**.

- Cable size.
- Number of conductors.
- Unique cable name.
- Locations in which the cables are terminated.
- Cable core numbers and allocations.

(10) Location Box/Junction Box Diagram

Diagrams of Location/Junction boxes show the details of termination of cable conductors, wires, and fuses on the termination board including Wago /ARA terminals.

Note: Whenever any alteration is undertaken, the location detail is required to be altered and updated, duly approved by Sr. DSTE/Dy. CSTE.

IRSEM Drg. No. 19-D8 and 19-D9 FOR LOCATION WIRING FORMAT may be referred **(Ref. 4.16)**.

(11) Relay Room Floor Plan

The relay room floor plan shows the arrangement of relay racks in relay room along with CT Rack and other equipment like EI equipment, data logger, Power Board, Maintenance PC if any. This plan also shows the location of doors and windows. **(Ref. 4.17)**.

(12) Drawings of Relay Room, Power Equipment Room, Battery Room, ASM Room etc.

Reference: Policy guidelines for signalling works by W. Rly, No. SG 216/0 Dt:-10/11/2022 **(Ref. 4.18)**.

(a) Interlocking equipment room and station building for a wayside station should be as per the latest drawing approved by PCSTE's Office for way side stations, and for other major stations, building drawing needs to be approved by CSE/PCSTE. The auto hut shall be built as per the drawing approved by PCSTE's Office.

(b) At stations, only one relay room needs to be provided for installing all the equipment, including ABS, TCAS etc.

(c) All buildings should be of the masonry type. The use of prefab structures shall be permitted on a case-to-case basis only with the approval of PCSTE.

(d) Generally, the relay room should be next to the ASM room. The required cable ducts and openings in the wall, shall be made while constructing the building itself. If the interlocking room is on the upper floor, then all outdoor cables to the interlocking room shall be taken through inside the building. The height of the relay room, including beams if any, shall be a minimum of 12 feet (from floor to ceiling).

(e) All the walls of the interlocking equipment room should be provided with glazed tiles up to roof level to avoid the need for periodic coloring, which is normally not possible once the installation is commissioned. Also, this will help in reducing dust in the relay room, which adversely affects relays and electronic equipment.

(f) The equipment layout plan for the relay room, IPS room, aanel Room, ASM room, ESM duty room/equipment room, battery room (VRLA/LMLA), OFC room, etc. shall be prepared in advance and approved by Sr. DSTE.

The IRSEM drawings, i.e. 21-D1: S&T Building Plan for End Goomties (EI), 21-D2: ASM Room Layout Plan, 21-D3: SM`s Table with Dual VDUs, can be referred **(Ref. 4.19).**

Typical Drawing for S&T Service Building (up to 100 routes with a single IPS) with a Centralized Interlocking System issued vide Railway Board letter No. 2017/Sig/3/85th SSC dated 08.01.2019 can also be referred **(Ref. 4.20).**

407 APPROVAL - SIGNALLING AND TELECOMMUNICATION ENGINEERING DRAWINGS

(1) The plan sizes shall be as per IRSEM para 8.1.3 which are as under –

Type of Drawing	Size	Measurement including Border	Border
Sketches	A-4	210 mm x 297 mm	10 mm
	A-3	297 mm x 420 mm	
Locking Table	A-3	297 mm x 420 mm	10 mm
Control Table	A-3	297 mm x 420 mm	10 mm

Circuit Diagram	A-3	297 mm x 420 mm	10 mm
Power Supply Diagram	A-3	297 mm x 420 mm	10 mm
Track Bonding Plan	A-4	210 mm x Any Length	10 mm
	A-3	297 mm x Any Length	
Cable Termination Diagram	A-3	297 mm x 420 mm	10 mm
Control cum Indication Panel (CCIP)	A-3	297 mm x Any length	10 mm
Signalling Interlocking Plan	A-3	297 mm x Any length	10 mm
Locking Diagram	A-3	297 mm x Any length	10 mm
Cable Core Chart	A-3	297 mm x Any length	10 mm
Cable Route Plan	A-3	297 mm x Any length	10 mm
VDU Diagram	A-3	297 mm x 420 mm for Standard Yard	10 mm
	A-2	420 mm x 594 mm for Bigger Yard	
Floor Plans for TSAA, Earthing Plan	A-3	297 mm x 420 mm	10 mm
Note: 30 mm margin is to be provided on left hand side for binding purpose.			

(2) The check and issue of drawings shall be as per IRSEM para 8.1.6 which are as follows:

(a) Signalling Interlocking Plans and Locking Tables/Control Tables shall be checked in full at two levels by officer before they are approved and signed by the officer in Junior Administrative Grade or above, authorised by the Principal Chief Signal and Telecommunication Engineer.

(b) Cable plans, power supply distribution diagrams, etc. shall be checked in full at two levels by officers before they are approved and signed by the Divisional Signal and Telecommunication Engineer/Senior Signal and Telecommunication Engineer.

(c) All Circuit Diagrams including those submitted by the contractors or firms (including PSUs) shall be checked in full at two levels by the officer before they are approved and signed by the Deputy Chief Signal and Telecommunication Engineer. Detailed wiring diagrams for individual stations prepared on the basis of approved typical circuit diagrams should be checked in full by an officer and a Divisional Signal and Telecommunication Engineer or Senior Signal and Telecommunication Engineer who may approve and sign them. They are shown below in Table below.

Levels of Checking & Approvals

HQ/ DIVISION	Type of Drawings	Drawn & Checked by	Level 1 checking	Level 2 checking	Approval
HQ level drawings	SIP, TOC, Circuit diagrams	JE/SSE/ D&D	ASTE	SSTE/ D&D	Dy. CSTE or Above
Divisional/ Unit level drawings	Cable core plan, Cable route plan, Power distribution diagram, Interface drawing for EI.	JE/SSE/ D&D	ASTE	ASTE/ DSTE	DSTE/Sr. DSTE/ Dy. CSTE
	Track Circuit bonding diagram, Location termination particulars, Perimeter earthing for EI.	JE/ SSE/D&D	ASTE	ASTE/ DSTE	DSTE/ Sr. DSTE/Dy. CSTE
Note: PCSTE may add more drawings and amend details given above as required					

408 STANDARD PROCEDURE ORDER FOR SIP APPROVAL

In addition to the instructions mentioned in the above paras, letter No.2017/CE-I/CT/13/Procedure simplification dated 22.04.2022 **(Ref. 4.04)** has issued Standard Procedure order for ESP, SIP, & GAD approval, which is as follows:

1) Approval of SIP - SIP should be approved as per the procedure and timelines mentioned in Railway Board letter No. 2016/Sig. /Drg. Off/1 Dtd.09.11.2017.

   a) Copies of the tentative SIP based on the approved Engineering Scale Plan (ESP) will be sent simultaneously to CTPM and the nominated ADRM of the concerned division.

   b) The nominated ADRM will obtain the comments of Sr. DOM and Sr. DSTE on the tentative SIP and advise the same to CTPM.

   c) After scrutinizing the division's comments, CTPM will send his comments to CSTE (Const.)/CSTE (Proj).

   d) On receipt of comments from CTPM, necessary modifications will be incorporated into the tentative SIP by CSTE (Const)/CSTE (Proj)/CSTE (Plg) and the plan got approved and signed by CTPM. In case of any technical difficulty or difference in opinion in complying with the comments of CTPM, matter will be discussed and decided by CSTE (Const)/CSTE (Proj)/CSTE (Plg) in consultation with CTPM.

   Timelines in working days for comments / approval shall be as under:

Work	Route	No. of days for preparation of SIP (From the date of approval of ESP)	Division	CTPM	CSTE (Con)/ CSTE (Proj)/ CSTE (Plg)	Total
Minor 15 days	Up to 50 routes	15	7	3	2	22
	From 50 to 200 routes	28-30	7	4	3	29

Major 30 days	More than 200 routes	40-45	10	7	3	50

e) The above timetable shall be strictly adhered to so that delay in the execution of signaling works is avoided. SIPs not getting approved as per the time lines given above shall be discussed in the plans meeting conducted by the AGM.

f) At the stage of approving the SIP, no change in the already approved ESP should be demanded. However, if changes are ESP is inescapable, the request for a change in ESP should be routed through the PHOD, by the department requesting the change.

2) It may be noted that the time line given in para (1) above shall be followed strictly. However, if in the tender documents if timeline given for approval of the above-mentioned drawings is stricter, then the same shall be followed for that specific contract work.

3) Based on the above, all Zonal Railways/Other Units should make a detailed procedure order to expedite approval of ESP, SIP & GAD.

409 DRAWINGS PREPARED BY ELECTRICAL DEPARTMENT

Some of the important drawings prepared for project execution are as under-

(1) Pegging plans: Pegging plans are the plans of the railway track to be electrified, indicating the position of the structure to support OHE.

(2) OHE Layout Plan: OHE layout plan is prepared after finally correcting pegging plan. The layout plan shows the OHE layout as per ESP. It includes the actual run of catenary/ contact wires, stagger of the contact wire, and number of brackets on each structure, the point at which OHE is terminated, anti-creep points, and all out of run wires and complete sectioning details as per the section diagram.

(3) Section diagram: The section diagram shows the location of insulated overlap, section insulator, isolator, and detailed plan of every switching and sectioning in schematic form.

(4) Cross-section diagram: Resection section diagram is prepared for every structure, indicating the cross-section of formation height, and nature of bank, whether new or old, nature of soil, type of foundation block, type and size of structure, and nature of deflection to be provided.

(5) Structural erection diagram: The drawing gives complete data relating to every OHE structure on one sheet of paper and forms the basis of every subsequent operation during erection, then during final checking, and subsequently for adjusting the OHE to the designed configuration during operation and maintenance.

(6) Profile drawing: These drawings shows the profile of the catenary and contact wire under every overline structure, the gradient and height of the contact wire, along with the encumbrance on the structure, until normal values are restored.

(7) As erected drawing (AED): During the course of construction, there would be several changes, modifications, and improvements that may be decided during work. All these changes shall be included in the AED

(8) General Service works

a) General supply arrangement: General general supply arrangement includes the location of the feeding substation and layout of feeding from the substation to the building or any other general service asset.

b) Wiring Diagram: The wiring diagram includes information about wiring points, switches, plugs, sockets, and distribution units to be installed. It gives a clear picture of the fittings to be installed and the wiring to be carried out.

c) Cable layout plan: The cable layout plan includes the path of the cable laid from the substation or from the mains, and its distribution, which gives information in case of failure.

410 SANCTION OF GRADE CONDONATION

As per IRSOD chapter II item 2, the powers of condonation for gradients steeper than the specified standard maximum gradient of 1 in 400 (0.25%) shall be as given in **Table 4.01**:

Table 4.01

SN	Description	Authority to sanction
1	Existing Yard: Steeper than 1 in 400 (0.25%) and upto 1 in 100 (1.0%)	General Manager through the Principal Chief Safety Officer (PCSO)
	Steeper than 1 in 100 (1.0%)	Railway Board through the Chief Commissioner of Railway Safety
2	For New Yard in New Line projects: Steeper than 1 in 400 (0.25%) and upto 1 in 260 (0.38%)	Commissioner of Railway Safety
	Steeper than 1 in 260 (0.38%)	Railway Board through the Chief Commissioner of Railway Safety

411 SANCTIONING OR APPROVING AUTHORITY FOR LAYING VARIOUS TRACK ITEMS

1) As per IRSOD chapter II item 2, the powers of condonation for gradients steeper than the specified standard maximum gradient of 1 in 400 (0.25%) shall be as given in table 4.02 below:

Table 4.02

SN	Description	Authority
1	**Turnouts on running lines with passenger traffic**	
	a) 1 in 8.5 turnout with curved switches can be laid in exceptional circumstances, taking off from straight track. **(Ref: IRPWM para 408(2)(b)**	With PCE's approval
	b) 1 in 8.5 turnout with curved switches can be laid from outside a curve up to five degrees in exceptional circumstances where, due to limitation of room it is not possible to provide 1 in 12 turnout. **(Ref: IRPWM para 408(2)(e)(iii))**	With PCE's approval

	c) During yard remodelling in existing yards, under exceptional circumstances where, due to site constraints and techno-economic reasons, turnout with a resultant lead curve radius not less than 290m can be provided. **(Ref: IRPWM para 408(2)(e) note(2))**	With PCE's approval
2	**Location of SEJ**	
	a) The improved SEJs (RT-6902, RT-6914, RT-6922, and RT-6930) may be located on curves up to 2°. SEJ beyond 2° and up to 4° shall be laid. **(Ref: IRPWM para 328)**	with approval of PCE in consultation with RDSO
3	**Super elevation, Cant Deficiency and Cant Excess**	
	a) On new lines/diversion/multi tracking works on A and B routes, exceptional cases of not achieving full speed potential due to non-exploitation of permitted Cant can be allowed with proper justification. **(Ref: IRPWM para 404(d) Note 2)**	with approval of PCE
4	Length of the transition curve and setting out the transition	
	a) A reduction in the transition length of the curve due to site constraints can be done (max. cant gradient of 1 in 360 can be permitted instead of 1 in 720).(Ref: IRPWM para 405(3) Note)	with approval of CTE
5	Change in super-elevation over turnouts	
	a) There should be no change of cant between points 20 metres outside the toe of the switch and 20 meters beyond the nose of the crossing. Normally, turnouts should not be taken off the transitioned portion of a main line curve. However, in exceptional cases, when such a course is unavoidable, a specific relaxation may be given, provided there is uniform cant over the length mentioned above. (Ref: IRPWM para 410)	with approval of CTE

Table 4.03

Checklist for preparation of General Arrangement Drawing (GAD) for Railway Bridges

SN	Item	Yes/ No
(A)	GENERAL (To be written on the right bottom corner) Chap. IX of IRWM	
1	Drawing is prepared on standard paper size i.e. A0= 841 x 1189 mm (Important/Major Bridge works) A1= 594 x 841mm (Other Bridge works) A2= 420 x 594mm Temporary arrangement & detailed drawings for bridge works. (**Ref.** Table 9.1 of IRWM para 903)	
2	Drawing is prepared on AutoCad or any other similar software	
3	Borders provided as per BIS: SP-46-1988	

4	Title block placed at right bottom corner as per para 903(d) of IRWM and the following basic details should be given in it: -	
5	**Name of the work -** to be mentioned correctly i.e. Name of Railway, Division/ Construction organisation, Project Work with location, name of the consultant, etc.	
6	**Drawing number-** to be mentioned correctly. (**Ref.** Para 904 of IRWM)	
7	**Scale-** to be mentioned in the title block correctly, size of drawing shall not be less than that mentioned in item 1 of (A) above.	
8	**Name & Signatures –** The name and signature of all officials involved in preparation of GAD to be written clearly and to be signed with date. For works by construction organization name and signature of Divisional Officers also to be ensured. Provision to be made for signature of Headquarter officials. (**Ref:** Para 904 of IRWM)	
9	**Reference –** Reference of Pink Book/others Item No. with the name of sanctioned work to be mentioned clearly. (**Ref.** Para 904 of IRWM)	
10	**Alterations –** Alterations should be clearly mentioned with the name and signature with date of the officials concerned.	
(B)	**NOTES** (To be written on the right side of plan) The following items to be covered in the Notes on the GAD Plan	
1	**Dimensions –** To be written clearly (preferably in mm and levels in meter). The font size should be reasonably big and easily readable)	
2	**Colour-** The colour of existing work, proposed work, proposed dismantling, and future work to be indicated. (Ref. Para 907- c) of IRWM)	
3	**Scaling and Direction-** No scaling of dimensions from the GAD should be permitted, all relevant dimensions to be written, North direction to be shown.	
4	**Shown to scale-** plan, section and elevation to be as per scale and scale to be mentioned.	
5	**Directions to Field Engineers-** Directions to Field Engineers before execution should be mentioned clearly, i.e. verification of various levels, including rail level, formation level, HFL, maximum observed scour level on upstream, foundation level, bore log data, type of soil, bearing capacity, etc. Clear directions in case there is apprehension of damage to nearby structures, etc.	
6	**Co-ordination –** Clear direction to the executive department to consult/intimate other concerned departments.	
7	**Traffic diversion-** In case of traffic diversion during execution, the same is to be mentioned with details like the chainage of take-off points on both ends, etc.	
8	**Speed restriction-** A clear mention of speed restrictions to be followed before/ during/after the execution.	
9	**Reference Drawings-** The drawings referred for detailing to be mentioned clearly.	

10	**Miscellaneous details-** Miscellaneous details like skin reinforcement, no plastering/cement wash, dry stone pitching, weep holes, backfill, inspection platform, pedestal, trolley refuges, OHE mast, safety measures, service cables, launching scheme, protective coating to reinforcement and concrete, station names with their MSL, railway boundary, modus operandi, etc. to be mentioned in the notes itself.	
11	**Codes and Specifications-** Reference of Railway Codes/Manuals (Bridge Rules, IRBM, etc.), IS Codes, IRC Codes with their order of preference and specifications to be followed, should be clearly mentioned.	
12	**Technical details-** All technical data used for preparation of GAD such as latitude/ longitude, track on single/double line, bridge on UP line or DN line, grade, rail level, formation level on approaches, HFL, LWL, bed level, free board & vertical clearance provided vis-à-vis the codal requirements, linear water-way, standard of loading, type of super- structure, type of bearing, type of sub-structure, type of foundation, design discharge, catchment area, seismic zone, wind zone, hydro-meteorological sub- zone for water-way calculation, exposure condition, clear cover to reinforcement, provision of guard rails, track on straight or on curve, any RAT/RAW within 50km on upstream, cross slope, name of river/stream etc. to be summarised in a tabular form. All reduced levels to be mentioned w.r.t. MSL.	
13	**Details of existing bridge-** Details of existing rail bridge/road bridge to be written in a tabular form i.e. existing bridge no., location, span, type of sub- structure/ foundation, distance from new bridge, rail level, formation level & foundation level, water-way and critical levels, any major incidents that happened to these bridges in the past, etc.	
14	**Details of trial pit/bore log-** Nature of the soil as determined from trial pit & bore log details, the details of location with chainage, reduced level at the top of the trial pit/bore log; SBC value for each stratum to be shown in tabular form and pictorial form.(Ref. Para 906- a(xii) of IRWM)	
(C)	**INSTRUCTIONS TO BE FOLLOWED IN THE PREPARATION OF GAD**	
1	Whether the proposed work is as per sanction or is there any deviation from sanction. In case of deviation, the details thereof. (Pink Book/Other Sanction)	
2	Whether GAD satisfies the latest approved SOD. Infringements of standard dimensions, if any, should be shown. (**Ref:** a. IRSOD b. Para 906- a(xvi) of IRWM)	
3	Relevant & up to date IRS and IRC Codes, etc. with their order of preference to be decided. (**Ref.** Various Codes, Manuals, Specifications, etc.)	
4	**L-Section:**	
	(i) Whether L-Section of Gauge Conversion Projects and Doubling Projects has been approved by open line?	

	(ii) In case of New Line Projects being executed by construction organisation, whether L-Section has been approved by construction organisation? In case of New Line Projects being executed by PSUs, whether L-Section has been approved by open line? (**Ref:** Board's letter No. 98/W- 1/General/ O /30 dated 10.06.2008)	
5	In case of construction of new bridge during doubling, whether Railway has considered the condition of existing single line bridge also for replacement in the near future? (Ref. Board's letter No. 2021/ED(Proj)/Misc/ Committee dated 12.11.2021)	
6	Whether provision of IRBM has been considered for site selection of bridge? (Ref. Para 308 of IRBM)	
7	Whether hydrological investigation has been carried out? A report to be submitted. If not, the reasons thereof. (**Ref:** a. Clause 4.1 of IRS Sub-structure Code b. Chapter 3 of IRBM)	
8	Whether design discharge has been calculated/provided as per the Sub-structure Code? (**Ref.** Clause 4.2 to 4.4 of IRS Sub-structure Code)	
9	Whether discharge due to RAT/RAW in upstream has also been taken into account? (**Ref.** IRC: 5- 2015 - Clause 106.3.5	
10	**Waterway:**	
	(i) Whether proposed waterway has been provided as per the Sub-structure Code? (**Ref:** Clause 4.5 of IRS Sub- structure Code)	
	(ii) In case of gauge conversion and doubling works, where there is no history of past incidents of over-flow/washout/excessive scour, etc. during last 50 years, whether waterway of existing bridge has been retained after taking measures for safety as considered necessary? (**Ref:** Clause 4.5.7 of IRS Sub- structure Code).	
	(iii) Whether waterway has been re-assessed based on the freshly estimated design discharge, where such history is there? (**Ref:** Clause 4.5.7 of IRS Sub-structure Code)	
	(iv) Whether clearance from Inland Waterways Authority of India/concerned Authority for navigational requirement for proposed bridge is taken, wherever required? (**Ref:** Para 302 (f) of IRBM	
11	Whether vertical clearance and free board have been provided as per the Sub-structure Code? If not, a note should be added that condonation should be taken from the competent authority before starting the work. (**Ref:** Clause 4.8 and 4.9 of IRS Sub- structure Code)	
12	Whether maximum scour depth below HFL at pier and abutment has been considered as per the Sub- structure Code? (**Ref:** Clause 4.6 of IRS Sub- structure Code)	
13	**Foundation:**	
	(i) Whether safe bearing capacity has been calculated by suitable method? (Ref: Clause 6.3.1 of IRS Sub- structure Code)	

	(ii) Whether open foundation has been adopted? If not, whether approval of CBE/SAG officer has been obtained? (**Ref:** Board's letter No. 2014/CE- III/BR/ Bridge Policy dated 15.11.2016)	
	(iii) Key details such as HFL, LWL, Bed Level, Scoured Bed Level, Founding Level, Grip Lengths, Diameter of Pile/Well, Well/Pile cap Level, etc. are shown in the GAD.	
	(iv) Whether distance between existing and proposed bridge has been adequately provided? (**Ref:** RDSO letter No. CBS/DWF dated 15.07.2019)	
	(v) Whether the location of proposed piers and abutments are in line with those of the existing bridge? If not, the reasons thereof. (**Ref:** Board's letter No. 2017/29/C E- III/BR/ Br. 588/ECoRdated 03.08.2017)	
	(vi) In case of doubling, whether new bridge is provided in downstream side?(It is preferable to provide a new bridge in downstream of an existing bridge)	
14	**Selection of span:**	
	(i) Whether most economical option has been considered? Proper and adequate justification for selection of span to be mentioned.	
	(ii) Whether overall length is more than existing bridge/water course? If so, the reasons thereof.	
	(iii) Whether overall length is less than existing bridge/water course? If so, the reasons thereof.	
	(iv) In case of doubling, the span arrangement should preferably be the same. Board's letters No. 2014/CE- III/BR/Bridge Policy dated 04.02.2015 & 21.04.2015	
15	**Super-structure:**	
	(i) Whether Board's guidelines followed for selecting the type of super-structure? If not, whether Board's approval has been taken? (Ref: Board's letter No. 2005/CE- I/BR-II/8 dated 28.05.2009)	
	(ii) Whether RDSO standard drawing/standard span is followed? If so, whether all the dimensions are as per RDSO standard drawing? If not, approval from PCE/ CAO obtained with proper justification should be obtained. (Ref: Board's letter No. 2013/C- III/BR/RDSO/Misc. dated 11.08.2014)	
16	**Size of pier/abutment cap**	
	(i) Whether size of pier/abutment cap has been provided based on the provisions of the Sub- structure Code, Seismic Code & IRBM including inspection arrangements?	
	(ii) While deciding the size of pier/abutment cap, whether the following key aspects have been considered:	

	• Space for inspection and maintenance of bearings including the space for jacks to lift the superstructure for repair/ replacement of bearings, etc. • Placement of seismic-restrainer. • Placement of the bearings, leaving an offset of 150 mm beyond them, • Space for the ballast wall. • Space for the equipment for pre-stressing operations where necessary, over and above space for end block in cast in-situ cases. • The drainage arrangement for the water on the cap. • To accommodate inspection ladders • Placement of OHE mast • Dimensions of girder as given in superstructure drawing. • Minimum seating width should be provided as per IRS Seismic Code. (**Ref:** a. Clause 7.1.1 & 7.2.1 of IRS Sub-structure Code b. Clause 14 of IRS Seismic Code C. Para 604(1) of IRBM)	
17	Whether bearings have been provided as per requirement and details shown correctly? (Ref. a. BS-102 (Rev.1) b. BS-131)	
18	Whether bridge is located in seismic zone III, IV & V? If yes, ductile detailing is mandatory for piers/portals as per the IRS Seismic Code. (Ref: Clause 5.3 of IRS Seismic Code First Revision – 2020)	
19	Whether RCC Boxes are provided?	
	If yes, whether the instructions latest Railway Board instructions are followed?	
20	**RUB/Subways alongside ROB:**	
	(i) Whether the instruction given in Railway Board letter dated 18.02.2021 have been followed for water logging and drainage problem in RUB/Subways? (Ref: Board's Letter No.2017/C E- IV/RUB/88 dated 18.02.2021)	
	a. Whether Height Gauges have been provided? (ref: a. Para 1107 (14)-b(i) of IRBM b. Railway Board Letter No.2017/CE-IV/LX/ Misc/244(L C) dated 15.10.20 20	
21	**Safety provisions:**	
	(i) Whether trolley refuges have been provided a. Para 646 &834 of IRPWM-2020 b. IRSOD C. Para 228 of IRPWM-2020	
	(ii) Provision of Side Pathways on Girder Bridge (**Ref:** a. RDSO letter No. CBS/DP G1 dated24.04.2019 b. Para 229 of IRPWM-2020)	
	(iii) Provision of Guard rails on Bridges (Para 220 of IRPWM 2020)	
22	Whether backfill material behind abutments, wing walls, RCC boxes, etc. have been shown? (**Ref:** Clause 7.5 of IRS Sub- structure Code)	
23	Whether weep holes have been provided adequately? (Ref: Clause 7.6 of IRS Sub- structure Code)	

24	Whether flooring details with curtain wall/drop wall/apron have been shown with cross- section? (ref: a. IRC SP: 13-2004 b. Para 818 of IRBM)	
25	Whether wing walls with cross-section, with dotted lines in elevation have been shown?	
26	Whether proper facilities for inspection like inspection ladder, steps, inspection platform have been provided? If not, the reasons thereof. (Ref. a. Para 6 of BS-102 (rev. 1) b. Para 6.3 of BS -113 c. RDSO drawing no. CBS- 0016)	
27	Whether reference of separate drawings like protection work, pitching etc. has been mentioned at appropriate place?	
28	Whether direction of flow has been confirmed from site and shown correctly in the plan?	
29	Whether river-training and protection works are required? If so, these have been provided as per IR Bridge Manual. (Ref: Chapter 8 of IRBM)	
30	Whether following information is shown on the drawing:	
	(i) The names of the nearest junctions or terminals stations, that on the left hand being the one from which the kilometrage starts). (Ref: Para 906- a(ii) of IRWM)	
	(ii) The boundaries of land according to the land plans. (Ref: Para 906- a(v) of IRWM)	
	(iii) Any known bench mark with the datum from which its value has been reckoned.(Ref: Para 906- a(vi) of IRWM)	
	(iv) The degree, radius, beginning and end of transitions, total angle of deflection and the tangent points of all curves on the bridges and its approaches.(Ref: Para 906- a(vii) of IRWM)	
	(v) All gradients, points of change of gradient on the bridges and its approaches (Ref: Para 906- a(viii) of IRWM)	
	(v) In the case of foundations, the nature of the soil as determined from trial pit, and bore log details.(Ref: Para 906- a(ix) of IRWM)	
31	The drawings for a bridge should include the site plan, plan and longitudinal section of the river or nala above and below the proposed site in the case of large bridges being rebuilt on account of insufficient waterway or being built at a new site and a sufficient number of cross sections showing highest flood level, ground plan of foundations, sections through the bridge in such directions as are necessary to show the intended form and dimensions of the various parts, front and side elevation of abutments and piers, and drawings of such details as have not been standardized. The standard of loading for which the bridge is designed should be recorded in the plan and reference to the type drawing of the particular girder should also be recorded. (**Ref:** Para 906- C of IRWM)	
32	Whether GAD has been prepared with half plan at top and half plan at bottom with longitudinal section, sectional elevation and key plan?	

33	Whether the dimensions of plan, elevation, cross section, longitudinal section have been cross checked for inconsistency/ errors. The dimensions should match?	
34.	In case of Important Bridge, whether preparation & approval of Design Basis Report is required in terms of extant policy of Railway Board? (**Ref:** a. Board's Letter No. 2013/C E-III/BR/RDSO/ Misc. dated 04.06.2014 b. Board's Letters No. 2014/C. E-III/ BR/Bridge policy dated11.11.2019 &10.03.2017)	
35.	Whether inspection and maintenance of bridge can be ensured as per the extant instructions, methodology and techniques or preparation of a bridge-specific inspection and maintenance manual is considered necessary in view of use of special type of span/use of new technology/peculiar features of bridge?	

Note: Latest version of Codes & Manuals, Special Publications and RDSO BS Reports should be referred to.

Table 4.04

Check list for preparation of GAD of ROB

SN	Checklist- General	Yes/ No
1	Whether the GAD has been prepared with a key plan, showing existing alignment with all features like ROB, bridges, curves etc., up to the curve/stations on both sides of ROB?	
2	**Description of spans:** Whether Overall length & effective length of span which are within railway boundary, is mentioned? **Width of ROB:** Whether the width of ROB at deck level has been mentioned?	
3	**Skew angle:** Whether Skew angle with existing track and proposed ROB is mentioned in the key plan? All square and skew dimensions shall be shown in the plan and elevation	
4	**General :** Whether the following has been written on Right Bottom Corner?	
	Name of work - Mention proposed ROB type, Division, Name of Road and Type, LC No., Railway KM, between Stations and block section etc., name of Consultant etc.	
	Drawing number- to be mentioned correctly.	
	Scale - to be mentioned correctly, Size of drawing to be not less than A1, on tracing paper (to be converted to tracing cloth after execution). 1) Scale 1 :100 as a rule 2) Key Plan also to be drawn on a scale up to curves, or station yard, or 1000 m at least on either side in the case of ROBs.	
	Name and Signature- The name and signature of all officials involved in preparation of GAD to be written clearly and to be signed with date. For construction organization works, name and signature of divisional officer also. Provision to be made for signature of Head Quarter officials.	

	LC No. & TVU: Whether LC No. and TVU with year is mentioned above title block?	
	Name of Road authority: Whether the name of road authority with address of concerned Engineer of road authority is mentioned?	
	Reference- Reference of PB/others, item no. with name of sanctioned work to be mentioned clearly.	
5	**Dimensions & Levels -** To be Written Clearly (Preferably in mm and levels in meter).	
	Colour- The colour of existing work, proposed work, proposed dismantling and future work to be indicated. (Ref. Para 907- c) of IRWM)	
	Directions- Whether North directions has been shown in the Key Plan? To be shown on Top Right Corner 'ONLY'.	
	Whether Plan section and elevation are to be as per scale? Scale to be Mentioned.	
	Whether Direction to Field Engineers has been Incorporated (Direction to field Engineers, before execution should be mentioned clearly i.e. verification of various levels including rail level, Formation level, foundation level, bore Log data, type of Soil, Bearing capacity, etc. (Clear directions in case there is apprehension of damage to nearby Structure etc.)	
	Co-ordination- Clear direction to executive department to consult /intimate to other concerned departments. Clear responsibility of other executive departments to be defined for Consultation /intimation to other departments.	
	Traffic diversion- In case of traffic diversion during execution, the same to be mentioned with details like chainage of take-off points on both ends, etc. Division should show and ensure.	
	Speed restriction- Clear mention of speed restriction to be followed before/ during and after the execution.	
	Reference Drawings - The drawings to be referred for detailing to be mentioned clearly. e.g. Inspection Arrangements, Structural Drawings, Type plans such as rain water harvesting, RCC Hume pipe, Height gauge, etc.	
	Miscellaneous details- Miscellaneous details like inspection platforms on pier/ abutments, service cables, launching scheme, railway boundaries, Modus operandi, etc. to be mentioned in the notes itself.	
	Codes and specification - Reference of IRS codes, IS Codes, IRC Codes with their preferential order and specification to be followed and should be clearly mentioned.	
	Technical Details - Whether GAD contains all technical details?	
	(all technical data used for reference in preparation of GAD to be written in a tabular form, like type of IRC loading, latitude/longitude, grade of road at approaches, rail level ,formation level on approaches, , ground level, vertical clearance, standard of loading, type of superstructure, type of bearings, type of substructure, type of foundation, seismic Zone, wind zone, exposure Condition, Clear Cover to reinforcement and all reduced levels to be mentioned w.r.t rail level.	

	Details of existing ROB- Whether details of existing ROB if any, have been incorporated? (details of existing road level/FRL to be written in a tabular form, i.e. existing ROB no, location, span, type of substructure/foundation, distance from existing ROB, rail level, road level, etc.)	
	Details of Trial pit/ Bore log- Whether details of trial pit/bore log have been incorporated? - (the details of location with chainage, reduced level at top of trial pit/bore log, SBC value for each stratum to be shown in a tabular form).	
	Alteration- Alteration should be clearly mentioned with the name and signature with date of official concerned.	
6	Whether the stipulations regarding speed restriction, traffic and power block etc. Have been firmed up and indicated in GAD? The traffic block and caution order requirement to be shown in tabular form.	
7	**Consent of competent authority for closing of LC:** The GAD should specifically contain a note regarding the status of Level crossing, whether (a) It would be closed during the construction of ROB or (b) It would be closed after the commissioning of ROB or In case LC is to be closed after construction of ROB, the consent of competent authority (collector) to be obtained, and copy of letter shall be enclosed along with check list. The same shall also to be mentioned in the note.	
8	In case of electrified sections, whether OHE protection arrangements like protection screen, etc. on the superstructure of ROB has been planned as per the RDSO standard arrangement? If a non-standard arrangement has been proposed, whether the same has been checked and certified? Sr. DEE/TRD and Sr. DEN should examine this aspect while signing the GAD.	
9	For ROB, whether a Copy of approved alignment plans up to Adjacent stations/ Curve on both sides has been Submitted for better appreciation? The approved project sheet should be sent along with and the reference of the same should be in the notes.	
10	Whether term of work i.e. Deposit basis or cost sharing basis, has been shown? If the work is on a deposit basis, enclose the detail of paid P&E charges and mention DEPOSIT WORK at the right corner of GAD. If the work is on a cost sharing basis, mention PB No./LB No. at right corner of GAD.	
11	Whether Road authority /NHAI have submitted Detailed Project Report (DPR) along with proposed GAD duly signed by concerned official of NHAI/Road authority through their consultant?	
	MISCELLENEOUS	
12	Whether the foundation of ROB has been finalized on the basis of detailed soil exploration and with due consideration of requirement of speed restrictions/traffic blocks? RL of bottom of foundation should be indicated in GAD.	

13	Whether detail of at least one span laying outside but adjacent to Railway boundary has been shown for considering their load coming on the pier under consideration.	
14	Whether the gradient of the road of approaches has been mentioned on either side. It should be min. 1 in 40 as per IRC.	
15	Whether the top of the pile cap is sufficiently below formation level? Whether the pile cap is sufficiently away from railway track so that the excavation of pile cap should not come in the line of load dispersion below sleeper, assuming a slope of 1V:1H.	
16	Whether provisions have been made for stairs located outside railway area at both ends of ROB for the passage of pedestrian? This is essential for the closure of the level crossing after the construction of ROB.	
17	Whether the horizontal and vertical clearances as applicable to electrified territory (25 kV AC) have been adopted in GAD even on routes having diesel traction to cater for future electrification?	
18	Whether the Head Room clearance under ROB in electrified section has been provided as minimum 6525mm as per Railway Board's letter No. 2007/RE/161/5-FTS-774 dt. 12.10.2011. If the proposed ROB comes on Electrified DFCC/Double stack container route, the minimum clearance shall be as per DFC SOD.	
19	Whether RDSO standard composite steel girders/Bow string girder has been adopted for ROB? PSC girders can be adopted for spans less than 24.4 m only.	
20	(i)Whether steel structures have anti-corrosive protection of long durability? (ii) Whether adequate arrangements for the drainage of the deck have been made?	
21	Whether Inspection ladders from road to pier top, inspection steps from track level to road level and inspection platforms in the piers/Abutments have been incorporated in the structural drawings to ensure proper inspection accessibility?	
22	Whether the shoring arrangement is required during foundation work? If yes, details shall be submitted.	
23	Whether the existing utilities are shown in the GAD? The signature of utility owner shall be obtained.	
24	Whether future tracks have been incorporated into key plan?	
25	Sanction of PCE is required for all cases where there is passenger carrying train traffic.	
26	Whether staircases has been provided at outside Railway land boundary in case of ROB is in lieu of any LC?	
27	Whether road width has been provided as per RDSO and IRC standard configuration?	
28	Whether road level of ROB is uniform within the Railway land limit?	

TABLE 4.05

Check list for preparation of GAD for RUB

SN	Check list- General	(Yes/ No)
1	Whether the GAD has been prepared with a key plan showing existing alignment with all features like bridges, curves etc., up to the curve/stations on both sides of RUB/Subway?	
2	**Internal size of Box:** Whether the span and height of the RCC box have been decided based on the type of road, nature of traffic, and TVU? The consent of road authority shall be obtained on the GAD.	
3	**Total length of RCC Box:** Whether the total length of the Box is mentioned? The minimum length of RCC BOX should be the distance between points where a slope of 1.5:1 drawn from the ends of sleeper to cut the bottom face of the slab of BOX. However, in no case, the minimum length of RCC BOX shall be less than 7850mm for a single line and 13150mm (7850+5300) for double lines.	
4	**Standard of loading:** Whether the loading is mentioned? It should be mentioned in GAD above the title block. Mention 25T loading for all BG routes. Mention DFC loading (32.5t) if the LC is coming in the feeder route or in the nominated route of the double stack container. Whether RDSO standard drawing no. of RCC box, according to loading, type of construction, depth of fill, & nos. of track crossings, has been mentioned?	
5	**Method of Execution:** Whether execution method is mentioned? a. Pushing through embankment b. Pushing method with Reliving girder or c. Cast in situ method	
6	**Skew angle:** Whether the skew angle of the existing road and proposed RUB/ Subway is mentioned in key plan? Skew angle of existing Road and Skew angle of proposed subway should be mentioned in the key plan. All possibilities shall be explored to avoid skew. All square and skew dimensions shall be shown in the plan and elevation.	
7	**General:** Whether the following has been written on Right Bottom Corner?	
	Name of work - Mention proposed RUB/Subway type, Division, Name of Road and Type, LC No., Railway KM, between Stations and block section etc., name of Consultant etc.	
	Drawing number- to be mentioned correctly.	
	Scale - to be mentioned correctly, Size of drawing to be not less than A1, on tracing paper (to be converted to tracing cloth after execution).	
	1) Scale 1 :100 as a rule.	

	2) Key Plan also to be drawn on a scale up to curves or station yard or 500m or less than 500 in case of RUB.	
8	**Name and Signature-** The name and signature of all officials involved in the preparation of GAD to be written clearly and to be signed with a date. Provision to be made for the signature of Head Quarter officers also.	
	LC No. & TVU: Whether LC No. and TVU with year is mentioned above in the title block?	
	Name of Road authority: Whether the name of the road authority with the address of concerned Engineer of road authority is mentioned?	
	Reference- Reference of PB/others, item no., with the name of sanctioned work to be mentioned clearly.	
9	**Dimensions & Levels** -To be Written Clearly (Preferably in mm and levels in meter). The font size Should be reasonably big and easily readable.	
	The Reduced level of the existing rail level shall consider as 100m. All levels such as Road level, Ground level, formation level, Top of Box, Bottom of Box, top of wing and return wall, founding levels etc. shall be indicated accordingly.	
	Colour- The colour of existing work, proposed work, proposed dismantling and future work to be indicated. (Ref. Para 907- c) of IRWM)	
	Directions- Whether North directions have been shown in the Plan? To be shown on Top Right Corner 'ONLY'.	
	Whether Plan, section and elevation to be as per scale? Scale to be Mentioned.	
	Whether Direction to Field Engineers has been Incorporated (Direction to field Engineers before execution should be mentioned clearly i.e. verification of various levels including rail level, Formation level, foundation level, bore Log data, type of Soil, Bearing capacity etc. Clear directions in case there is apprehension of damage to nearby Structure etc.).	
	Co-ordination- Clear direction to executive department to consult /intimate to other concerned departments. Clear responsibility of other executive departments to be defined for Consultation /intimation to other departments.	
	Traffic diversion- In case of traffic diversion during execution, the same to be mentioned with details like chain age of take-off points on both the ends etc. Division should show and ensure.	
	Speed restriction- Clear mention of Speed restriction to be followed before/ during and after the execution.	
	Reference Drawings - The drawings to be referred for detailing to be mentioned clearly. e.g. Inspection facilities, structural drawings, Height gauge etc.	
	Miscellaneous details- Miscellaneous details like weep holes, backfill, railway boundary, Modus-operandi etc. to be mentioned in the notes itself.	
	Codes and specification - Reference of Railway codes, IS Codes, IRC Codes with their preferential order and specification to be followed and Should be clearly mentioned.	

	Technical Details - Whether GAD contains all technical details? (all technical data used for reference in preparation of GAD to be written in a tabular form like latitude/longitude, RCC Box of single/Double, subway on UP line /DN line/yard lines, grade on approaches, rail level, road level on approaches, bed level, standard of loading, type of foundation, exposure Condition, Clear Cover to reinforcement, track on Straight or on Curve, etc. All reduced levels to be mentioned w.r.t rail level).	
	Details of existing LC- Whether details of existing LC, if any, have been incorporated?	
	Details of Trial pit/ Bore log- Whether details of trial pit/bore log have been incorporated? - (the details of location with chainage, reduced level at the top of the trial pit/bore log, SBC value for each stratum to be shown in a tabular form).	
	• The classification of soil shall be as per IS-1498, IRS substructure code and IRC-78. • The depth of soil exploration shall be as per IS 1892. • The location of trial pit should be near to the proposed subway and may be indicated on the plan. • Depth of bore should be at least 5m below the bed of BOX to estimate a feasible drainage scheme. It should also be sufficiently below the proposed deepest foundation level of BOX/wing or return wall.	
	Alteration-The alteration should be clearly mentioned with the name, date and the signature of official concerned.	
10	Whether the stipulations regarding speed restriction, traffic, power block, etc. have been firmed up and indicated in GAD?	
11	Consent of competent authority for the closing of LC: The GAD should specifically contain a note regarding the status of level crossing, whether • It would be closed during the construction of RUB or • It would be closed after the commissioning of RUB	
12	**Drainage arrangement:** Whether following details has been incorporated? (a) The drainage arrangement shall be adopted as per recommendations for waterlogging and drainage problems for RUB/Subways issued vide Rly Board's letter No.2017/CE-IV/RUB/88 dated 22.04.2020 or latest instructions of Railway Board & as per Rly. Board's Letter No.2017/C E- IV/RUB/88 dated 18.02.2021) RUB or the latest instructions of Railway Board. (b) The drainage scheme should be shown in GAD, and its functional feasibility at the site should be carefully verified. (c) All arrangements for storm water outlay shall be clearly shown in the drawing, such as sump detail, soak pit, bore hole, outfalls in the river, Nalla, or open area, etc. and their reduced levels.	

	Approach: Whether following details incorporated? a. Mention Type of approach and earth-retaining structures according to site condition: Open cutting by providing a suitable cross slope: Open cutting with soil protection with turf: Open cutting with soil protection with pitching: Earth retaining wall (RCC or CC retaining wall/RCC U wall) b. Gradient of road at approaches on either side should be as perIRC:73 -2023 Table 7.1 &7.2 i.e. Ruling gradient: 1 in 30 & Limiting gradient: 1 in 20 (for low volume rural road)	
13	• Suitable railings (1.2m high from GL for RCC wall) or spoil bank (0.6m high from GL for open cut) on both of approaches should be provided. • Detail of approach on either side should be shown in key plan.	
MISCELLENEOUS		
14	Whether term of work, i.e., deposit basis or cost sharing basis, has been shown? • If the work is on a deposit basis, enclose the details of paid P&E charges and mention DEPOSIT WORK at the right corner of GAD. • If the work is a on cost sharing basis, mention PB No./LB No. at right corner of GAD.	
15	Whether Road authority /NHAI have submitted Detailed Project Report (DPR) along with a proposed GAD duly signed by concerned official of NHAI/Road authority through their consultant?	
16	Whether the foundation of Subway has been finalized on the basis of detailed soil exploration and with due consideration of requirement of speed restrictions/ traffic blocks?	
17	Whether the subway has been proposed at the same location of LC to avoid wastage of railway land? If subway is not feasible at the existing location of LC, detail justification should be brought out.	
18	Whether The longitudinal grade of road surface of Subway has been shown in L-section on either side. The slope should not less than 1:40.	
19	Whether height gauge as per RDSO drawing No. M-0001 at either side of box has been shown or note regarding the same to be incorporated?	
20	Whether the type of wing and return wall (CC or RCC) proposed is mentioned in the drawing?	
21	Whether shoring is required while box pushing/ cast-in- situ construction?	
	If yes, details shall be submitted.	
22	Whether speed restriction/traffic block is required?	
23	Whether the existing utilities are shown in the GAD?	
	The signature of utility owner shall be obtained.	

24	Whether future tracks have been incorporated in the key plan?	
25	Whether the details of either end of the bridges along with the distance from the proposed subway to be shown in key plan?	
26	Whether the details of OHE mast, TP, gate, hut, canal, pipe crossings, or any other structure have been mentioned in the Key plan/ plan?	
27	Whether the Standard RDSO relieving girders have been provided for LHS work, if applicable?	
28	Sanction of PCE is required for all cases where there is passenger carrying train traffic.	

Table 4.06

Checklist for ESP approval

SN	Items	Yard Sticks/Requirements
1	Title / Signature Block and Numbering	Title Block: Following information to be incorporated in the title block.
		i. Bilingual
		ii. Name of Railway
		iii. Name of Division/Construction Organization
		iv. Name of work
		v. Reference to sanction particulars. (PB/LB item number)
		vi. Scale of drawing should be 1: 1000
		vii. Drawing number of DRM or CAO/C or Zonal HQ
		viii. Dated initials of the concerned officials.
		ix. Signature box for 'Drawn by' and 'Checked by' with concerned officials' digital sign to be added in block.
		x. Reference drawing number like approved plan being superseded, the standard drawing, etc.
2	Key Plan	Key plan (not to scale) should be shown in ESP on Top Right or Left Corner.
3	Scale of Drawing	i. Scale 1 cm to 10 m (1:1000) ii. Details too small for complete dimensioning in the main representation shall be shown adjacently in separate detail view of recommended scale 1:2, 1:5,1:10,1:20 and 1:50 **[Ref: Engg. Code Para 468 and IRWM para 905(c)]**
4	North Direction	The north direction should be shown at top right corner of plan. **[Ref: IRWM 906 (a)(i)]**
5	Color Scheme & Line Weight	i. Existing details (track, PF, bridge etc.) in black. ii. Work to be dismantled in black dotted line. iii. Proposed work in Red. For Phase work, Phase-I in Red, Phase- II in Blue, dismantling of temporary work in Phase-I in Red- dotted. All other future works in green. iv. Mention executing agency of each phase work / works proposed in the ESP such as Open line/Const./RVNL, etc. v. Cancellation/Modification/Alteration proposed shall be strictly as per colour scheme as detailed above. vi. Existing Railway land boundary Black chain dotted and proposed Railway Boundary in Red chain dotted. vii. Proposed land acquisition to be shown hatched in Red. viii. Other details which need to be required should be shown in fainted colour.

6	Chainage	i. All chainages should be in meter and reckoned from centre line of the station building, which shall be at zero (0.0 m) chainage. However, proper chainage in Kilometer/meter may also be mentioned, and mathematically, the figures should be consistent. ii. Chainages of turnouts, dead end, FM, LC gate, Bridge, Gradient post, Curve chainages (T1, J1 J2, T2), trap point and other important fixtures should be mentioned with respect to centre line of station building. Chainages should be marked positive in increasing kilometers and negative in decreasing kilometers. iii. Notation line mentioning chainage value of each relevant point/ structure on the track should be shown with adequate offset for clarity of drawing.
7	Gradient	i. Chainage and gradient values should be the same as those of approved L-section/ESP unless proposed for change with specific justification. ii. Grade post should be marked at the exact location with a rise and fall. Indicate the line no. to which it belongs to under the grade post chainage. iii. Yard gradient post with their chainages should be shown up to 2.5 km on both sides of the station. iv. Remarks for departure from recommended gradient 1:1200 for new yard should be marked as per para 2 of chapter 2 of IRSOD 2022. v. Maximum gradient in station yards shall be as per para 2(i) of chapter 2 of IRSOD 2022. vi. No change of gradient within 30 meters of SRJ of any points and crossings or between crossovers, per para 2(f) of chapter 2 of IRSOD 2022. vii. In new lines, preferably no level grade in yards, (from drainage point of view). viii. If gradient is 1 in 80 or 1 in 100 and steeper towards/away from yard limits, proper catch siding in former case or slip siding in latter case is provided. [Ref: Para 232 of Engg. Code] ix. Re-grading profile should be shown (if applicable) x. Gradient rounded off in whole no. ….. (If not) Note should be added that 'The gradient in fraction should be rounded off in the completion drawing, and the adjustment should be done in formation in level suitably.'
8	Curve	i. Transition curve shall be for 160 KMPH speed potential, if not, then reason thereof. **{Ref: Rly. Board letter no. 2013/W-I/Genl.I0 / 30 Pt. II, Dated:12.05.2017}** ii. Curve Length with Tangent & Circular Curve Points (TP1/J1 & TP2/J2) chainages with nomenclature etc. shall be shown. Representation of Curve to be shown Table 4.06A.

		iii. Other Curve details (Radius, Degree, Deflection angle, Tangent length, Transition length (in case of unequal transition, length of both transition curve to be shown), Super elevation, Speed potential). iv. If Permanent speed restriction (PSR) is imposed due to certain reasons, note regarding the same should be added with explanation and supporting calculations. v. For high speeds, in group 'A' and 'B' routes, a straight with a minimum length of 50 m shall be kept between two transitions of reverse curves. vi. Lead radius of Turnout taking off from curved track (similar flexure) should not be less than 350 m. **[REF IRPWM 408(2)(e)(i)]** Note: On groups 'A' and 'B' routes on straights less than 50 m between reverse curves should be eliminated by suitably extending the transition lengths. In doing so, it should be ensured that the rate of change of cant and versine along the two transitions so extended is kept the same. Whenever such straights between reverse curves can neither be eliminated nor the straight length increased to over 50m, speed in excess of 130 Kmph should not be permitted. **[Ref: Para 405, 9(b) of IRPWM 2020]**
9	Track & related items	i. Minimum track centre should be 5.3m for doubling & 7.8 m for 3rd & 4th line. **[Ref: Railway Board's letter no. 2013/W-1/Genl./0/30Pt.II dt. 28.05.2018]** ii. Designation and Nomenclature of each existing and proposed line. iii. Direction of Traffic in UP and DN main line to be marked. iv. CSR of each line from FM to FM with' chainages. Minimum CSR provided to be 750m. v. FM should be provided at location where distance between track centres starts reducing from 5.3 m. vi. Centre to centre of track distance, especially at crossover location. vii. Next station to be marked with their Kilometer at both ends of yard. viii. Provision of Track machine siding in projects for newlines, doubling, GC and yard remodeling should not less than 300m. **[Ref: RB letter no. 2007/track- III2/TK/24 vol II dt 14.03.2012]**
10	Isolation	i. Isolation to be provided for each sidings/Loop lines. ii. Trap points with isolation as required, opening away from the important running lines. **[Ref: Railway opening for public carriage passenger rule 2005 para 36, 8(c)(ii)]**

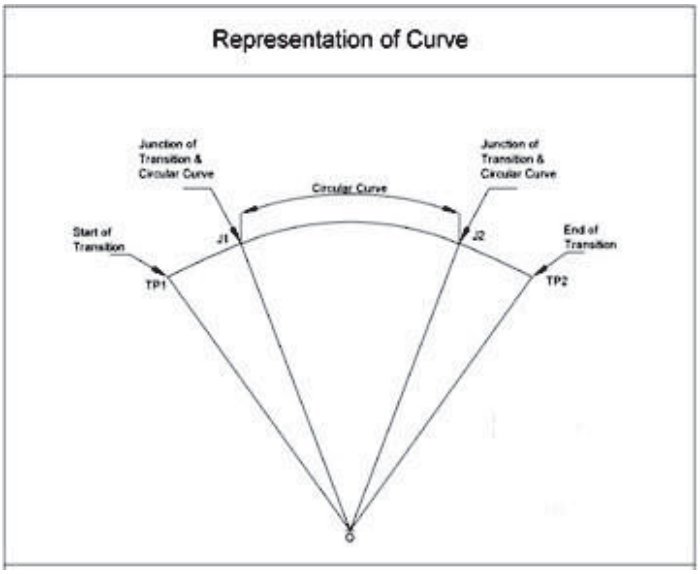
		iii. Dead end /over run for Isolation (signal overlap) and simultaneous reception provided. (Minimum length 120 m) iv. Sand hump details with proper connection with 1:12 CS or 1: 8 ½ SS to be shown & mention RDSO specifications / RDSO drawing no. alongside the location of sand hump.
11	Turnouts	Turnouts in running lines over which passenger trains are received or dispatched laid with 1 in 12 curved switch or flatter. **[Ref: Para 408 (2)(a) of IRPWM]**. 1 in 8.5 turn out with curved switches can be laid in exceptional circumstances taking off from straight track with the approval of PCE **[Ref: Para 408 (2)(b) of IRPWM]**. i. Marked Cross-over length should be equal to calculated length to avoid kink and wearing of Track. ii. Turnout & crossover should be drawn with proper curvature and details mentioned alongside the specific location. iii. There should not be any turnout on LC Gate. iv. No turnout should be taking off from transition length, if it is unavoidable, CTE approval must be taken. **[Ref 410-IRPWM- 2020]**
12	Bridges	i. Bridge type and number with span. ii. Direction of Flow of Stream, River to be marked & to be shown in light blue color. iii. There should not be any point & crossing on Major Bridge. iv. Major Bridge with approaches up to 50 m on either side should be in Level.
13	L.C. Gate	i. TVU with Month/Year, Km. of L.C. Gate, LC no., Class of LC and whether manned or unmanned. **[Ref IRPWM para 902]** ii. Gate lodge for LC to be shown. iii. Planning of Elimination of LC to be indicated with status. **[Ref.: Railway Board's Letter no. 2013/W-I/ Genl./0 / 30 pt-II Dated:-18.06.2013]**
14	Clearance and Infringement	i. Clearance from center of track to any structure on platform should be as per IRSOD ii. Clearance of any new structure keeping margin for one additional line in future. iii. Infringement should be shown in tabular form. iv. In case of no infringement, Table of infringement should be drawn and written as "NIL" in table. [**Ref:** Para -906 (a) - XVI of IRWM] **(Format of same is as per Table 4.06B)** v. All existing infringements need to be tabulated with status/details of CRS condonation.

15	FOBs	i. FOB should be provided with provision of ramp, lift or pathway at the end of platform. ii. Width of FOB and Staircase to be shown. iii. Long term facilities for Divyangs (Engraving on the edge of platform and facility for Inter- platform transfer either by lift/ ramp at FOB or subway/ pathway at the end of PF) should be provided. **[Ref: RB's letter no. 2012 / LM / (PA) / 3 / 5 dated:11.09.12]**
16	Platforms	i. Type of Platform, Passenger/Goods. ii. Level of Platform - All new platforms shall be high-level. **[Ref as per Railway Board's letter 2012/LM(PA)/03/05 dated 18.08.2017]** iii. Length & Width of platform should be marked at ends, at middle and at any offset points. iv. Horizontal distance from center of track to face of passengers or goods PF coping shall be as per SOD. Radius of curve, if platform is located on Curved track (Do not permit platform on a curve having radius less than 875 m.)**[Ref: Para 6/g & h of chapter II of IRSOD].** v. FOB should be provided with provision of ramp / lift or pathway at the end of platform. vi. Segregation of goods PF/Lines with passenger platform and lines.
17	Service Building	i. Mention approved GAD no. of existing/proposed Station building in Note. ii. It is to be confirmed that proposed changes will be accommodated in existing RRI buildings & no further RRI building should be required. iii. If new work over traction facility is proposed, clarify whether existing RRI building is sufficient to accommodate the proposed work. In case new RRI building is proposed mention approved GAD no. from HQ
18	Alteration	i. In case of Alteration in already approved plan, give complete details in Alteration table with serial numbering. The specific alteration should also be clearly indicated at the specific location. (Colour scheme to be followed as above)
19	Miscellaneous	● Terms of Reference attached ● Approved Concept Plan attached ● Speed of route. ● Note should be added: ● "Authentic Land plans should be referred for proper verification of Land boundary indicated on this plan." ● "Comprehensive instructions of Railway Board for provision of passenger amenities should be complied according to Rly. Bd. letter no. 2018/LM/(PA)/03/06 dt. 09.04.2018." ● The levels in ESP, Project Sheet and GAD of Bridges must be verified before execution.

		● The proposed layout should be checked in the field for the feasibility of execution.
		● The gradient, Track center and alignment should be as per corresponding project sheet no. (Mention drawing no.)

Table 4.06A

CURVE NOMENCLATURE Item No 8(ii) of Checklist



CURVE NO. (R/L)	
Line No. / Main line UP or DN	
Deflection Angle (Δ)	
Degree (D)	
Radius (R)	
Length of Curve (CL)	
Tangent Length (TL)	
Length of Transition curve (LTC)	
Shifts (S)	
Cant Actual (Ca)	
Cant Deficiency (Cd)	
Speed Potential	

Table – 4.06B

INFRINGEMENT TABLE

Item No 14(iii) of Checklist

SN	Type of Infringement	Amount of Infringement	From Chainage (Km)	To Chainage (Km)	Total length in Mtrs	Standard Dimension & IRSOD Para
1	2	3	4	5	6	7

If there is no infringement, this table should be shown as “NIL”

Table 4.07

Checklist for SIP approval

SN	Item	Description	Y/N
1	Title Block	a) Format, font, and information in title block are as per standard. b) Name of the station: shown correctly in English & Hindi. c) Name of the work with a brief description is mentioned. d) Plan No. is correct as per the register maintained by Open Line. e) Supersedes Signalling Plan, ESP Plan numbers are correct. f) Other information in the title block columns is correct as per Working Time Table (WTT)	
2	General Layout	a) Station Building symbol (PI/RRI/EI) is shown with centre line & KM. b) Yard layout is correct: lines, points, sidings, traps, etc. as per ESP c) Work to be dismantled is shown dotted as per ESP & referred SIP. d) Description of UP, DN, main, and loop lines/sidings is correct and shown wherever needed. e) Name of the adjacent block stations with their distances at both ends and name of the junction stations to be indicated. f) Signals are placed wherever required as per yard layout and the symbolic aspect is correct. g) Gradient of station yard is more than 1:400 h) All chainages are matching for Points, Dead Ends, LC gate, FM, P/F end, sidings, traps, bridges, etc. with that of ESP.	
3	Gradient posts	a) Chainages and grades of all Gradient Posts are correct; no Gradient Posts are missing. b) Consecutive gradients are matching.	
4	Points	a) Numbering is correct. b) Chainages & descriptions (1:12 or 1:8.5) are shown correctly. c) Crank handles are grouped & numbered properly.	
5	Tracks	a) Numbering is correct b) Maximum length DC track circuit: 350 m for practical purposes. c) One Point, One Track circuit d) Calling ON track – 5RL, Adv. Starter track -3RL e) When another Point originates from a line before FM if the previous point is placed, the track may be fouling – marked as F f) Point and LC gate tracks should be as small as possible.	
6	Signals	a) Aspect, Chainages, and numbering is correct. b) Signalled movements/routes are shown on the lines.	

		c) Aspect control chart is correct & matches that of the signal aspect. d) If the gradient is less than 1:260 in the approach of Home, then the Home signal is to be provided at 300m from FP/BSLB if cris-cross movement is to be done. f) BSLB is placed for trailing point/ station with no loop (DL station). g) Starters placing Glued joint 3m beyond FM, starter 0-3m from the glued joint. i) Advance Starter: 120m from Shunt. j) Signal line: Home at 300m from Adv. Starter. k) Double Line: Home at 180m from FP/BSLB. l) In case of LC (OSL) gate in the vicinity, follow CSTE DRG. m) Distant Signal at 1000m beyond Home Signal. n) Goods Warning Board at 400m/600m beyond distant signal as the case may be. o) SH7/SH44 are to be provided, other shunts as per requirement e.g. for a siding shunt for going in & going out are needed. p) Stop Boards where signals are not given.	
7	Block Instrument	a) Which type of block instrument – symbol & description. b) Axle Counter resetting & cooperation arrangement. c) Details of in-built block. b) HADAC symbol for block sections c) For MSDAC DPs in the yard should be shown. d) Track naming – AXT.	
8	LC gates	a) Name, Class, Manned/Unmanned, Inter Locked/Non-Inter Locked TVU, Chainage, and Centre Line to be shown with the gate. b) If Manned – gate lodge is shown & gate equipment is shown near it. c) Sliding boom: at WSL LC gate- Sliding boom to be provided. At OSL LC Gates- Sliding Boom to be provided if interlocked. d) Interlocking of LC Gates required for all WSL LC Gates, and OSL LC gates should only be interlocked if is in the vicinity of the station & TVU > 20000 e) Lifting barriers – Mechanical or Electrical. f) Direction of barrier locking is right as per traffic direction. g) If the road width is >8m, two lifting barriers are provided. h) If the new barrier is provided, the earlier one is cut, and the new one is made in red. i) WSL: gate control slot, gate console, and emergency triple	

		lock is shown. Corresponding control at station provision to throw danger in case of emergency for all signals directing towards LC gate. j) OSL: gate console & gate panel both. k) Gate telephones- Individual for each LC, corresponding telephone at the station. l)Road signals & descriptions shown. The normal aspect should be checked as per WTT.	
9	Other Items to be checked	a) Control Panel – Spare for Signal, CH, point, and slot are shown. b) Bridges- Name & description are correct. c) Crank Handle box is shown. d) Previous Plan History e) Note for containing signals, SLB, starter within 3m of GJ, dispensation.	

Annexure – 4A

Approval of GAD and Structural Drawings of Railway Bridges and ROBs

S. No.	Executing Agency	Railway Bridges		ROB Composite I Girder		ROB Bow String Girder	
		GAD	Structural Drawings	GAD	Structural Drawings	GAD	Structural Drawings
1.	DFCCIL(Para 318 of IRBM modified by A&C Slip No. 36 dated 27.03.2018)	Where linear waterway is being reduced or vertical clearances are inadequate and where new bridge (during construction of during service) is likely to affect any of existing bridges– By CBE of Zonal Railway All other bridges – CBE of DFCCIL	By CBE of DFCCIL	CBE of Zonal Railway	CBE of DFCCIL	CBE of Zonal Railway	CBE of DFCCIL
2.	RVNL(Railway Board's letter No. 2021/2/CE-III/BR/1/Bridge Policy dated 28.10.2021)	i) All important, major, minor railway bridges affecting existing bridges during Doubling/ Tripling/ Quadrupling works, all important bridges on NL/GC works – By of Zonal Railway ii) All major and minor bridges not affecting existing bridges– By Nodal CE/C	By centralized design cell of RVNL headed by ED/CGM except for important, major and other typical bridges which shall be further submitted to Zonal Railways for approvals by CBE and CE/C for further Certifications during submission of opening documents to CRS	CBE of Zonal Railway	CBE or CE/Constn. (Nodal)	CBE of Zonal Railway	CBE or CE/Constn. (Nodal)

Annexure – 4A (Contd)

Approval of GAD and Structural Drawings of Railway Bridges and ROBs

S. No.	Executing Agency	Railway Bridges		ROB Composite I Girder		ROB Bow String Girder	
		GAD	Structural Drawings	GAD	Structural Drawings	GAD	Structural Drawings
3.	PSUs(Para 317 of IRBM modified by A&C Slip No. 38 of IRBM dated 14.01.2020,Ref. No. 2021/2/CE-III/BR/1/Bridge Policy dated 19.07.2021 &17.05.2021)	Where linear waterway is being reduced or vertical clearances are inadequate and where construction is likely to affect any of the existing Bridges (during construction or during service), after clearance of concerned divisional branch officers and DRM – By CBE of Zonal Railway For all other railway bridges– By concerned CE/C All railway bridges on open line – By CBE of Zonal Railway	For railway bridges being executed by open line – By bridge branch at HQ level of Zonal Railway For railway bridges being executed by construction organization– By Construction organization	Affecting the existing lines after clearance of concerned divisional branch officers and DRM – By CBE of Zonal Railway Other ROBs– By concerned CE/Constn.	Bridge works executed by open line – By Bridge Branch at HQ Level of Zonal Railways. Bridge works executed by Construction Organization – By Construction Organization	Affecting the existing lines after clearance of concerned divisional branch officers and DRM – By CBE of Zonal Railway Other ROBs– By concerned CE/Constn.	Bridge works executed by open line – By Bridge Branch at HQ Level of Zonal Railways. Bridge works executed by Construction Organization– By Construction Organization
4.	Zonal Railways (Para 317 of IRBM modified by A&C Slip No. 38 of IRBM dated 14.01.2020)	Where linear waterway is being reduced or vertical clearances are inadequate and where construction is likely to affect any of the existing Bridges (during construction or during service), after clearance of concerned divisional branch officers and DRM – By CBE of Zonal Railway For all other railway bridges– By concerned CE/C All railway bridges on open line – By CBE of Zonal Railway	For railway bridges being executed by open line – By bridge branch at HQ level of Zonal Railway For railway bridges being executed by construction organization– By Construction organization	Affecting the existing lines after clearance of concerned divisional branch officers and DRM – By CBE of Zonal Railway Other ROBs– By concerned CE/Constn.	Bridge works executed by open line – By Bridge Branch at HQ Level of Zonal Railways. Bridge works executed by Construction Organization – By Construction Organization	Affecting the existing lines after clearance of concerned divisional branch officers and DRM – By CBE of Zonal Railway Other ROBs– By concerned CE/Constn.	Bridge works executed by open line – By Bridge Branch at HQ Level of Zonal Railways. Bridge works executed by Construction Organization– By Construction Organization

Reference Document

SN	Para No	Ref. document details	
1	403	4.01	Approval of Engineering Drgs. – Rly. Bd. Lr. no. 2017/CE-1/CT/13/ Procedure simplification dt. 20.10.2017
2	403	4.02	Advance correction slip no. 36 of IRBM dt. 27.03.2018
3	403	4.03	Advance correction slip no. 38 of IRBM dt. 14.01.2020
4	404 408	4.04	Standard procedure order for ESP, SIP & GAD approval in zonal Rly. 2017/CE-UTC/13/Procedure simplification dt. 22.04.2022
5	405	4.05	Approval of bridge designs and drawings for works being executed by RVNL – Rly Bd. Lr. no. 2021/CE-III/BR/1/Bridge Policy dt. 28.10.2021
6	406	4.06	Rly bd letter no. 2018/Sig/36-SD/1 dated 26.11.2019, for standard scheme for preparation of SIP.
7	406	4.07	Rly bd letter No. 2020/Sig/Drawings dated 02.03.2022 regarding guidelines for use of standard layouts of double line sections.
8	406(2)	4.08	IRSEM Drg. No. 8- D2 (Sheets 1 of 4, 2 of 4, 3 of 4, 4 of 4) of control table for double line station for guidance.
9	406(3)	4.09	IRSEM Drg. No. 17- D2 for track circuit bonding diagram for a 4-road station (double line) for guidance.
10	406(4)	4.10	SWRD related details in Operating Manual Chapter station working rules (SWRs) and temporary working order.
11	406(5)	4.11	Interface Circuit and logic Circuit Diagram related details in CHAPTER 4 of Electronic Interlocking notes of IRISET S-18 regarding installation of electronic interlocking system.
12	406(6)	4.12	IRSEM Drg. No. 21- d5 (Sheet 1 of 2 and 2 of 2) for CONTACT ANALYSIS FORMAT for guidance.
13	406(7)	4.13	IRSEM drg. no. 8- d3 VDU layout plan for electronic interlocking (EI) for guidance.
14	406(8)	4.14	IRSEM Annexure: 9-A7 Joint Inspection/Handing Over of New Assets.
15	406(9)	4.15	IRSEM Drg. No. 15-D9 (Sheet 1 of 3, 2 of 3 and 3 of 3) i.e. CABLE CORE PLAN for guidance.
16	406(10)	4.16	IRSEM Drg. No. 19-D8 and 19-D9 for location wiring FORMAT for guidance.
17	406(11)	4.17	Relay room floor plan for guidance.
18	406(12)	4.18	Policy guidelines for signalling works by W. Rly, No. SG 216/0 Dt:- 10/11/2022.
19	406(12) (f)	4.19	IRSEM drawings i.e. 21-D1: S&T Building Plan for End Goomties (EI), 21-D2: ASM Room Layout Plan, 21-D3: SM`s Table with Dual VDUs etc. for guidance.
20	406(12) (f)	4.20	Typical Drawing for S&T Service Building (up to 100 routes with single IPS) with Centralized Interlocking System issued vide Railway Board letter No. 2017/Sig/3/85th SSC dated 08.01.2019.

***

CHAPTER 5
TENDER, CONTRACT & CONTRACT MANAGEMENT

501 TENDER AND CONTRACT

Subsequent to sanction of project/work and its detailed estimate, project execution authorities deliberate and decide on requirement of type and number of tenders and contracts along with their approximate cost and quantities, for completion of project. The tender stage can be divided in three parts:

- Tender Planning
- Invitation of Tender
- Finalisation of Tender and Issue of Letter of Acceptance

502 TENDER PLANNING

Planning to process any tender should be done by project officials at competent level. These include following important aspects:

(1) PRE-REQUISITE OF TENDERS-

(a) SANCTION OF WORK:

Before inviting any tender for a project/work, it should be ensured that project/work and its detailed estimate is sanctioned by the competent authority. If the Detailed Estimate of work is not vetted by associate finance for sanction of competent authority, then tender can be floated in rare urgent cases, with pre-vetting of tender schedule by associate finance and with approval of CAO/C. However, a letter of acceptance in such cases should be issued only after sanction of detailed estimate of project/work (Ref. Para 5.0 of Railway Board letter No. 2017/Trans/01/Policy dated 08/02/18 **(Ref. 5.14)** and Item No. 5 of Model SOP 2018 **(Ref. 5.15)**, Item no. 1 of Railway Board letter No.2022/F(X)II/PW/3 dated 20/07/2022 **(Ref. 5.26)**.

(b) SCOPE OF WORK:

The scope of work should be in accordance with the sanctioned work.

(c) SITE AVAILABILITY:

At the time of inviting the tenders, it should be ensured that the site is available free from all encumbrances (**Ref.** - Railway Board letter no. 2010-BC-AP-3.34/08.09 dt. 05/11/13 **(Ref. 5.10)**.

Further, at the time of inviting EPC tender, it should be ensured that no major impediment is anticipated in acquiring the balance land and associated permits. Shifting of all the utilities through separate agency should be done to the extent possible before inviting EPC tender. In case of multitracking projects, Method Statement and Sequence of working including yard remodelling should be prepared and got approved from Zonal Railway Headquarter before inviting of EPC tender [Item no. 8 & 11 of Railway Board letter no. 2018/CE-I/CT/36-EPC Contract Policy dated: 30/12/19 **(Ref. 5.20)]**.

(d) AVAILABILITY OF FUND:

Before the process of inviting tenders, it should be ensured that sufficient funds is

available for execution of work so that work does not get hampered due to paucity of funds. In case of non-availability of sufficient fund for a particular work, demand for funds should be raised timely through re-appropriation of funds.

(e) AVAILABILITY OF DRAWINGS:

In the Item rate tenders, all the requisite drawings should be approved/ available at the time of seeking approval from competent authority to float the tender and a certificate has to be endorsed in this regard.

In EPC tenders, Alignment and longitudinal section of the project, conceptual General arrangements drawings (GADs) of stations/ other service/residential buildings, Layout Plans for Buildings, conceptual GADs of Important bridges/ Major Bridges/Minor Bridges/ ROBs/ RUBs/LHSs/FOBs, Engineering Scale Plans (ESPs), Signal Interlocking Plans (SIPs), etc. should be ready for all the stations well before inviting the tender [Item no. 9 of Railway Board letter No.2018/CE-I/CT/36-EPC Contract Policy dated: 30/12/19 **(Ref. 5.20)** & article 2.1 of Standard EPC agreement].

(2) ASSESSMENT OF TYPE AND APPROXIMATE COST OF TENDER

Based on existing resources available with project implementation unit (PIU i.e., Chief Engineer and its subordinate offices) to undertake project execution smoothly, requirement of tender is assessed along with approximate cost for different types of contracts, such as

(a) Consultancy and other contracts required for the project works

(b) Construction contract to execute the work.

(c) Stores contract for supply of items.

(3) SECTIONING OF ENTIRE WORK IN DIFFERENT PACKAGES:

(a) The scheme for execution of project in different parts or sections should be prepared by Dy. CE/C and got approved from concerned CE/C.

(b) The scheme shall include number of tenders, completion period and time schedule. While dividing a project into number of sections/ zones/ works depending upon the length/quantum of work /cost of the work involved, chances of fair competition in the tendering process should be visualized by assessing availability of sufficient agencies for such value of work.

(c) Tenders should be planned and invited based on priority/Stage & time involved in the completion of work.

(d) Approval to float the tender should be taken from the competent authority as per concurrent delegation. The tenders in construction works should be invited for value more than Rs. 20 crores only, so that they are evaluated at SAG level tender committee. In case any tender below 20 crores is to be invited, then personal approval of CAO/C should be taken [letter. No. 2015/W-I/Genl./CORR.GM/Pt. III dated: 30/11/18 **(Ref. 5.19)]**.

(4) SEQUENCE OF FLOATING OF TENDER:

(a) Normally composite tenders incorporating various activities in a project should be preferred to avoid disputes amongst working contractors in the project. However, in case separate tenders are planned for execution of different works in a project, they can be invited in following series in the descending order of priority/time involvement, to avoid

inter-contract dependency and related litigations.

(i) Shifting of utilities i.e., Electrical/S&T/Civil.

(ii) Important and Major Bridges.

(iii) Earthwork including Minor Bridges and Blanketing including shifting of utilities i.e., Electrical/S&T/Civil may also be included in this tender.

(iv) Misc. Civil Works of platform, circulating area & other passenger amenities work. Station Building and Quarters.

(v) Leading of P. Way Materials and PSC sleepers.

(vi) Ballast Supply.

(vii) P. Way linking work including Welding Work.

(b) Other tenders related to required services for implementation of project such as office work, design & drawing, utility shifting, project supervision, project management, etc. should be invited as per requirement at different stages.

(5) ASSESSMENT OF QUANTITIES FOR TENDER:

(a) Quantities of items should be worked out carefully for each tender duly assessing the requirement for the respective part of work or service.

(b) The team involved in the preparation of tender estimate / execution of work should visit the site / route of construction to have proper assessment. The team must include officials up to CDM / SSE / JE level. The very purpose to include every member is to get acquainted with the site condition.

(c) Due care taken at the stage of assessment of tender items and quantity stage helps to-

(i) Reduce number of Addendum / Corrigendum in contract such as extension of time, variation and need to introduce NS items during execution of work.

(ii) Avoid delay in the payment, as well as requirement of extension of time.

(iii) Reduce contractual Litigation.

503 TENDER INVITATION & FORMULATION OF TENDER DOCUMENT

Different activities involved at this stage are -

(1) PREPARATION OF TENDER SCHEDULE:

(a) Preparation of tender schedule is one of the important activities.

(b) Half the job of contract management is over, if the tender schedule is prepared carefully & tender conditions are incorporated based on the site requirements.

(c) Generally Standard schedule of rates for various works available in the construction organization should be used. However, while incorporating NS item (i.e., item beyond Standard schedule of rates), due care should be taken regarding its rate, specification and conflict amongst specification of works and subject NS item.

(d) NS directory of various items be prepared for future use, which have been introduced during the execution of work.

(e) Tender Schedule of other units, where work of similar nature has/ have been executed should be studied before finalization of tender schedule. This helps in reducing the

possibility of introducing new items in contract during the execution of work to a great extent.

(f) Introduction of any item, at the later stage, has to pass through many stages viz., getting administrative approval, technical check of items, finance vetting, its sanction & incorporating in Addendum / Corrigendum. Lot of time & energy is consumed in these activities which ultimately delays the work.

(g) While preparing the tender schedule it should be ensured that the average of LARs of similar type of works under similar condition and geographical proximity is considered duly catering any special features of work, for e.g., site condition, type of work, law and order, accessibility, climatic conditions, availability of resources, etc. [Railway Board Letter no. 2013/CE-I/CT/O/12/ZT dt 07/06/13 **(Ref. 5.07)]**.

(2) SELECTION OF TYPE / FORM OF TENDER:

There are various types of tenders for the works specific requirement.

(a) Depending upon type of contract proposed for execution, payment terms and role / responsibility of contractor, such as -

(i) Item rate contract - The contractor agrees to carry out a work as specified, within a given period, at the fixed/accepted unit rates for each of the various items or group of items comprising such work. The sum to be paid will depend on actual measurement of the quantity of work done against each item of work. In this type of contract, major responsibility during execution rests with the department leading to variation, extension and litigation.

(ii) Lumpsum contract - The contractor agrees to carry out a work as specified and within a given period for a fixed total sum, payment being dependent on his completing the work to specification and time, irrespective of the actual quantities. The payments in between can be made on completion of the various stages as mutually agreed in the contract. In this type of contract, major responsibility towards uncertainty during execution stage rests with contractors and thus gets away with the issue of variation or extensions, but may lead to disputes especially in case proper preliminary studies of ground conditions have not been done.

(iii) EPC (Engineering, Procurement and Construction) contract – This is a design and build contract of Lumpsum type where contractor is allowed to use its engineering and procurement skills & capabilities to a predefined extent, during the stage of tendering, execution and defect liability period. In this type of contract, the Project risks (commercial & technical) due to design and drawing rest with contractor whereas railways guarantees the availability of right of way, forest and other statutory clearances before undertaking the project. The agency is liable to undertake geotechnical investigation, verifying field data, preparation of GADs, detailed drawings, structural drawings, supply of materials and executing earthwork, construction of bridges, RUBs, ROBs, etc.

(b) Depending upon prospective tenderers, such as -

(i) Open tender – This is the default mode of tendering in which all the tenderers fulfilling eligibility criteria of that tender can compete without any restriction.

(ii) Special limited tender - This mode of tendering is adopted for specialized nature

or urgent nature of works, in which only few selected tenderers fulfilling eligibility criteria can compete.

(iii) Limited tender - This mode of tendering is adopted for routine nature of works, in which tenderers appearing on approved list of contractors of a particular classification can only compete.

(iv) Single tender - This mode of tendering is adopted in urgency, affecting communication or works of last mile of a project which are targeted for completion in the current financial year, in which, only one contractor is considered competent to do the work and is allowed to quote rates.

(c) Depending upon number of offers to be submitted by each tenderer such as:

(i) Single packet tender – In this type of tender, each tenderer submits only one offer consisting of both the technical and financial offer for the work. In such tenders, both the technical & financial offers are opened simultaneously. The technical evaluation for adjudging the capability often gets influenced by the cost of financial offer.

(ii) Two packet tender - In this type of tender, each tenderer submits one separate offer for technical and financial each. In such tenders, technical evaluation for adjudging the capability doesn't gets influenced by the cost of financial offer. In this system, financial offers can be taken either from all the tenderers along with technical offer (Two packet single stage) or subsequently from only technically qualified tenderers (Two packet two stage)

In all works contract tenders requiring techno-economic evaluation, 'Two Packet System' of tendering should be adopted.

As per concurrent delegation, for tenders valuing more than Rs.10 Cr, two-packet system should mandatorily be followed. Decision to adopt Single packet system of tendering in case of works tenders valued more than Rs. 10 Cr. needs approval of CAO/C in consultation with FA& CAO/C. For tenders valuing up to Rs. 10 Cr., decision to adopt two-packet system should be taken by the tender inviting authority with the concurrence of associate finance [Railway Board letter no 94/CE-I/CT/4 pt.17 dated 13/08/12 **(Ref. 5.06)]**.

Further, composite tenders for works of the project should be invited in EPC mode to avoid interaction with multiple agencies for same work and to transfer the execution stage risks to contractor. The current instructions of inviting EPC tender mention as under –

- New lines, GC works, Doublings, Large colonies, workshops and important bridges should be in EPC mode;
- In case of deviation from EPC mode for above works, personal approval of GM to be taken;
- In case of major yards, the decision of its exclusion from EPC can be taken by CAO/C;
- Scope of work/items to be included in EPC tender to be approved by CAO/C;

  [Railway Board Letter no. 2015/W-I/Genl./CORR.GM/Pt.III dated: 30/11/18 **(Ref.5.19)]**

Thus, the preferred mode of tendering for execution of works in Construction Organization is Two packet single stage Open EPC tender. However other modes may be selected depending upon stage of work in any project with approval of competent authority as per concurrent delegation. A judicious decision should be taken between EPC and Item rate tendering. Project components with high risk can be considered for Item rate (BOQ) based tendering [Railway Board Letter no. 2023/ GatiShakti/Genl./CAO-Conf. dated: 29.05.23 **(Ref. 5.31)**].

(3) CONTRACTS FOR CONSULTANCY/ NON-CONSULTANCY SERVICES:

In order to continue project works in case of non-availability of departmental manpower, a lot of consultancy and non-consultancy services have been permitted in the recent past on Indian Railways. These tenders are also dealt in similar way. Such tenders are for -

(a) The General Consultants (GC) contract – Required for office support to the project unit wherever manpower of adequate skills is not available. The GC is used for various activities like examination of DPRs submitted by different consultants, preparation of estimates and tender schedules, and assist the department in pre-bid meetings and their responses, preparation of brief for the tender committee, examination of contract agreements, response to references by contractors/consultants, arbitrations, preparation of periodical reports and presentations, review the progress of projects and suggest necessary interventions, various compliances, suggest economy measures, etc.

(b) Project Supervision Services (PSS) contract – Required for supervision of non-EPC contracts, and supply of manpower for other technical services like site supervisors, draftsmen, etc. for construction projects of New lines, Gauge Conversion, Doubling, Railway Electrification, Station Development and Signalling works. Wherever GC is deployed individual manpower through PSS must not be used for office support.

(c) Detailed Design Consultants (DDC) contract – Required for design support to HQ office wherever sufficient manpower with design/drawing skills is not available. DDC is allowed to a project unit for a specific project requiring special design competence with approval of concerned PHOD. Care must be taken such that there is no unnecessary overlap of the work of design key-personnel between GC and DDC in a project unit.

(d) Project Management Services (PMS) – Required for supervision of EPC contracts specified in the PMS agreement.

(e) Contracts for specific services like surveying, architectural services, geotechnical investigations, final location survey, etc.

(f) Contract basis re-engagement of retired personnel and engagement of technical personnel, to be deployed for sites not covered by any PMS/PSS or in office, if GC/DDC is not available. These may also be used as a back-up whenever there is a sudden failure of PMS/PSS/GC/DDC.

(**Ref.** Railway Board letter no. 2018/Trans Cell/S&T/Contractual Staff dated 20.11.18, **(Ref. 5.18)**, Railway Board letter no. 2023/CE-I/CT/l/Policy dated 15.03.23 **(Ref. 5.29)**.

The use of these contracts may be proliferated to avoid dependency of project works on departmental manpower.

(4) TENDER DOCUMENT

Tender document is the basic document for submission of tender/offer by the tenderer. All requirements for tendering stage like qualification criteria, earnest money, completion period, tender schedule etc., requirements for contract stage like, commencement of work, extension of time, variation etc., and requirement of litigation etc. are communicated through these documents. Any ambiguity or contradiction in this document will lead to contractual dispute. Project specific tender documents should be prepared in consultation with concerned departments.

The standard tender document requires many projects and contract specific information, which must be filled carefully for drafting a proper tender document. The documents to be attached / submitted with tender document includes -

(a) Check List of Documents and Covering Note

(b) Instructions to the tenderer

(c) Site data, drawings and specification

  (i) The requisite drawing and information should be made part of tender document.

  (ii) In case of EPC, tender document must contain Alignment and longitudinal section and Geotechnical data, conceptual General arrangements Drawings (GADs) of stations/ other service/residential buildings, Layout Plans for Buildings, conceptual GADs of Important bridges/ Major Bridges/Minor Bridges/ ROBs/ RUBs/LHSs/FOBs, Engineering Scale Plans (ESPs), Signal Interlocking Plans (SIPs), Project Feasibility Report (DPR), etc.

(d) Tender schedule & Forms of tender

(e) Special conditions of works as applicable

(f) Scope of work as defined in the tender documents/drawings

(g) Standard condition of tender and contract issued by Railway Board from time to time for different types of tender such as;

  (i) Indian Railway Standard General conditions of contract for Item rate Works Contract (IRGCC- 2022)

  (ii) Indian Railway Standard RFP (Request for proposal) document and agreement for Railway Projects on EPC mode

  (iii) Indian Railway Standard RFP document and agreement for Station development on EPC mode for EPC contract

  (iv) Indian Railway Standard RFP and form of agreement for appointment of project supervision services agency (PSSA) for providing project supervision

  (v) Indian Railway Standard RFP and form of agreement for appointment of Authority Engineer for providing project management services for EPC contract

  (vi) Indian Railway Standard RFP and form of agreement for appointment of General Consultant

  A brief about these Standard conditions of tender and contract issued by Railway Board have been given in paras 511-514.

(h) While preparing tender documents care should be taken to ensure that

(i) there are no hidden items and rates for each item asked.

(ii) A clear division of risk is there - unknown risks may be borne by the department.

(i) In case of geotechnical investigation based on preliminary reports, a reference value band can be specified in the tender documents and any variation during actual confirmation, to be borne by the owner.

(j) Details about what is required to be done by the contractor along with quantum should be clearly brought out so that contractors can bid correctly. The practice of putting everything in specification without giving details, does not serve any purpose.

(k) Applicability/Non - applicability of various optional clauses such as eligibility criteria, bid capacity, advances, contractor measurement book, e-Reverse auction, price variation clauses etc. should be clearly mentioned.

(5) BID SECURITY /EARNEST MONEY DEPOSIT:

In order to ensure seriousness of bids, an earnest money or bid security is required to be deposited by all the bidders along with their offer through any of the permitted financial instruments for an amount, as mentioned in NIT. Non-submission of this security leads to summarily rejection of offer.

(6) ELIGIBILITY CRITERIA/ QUALIFYING CRITERIA:

In order to have competitive tendering amongst tenderers competent to execute any work, some qualification criteria are fixed for each tender as per the concurrent guidelines. The qualification criteria may be in terms of technical capacity, financial capacity, marks based on overall capacity, bid capacity etc.

As per concurrent guidelines, technical and financial qualification criteria is mandatory for works costing more than Rs. 50 lakh. Relaxation of standard eligibility criteria stipulated by Railway Board in works costing more than Rs. 50 lakh, needs personal approval of GM with concurrence of PFA or CAO/C with personal concurrence of FA & CAO/C in construction [Note no. 7 of item 5, Part A of Model SOP-2018 **(Ref. 5.15)**].

Additional eligibility criteria for specialized works need approval of PHOD [Note no. 9 of Item no. 5, Part A of Model SOP-2018 **(Ref. 5.15)]**.

Similar nature of work for technical qualification needs approval of competent authority as per concurrent delegation and must be specified for each tender [Railway Board letter no. 2012/CE-I/CT/O/5 dated 09/04/12 **(Ref. 5.05)**].

While fixing eligibility criteria and defining similar nature of works for ensuring desired level of quality and speed of work, the availability of experienced and reliable agencies should also be kept in mind to avoid restrictive bidding and ensure fair completion.

(7) APPROVAL TO INVITE TENDER:

Approval of competent authority as per concurrent delegation of powers, should be taken before inviting the tender. Proposal for inviting the tender should be in accordance to the standard checklist of the Railway.

(8) INVITATION OF TENDER:

As per concurrent guidelines, all tenders should be invited through internet (e-tender). The internet portal for inviting tenders for procurement of Works & Services is IREPS and internet portal for inviting tenders for services which are available on GeM is GeM. Any

tender not being invited through internet or any tender for service which is available on GeM but not invited through GeM portal must have approval from competent authority for such dispensation [Railway Board letter no. 2014/CE-I/WP/5 dated 05/02/16 **(Ref. 5.12)**, Railway Board letter no. 2018/Trans Cell/ S&T/Model SOP dated 21/09/20 **(Ref. 5.23)**].

(9) PUBLICATION OF NOTICE:

(a) Tender notice should be published on the internet website and in the leading newspaper.

(b) Tender notice should be crisp and clear.

(10) PRE-BID CONFERENCE:

Provision for pre bid conference is must for large tenders in order to clarify doubts or provide site specific information to all the prospective tenderers. This conference should be arranged well before date of submission of tender.

(11) NOTICE PERIOD:

For Works Contract: Sufficient notice should be given for the submission of tenders, which in the case of large works should not be less than 21 days. This period may be reduced from 21 days in the exceptional circumstances in consultation with the Principal Financial Adviser. However, for tenders valued up to and including Rs. 2 crores invited through e-tendering; the tender notice period can be reduced up to 14 days in consultation with associate finance [Railway Board letter No.2018/Trans. Cell/S&T/NIT Period dated 26/07/18 **(Ref. 5.17)**].

The minimum tender notice period in case of Limited tender and Special limited tender should be 14 days [Item No. 5(ii) & 5(iii), Part A of Model SOP-2018 **(Ref. 5.15)**]. There is no minimum tender notice period stipulated in case of Single tender and executive can decide minimum tender notice period for each single tender depending upon urgency, complexity and volume of tendered work.

The notice period is calculated with respect to date of inviting tender on internet.

For Supply and Service tenders invited through GeM contract, minimum tender notice period should be 10 days [General Terms & Conditions on GeM dated 02/05/23 **(Ref. 5.30)**].

504 FINALISATION OF TENDER AND ISSUE OF LETTER OF ACCEPTANCE

(1) OPENING OF TENDER:

e-Tender should be opened by tender opening committee consisting two members one each from executive and finance department as nominated, on the scheduled date and time on tendering portal i.e., IREPS or GeM with the help of Digital signature certificates (DSC) of the above two authorized members and Digital encryption certificate (DEC) of the executive department. The information of tender is available to all bidders online immediately.

Tender other than e-tender should be opened on the schedule date, time and place as mentioned in the tender document. Prospective bidders or their authorized representatives can witness the tender opening. Rate of various items of the tender schedule along with technical details and commercial conditions, if any, read loudly and also recorded in the register duly signed by the tender opening committee.

(2) BRIEFING NOTE & COMPARATIVE STATEMENT:

The summary of relevant information (Briefing note) and comparative statement of financial offers (Comparative statement) submitted in a tender are prepared and vetted by associate

finance for the guidance of tender evaluation committee and tender accepting authority. Vetting of Briefing Note and Comparative Statement has been dispensed with for e-Tenders invited on IREPS because such information is auto generated by the tendering portal IREPS, and are thus directly seen by tender committee [Para 2.0 of Railway Board letter No. 2017/ Trans/01/ Policy dated 08/02/18 **(Ref. 5.14)**].

(3) TENDER COMMITTEE (TC) AND MINUTES OF TC MEETINGS:

(a) The offers received in any tender are normally evaluated by a tender committee (TC) consisting of three officers and accepted by an officer of competent level as per concurrent delegations. There are few exceptions for three-member tender committee as under –

(i) In case of small e-Tenders costing less than Rs. 50 lakhs, when original lowest offer can be accepted without any tender committee

(ii) In case of e-Tenders costing up to Rs. 5 Crore or other tenders costing up to Rs. 20 lakhs, when TC consists of two members

(iii) In case of tenders with different components, when TC can be more than three [Railway Board letter no. 2017/CE-I/CT/9 dt. 10/09/20 **(Ref. 5.22)**].

(b) In case of single packet tender, the evaluation of technical and financial offer is done simultaneously. In case of two packet tender, tender committee first evaluates and recommends acceptance of technical offers. Subsequent to acceptance of technical offers, the financial offers of technically qualified tenderers are opened. These offers are then evaluated following due procedure including e-Reverse auction (e-RA), where ever applicable.

e-RA is an online process where a competitive negotiation is conducted on IREPS portal, amongst tenderers selected from technically qualified, within given time frame to get lowest possible cost, subject to following conditions-

(i) This is applicable in Item rate tenders for works and service contract costing above Rs. 50 crores;

(ii) The condition of applicability of e-RA must be incorporated in tender document;

(iii) The selection of tenderers for participating in e-RA depends upon number of offers qualified in a tender. If there are less than 3 qualified tenderers, then e-RA process would be dispensed with, if there are 3 to 6 qualified tenderers, then lowest three tenderers would be selected to participate in e-RA and if there are more than 6 qualified tenderers, then lowest 50% (rounded off to next higher integer) would be selected to participate in e-RA;

[Railway Board letter No. 2017/Trans/01/Policy/Pt-S dated: 28/03/18 **(Ref. 5.16)**].

(c) The level of authority competent to accept a tender is governed by the offered amount in case of financial offer and by estimate value of tender in case of technical offer. The tender once deliberated by a particular grade cannot be deliberated or accepted by a grade lower than initial deliberation level or acceptance level. The level of acceptance and tender committee goes higher in case of non-availability of officials at competent level.

(d) The process of tender committee is as follows -

(i) Draft tender committee minutes is initiated by convener member on e-Tender portal IREPS and is communicated among the tender committee members and are finalized on IREPS e- portal only.

(ii) While finalization the teender committee minutes it is ensured that average of LARs be taken instead of single LAR.

(iii) The date of meetings of tender committee and up to date validity of offer should be mentioned in the top sheet of the TC minutes. Validity of the offer should be got extended timely if any required.

(iv) Negotiation with tenderer should be done only in exceptional cases that too with lowest eligible tenderer [CVC letter no. 8(1)(h)/98(1) dated 18.11.98 **(Ref. 5.02)**]. If negotiation is to be conducted with the lowest tenderer, then letter of offer of Negotiation is issued through IREPS e-portal and tenderer submits their negotiated offer on the portal itself. While asking negotiated offer, suitable protective clause should be there regarding validity of original offer in case of failure of negotiation.

(e) Tender should be finalized within shortest possible time.

In case if Tender is not invited through IREPS, all above processes are done in files duly maintaining confidentiality.

(4) LETTER OF ACCEPTANCE (LoA)

Subsequent to the TC recommendations, the accepting authority is competent to accept, or modify or reject the recommendations. Once any original offer of a tenderer is considered to be acceptable with or without any modification, or negotiated offer of a tenderer is considered to be acceptable, LoA is issued.

In case a conditional offer submitted by tenderer, the conditions offered in the tender should be commented upon in LoA regarding the acceptance/ modification/ rejection of these conditions. Restriction for increase and decrease in quantity or banning of rates should also be mentioned in LoA [Railway Board letter no. 2012/CE-I/CT/O/10 dated 26/08/13 **(Ref. 5.09)**]. In case of e-Tender all activities related to issue of LoA is done on the e-Tender portal IREPS. In other cases, this process is done manually in files.

The LoA should be marked to all concerned officials directly involved in execution and other officials as per standard list of addressees.

With the issue of acceptance letter, the accepted tender now changes into contract. In cases when acceptance of offer is done with some modification to original offer, LoA becomes Contract only after acceptance of conditional LoA by the tenderer.

In case of Item rate tenders for New Line/Double Line, LoA should be issued only when 70% land has been acquired before the start of work and as stipulated [Railway Board letter No. 98/W-I/ Genl./O/30/Pt-I dated 03/07/13 **(Ref. 5.08)**].

In EPC tenders, LoA should be issued only when land acquisition is 90% complete and corresponding essential clearances have been obtained as stipulated [Railway Board letter No.2018/CE-I/CT/36-EPC Contract Policy dated: 30/12/19, (**Ref. 5.20)**].

505 DOS AND DON'TS ON TENDER HANDLING

(1) Issue Corrigendum/Addendum for any change in tender details and documents only through advertised notices with adequate notice period to avoid complaints.

(2) Prepare tender schedules with clarity and care, ensuring that -

  (a) Quantity of items to be executed/ supplied or activities/ works for which payments are required to be made are clearly shown along with unit of measurement.

  (b) Penalty clause, wherever applicable, should be unambiguous about quantum of penalty to be levied for non-performance.

  (c) While indicating estimated values for NS items based on rate analysis/ LARs, the description of NS items should be unambiguous.

  (d) The values/estimated cost arrived at is on the basis of LARs, care may be taken to ensure that no changes in description have been made.

  (e) Technical specifications should have clarity and should not restrict competition while ensuring at the same time that the quality is not compromised by relaxing the accepted benchmarks/technical approval.

(3) Do obtain undertaking by members evaluating tender regarding no personal involvement of themselves in any firm participated in tender [Railway Board letter no. 2004/V-1/CVC/1/18 dt 02/01/06, **(Ref. 5.03)**].

(4) Decide eligibility of an offer/tender based on the credential(s) and Constitution of the firm submitted at the time of tender under evaluation and not on the basis of additional credential(s) supplied by the same tenderer afterward and/or submitted in some other tender.

(5) Avoid deviation from tender conditions while considering offers, both in case of technical and financial eligibility criteria.

(6) Don't introduce any new parameter for evaluation of offers at tender committee stage.

(7) Don't accept an offer beyond validity period. Extension of validity should be taken well before the stage arrives.

(8) Don't communicate orally with the tenderer regarding any clarification related to their submitted offer.

506 CONTRACT MANAGEMENT

The railway contracts being handled both in physical mode keeping separate file for each contract in all concerned offices and digital mode which can be accessed by anyone all concerned on web portal. A digital platform named "Indian Railway Works and Contract Management System (IR-WCMS)" has been launched to handle works contract. This contains module for all stages of contract management such as Performance Guarantee, Contract agreement, Billing, NS items and Variation, Extension of DOC, Release of PG/SD, Correspondence between Railways and contractors, Advances to contractors, e-Measurement Book (e-MB), etc.

As per latest instructions, all Construction units have been advised to handle all new works contracts awarded after 30.06.2022 only on IR-WCMS. Any deviation to these instructions needs approval of General Manager. However, in no case, a contract should be handled both manually and on IR-WCMS [Railway Board letter no. 2018/CE-I/CT/30 dt 24/06/22 **(Ref. 5.25)**, Railway Board

letter no. 2018/CE-I/CT/30 dt 01/08/22 **(Ref. 5.27)**, Railway Board letter no. 2018/CE-I/CT/30 dt 22/11/22 **(Ref. 5.28)**. The important stages and activities in contract management are as under -

(1) KICK-OFF MEETING

Immediately after award of contract, kick-off meeting should be held with the contractor. Detailed Programme should be charted out in the meeting regarding deployment of men & machineries for the timely completion of project.

(2) PERFORMANCE GUARANTEE (PERFORMANCE SECURITY)

The sum of money based on the contract value mentioned in LoA, as a guarantee for successful completion of contract is submitted/ deposited by contractor to Railway through permitted financial instruments with a validity up to minimum 60 days beyond the extended completion period. This guarantee should be submitted by contractor within the time frame mentioned in contract, but before signing of contract agreement. In case of extension of the date of completion of the work, validity of performance guarantee should also be got extended. As per present guidelines, the PG is 5 % of contract value for both Item rate and EPC contracts.

(3) SECURITY DEPOSIT (RETENTION MONEY)

The sum of money based on the rates mentioned in contract, as a guarantee for executed work is submitted/ deposited by contractor to Railway through permitted financial instruments. This money can be deposited in advance or can be recovered through on-account bills. The current rate of SD is 5 % of contract value for both Item rate and EPC contracts.

(4) PAYMENT OF ADVANCES

Contracts beyond a threshold value are inclusive of provisions to pay interest bearing advances to contractor at different stages of contract for fast mobilisation and expeditious execution of work. The current limit of such advances is up to 20% for Item rate contract and up to 15% for EPC contract. The payment of advances and their recovery along with interest should be made as per contract conditions.

(5) BAR CHART PROGRAMME:

The detailed programme for execution of work in the form of Bar Chart/PERT/ CPM or through Project Management Software such as Primavera/Sure Track/ MS Project etc., as required, should be submitted by contractor to Engineer within 30 days after the date of receipt of LoA in Item rate contracts having initial completion period of two years or less and within 90 days after the date of receipt of LoA in other Item rate contracts. This programme should be submitted within 30 days after the date of receipt of LoA in EPC contract. This detailed programme of work indicating the time schedule of various items of works in the form of Bar Chart/PERT/CPM should be examined, modified and accepted by Engineer for monitoring the progress of work.

(6) HANDING OVER OF DRAWINGS, SITE AND CLEARANCES:

The Engineer should provide all the drawings, details, sites and clearances required to execute the work immediately as it has a very severe impact on completion of contract as well as associated litigations.

In EPC contract, contractor is responsible for submission of detailed design and drawing of structures within stipulated timeline as mentioned in contract document and department is responsible for approval of same within stipulated timeline.

Regarding handing over of site, EPC contract for railway project mentions, "Not less than 95% of core land length & 90% of non-core land length to be provided before appointed date and balance within 180 days of appointed date. If ROW is not provided in 240 days of appointed date, for commencing construction on any part of the site, the affected work shall be deemed to be withdrawn". As per EPC contract for Station development "ROW shall be provided within 180 days of appointed date, in phased manner".

Railway compensates contractor for any delay in these by allowing extension of time and Price variation on railway account both in Item rate & EPC contract, and additionally by paying agreed sum of money mentioned in contract conditions of EPC contract.

The EPC agreement provides for damages for delays on account of the department and contractor. It is, therefore, essential to sensitise concerned officers and staff about time-bound decisions/processing of case related to EPC contract. The provision of single window monitoring by railways by creating authority (SAG/HAG grade railway officer who has been entrusted with all the decisions) reduces lot of time in decision making, mitigating the project risk for both design and construction aspect.

The summary of such penal / damage provisions as per standard EPC agreement for Railway projects, is as under.

Damages for Default of Department as per standard EPC agreement

SN	Activity	Quantum	Article
1.	Damages for delay in handing over the site which includes: ROW not less than 95% of core land length and 90% of none core land length. Clearances – Environment, forest, NOCs for ROBs and LHS	Damages at the rate per day per meter length of ROW, as prescribed in tender documents.	4.1, 8.2, 8.3
2.	Authority doesn't provide any machinery and equipment at the designed time	Amount equal to twice the rate at which machinery or equipment was to be given to the contractor on hire.	4.4.3
3.	Delay in shifting of obstructing utilities beyond 180 days from the date of notice by the contractor	Damages at the rate per day per meter of length affected	9.2
4.	Failure to provide traffic blocks or power blocks.	Damages at the rate specified per days, per hour.	4.7.6
5.	Delay in authorization by CRS beyond 60 days from the date of completion of all safety / critical items.	Payment towards testing and commissioning paid with an interest of Bank Rate +3%.	12.6
6.	Delay in payment beyond 30 days	Delayed payment will accrue an interest of Bank Rate + 3%	17.7
7.	Delay in approval of GAD of ROB, RUB or canal crossing	Damages at the rate per day per meter	4.1.4

8.	Delay in conducting tests on completion beyond 30 days of request for test by contractor	Damages at the rate specified per days.	12.1.1
7.	Delay in approval of route control charts, SIP	Damages @ 0.001% of the contract price per day	10.2.6

Damages for Default of Contractor as per standard EPC agreement

SN	Activity	Quantum	Article
1.	For delay in submitting performance security beyond 30 days after LoA	Damages @0.05% of contract price per day	7.1.3
2.	Delay in achieving Project milestone completion and project scheduled completion	Damages @ 0.05% of the contract price per day	10.3.2
3.	Completion of punch List (deficiency) items	Damages @ 0.2% of the cost of completing such items as estimated by the Engineer.	12.3
4.	Non-removal of the contractor's equipment, material, debris and temporary work from site within 15 days after work	An amount equal to 120% (one hundred and twenty percent) of the actual cost of removal incurred by the Authority.	12.4.2
5.	Contractor's failure to rectify Defects.	Railway shall rectify the defects and recover damages @ 120% of the cost incurred.	15.4
6.	Exceedance of total duration of traffic blocks and Power Blocks by more than 20%	Damages @ specified per hour will be recovered.	4.7.7
7.	Delay in submission of route control charts, SIP	Damages @ 0.001% of the contract price per day	10.2.5

(7) SUBLETTING OF CONTRACT:

The contract for works can be subletted up to 50% of original contract value in Item rate contract and EPC contract for station development and up to 70% in EPC contract for Railway project. This subletting is subject to approval of competent authority and the qualification of sub-contractor as per minimum eligibility criteria prescribed for sub-contractor. Subletting of contract does not dilute the responsibly of main contractor and also does not establish any relationship between railway and sub-contractor.

(8) OFFLOADING OF PART(S) OF WORK:

In item rate contract governed by Indian Railway Standard General Conditions of Contract 2022, at the final stage of completion/ commissioning of work, in case the contractor fails to complete the final part(s) of the work and the value of such part(s) of the work is limited to 5% of the original contract value, the Engineer may allow/ decide for offloading of such

part(s) of works as per conditions of contract and execution of same through some other mode. The extra expenditure so incurred in execution of the offloaded work through other mode, would be recovered from the contractor, but not exceeding the value of Performance Guarantee available in the contract.

(9) QUANTITY VARIATION:

(a) Provisions of acceptance letter should be closely observed during the execution of work.

(b) In Item rate contracts, quantity of all the items, to be executed, should be reassessed and variation in quantity and requirement of any new NS item, if any, should be processed based on agreed rate immediately for sanction by competent authority, so that these may not be the reason of delay in execution of work as well as payment to the contractor. Variation should be limited so as not to completely change the scope, character and purpose of original contract [Railway Board letter no. 2013/CE-1/CT/O/29/VAR dt 05/03/14 **(Ref. 5.11)**].

NS items, if required, should be processed with due care. Requirement of NS items, more or less, remains the same in similar type of work and so while preparing the new NS items, already sanctioned NS item of similar nature should be kept in mind and processed accordingly. Before operating the NS items, administrative approval of authority competent to accept that item must be taken.

(c) EPC contract which is a form of lump sum contract without any mention of actual quantity to be executed in contract, no variation other than change of scope is possible. Change of scope means change in specifications, omission/addition of works, plants, materials or variation in quantities due to change in L-section/Alignment/Engineering scale plan. Rates for change of scope should be estimated based on analysis of Rate (AOR) of Zonal Railways for item other than Building, and CPWD rates for Building items. The total value of change of scope is limited to 25% of Contract price for railway project and 10% of contract price for station development works, unless mutually agreed.

(10) EXTENSION OF TIME:

Any delay in likely completion of work within due date of completion needs to be foreseen during execution of contract. The contractor should request for justified extension of time along with justification for additional time requirement attributable to various delays by the department or contractor. Engineer after careful examination of justification regarding their attribution towards the department or contractor or other reasons should extend the validity of contract under respective clauses either without any damage (if delay is not attributed to default of contractor) or with agreed damage (if delay is attributed to the default of contractor).

(11) BONUS FOR EARLY COMPLETION:

Completion of works earlier than the stipulated date of completion results into bonus payment to contractor as per terms of contract. The rate of payment of bonus should be as mentioned in contract agreement. The current rate is 3% and 5% of original contract price respectively for EPC and Item rate contracts.

(12) PRICE VARIATION:

The contract prices are adjusted / modified up to current level by applying appropriate formulae for different types of works mentioned in contract agreement. The applicability of

price variation in a contract should be clearly mentioned in contract. While preparing the PVC bill, care should be taken to deduct the payment if indices/rates have been decreased from the base period index / rate.

(13) RELEASE OF PAYMENT (ON ACCOUNT BILL):

The works executed in a contract is paid to the contractor through on-account bill(s) as per progress of work or achievement of different stages of millstones mentioned in contract. Such on account bills are prepared by the departmental engineer or contractor's authorized engineer duly recording in Measurement books, as per conditions of contract [Railway Board letter no. 2018/CE-I/ CT/36-EPC Contracts policy/Pt-1 dated 09/10/20 **(Ref. 5.24)**. The condition of Contractor's Measurement is made mandatory for works costing more than Rs. 5 Crores, in terms of para 10.0 [Railway Board letter No. 2017/Trans/01/Policy dated 08-02-2018 **(Ref. 5.14)**].

Engineer should pay such bills as expeditiously as possible. Further, in EPC contract any delay in payment beyond the days specified, department pays an interest @ basic rate + 3%, calculated at quarterly rests.

Any claim other than monthly on-account bills raised by contractor as per contract conditions should also be judiciously and expeditiously disposed to avoid any future claim in the form of litigation.

(14) MAINTENANCE PERIOD (DEFECT LIABILITY PERIOD):

The works executed in a contract are with some maintenance period (also called the defect liability period). Such periods may be contract-wise or structure-wise or item wise and explicitly defined in contract conditions. In the Item rate contract, a maintenance certificate is issued after passing of such period and security deposit available cannot be released without issue of aforesaid Maintenance certificate.

In EPC contract however such certificates need not be issued, but contractor is responsible for rectification of defects noticed and in case of its failure to do so, railway rectifies such defects attributable to contractor at his risk & cost, to be recovered from any money due to the contractor. Any material or work replaced in DLP would further warrant for 12 months for such repair or replacement. Normally EPC contracts have larger defect liability periods ranging up to 2 years.

(15) DETERMINATION OF CONTRACT:

The contract should be short-closed/terminated within the extended validity of contract under respective clause of contract conditions, depending upon the fact whether the work is being short closed on railway default or work is completed successfully as per terms of contract or work could not be completed owing to default of contractor. Subsequent to determination of contract under respective clause, all processes like final bill preparation & payment, any other payment due to the contractor should be done expeditiously. In case, termination is on contractor default, guarantees/ deposits should be forfeited in terms of conditions of contract. In all other cases guarantees/deposits should be released as per timeline mentioned in contract.

The termination of contract can be done in parts also. In such cases, full performance guarantee should be forfeited and balance works of the contract should be carried as per original terms and conditions of contract. The terminated portion of work would be carried

through some other mode.

(16) FORFEITURE OF PERFORMANCE GUARANTEE OR SECURITY DEPOSIT:

The full amount performance guarantee and security deposit or part thereof can be forfeited / encashed towards the amount due to railways owing to contractor default, as per contract conditions.

(17) RELEASE OF PERFORMANCE GUARANTEE:

(a) The performance guarantee should be released after the physical completion of the work based on the completion certificate issued by the competent authority stating that the work has been completed satisfactorily in all respects. The certificate, inter alia, should mention that work has been completed in all respects and all the contractual obligations have been fulfilled by the contractor and there is no due from the contractor to Railway against the contract concerned. [Railway Board Letter no. 2010/CE-I/CT/11, dated 11/06/10 **(Ref. 5.04)**].

(b) The competent authority, to release the performance guarantee is the authority who is competent to sign this contract [Note no. 11 (C) (i) of item 5, Part A of Model SOP-2018 **(Ref. 5.15)**].

(c) In EPC contract, Performance Security should be released within 60 (sixty) days of the expiry of the Defects Liability Period or the extended Defects Liability Period.

(18) FINAL BILL:

(a) Final Bill should be recorded immediately after the completion of work.

(b) Final Bill should be passed after sanction of final Addendum/Corrigendum issued in the contract, if any, duly vetted by the finance.

(c) At the time of final bill, either a no claim certificate or list of claims should be taken from the contractor. In case contractor gives any claim then final bill should be processed only after examining the fact that none of the claims raised by contractor comes under "Excepted Matter" as per terms of contract.

(d) In EPC contracts, final payment should be made within 60 days of receiving completion certificate, if there is no dispute.

(19) RELEASE OF SECURITY DEPOSIT:

In Item rate, contract security deposit should be released only after final payment of the contract as per contract and execution of Final Supplementary Agreement or certification by Engineer that railway has no claim on contractor and Maintenance Certificate issued, on expiry of the maintenance period.

In EPC contract, security deposit should be released within 15 (fifteen) days of the date of issue of the Completion Certificate. The Completion Certificate should be issued by competent authority, upon completion of all items in the Punch List and/or issuance of authorisation by the Commissioner of Railway Safety and compliance of all CRS observations pertaining to contractor.

507 DOS AND DON'TS ON CONTRACT MANAGEMENT

DOs:

(1) Ensure that all documents required to be submitted by the contractor, before starting of work as mentioned in the tender document, have been submitted.

(2) Make copy of contract agreement available with the site-in-charge/supervisor of the work so as to ensure that work is executed as per the specification of the contract.

(3) Measure initial ground levels jointly with the contractor before commencing of earthwork and recorde in the machine numbered level books. Dates of recording initial and final ground level should be clearly mentioned in the level book.

(4) Take approval of competent authority for variation beyond quantity mentioned in agreement before taking up work and processing Bill for the same.

(5) Bring on record the 'exceptional and unavoidable' circumstances leading to variation of quantity in excess to the agreemental quantity before processing the contract for variation.

(6) Prepare final Bill on actual measurement of work done at site and not on lump-sum basis.

(7) Maintain Measurement Book properly. It should clearly mention the details of items executed including it location to ensure traceability.

(8) Mention items test checked and date of test check in the Measurement Book [Railway Board letter no. 97/CE. I/CT/42 dated 04/07/97 **(Ref. 5.01)**].

(9) Verify compliance to contract conditions regarding availability of 'Completion Certificate', 'No claim certificate' and 'Final supplementary agreement' before payment of Final Bill.

(10) Ensure prompt clarification/ reply to contractor's query, representation and correspondence, in terms of conditions of contract to his registered e-mail id and correspondence address.

(11) Establish effective management control system to ensure timely clearances.

(12) Resolve disputes expeditiously including the disputes on items exclusively mentioned as "Excepted matters" or "Matters not arbitrable"

DON'Ts:

(1) Don't pass final Bill without the sanctioned variation or change of scope.

(2) Don't delay claims of contractor in terms of contract agreement.

508 DOS & DON'TS IN EPC CONTRACTS

DOs:

(1) Prepare realistic DPR and update duly considering all soft costs applicable to EPC type of contracts. A few such costs are as under:

   (a) Activities related to estimation of BOQ on the basis of field surveys and geo-technical investigations by bidders,

   (b) Design & drawings of all structures involved in the project,

   (c) Supervision of complete work including QA & QC measures and various testing,

   (d) Ensuring various insurances during work and Bank Guarantee,

   (e) Contractor's funds blocked during execution of work due to various milestones of payment, liabilities including of extended defect liabilities duration,

(f) Preparation of CRS papers, completion drawings

(g) AMC, if any, and

(h) Contingencies

(2) Methodology adopted by railway PSUs i.e., RVNL/IRCON/RITES for framing DPRs/tenders for execution of railway works on EPC basis may also be referred.

(3) Minimum 90% land must be available while issuing LoA.

(4) All tentative GADs including ESPs, SIPs etc. should be got approved before inviting tenders.

(5) All utilities to be shifted before tendering to the extent possible.

(6) In case of multi-tracking works, method statement and sequence of work including yard remodelling should be approved from zonal HQ before inviting tender.

(7) In case of Railway Electrification works, provisions of traffic block should be agreed DRM & CPM/RE before inviting tender.

(8) Commitments made by Railway in regard to funds, cautions, blocks, track machines etc., to be strictly adhered to, to avoid penalties on Railway.

DON'Ts:

(1) Avoid new requirements to be added during execution, to the extent possible.

(2) Avoid alterations to be made in approved drawings during execution, to the extent possible.

509 RESOLUTION OF DISPUTES

All unpaid claims or disputes arising out of or in connection with contract can be raised by contractor/ consultant within the time frame mentioned in the contract. All the genuine claims raised by contractor should be addressed by executives in terms of contract as expeditiously as possible.

Any claim/dispute may be referred by the Contractor/ Consultant to the competent authority of Railway for settlement through conciliation or decision by Dispute adjudication board (DAB) or adjudication through Arbitration, as mentioned in respective contract conditions. The obligation of the Railway and the Contactor shall not be altered by reasons of issue being or under reference to Conciliator/ Dispute Adjudication Board/ Arbitration tribunal.

(1) CONCILIATION OF DISPUTES:

(a) All disputes and differences to be referred through "Notice of Dispute", during the progress of the contract or after its completion, but not later than 30 days of issue of Completion Certificate. Competent authority, within 30 days after receipt of the "Notice of Dispute", notify the name of conciliator(s) to the contractor / consultant.

(b) The Conciliator(s) assist the parties to reach an amicable settlement in an independent and impartial manner within the terms of contract. If the parties reach agreement on a settlement of the dispute, it becomes final and binding only if a settlement agreement is drawn and signed by Authority/Engineer In-charge, contractor/ consultant and conciliator(s).

(c) Once conciliation has been resorted to for any dispute, any arbitral or judicial proceedings can't be initiated in respect of that dispute during the conciliation proceedings. The conciliation proceeding gets terminated either by conciliator / any party after signing or

after signing of settlement agreement.

(2) DISPUTE ADJUDICATION BOARD (DAB):

(a) The DAB should be formed within 90 days of signing of contract agreement. The appointment of DAB shall be effectuated by way of a tri-partite agreement among the railway, contractor and the respective DAB members.

(b) The DAB has to give its decision within 90 days of a dispute referred to it by any of the parties as per terms of contract, duly recording the reasons before arriving at the decision. This time limit is extendable subject to the Parties mutual agreement.

(c) The DAB decision shall not be binding. In case any party is not satisfied by the decision of DAB, then the aggrieved party may approach Standing Arbitral Tribunal or submit request for arbitration.

(d) Once the decision is given by DAB, DAB cannot review the decision at its own or on the request of one party, unless both parties agree for review of decision by DAB.

(e) In case DAB decision is not challenged by either party within 180 days of receipt of decision of DAB, the decision is considered as final.

(3) ARBITRATION:

(a) Arbitration is a quasi-judicial process and an arbitration award is equivalent to court order.

(b) The Arbitration proceedings is assumed to have commenced from the day, a written and valid demand for arbitration is received by the railway.

(c) In EPC contracts, a Standing Arbitral Tribunal (SAT) should be formed within 90 days of signing of contract document. Each party should prepare and furnish once in every six months, an account giving full and detailed particulars of all claims, which even after decision of DAB are unsettled, during the last preceding six months. The SAT should not entertain any dispute which has not been raised in the statement of half-yearly claim before the SAT and such claim stands excluded from the scope of SAT.

In other contracts, appointment of arbitrator(s) should be done as per timeline given in arbitration agreement of contract either from serving or retired officers of railway depending upon the fact that whether both parties have or have not waived off applicability of Section 12 (5) of the arbitration and Conciliation Act.

(d) Hon'ble courts can interfere into appointment process, if either appointment of arbitrators is not done or done after lapse of timeline.

(e) The claimant has to submit his claims and the relief or remedy sought against each claim within a period of 30 days from the date of appointment of the Arbitral Tribunal. If claim(s) is not submitted in time, AT should terminate the proceedings. No new claim can be added during proceedings by either party but the original claim or defence thereof may be amended or supplemented during arbitration proceedings subject to acceptance by Tribunal.

(f) Railway should submit its claim and counter claim(s), if any, within a period of 60 days of receipt of copy of claims from Tribunal. If counter claim is not submitted in time, AT may or may not allow extension of time for submission, but will continue with the process of adjudication without counter statement.

(g) Any plea submitted/objections regarding appointment of Tribunal, validity of arbitration agreement, jurisdiction and scope of the Tribunal to deal with the dispute, applicability of time 'limitation' to any dispute, any violation of agreed procedure regarding conduct of the arbitral proceedings or plea for interim measures of protection should be submitted immediately after appointment of AT or as and when it arises, so that AT can decide and pass its order on such plea before entering into the merit of the disputes.

(h) Arbitral proceedings continue even if party(ies) fail to appear in hearings. AT has limited timeline to adjudicate over the dispute and publish award, unless both parties agree to extend the same.

(i) A copy of the proceedings duly signed by all the members of tribunal for each hearing should be ensured.

(j) Where the arbitral award is for payment of money, no interest is payable on the money till the date on which the award is made.

(k) Arbitration award can be challenged only with the opinion of a Law officer (Attorney General/ Solicitor General / ASG, for India) in consultation with Department of Legal Affairs through legal adviser in [Railway Board letter No. 2016/CE(I)/CT/ARB/3 (NITI Aayog)/Pt. dated 05/05/20 **(Ref. 5.21)**].

(l) Even in case arbitration award is challenged in the Court of Law, 75% of award amount, pending adjudication by Court of Law, shall be made. Railways Board letter No. 2016/ CE(I)/CT/ARB/3 (NITI Aayog)/Pt. dated 08/03/17 **(Ref. 5.13)**.

(m) Mere admission of challenge of Arbitral award by Hon'ble court does not implies stay on the award, unless specific injunction to stay the award has been given by court.

(n) Parties cannot approach any Court of Law for settlement of disputes or differences unless an attempt has first been made by the parties to settle such disputes or differences through Conciliation/ DAB and Arbitral Tribunal.

(o) Fees payable to the arbitrator(s) is governed by the instructions issued by Railway Board from time to time irrespective of the fact whether the arbitrator(s) is/are appointed by the Railway Administration or by the court of law unless specifically directed by Hon'ble court otherwise on the matter.

Ref: Clause 63 & 64 of Indian Railway Standard General Conditions of Contract for works, Article 24 of Standard EPC agreement for railway projects, station development, Clause 10 of Schedule 1 of Indian Railway Standard form of agreement for appointment of project supervision services agency (PSSA), Authority Engineer for providing project management services for EPC contract, General Consultant.

510 DOS AND DON'TS IN ARBITRATION

DOs:

(1) Ensure expeditious and proper response to contractor issues in writing at their authorised address.

(2) Study claims in depth with reference to terms of contract and ensure well drafted counter statement of facts relating to contract clauses, the A & C act and judgements

(3) Expedite nomination of Arbitral Tribunal in terms of contract agreement.

(4) Ensure counterclaims after receipt of copy of contractor's claim from Arbitral Tribunal

(5) Submit claim/ counter claim within the time limits mentioned in agreement or as directed by AT.

(6) Deny any claim which has not been submitted within the timelines mentioned in terms of contract or which comes under "Excepted Matter" and referred to AT

(7) Mark all correspondences during arbitral proceedings to both the AT and the opposite Party.

(8) Ensure attending all arbitration hearings by a competent officer of appropriate level without fail

(9) Cooperate with AT in conduct of proceedings and expeditious adjudication of disputes

(10) Seek extension of time from AT only under exceptional circumstances that too well in advance,

(11) Raise all issues related to proper functioning of AT including biased hearing before the AT in writing and just in time, which may be a ground for challenging the award in future, in order to allow such challenge by competent authority and its admission by Hon'ble courts.

(12) Represent in writing to AT regarding any detail of hearing not include in written proceeding details immediately.

DON'TS

(1) Don't delay appointment of Tribunal even in case of delay in waiver of section 12(5) of A&C act or delay in communication of contractor's nominee in AT.

(2) Don't refer the claims on account of "Excepted matter" or "Matters not arbitrable", mentioned in contract

(3) Don't seek frequent exemptions for petty reasons.

(4) Don't miss any hearing during the AT proceedings, due to reasons whatsoever.

(5) Don't challenge the award for petty reasons.

(6) Don't allow a court case to get into default or unattended with proper advocate, even if contractor is not allowed to approach court as per terms of contract

511 STANDARD CONDITIONS OF TENDER AND CONTRACT

The documents for standard conditions are issued by Railway Board and updated time to time. These documents are available on internet websites and the latest detailed provisions in these documents may be seen before invitation of any tender [Link of these documents **(Ref. 5.32)**]. A brief of items which get addressed through these documents are given in subsequent paras. -

512 INDIAN RAILWAY STANDARD GENERAL CONDITIONS OF CONTRACT

This document is used for Item rate works contract and contains two parts-

(1) Part I - Instructions to Tenderers (ITT)-

This part has 9 clauses and eight annexures numbered as I (1st & 2nd sheet), II, III, IV, V, VI, VIA, VIB. This part contains information about preparation of offer and its submission, opening and procedure to deal with offers etc. It includes various prerequisites such as bid security, validity of offer, technical eligibility and financial eligibility criteria, bid capacity, qualification marks, constitution of participating firms, power of attorney, etc. It mentions requirement of mandatory document to be submitted along with the offer, non-submission of which may

lead to summarily rejection of offer.

(2) Part II- Standard General Conditions of Contract –

This part has 64 clauses and twelve annexures numbered as VII, VIIA, VIIB, VII, IX, X, XI, XII, XIII, XIV, XV and XVI.

The provisions under clause 1 to 62 and ten annexures numbered as VII, VIIA, VIIB, VII, IX, X, XI, XII, XIII and XIV, deals with the stage of execution of works like subletting of contract, security deposit & performance guarantee, submission of work completion programme, extension of time, arranging competent staff and engineer for execution, variation and extra items required for work, quarterly claims of contractor, measurement and payment to contractor, price variation clause, completion certificate, maintenance certificate, final supplementary agreement, compliance with various acts and law connected with execution of works, termination of contract on railway account and termination of contract on contractor default.

The provisions under clause 63 & 64 and two annexures numbered as XV and XVI deals with settlement of disputes arising out of contract through alternate dispute resolution mechanism i.e., conciliator, Dispute adjudication board (DAB) and Arbitration Tribunal (AT).

513 INDIAN RAILWAY STANDARD RFP (REQUEST FOR PROPOSAL) DOCUMENT AND AGREEMENT FOR RAILWAY PROJECTS ON EPC MODE/ INDIAN RAILWAY STANDARD RFP (REQUEST FOR PROPOSAL) DOCUMENT AND AGREEMENT FOR STATION DEVELOPMENT ON EPC MODE

These documents are used to finalise tenders of EPC contract and execution of project works and Station development works in EPC mode. These documents are divided into two parts:

(1) RFP document –

The RFP document for both Project works and Station development works are similar. They have six chapters containing many clauses, Five appendices (IA, IB, II, III, IV and V) and six annexures (I, II, III, IV, V and VI). This document contains information about preparation of offer and its submission, opening and procedure to deal with offers etc. It includes various prerequisites such as bid security, technical eligibility and financial eligibility criteria, bid capacity, validity of offer, qualification marks, constitution of participating firms, power of attorney, etc. It mentions requirement of mandatory document to be submitted along with the offer, non-submission of which may lead to summarily rejection of offer.

(2) Agreement –

The agreement for both Railway Projects and Station development on EPC mode are similar. The agreement for Railway Project has general contract conditions in 26 articles (1 to 26), whereas the agreement for Station development has general contract conditions in 25 articles (1 to 25), with a difference that definitions mentioned in article 26 of agreement for Railway Project has been made part of article 1 of agreement for Station development. The various articles of EPC contract agreement for Railway project are as under -

Article No.	Article description
1	Definitions and Interpretation
2	Scope of the Project
3	Obligations of the Contractor

4	Obligations of the Authority
5	Representations and Warranties
6	Disclaimer
7	Performance Security
8	Right of Way
9	Utilities and Trees
10	Design & Construction of the Project
11	Quality Assurance, Monitoring and Supervision
12	Completion Certificate
13	Change of Scope
14	Traffic Regulation
15	Defects Liability
16	Authority Engineer
17	Payments
18	Insurance
19	Force Majeure
20	Suspension of Contractor's Rights
21	Termination
22	Assignment and Charges
23	Liability and Indemnity
24	Dispute Resolution
25	Miscellaneous
26	Definitions

These documents have 16 schedules (A to P) which generally contain contract specific details and various standard formats. The Various Schedules, which are required for a Project are as under -

Schedule	**Description**
A	Site of the Project
B	Description of the Project
C	Project Facilities/Utilities
D	Specifications and Standards
E	Applicable Permits
F	Form of Bank Guarantee
G	Contract Price Weightages
H	Drawings
I	Project Completion Schedule
J	Tests on Completion
K	Provisional Certificate / Completion Certificate

L	Selection of Authority Engineer
M	Forms of Payment Statements
N	Insurance
O	Provision of traffic blocks and Power Blocks
P	Machinery and Equipment

514 INDIAN RAILWAY STANDARD RFP AND FORM OF AGREEMENT FOR APPOINTMENT OF PROJECT SUPERVISION SERVICES AGENCY (PSSA) FOR PROVIDING PROJECT SUPERVISION / FOR APPOINTMENT OF AUTHORITY ENGINEER FOR PROVIDING PROJECT MANAGEMENT SERVICES FOR EPC CONTRACT / FOR APPOINTMENT OF GENERAL CONSULTANT

These documents are used for entering into contract for Project supervision services / Project management services / General Consultant in order to arrange qualified manpower in project offices, to be used at key place for monitoring, quality control, expert advice on various issues, handling of ongoing project and contracts, etc. These documents have been divided in two parts -

(1) PART I (TENDER RELATED) –

They contain four chapters about preparation of offer and its submission, opening and procedure to deal with offers etc. It includes various prerequisites such as Bid security, technical eligibility & financial eligibility criteria, Bid capacity, Validity of offer, Qualification marks, constitution of participating firms, Power of attorney, etc. It mentions requirement of mandatory document to be submitted along with the offer, non-submission of which may lead to summarily rejection of offer.

The various standard forms to be submitted by bidder is part of this (i.e., From 1 to 17 in Appendix I and Appendix II - Letter Comprising the Bid, Particulars of the Bidder, Statement of Legal Capacity, Power of Attorney for Signing of the Bid, Power of Attorney, Joint Bidding Agreement, Financial Capacity of the Bidder, Particulars of Key Personnel, Proposed Methodology and Work Plan, Abstract of Eligible Assignments of the Bidder, Abstract of Eligible Assignments of Key Personnel, Curriculum Vitae (CV) for Proposed Key Personnel, Eligible Assignments of Bidder, Eligible Assignments of Key Personnel, Deployment of Key Personnel, Affidavit and Financial Bid).

(2) PART II (CONTRACT RELATED) –

Schedule 1 of these documents contains from of contract agreement for various type of services and deals with required services from agency including its quality and timeline along with penal provisions, required personnel and their deployment, performance of agency personnel, substitution of key personnel and other personnel, penal provisions for delay in services, extension of time of contract, payment to agency, confidentiality of information, termination of contract, resolution of disputes, etc. through 19 clauses.

These documents contain five annexures which include Terms of Reference, Financial Bid, Payment Schedule, Performance Security, Bank Guarantee of Bid, Bid Security, Bid Forms, and Letter of Award.

The Term of Reference includes detailed role and responsibility of these agencies as well as their personnel towards successful completion of project/ contract including advisory services, quality control, effective project management, review meetings. It also includes qualification

for various personnel to be deployed through these agreements, their monitoring, payments and deductions.

The breakdown of financial bid as quoted against different key personnel becomes part of agreement for making payment to consultants.

It contains an appendix to indicate various clauses in these documents which are project/ contract specific and needs to be changed for each project/contract.

Further, the document for PMS and PSSA contains detail of the Project/ EPC contract for which PMS or PSSA is being engaged along with copy of contract agreement(s) or draft contract agreement(s).

SN	Para No.	Ref. document details	
1	507(8)	5.01	Railway Board letter no. 97/CE. I/CT/42 dated 04/07/97
2	504(3)(d)(iv)	5.02	CVC letter no. 8(1)(h)/98(1) dated 18/11/98
3	505(3)	5.03	Railway Board letter no. 2004/V-1/CVC/1/18 dt 02/01/06
4	506(17)(a)	5.04	Railway Board letter no. 2010/CE-I/CT/11 dated11/06/10
5	503(6)	5.05	Railway Board letter no. 2012/CE-I/CT/O/5 dated 09/04/12
6	503(2)(c)(ii)	5.06	Railway Board letter no 94/CE-I/CT/4 pt.17 dated 13/08/12
7	503(1)(g)	5.07	Railway Board Letter no. 2013/CE-I/CT/O/12/ZT dt 07/06/13
8	504(4)	5.08	Railway Board letter No. 98/W-I/Genl./O/30/Pt-I dated 03/07/13
9	504(4)	5.09	Railway Board letter no. 2012/CE-I/CT/O/10 dated 26/08/13
10	502(1)(c)	5.10	Railway Board letter no. 2010-BC-AP-3.34/08.09 dt 05/11/13
11	506(9)(b)	5.11	Railway Board letter no. 2013/CE-1/CT/O/29/VAR dt 05/03/14
12	503(8)	5.12	Railway Board letter no. 2014/CE-I/WP/5 dated 05/02/16
13	509(3)(l)	5.13	Railway Board letter no. 2016/CE(I)/CT/ARB/3 (NITI Aayog)/Pt. dated 08/03/17
14	502(1)(a), 504(2), 506(13)	5.14	Railway Board letter No. 2017/Trans/01/Policy dated 08/02/18
15	502(1)(a), 503(6), 503(11), 506(17)(b)	5.15	Relevant abstract of Model SOP 2018
16	504(3)(b)(iii)	5.16	Railway Board letter No. 2017/Trans/01/Policy/Pt-S dated 28/03/18
17	503(11)	5.17	Railway Board letter No.2018/Trans. Cell/S&T/NIT Period dated 26/07/18
18	503(3)(f)	5.18	Railway Board letter No.2018/Trans. Cell/S&T/Contractual Staff dated 20/11/18
19	502(3)(d), 503(2)(c)(ii)	5.19	Railway Board letter No. 2015/W-I/Genl./CORR.GM/Pt.III dated: 30/11/18
20	502(1)(c), 502(1)(e), 504 (4)	5.20	Railway Board letter No.2018/CE-I/CT/36-EPC Contract Policy dated: 30/12/19

21	509(3)(k)	5.21	Railway Board letter no. 2016/CE(I)/CT/ARB/3 (NITI Aayog)/Pt. dated 05/05/20
22	504(3)(a)(iii)	5.22	Railway Board letter no. 2017/CE-I/CT/9 dt 10/09/20
23	503(8)	5.23	Railway Board letter no. 2018/Trans Cell/ S&T/Model SOP dated 21/09/20
24	506(13)	5.24	Railway Board letter no. 2018/CE_I/CT/36-EPC Contracts policy/ Pt-1 dated 09/10/20
25	506	5.25	Railway Board letter No. 2018/CE-I/CT/30 dated 24/06/22
26	502(1)(a)	5.26	Railway Board letter No. 2022/F(X)II/PW/3 dated 20/07/22
27	506	5.27	Railway Board letter No. 2018/CE-I/CT/30 dated 01/08/22
28	506	5.28	Railway Board letter No. 2018/CE-I/CT/30 dated 22/11/22
29	503(3)(f)	5.29	Railway Board letter No. 2023/CE-I/CT/1/Policy dated 15/03/23
30	503(11)	5.30	Abstract of General Terms & Conditions on GeM dated 02/05/23
31	503(2)(c)	5.31	Railway Board letter No. 2023/GatiShakti/Genl./CAO-Conf. dated 29/05/23
32	511	5.32	Summary of internet link for standard documents for procurements

***

CHAPTER 6
FORMATION DESIGN AND BLANKETING

601 DESIGN OF FORMATION

(1) Formation

Formation in case of embankments collectively refers to layers comprising of blanket, prepared subgrade and subgrade. In case of cuttings, it refers to the soil/rock layers below the track which contribute in bearing the load from track structure. It is the platform over which track structure comprising of ballast, sleepers and rails is laid. A typical cross section of the formation in embankment is given in **Fig. 6.01** below.

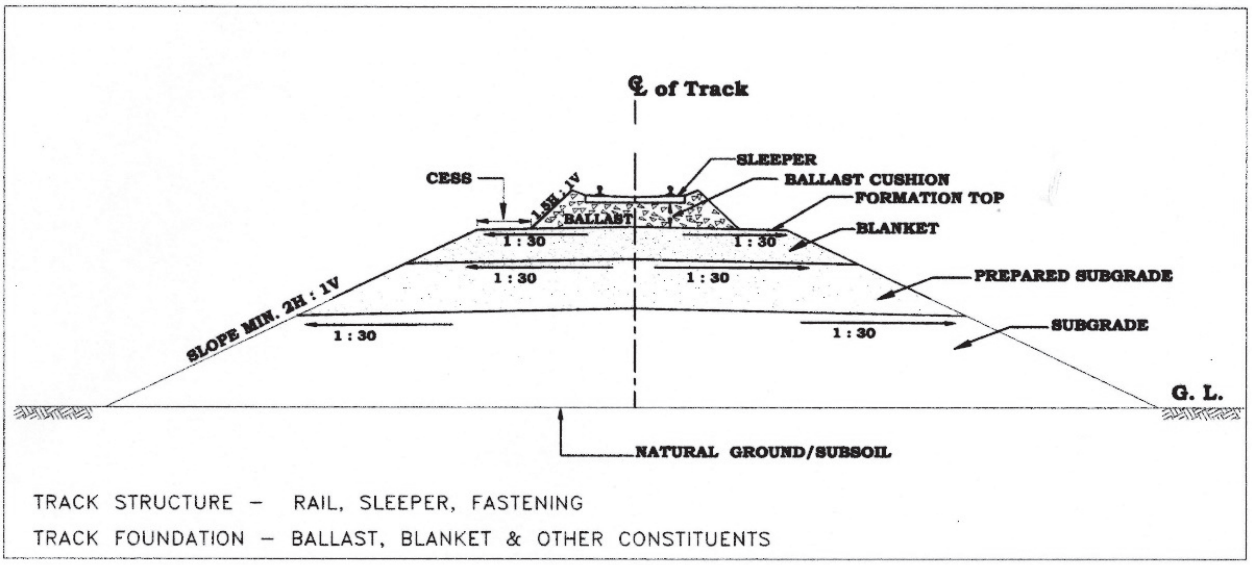


Fig. 6.01: Typical Cross Section of Formation

The requirement is to construct the formation that is structurally sound, so as not to fail under its own load & live loads and its' settlements are within permissible limits.

(2) Design of Formation

The aim of formation design is to construct a formation that gives trouble free service under the most adverse conditions of loading and weather conditions, with normal maintenance regime. Design of formation basically involves deciding the geometry (i.e. width and thickness) of various layers in the formation, their material properties, design of slopes and drainage arrangements etc.

Various criteria/aspect involved in the design of formation are as under:

602 SOIL EXPLORATION AND SURVEY

As formation design will primarily depend upon the type of soil being used in construction, it is essential that soil exploration is done properly as detailed in Para 1.2 and 1.3 of RDSO Specification No. RDSO/2020/GE: IRS-0004, September-2020.

(1) Soil Classification

Soil is classified as per IS: 1498-1970, primarily on the basis of dominant particle size and its plasticity characteristics. Soil particles consist of mainly following four size fractions:

Gravel: 80 - 4.75 mm

Sand: 4.75 mm – 0.075 mm (75 micron)

Silt: 75 – 2 microns

Clay: less than 2 microns

Particle size distribution of soil is determined by a combination of sieving and sedimentation analysis and its' plasticity characteristics are determined by the Liquid Limit and Plastic Limit.

(2) Symbols used in Soil Classification

The symbols assigned to various soils consist of two letters, first letter signifying dominant particle size and the second letter signifying grading/plasticity as given below:

Primary Letter	Secondary Letter
G: Gravel	W: Well graded
S: Sand	P: Poorly graded
M: Silt	M: With non-plastic fines (Silt)
C: Clay	C: with plastic fines (Clay)
O: Organic soil	L: Of low plasticity
P: Peat	I: Of medium plasticity
	H: Of high plasticity

When a coarse-grained soil possesses characteristics of two groups, either in particle size distribution or in plasticity, it is designated by combination of two group symbols (e.g. GW-GC, GP-GC, GW-GM, GP-GM, SW-SC, SP-SC, SW-SM, SP-SM etc.). Similarly, boundary line classifications can occur within the fine-grained soils also, between low and medium or between medium and high liquid limits and between silty and clayey soils. The common dual classification for such fine-grained soils are ML-MI, CL-CI, OL-OI, MI-MH, CI-CH, OI-OH, CL-ML, ML-OL, CL-OL, CI-MI, MI-OI, CI-OI, MH-CH, MH-OH, and CH-OH. Brief write up on Soil Classification is given in Appendix-L of RDSO Specification no. RDSO/2020/ GE: IRS-0004, September-2020.

(3) Frequency of Sampling

(a) During Preliminary Survey

Exploratory boring with hand/auger samples and soil sampling should be undertaken along the alignment and soils samples also should be collected from borrow pit area, at an interval of 500m or closer, wherever change of soil strata occurs. The boring should be done up to 1.50 to 2.0m depth below existing ground level. For embankments of more than 4m height and embankments with problematic sub-strata, the boring should be taken down to a depth equal to twice the height of embankment. Samples should be collected from each stratum in each boring.

In case of soft clays and sensitive clays, in-situ vane shear tests should be conducted to determine its shear strength and depth of underlying compressible clay layer. Undisturbed samples should also be collected to know the actual moisture content,

natural dry density and shear & consolidation parameters of the soil.

(b) During Final Location Survey

Bores are made along the alignment normally at 200m or 300m apart in case of uniform type of soil and closely spaced in critical zones. Soil samples within the boreholes are obtained at every change of stratum and interval not exceeding 1.5m. In case of sandy and gravelly soils, Standard Penetration Test (SPT) may be adequate, as taking out samples in these types of strata is difficult.

In case of very soft clays, vane shear tests should be conducted for each boring. Free swell index test should also be carried out in case of expansive soil and organic soil and organic contents of soil should be determined if soil is suspected to be having large organic contents.

(4) Approval of soil exploration results

The results of soil exploration shall be reviewed and finally approved at the level of CAO/C, as this will be the basis of further design. In case of PSUs, the powers of PCE/CAO shall be exercised at appropriate level of authority as nominated by CMD/ MD of the PSU.

603 SUITABILITY OF SUBSOIL AND GROUND IMPROVEMENT

Field tests are conducted on sub-soil strata i.e., Cyclic Plate Load Test for determination of Elastic Modulus in second cycle of loading (Ev2), Standard Penetration Test to determine "N" value and Unconfined Compression Test/Vane Shear Test to determine Unconfined Compressive Strength/ Undrained Cohesion (Cu).

(1) Suitability of sub-soil

Strengthening of sub-soil or ground improvement needs to be undertaken, including in cuttings, if any of the following parameters do not meet the specified requirements:

(i) Ev_2 is less than 20 MPa, or

(ii) Cu is less than 25 Kpa, or

(iii) "N" value is less than 5.

(2) Ground Improvement

Depending on the depth of the weak subsoil, properties of the subsoil (mainly shear strength and permeability), height of the embankment, time schedule for completion of the project etc., the ground improvement shall be designed and executed using any of the techniques detailed in Chapter-2 of RDSO Specification no. RDSO/2020/GE: IRS-0004, September-2020. Some of the commonly used ground improvement techniques are as under:

(i) Total/partial removal and replacement of weak sob-soil

(ii) Preloading of weak sub-soil

(iii) Using vertical drains

(iv) Using stone columns

(v) Using Cohesive Non-swelling Soil (CNS)

604 FORMATION WIDTH

Para 212 of IRPWM, with Annexure-2/2(A) and Anenxure-2/2(C), specifies the formation width for new Single line and Double line construction respectively. The specified formation width for single line is 7.85m and double line it is 13.15m with track center of 5.30m; for both embankments as well cuttings (excluding side drains). This is with consideration of 350mm ballast cushion, 1.5:1 ballast side slope and provides minimum 900mm cess width.

Additional width of formation will have to be provided to cater for increase in extra ballast on outside of curves and for extra clearances required in curves.

605 CROSS SLOPE OF FORMATION

Top of formation should have a cross slope of 1 in 30 from center of formation towards both sides for single line/multiple line in new construction.

In case of double line or multiple line construction work in existing lines, the cross slope of 1 in 30 should continue from the edge of existing formation towards cess/ drain side (single slope) to avoid any stagnation of water between the two tracks.

606 MINIMUM TRACK CENTRE DISTANCE ON STRAIGHT TRACKS

(i) Minimum distance centre to centre on straight tracks should be kept as 5300mm for new works/addition to existing works.

(ii) In case new OHE masts/signal posts are required to be provided in between tracks under unavoidable circumstances, the clearance of 5300mm at formation level shall be increased by equal to the width of such provisions/ structures/ foundations, as the case may be.

(iii) Survey of all minor/major bridges should be done before deciding track centre. Track centre may be increased from minimum 5300mm if increase in track centre facilitates for elimination of reverse curves, ensures minimum degree of reverse curves in approach of Important/ Major bridges, minimum dismantling of wing walls and return walls of existing minor bridges and saving of portals of existing OHE.

(iv) In doubling works, new reverse curves should not be provided. If increase in track centre for construction of bridge becomes inescapable than reverse curve may be avoided by adjusting apex/tangent length of curves on either side thereby providing required track centre between two curves on either end of bridge.

(v) Reverse curves should be avoided in approaches of yards also. One of the options to ensure this is by continuing the track centre distance in the yard to outside the yard also, up to the first curve on the yard approach.

(vi) Drainage arrangements between tracks should be kept in mind while planning track centre more than 6.10m.

607 MINIMUM HEIGHT OF EMBANKMENT

In case of New Line construction projects, minimum height of embankment above ground level or highest flood level (HFL), whichever is higher, should not be less than one meter to ensure proper drainage and avoid trespassing. However, in case of Doubling/Quadrupling and Gauge Conversion projects, minimum height of embankment should be decided by Chief Engineer/Construction in-

charge of the project, on techno-economic consideration, with the approval of CAO/C.

608 SIDE SLOPES OF EMBANKMENT

(i) Side slopes of the embankment should be so fixed that they are stable from Slope Stability point of view.

(ii) Usually side slopes of 2H:1V would be safe for most of the soils up to embankment height of 4m. However, slope stability analysis has to be carried out in detail for any height of embankment in following situations:

  (a) When subsoil is soft, compressive and marshy, for any depth

  (b) When subgrade soil (fill material) has very low value of cohesion "C'" such that $C^1/\gamma H$ (where "H" is height of embankment and 'γ' is bulk density of soil) is negligible, i.e. in range of 0.01 or so.

(iii) The slopes should be analyzed using "Limit Equilibrium Approach" and using "Bishop's Simplified Method", as detailed in Chapter-5 of RDSO Specification no. RDSO/2020/GE: IRS-0004, September-2020; to achieve the Factor of Safety as under:

  (a) Factor of safety of 1.40 normally.

  (b) Factor of safety of 1.20 can be allowed at the end of construction stage, to achieve economy. However, a minimum factor of safety of 1.40 must be ensured for the long-term stability.

(iv) Moving train loads need not be considered in the slope stability analysis. However, in the case of low height embankments, of heights up to 4m, minimum factor of safety of 1.60 should be ensured.

(v) Design parameters adopted for slope stability analysis should have the approval at SAG level (i.e., Chief Engineer of Zonal Railway or equivalent).

(vi) In case of embankments of more than 6m height on soft sub-soil, a flatter slope and/ or berm/sub-bank may be required. The same shall be provided as per the results of the slope stability analysis. In case, berm is required to be provided the minimum width of berm may be kept as 2.0m, which may be increased as per requirement of rolling equipment to ensure proper compaction, provision of drain on inner side of berm as required and use of berm as road during maintenance etc. and also fulfilling design requirements.

(vii) The side slope of embankment should not be steeper than 2H: 1V.

609 SIDE SLOPES IN CUTTINGS

Theoretically, slope stability analysis shall be performed to decide the side slopes in cuttings also. However, such analysis may not give realistic results in most of the cuttings because of highly heterogeneous nature of material in cuttings, large number of random discontinuities being present in the strata being excavated (especially rocky strata), large variation in pore pressure etc. As these requirements are, apart from being costly affair, difficult to be satisfied and involve a considerable element of uncertainty, design based on stability analysis is justifiable only for occasional critical cuts.

For normal cuttings, the commonly adopted approach is to adopt the permissible side slope values for different type of rocks, as given in Para 4.2.2 of Chapter-IV (Table 5.5) of RDSO Guidelines No.

GE/G-2 "Guidelines for Cuttings in Railway Formation", to commence the excavation from the top. These values are as under:

Table 6.01: Typical Design Slopes for Rock Cuts

SN	Rock Type	Range of permissible Slope (H : V)
A.	**Sedimentary Rocks**	
1.	Massive Sand stone and Lime stone	0.25 : 1 to 0.50 ; 1
2.	Jointed/Inter bedded/ Layered Sand stone, Lime stone & Shale	0.50 : 1 to 0.75 : 1
3.	Massive Clay stone and Silt stone	0.75 : 1 to 1 : 1
B.	**Igneous Rocks**	
1.	Massive Granite and Basalt	0.25 : 1
2.	Jointed Granite and Basalt	0.50 : 1
C.	**Metamorphic Rocks**	
1.	Gneiss, Schist and Marble	0.25 : 1 to 0.50 : 1
2.	Slate	0.50 : 1 to 0.75 : 1
D.	**Weathered Rocks (All types)**	1 : 1

With progress of excavation, additional information is gathered about type of strata, its' properties and behaviour of excavated portion etc. Based on this information, the side slopes shall be improvised for further excavation and additionally suitable stabilisation and/or protection measures can also be taken, if required, to stabilise the cutting. Details in Para 4.0 of Chapter-IV of RDSO Guidelines No. GE/G-2 can be referred for further details.

610 UNSUITABLE SOIL FOR CONSTRUCTION OF EMBANKMENT

Construction of embankment is to be carried out normally with soil available in nearby area, but unsuitable soil should be avoided, which are as under:

(i) Soils to be normally avoided are:

(a) Organic clays, organic silts, peat, chalks, marls, dispersive soils and soils containing soluble material (e.g., rock salt or gypsum).

(b) Poorly graded gravel and sand with uniformity coefficient Cu < 2 should not be used to safeguard against liquefaction. Generally, most liquefiable soils are falling in gradation zone (indicated in Fig.L1 of Appendix-L of RDSO Specification No. RDSO/2020/GE: IRS-0004) and having Cu < 2 shall not be used.

(c) Clays and silts of high plasticity (CH & MH) in top 3m of embankment.

(d) Shales and soft rocks which become muddy after coming into contact with water.

(ii) There may be some typical situations in construction of formation and cuttings, where it is not possible to avoid conditions as given below, for economical or any other reason, then Railway may decide special investigations and other measures to formulate suitable scheme of construction.

(a) Cuttings passing through unsuitable soil, as defined above.

(b) Construction of embankment on sub-soil of unsuitable types of soils.

611 SINGLE LAYER AND TWO LAYER SYSTEM OF CONSTRUCTION

Depending upon the techno-economic considerations, the formation can be designed and constructed in Single layer or Two-layer system as shown in **Fig. 6.02** and **Fig. 6.03** below, based on the availability of local soils/materials. The only difference between the two systems is that "blanket layer" of single layer system has been bifurcated in two layers namely "blanket" and "prepared subgrade" in two-layer system.

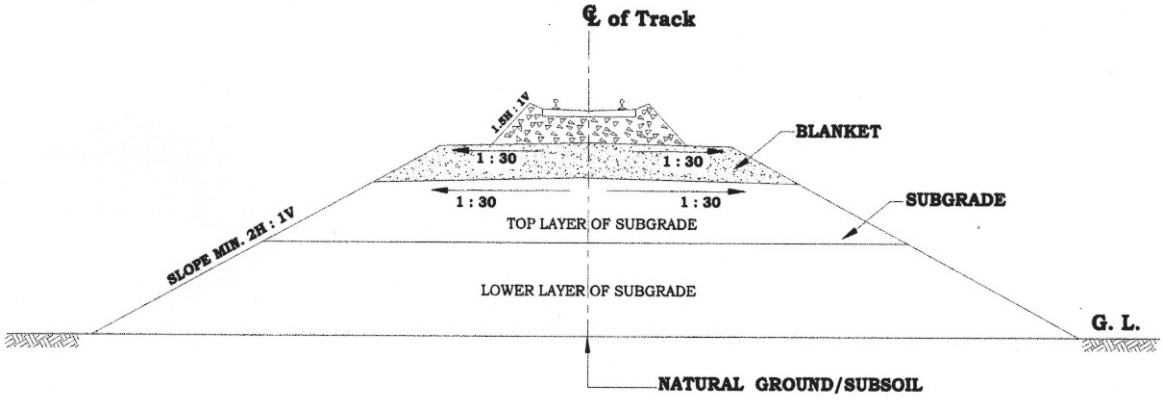


Fig. 6.02: Single layer system

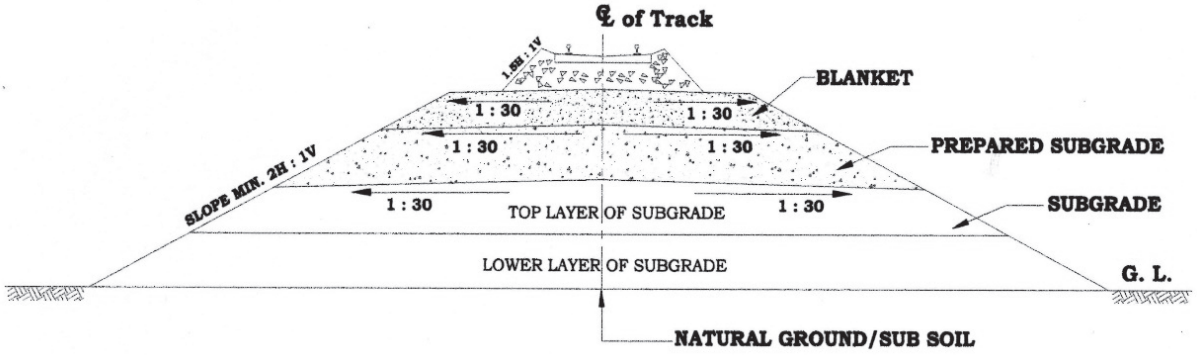


Fig. 6.03: Two-layer system

612 SOIL QUALITY CLASS

The soils for their use in Indian Railway formation have been grouped based on percentage of fines present in the soil, as given below:

Table 6.02: Soil Quality Class

Description w.r.t. Fine Particles (Size less than 75 micron)	Soil Quality Class
Soils containing fines > 50%	SQ1
Soils containing fines from 12 to 50%	SQ2
Soils containing fines < 12%	SQ3

613 FILTER CRITERIA

The Filter Criteria at the interface of two materials, different size and gradation (e.g., interface of blanket and prepared subgrade in double layer system and interface of blanket and subgrade in single layer system), is considered to be fulfilled when following three criteria are fulfilled:

(i) Criteria–1: D15 (blanket) < 5 x D85 (sub-grade/prepared subgrade)

(ii) Criteria–2: D15 (blanket) > 4 to 5 x D15 (sub-grade/prepared subgrade)

(iii) Criteria-3: D50 (blanket) < 25 x D50 (sub-grade/prep. subgrade)

614 DETAILS OF VARIOUS LAYERS IN FORMATION

(1) Types of Blanketing Material

(a) It is difficult to get natural blanket material. Normally, the blanket material shall be produced mechanically or by crushing the stones and/or by mixing, naturally available materials using suitable equipment/plants like pug mill, wet mix plant, crusher etc. Some typical methods used for mechanized production of blanket material are given in Appendix-A of RDSO Specification No. RDSO/2020/GE: IRS-0004, September-2020.

(b) However, if naturally available material conforms to specifications, the same can be also used.

(c) Decision to use natural blanket material or manufactured blanket material shall be taken based on-site conditions of final location survey report. The type of blanket material to be used, whether natural or manufactured (mechanical crushing and/or blending) may be indicated clearly before start of work and should be indicated in tender document.

(2) Specifications of Blanket material

(a) Cu > 7 and Cc between 1 and 3

(b) Fines (passing 75 microns): 3% to 10%

(c) Los Angeles Abrasion Value < 40%

(d) Minimum soaked CBR value: 25 (Soil compacted at 100% of MDD in lab)

(e) Field compaction: 100% of MDD in Field Trial

(f) Minimum Ev_2: 100 MPa (for 25T Axle Load) and 120 MPa (for 32.5T Axle Load)

(g) Size and Gradation: Within specified range **(Table 6.03)** or should lie more or less within the Enveloping Curve in **Fig. 6.04**

(h) Filter Criteria: To be satisfied (not required to be checked when a separator layer of non-woven geotextile has been provided below the blanket, as detailed in Para 5.14.8 subsequently)

Table 6.03: Size and Gradation of Blanket Material

SN	IS Sieve Size	% Passing (By weight)
1	40 mm	100
2	20 mm	80 – 100
3	10 mm	63 – 85
4	4.75 mm	42 – 68
5	2 mm	27 – 52

6	600 micron	13 – 35
7	425 micron	10 – 32
8	212 micron	6 – 22
9	75 micron	3 – 10

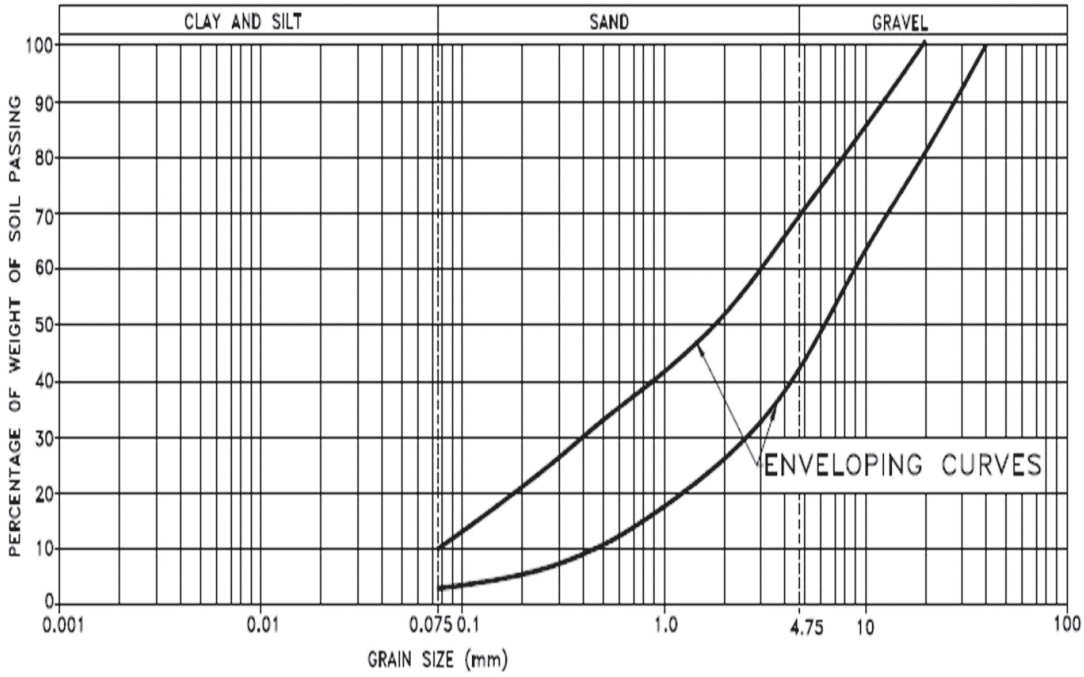


Fig. 6.04: Enveloping Curve for Blanket Material

(3) Requirement of Blanket Layer

The provision of blanket layer shall not be needed when formation/earth fill embankment have:

(i) Rocky beds except those, which are very susceptible to weathering e.g., rocks consisting of shales and other soft rocks, which become muddy after coming into contact with water.

(ii) Soils conforming to specifications of Blanket material.

(4) Thicknesses of Blanket Layer and Prepared Subgrade Layers

Thickness of Prepared sub-grade and blanket layer have been rationalized based on UIC-719 R calculation with ballast cushion of 350mm, and they are as under:

Table 6.03: For 25 T Axle load

SN	Soil type category in sub-grade	Prepared Sub-grade		Recommended Blanket thickness (mm)	Remarks
		Soil Type	Thickness (mm)		
1	SQ1	SQ1*	---	550	Single layer
2	SQ1	SQ2	500	400	Two layer
3	SQ1	SQ3	500	300	Two layer
4	SQ2	SQ2*	---	400	Single layer

5	SQ2	SQ3	350	300	Two layer
6	SQ3	SQ3*	---	300	Single Layer

(*) Subgrade soil is continued up to blanket layer

Table 6.04: For 32.5 T Axle load

SN	Soil type category in sub-grade	Prepared Sub-grade		Recommended Blanket thickness (mm)	Remarks
		Soil Type	Thickness (mm)		
1	SQ1	SQ1*	---	700	Single layer
2	SQ1	SQ2	500	550	Two layer
3	SQ1	SQ3	500	450	Two layer
4	SQ2	SQ2*	---	550	Single layer
5	SQ2	SQ3	350	450	Two layer
6	SQ3	SQ3*	---	450	Single laye

(*) Subgrade soil is continued up to blanket layer

(5) Reduction in thickness of Blanket Layer

To reduce thickness of Blanket Layer (which is costly granular material obtained by quarrying or mining) on techno-economic considerations and/or to reduce the adverse impact on environment due to quarrying/mining, geogrid can be used, as shown in **Fig. 6.05** below. The design has to be submitted to RDSO for approval.

Specifications of geogrid to be used for this purpose are given in Appendix-C of RDSO Specification No. RDSO/2020/GE: IRS-0004, Sept'2020.

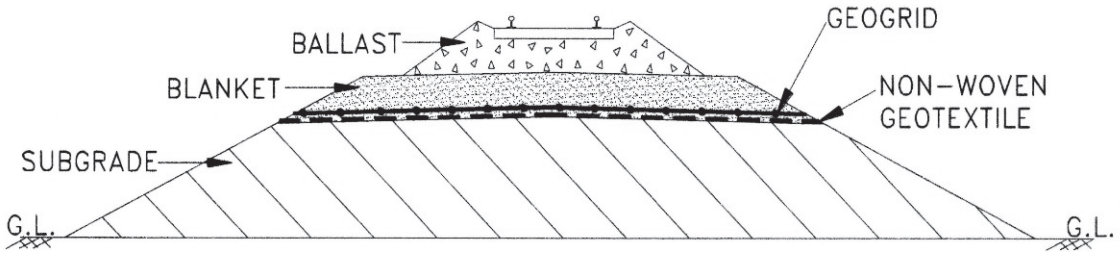


Fig. 6.05: Reduction in Blanket thickness using Geogrid

(6) Specification of Prepared Subgrade Material

(a) Soil Quality Class: SQ2 or SQ3

(b) Minimum soaked CBR value: 8 (Soil compacted at 98% of MDD in lab)

(c) Field compaction: 98% of MDD in Field Trial

(d) Minimum Ev_2: 60 MPa

(e) Maximum Plasticity Index: 12

(7) Specification and Thickness of Subgrade Layers

Table 6.06: Specification and Thickness of Subgrade Layers

Layer	Specification	Thickness
(A) Single Layer System		
Subgrade Top Layer	(i) Soil Quality Class: SQ1(*) / SQ2 / SQ3 (ii) Minimum CBR Value: 6 (For SQ2/SQ3 soil) : 4 (For SQ1 soil) (Soil compacted at 98% of lab MDD) (iii) Field Compaction: Min. 98% of Field Trial MDD (iv) Minimum Ev_2: 45 MPa (For SQ1 soil) : 60 MPa (For SQ2 / SQ3 soil)	100 cm
Subgrade Lower Layer (Fill)	(i) Soil Quality Class: SQ1 / SQ2 / SQ3 (ii) Minimum CBR Value: 3 (Soil compacted at 97% of lab MDD) (iii) Field Compaction: Min. 97% of Field Trial MDD	As per embankment height
(B) Two Layer System		
Subgrade Top Layer	(i) Soil Quality Class: SQ1**(*)** / SQ2 / SQ3 (ii) Minimum CBR Value: 5 (For SQ2/SQ3 soil) : 4 (For SQ1 soil) (Soil compacted at 97% of lab MDD) (iii) Field Compaction: Min. 97% of Field Trial MDD (iv) Minimum Ev_2: 30 MPa (For SQ1 soil) : 45 MPa (For SQ2 / SQ3 soil)	50 cm
Subgrade Lower Layer (Fill)	(i) Soil Quality Class: SQ1 / SQ2 / SQ3 (ii) Minimum CBR Value: 3 (Soil compacted at 97% of lab MDD) (iii) Field Compaction: Min. 97% of Field Trial MDD	As per embankment height
(*) To be used only with dispensation from PCE or CAO/C		

(8) Separator layer below the blanket

When the subgrade or prepared subgrade is of SQ1 or SQ2 category, a suitable non-woven geotextile layer may be used as “separator layer” just below the blanket layer to prevent upward migration of fines from subgrade/prepared subgrade causing contamination of blanket layer on top and to prevent penetration of coarse blanket layer particles into soft/ fine grained particles of subgrade/prepared subgrade below. Specification of non-woven geotextile to be used as “separator layer” is given is Appendix-C of RDSO Specification No. RDSO/2020/GE: IRS-0004, September-2020.

615 APPROVAL OF DESIGN OF FORMATION

Design of formation, including adoption of single layer or two-layer system, and use of SQ1 soil (in top layer of subgrade) shall be decided by PCE / CAO(Construction), based on soil investigation. In case of projects being executed by PSUs, these powers shall be exercised at appropriate level of authority as nominated by CMD/MD of the PSU.

616 UNIFORM TOTAL THICKNESS OF FORMATION LAYERS

(i) The specifications of soil strata below the ground level must be ascertained from the results of soil exploration.

(ii) Total required thickness of formation layers, as specified in paras above, for blanket, prepared subgrade and subgrade top layer should be provided/ensured uniformly in embankment/ cutting for effective stress dispersal, even where embankment height is less than 1.5m or total uniform required thickness. It is further explained as below:

(a) For Embankment (where height of embankment is less than required total uniform thickness): If the specification of sub-soil meets the required specification of blanket/ prepared subgrade/prepared subgrade top layer, up to required total depth of uniform thickness below ground level, then there will be no need of excavation, else the excavations will be done as per the requirement, to satisfy the provision of uniform thickness. Detailed description and few examples are given in Appendix-B of RDSO Specification No. RDSO/2020/GE: IRS-0004, September-2020.

(b) For Cutting: If the specification of sub-soil does not meet the required specification of blanket/prepared subgrade/subgrade top layer i.e., total required uniform thickness, below the proposed level of excavation in cuttings, the excavation level for cutting shall be enhanced to the level so as to satisfy the total required uniform thickness requirement. Detailed description and few examples are given in Appendix-B of RDSO Specification No. RDSO/2020/GE: IRS-0004, September-2020.

617 DRAINAGE ARRANGEMENTS IN EMBANKMENTS AND CUTTINGS

Drainage is most important factor in the stability of embankment/cutting. Therefore, drainage system should be efficient enough to prevent stagnation and allow quick flow of water.

(1) Drainage in Embankments

In embankments, cross slope is provided on top of formation to drain out surface water. Therefore, normally there is no need of side drains in case of embankments. In case of double line construction, central drain between the tracks should be avoided to extent possible as it is not only difficult to construct but difficult to maintain also. Only in very rare situations, suitable arrangement for construction of central drain with precast concrete channel/subsoil drains along with proper outfall should be made. Wherever there is level difference between two adjacent tracks, suitable non-load bearing dwarf wall may be constructed to retain earth.

(2) Drainage in Cuttings

(a) Side drains: Side drain width is generally standard 1.2m wide on top, 0.6m at bottom. The depth is 0.3m minimum, with deeper drains as per longitudinal slope depending upon length of cutting. Top of the drain is kept at or higher than bottom level of blanketing layer.

(b) Catch water drains: When natural topography is having one side slope and surface runoff has a tendency to flow into the cutting, network of catch water drains on top of cutting is provided to intercept water heading towards cutting and dispose of at proper discharge locations. Catch water drain should be made pucca with joints sealed with bituminous compound. These drains should have section enough to carry 50% more discharge than required to account for any blockage. These drains should have enough slope to develop self-cleansing velocity and shall have well designed discharge points.

618 EROSION CONTROL OF SLOPES

Slopes in soft rock or soil are prone to erosion due to wind and rains.

(1) Selection of Erosion Control Method

Following points may be considered while adopting suitable method for erosion control on soil slopes:

(i) Developing vegetation cover would be the best method to prevent soil erosion. This may be attempted by using "Simple Turfing Method".

(ii) At locations where a simple turfing method cannot ensure vegetation cover, natural fibre based netting (like Geo-jute or Ge-coir nettings) can be adopted to support vegetation growth. For Geo-jute, RDSO Specification No. 2007/GE:G-008 (Feb'2007) and for Geo-coir RDSO Specification No. 2020/GE:G-0022 (April, 2022) can be referred.

(iii) Where vegetation cover alone is not sufficient and soil surface needs to be protected in absence of vegetation cover, use of engineering systems like Geo-mats and Geocell can be made to aid growth of vegetation.

(iv) Organic mulch application or hydroseeding can be adopted to grow vegetative turfing, even on inaccessible or near vertical slopes also.

(v) For further details on various types of erosion control systems, Chapter-8 of RDSO Specification No. RDSO/2020/GE:IRS-0004, September-2020, may be referred.

619 USE OF GEOSYNTHETICS IN RAILWAY FORMATION CONSTRUCTION

(1) Use of Geosynthetics

Considering various functionalities provided by the Geosynthetics, they have been used or can be used for many applications related to construction of Railway formation. In addition to the use of Geosynthetics mentioned in para above, Geosynthetics can also be used for specific applications detailed in Para 619(2) below.

The decision on use of Geosynthetics shall be taken based on the techno-economic considerations for every site of work, with the approval of PHOD in Open Line and Construction departments of Zonal Railways and equivalent officer in PSUs.

(2) Specific use of Geosynthetics in construction of Railway formation

(A) Construction of embankment over soft subsoil

In case of embankments over weak/fine grained soils and having water table also at higher level, it is a good practice to provide about 1000mm thick "separator-cum-drainage layer" of sand at the ground level. Its thickness may vary depending on the

bank height, characteristics of subsoil and location of water table. In areas with scarcity of sand, thickness of sand layer can be reduced by laying a layer of geo-composite drain, sandwiched between two layers of sand of about 75mm thickness, as shown in **Fig. 6.06** Below. Specification of the geo-composite drain to be used are given in Appendix-C of RDSO Specification No. RDSO/2020/GE: IRS-0004, September-2020.

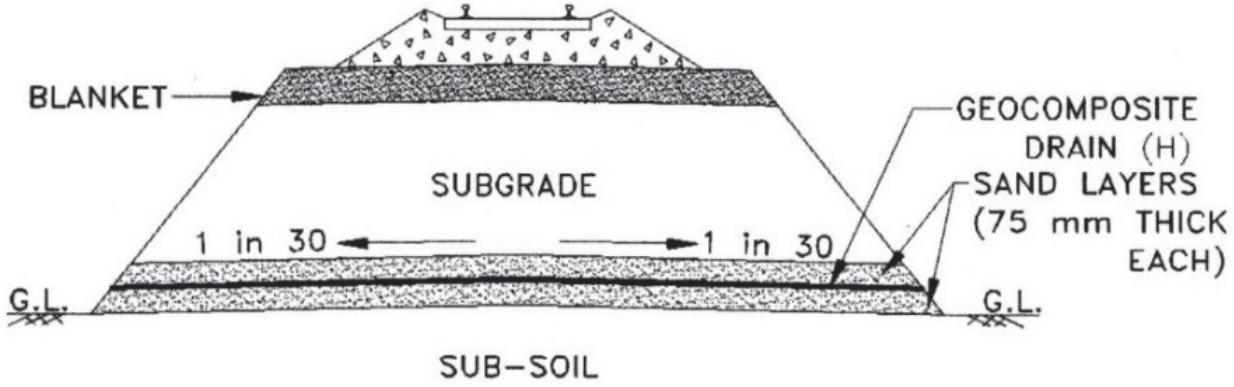


Fig. 6.06: Use of Geocomposite drain at base of embankment

(B) Drainage behind Bridge abutment/Retaining wall

Geo-composite drain (vertical) can replace the 600mm thick natural graded filters (consisting of different sizes of boulders and gravels). Provided behind bridge abutment and retaining wall for drainage, as shown in **Fig. 6.07**. This arrangement is useful in places where availability of graded filter material is matter of concern. It also eliminates the need for weep holes in bridge abutments and retaining walls. Specification of such geo-composite drain (vertical) are given in Appendix-C of RDSO Specification No. RDSO/2020/GE: IRS-0004, September-2020.

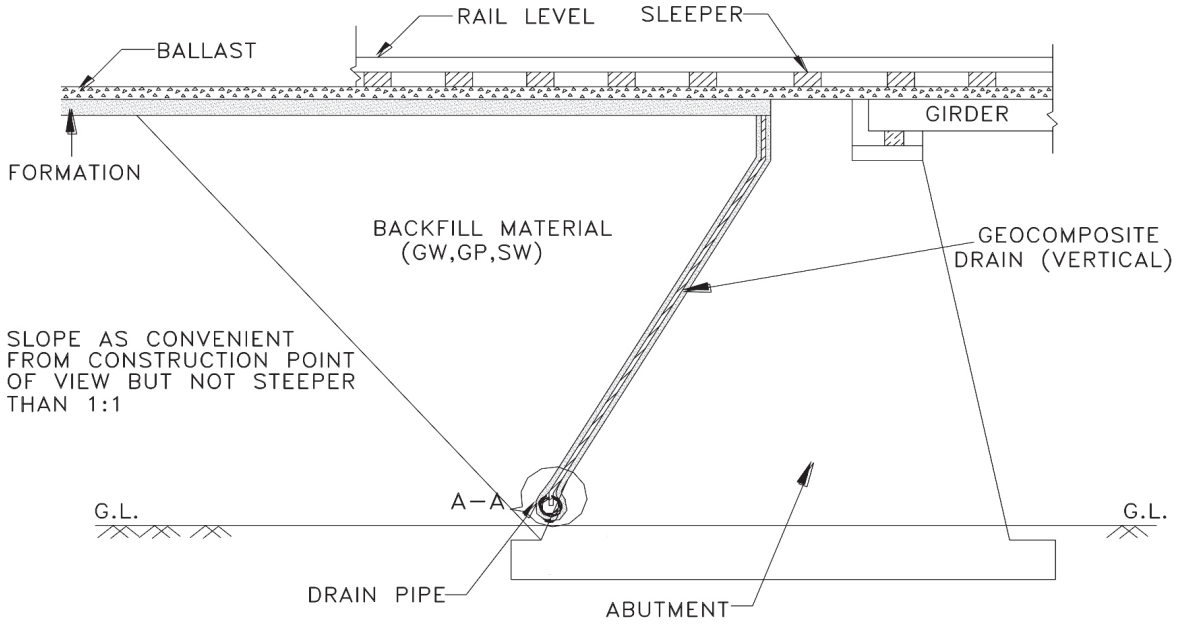


Fig. 6.07: Use of Geocomposite Drain behind Bridge Abutment

**

CHAPTER 7
EARTHWORK IN CONSTRUCTION PROJECTS

701 EXECUTION OF EARTHWORK IN FORMATION

Before taking up actual execution of work, detailed drawings need to be prepared for the entire length of the project to give alignment, formation levels, formation width at ground level, cross sections of catch water drains & side drains, cross section and levels of subgrade, blanket levels etc. to facilitate smooth execution at site.

(1) Preliminary works

(a) Site Clearance: Full formation width at ground level plus additional extra width of 1m on both sides should be cleared of all obstructions viz. vegetation, trees, bushes, building, fences, abandoned structures etc. and thereafter it should be dressed and leveled. Depressions if any, should be filled with suitable soil duly compacted. Finally, leveled surface should be properly compacted by mechanical means to get leveled and uniform ground surface.

(b) Benching of existing ground: When embankment is constructed on ground having steep slope, then the ground should be suitably benched so that new material of embankment gets well bonded with the existing ground surface.

(c) Construction of surface drainage: Surface drainage shall be constructed, wherever required, so as to maintain the natural water drainage facilities and prevent the introduction of surface water into the earthworks.

(d) Setting out of Construction Limits: Centre line of alignment (@200m c/c or so) and full construction width should be demarcated with reference pegs/dug belling about 90 cm away from proposed toe of the bank. Care should be taken not to disturb the pegs during construction. Pegs should be preferably painted for identification.

(e) Selection of Borrow Area: Borrow area should be selected sufficiently away from the alignment, as far as possible at the extreme of Railway land but normally not less than 3m plus height of bank to prevent base failure. Existing borrow pits, close to the toe of bank, may be filled or its' depth should be taken into account in analyzing slope stability of the embankment.

(2) General aspects

(a) A field trial for compaction, on a test section, shall be conducted on fill material to assess the optimum thickness of layer and optimum number of passes for the type of roller planned to be used to arrive at desired density. Procedure for field compaction trial is given in para 704.

(b) As manual method of construction cannot achieve desired progress and quality of earthwork, it would be necessary to deploy modern equipment such as earthmovers, motor grader, scraper, dumpers, mobile water sprinklers, vibratory rollers, sheep foot rollers etc. It is desirable to maintain records of work done by various equipment at a particular site to assess the output and quality control.

(c) 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 maintaining the same to achieve the slope and grade.

(d) If the soil has less than required moisture content, necessary amount of water shall be added either in borrow pits or after the soil has been spread loosely on the embankment. Addition of water may be done through flooding or irrigating the borrow pits or sprinkling the water on the loosely sprayed soil through a water tank sprinkling system. Use of hose pipes need to be avoided.

(e) If the soil is too wet, it should be allowed to dry till moisture content reaches to accepted level required for the compaction.

(f) Clods or hard lumps of soil of borrow area shall be broken to 75mm or lesser size before placing on embankment.

(g) Each layer should be compacted with recommended type of roller up to required level of compaction commencing from the sides, before putting next upper layer.

702 CHECKS ON CONSTRUCTION MATERIALS

To ascertain the suitability of soil/earthen material being used for construction of embankment, quality control checks are required to be carried out on borrow material as well as the blanket material.

(1) Tests on Borrow Material (Subgrade and Prepared subgrade)

The details of tests to be carried out on the borrow material (to be used as subgrade and prepared subgrade) with their testing frequency, are given in **Table 7.01** (placed at the end of chapter).

It would be in the interest of the execution agency to have frequent tests conducted at source/manufacturing point on his own, to judge the suitability of the material to avoid any complication at later stage. However, the final acceptance of the borrow material should be at the site, before laying of the material.

Once the material has been found fit for use as fill material, further lab tests shall be carried out, to assess OMC & MDD or γ_{max} & γ_{min} (if Relative Density test is to be used for checking quality of compaction, in material with fines up to 5%).

(2) Tests on Blanket Material

The details of tests to be carried out on the blanket material, with their testing frequency, are given in **Table 7.02** (placed at the end of chapter).

It would be necessary to carry out wet analysis to assess the actual percentage of fines.

It would be in the interest of the execution agency to have frequent tests conducted at source/manufacturing point on his own, to judge the suitability of the material to avoid any complication at later stage. However, the final acceptance of the blanket material should be at the site, before laying of the material.

Once the blanket material has been found fit for use as fill material, further lab tests shall be carried out, to assess OMC & MDD (IS : 2720 part- 8) or γ_{max} & γ_{min} (IS : 2720 part- 14) (if Relative Density test is to be used for checking quality of compaction, in material with fines up to 5%).

703 COMPACTION OF EARTHWORK

Compaction is the process of increasing the density of soil, by mechanical means, by packing the soil particle closer together with reduction in air voids and to obtain a homogeneous soil mass having improved soil properties. For all the type of soil/ earthen material to be used in the construction of embankment, Modified or Heavy Proctor Test is carried out in the lab to determine their Maximum Dry Density (MDD) and Optimum Moisture Content (OMC).

(1) Factors affecting compaction

(a) Compaction Effort: The compaction effort is decided by the type of compaction equipment used, its' weight, vibrating frequency etc. The method of compaction is primarily of four types i.e., kneading compaction, static compaction, dynamic or impact compaction and vibratory compaction. Different types of action are effective for different type of soils. Using the details given in Annexure-F of RDSO Specification No. RDSO/2020/GE: IRS-0004, September-2020, suitable type of compaction equipment to be used is decided based on the type of soil/material to be compacted.

(b) Moisture Control: Proper control of moisture content is necessary for achieving desired density. The compaction of soil is carried out near its OMC (Optimum Moisture Content). However, the values of OMC obtained in lab are fine-tuned during "field compaction trial" to determine the OMC value to be used as "placement moisture content". If this OMC is more than the natural moisture content (NMC) of the soil, calculated amount of water 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 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, coarse grained sandy and 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 for each layer is necessary to achieve uniform compaction. Optimum layer thickness depends on type of soil and compaction effort. Normally, 200-300 mm layer thickness is optimum in the field for achieving homogeneous compaction. However, the thickness of layer to be adopted is determined in "field compaction trial".

(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. The optimum number of passes (for given type of roller, with a given layer thickness and at a predetermined moisture content), is determined in "field compaction trial".

(2) Compaction procedure for different soil types

(a) For Cohesionless Gravely and Sandy Soils: Sandy and gravely soils should be compacted with vibratory rollers. If fines are less in these types of soils, they can be compacted with minimum number of passes of vibratory rollers without strict control of OMC. With higher percentage of fines, such soils are to be brought to OMC to get effective compaction. Since top layer of sand and gravel remains loose, in final pass the roller

should move smoothly without vibration.

(b) For Silty and Clayey Soils: Silty soils are fine grained and they can be plastic or non-plastic depending on the clay content. These can be compacted near about OMC either with smooth rollers or vibratory rollers. Vibratory rollers will impart higher energy and higher degree of compaction. Compaction of silty clays will have to be handled in a manner similar to clays.

(c) For Clays: Water content plays a very important role in compaction of clay. Main objective is to achieve uniform mass of soil with no voids between the lumps of clay. If moisture content is too high, roller tends to sink in layer and if it is too low then chunks will not yield to rolling by rollers. Appropriate water content is in the range of about plastic limit plus 2%. Sheep foot rollers are most effective in breaking the clods. For better results, final rolling with vibratory rollers shall be done after initial rolling with sheep foot roller. Thickness of layer should not be more than depth of sheep foot of roller plus 50mm.

704 FIELD COMPACTION TRIAL

(i) Compaction process in lab & field is not exactly same, for all type of soils. Therefore, "field compaction trial" is carried out to decide the optimum compaction effort and to determine the attainable dry density, for the soil/earthen material being used in the field, with the type of compactor being used and other field parameters (layer thickness and number of passes) being used in the field. The details of compaction equipment being used are recorded as per **Table 7.03** (placed at the end of chapter).

The list of equipment used is recorded as per **Table 7.04** (placed at the end of chapter).

(ii) The field moisture content, optimum layer thickness, the MDD achieved and minimum number of passes of roller; as finalized in the field compaction trial, are to be used as reference parameters for actual execution of the work in the field.

(iii) The procedure for conducting "field compaction trial" is as under:

Step 1: Construct a test ramp about 20-30m long, 10-12m wide & 0.15m thick on one side end & 0.55m on other end, preferably at the construction site, over a level ground surface under nearly identical conditions **(Fig. 7.01)**.

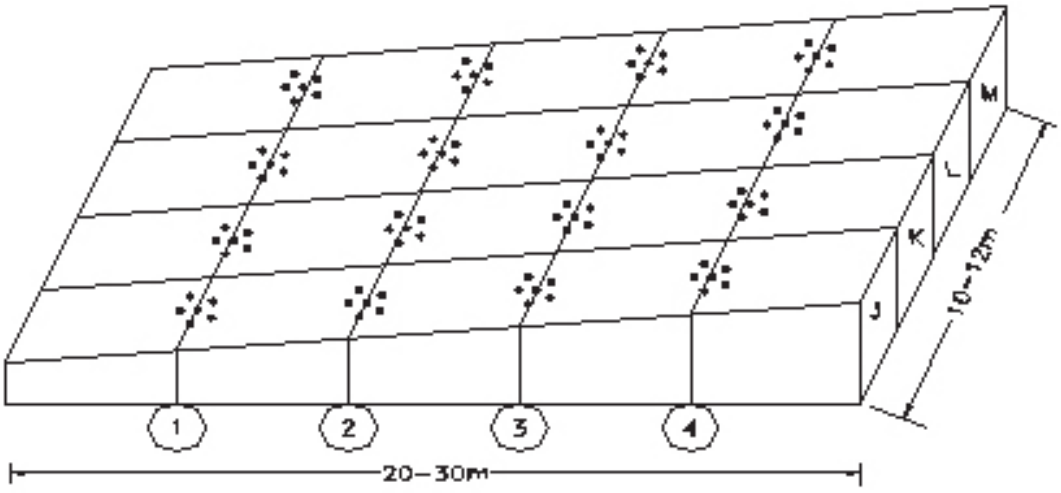


Fig. 7.01: Test ramp at site

Step 2: Divide the ramp equally into four segments longitudinally (segments J, K, L and M in Fig. 7.01), of about 2.5m width each (more than width of roller). Each strip will be used for conducting trial at specific moisture content, viz. OMC-4%, OMC, OMC+4% and PL-2%. Here OMC is Optimum Moisture Content obtained in lab test.

Note: Experience shows that most suitable water content falls within a small range of 3% below to 1% above the OMC for most of the soil.

Step 3: Start trial on first segment at a particular moisture content (Step 2).

Step 4: Fix four number sampling points on this strip at locations where layer thickness of about 225mm, 300mm, 375mm & 450mm are to be obtained after rolling (Cross Section at 1, 2, 3 and 4 in Fig. 7.01).

Step 5: Collect samples around the sampling points (Step 4). Determine moisture content by any suitable standard method.

Step 6: Compare the moisture content with that of the relevant desired moisture content (Step 3).

Step 7: Wait for natural drying if moisture content is on higher side or sprinkle appropriate amount of water uniformly followed by ploughing etc. and leave for 5 to 30 minutes depending on type of soil, in case the moisture content is on lower side (Step 3).

Step 8: Determine moisture content once again at sampling point before rolling. Observations of determination of moisture content are recorded as per **Table 7.05** (placed at the end of chapter).

Step 9: Roll the strip and measure the density (by any standard method) of the soil after every two passes commencing from four roller passes. The observations are recorded as per **Table 7.06**.

Note: Measurement of dry density and moisture content are taken after removing top 5cm layer of earth with least possible disturbance. If the layer thickness is small, density ring should be used.

Step 10: Carry out testing on each strip at different specific moisture content as for first strip explained above. Compile the result of trial of all strips as per **Table 7.07** (placed at the end of chapter).

Step 11: From these test result, two sets of graphs are plotted first set of graph – Dry density v/s number of roller passes for each water content and layer thickness **(Fig. 7.02)**. For each layer there would be four (depending on range of moisture content chosen) curves for different moisture content.

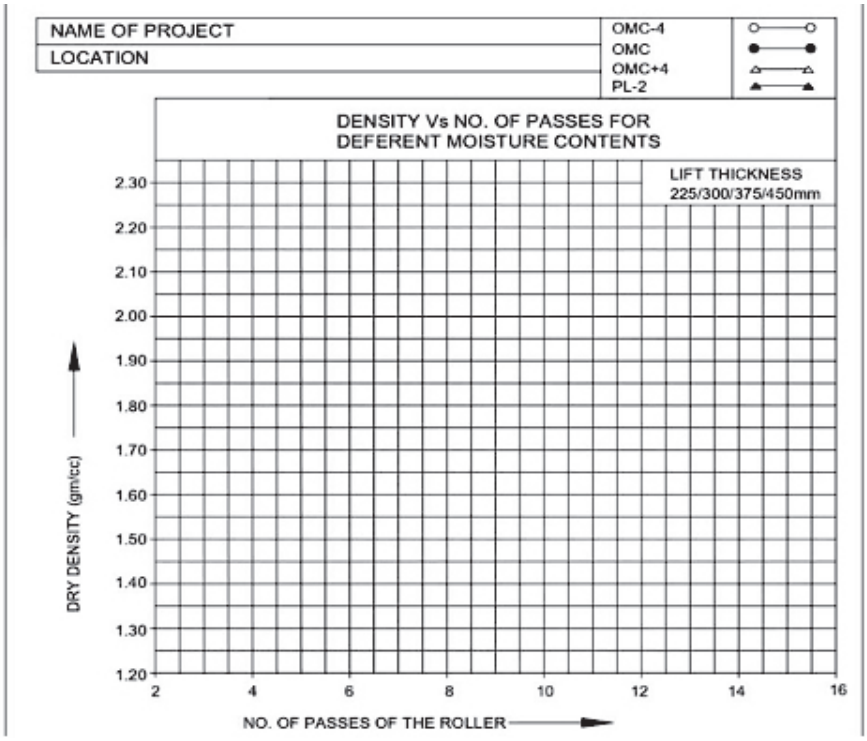


Fig. 7.02: First set of Graphs

Second set of graphs: Maximum dry density v/s moisture content for each layer thickness **(Fig. 7.03)**.

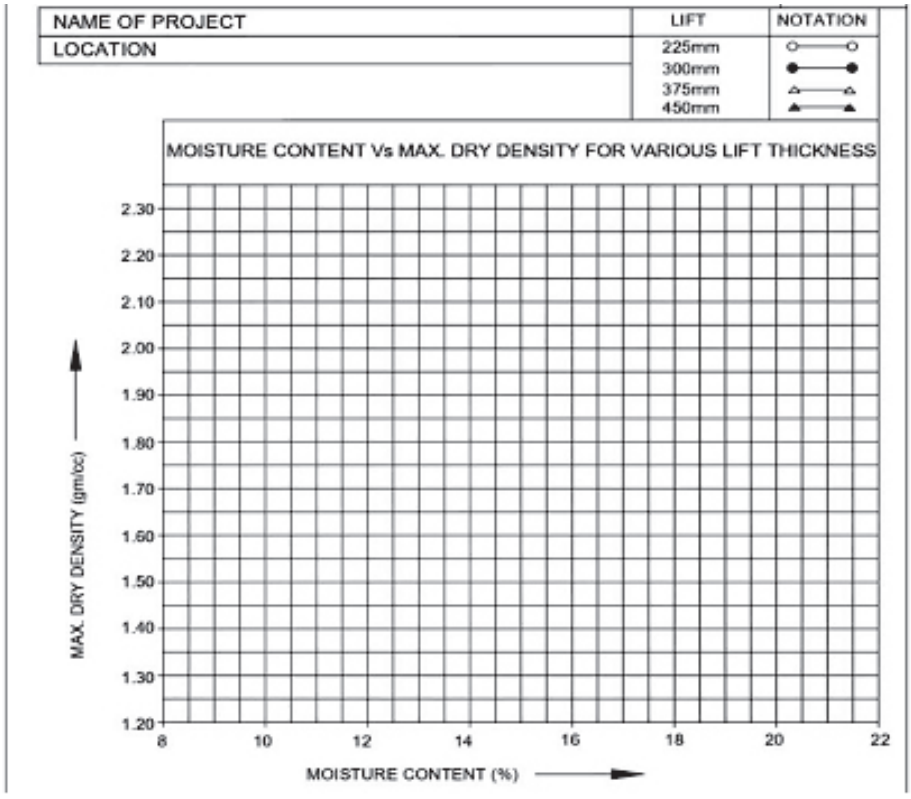


Fig. 7.03: Second set of Graphs

Step 12: Minimum MDD to be achieved in the field compaction trial should not be less than 98% of the MDD obtained in lab. In case, there are difficulties in achieving 98% of lab MDD values, in the field trials, the same may be relaxed up to 95% of the MDD with the specific approval of Chief Engineer (Construction), recording reasons for such relaxation. In case of PSU, existing provision of equivalent authority for acceptance criteria shall continue.

Step 13: Second Set of graphs will give field moisture content and optimum layer thickness, for the minimum MDD to be achieved in the field compaction trial. From these field values, minimum number of passes of roller are read from first set of graphs.

705 COMPACTION OF/NEAR SIDE SLOPES

Since it is difficult to get the same compaction effort as in other parts of the embankment, following steps shall be taken for compaction of/near side slopes:

(i) Extra embankment width of 500mm on either side shall be rolled/compacted to ensure proper compaction at the edges.

(ii) The extra width of soil rolled should be cut and dressed mechanically to achieve regular side slope.

(iii) The side slopes shall also be compacted with 6-8 passes of slope compactors (10-20-ton capacity). Details of some of the slope compactors are available at Appendix-E of RDSO Specification No. RDSO/2020/GE: IRS-0004, September-2020.

(iv) Suitable erosion protection measures should be provided on the side slopes, as detailed in Para 618 of Chapter-6.

(v) In areas, susceptible to flooding, the sides of an embankment (except approach bank of bridges) should be protected with a layer of rockfill or stones, with an intermediate granular layer, up to 1m above HFL.

706 BACKFILL ON BRIDGE APPROACHES AND SIMILAR LOCATIONS

(i) The backfills resting on natural ground may settle in spite of heavy compaction and may cause differential settlements, vis-a-vis, abutments, which is comparatively much stiffer. To avoid such differential settlements, while on one hand it is essential to compact the backfill in the properly laid layers of soil, the coefficient of subgrade reaction should have gradual change from approach to the bridge abutment.

(ii) Backfill on bridge approaches should be placed in accordance to Para 7.5 of Bridge Substructure Code (including latest correction slips). Sketch of the details are given in **Fig. 7.04** below:

(iii) Fill material being granular and sandy type, need to be placed in 150mm or lesser thick layers and compacted with vibratory plate compactors.

(iv) While placing backfill material, benching should be made in approach embankment to provide proper bonding.

(v) Geo-composite drain (vertical) can replace the natural graded filters (consisting of 600mm thick boulders/cobbles etc. as shown in Fig. 7.04 above), provided behind bridge abutment and/or retaining walls for drainage, in places where availability of graded filters is matter of concern. Detailed elaboration is given in Appendix-C of RDSO Specification No. RDSO/2020/GE: IRS-0004, September-2020.

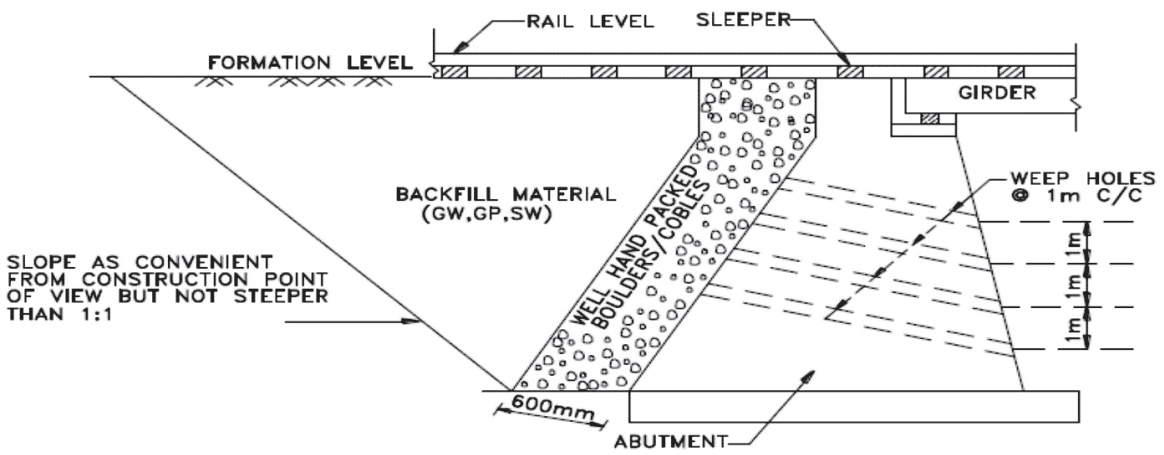


Fig. 7.04: Backfill behind bridge abutment

Note:

1. Behind abutments, wing walls, and return walls, boulder filling and backfill materials shall be provided up to full height.
2. The boulder filling shall consist of well hand packed boulders and cobbles not less than 600mm with smaller size towards the back.
3. Behind the boulder filling, backfill material shall consist of granular materials of GW, GP, SW groups, as per IS: 1498.

707 SANDWICH CONSTRUCTION OF EMBANKMENT WITH COHESIVE SOILS

Sandwich type of construction may be adopted, as given in **Fig. 7.05** below, for construction of embankments with cohesive soils having very low permeability (less than or equal to 10-2 cm/sec) and where height of embankment is greater than 3m. In such situations, a layer of coarse sand (cu > 2) about 20 to 30 cm thick should be provided at embankment height intervals of 2 to 3m; to improve factor of safety against slope failure, drainage and dissipation of pore water pressure. It is desirable to have a bottom layer of coarse sand in all cases where soil of low permeability are used even for depths up to 3m. However, before adopting such construction, it may be necessary to carry out a detailed technical study along with economics of sandwich construction, depending on site conditions and availability of material, if required, in consultation with RDSO.

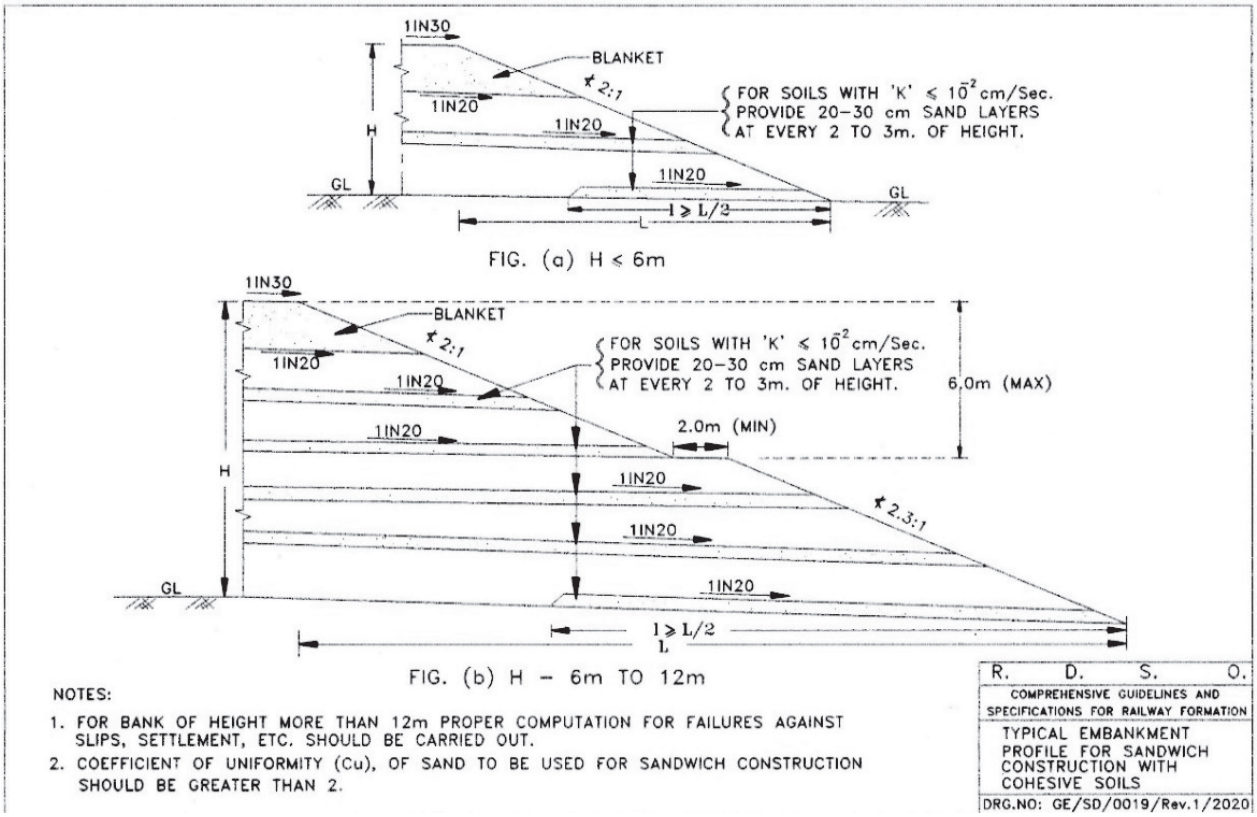


Fig. 7.05: Typical embankment profile for Sandwich Construction

708 METHODS FOR IN-SITU DRY DENSITY MEASUREMENT

Any of the following methods could be used for dry density measurement as per requirement at site:

(i) Core cutter method

The test is carried out as per IS: 2720 (Part-29) and it measures in-situ bulk density of the compacted earthwork. The moisture content is determined using some other suitable method (e.g. rapid moisture meter using calcium carbide powder). In some of the coarse-grained soils (with little fines), taking core cutter samples is difficult.

(ii) Sand replacement method

The test is carried out as per IS: 2720 (Part-28) and it measures in-situ bulk density of the compacted earthwork. The moisture content is determined using some other suitable method (e.g. rapid moisture meter using calcium carbide powder). This method can be used for density measurement in all type of soils.

(iii) Nuclear moisture density gauge

The test is carried out as per procedure given in Appendix-H of RDSO Specification No. RDSO/2020/GE: IRS-0004, September-2020. Besides, bulk density it determines moisture content and degree of compaction also. It is a faster method and should be widely used for large construction projects.

709 QUALITY CONTROL MEASURES FOR EARTHWORK

(1) Setting up of GE Lab at Construction/Rehabilitation Site

A well-equipped Geotechnical Engineering (GE) Field Laboratory shall be set up at all construction projects connected with new lines, doubling and gauge conversion works as well as, where rehabilitation of failing formation is being undertaken. The aspects to be looked after by the field GE labs and the minimum equipment to be kept in these GE labs are given in Para 6.2.8 of the RDSO Specification No. RDSO/2020/GE: IRS-0004, September-2020.

(2) Quality of Compaction achieved in field

(a) Coarse grained soils, containing fines passing 75 micron IS Sieve up to 5%, should have the Density Index (Relative Density) of minimum of 70% as obtained in accordance with IS:2720 (Part 14).

(b) For other soils, the level of compaction to be achieved in field, as a percentage of MDD value achieved in field compaction trial, for various layers shall be as per Para 614 (2), Para 614 (6) and Para 614 (7) of Chapter-6.

(c) During widening of embankment in case of gauge conversion and rehabilitation of unsuitable formation, compaction of earthwork should be at minimum 95% of MDD as obtained by Laboratory Test as per Heavy Compaction Test (IS:2720, Part-8) or 70% Relative Density for coarse grained soils which contain fines (passing 75 micron IS sieve) up to 5% (IS:2720, Part-14).

(3) Frequency for checking Quality of Compaction

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

(a) At least one density check for every 30m length for blanket layers and top one meter of prepared sub-grade/subgrade along the alignment, for each compacted layer, in a staggered pattern as detailed in Para 7.4.1(a) of RDSO Specification No. RDSO/2020/GE: IRS-0004, September-2020.

(b) At least one density check for layers other than as specified in (i) above, every 500 sqm or 75m c/c whichever occurs earlier along the alignment, for each compacted layer, in a staggered pattern as detailed in Para 7.4.1(a) of RDSO Specification No. RDSO/2020/GE: IRS-0004, September-2020.

(c) In case of important bridge approaches (100m length on either side), at least on density check for every 25m length shall be adopted.

(4) Deformation Modulus (Ev2) Measurement

(a) It is a parameter which gives the deformation characteristics of compacted soil. It is calculated taking values from the load settlement curve obtained from the second cycle of loading in the Plate Load Test, as per the procedure given in Appendix-H of RDSO Specification No. RDSO/2020/GE: IRS-0004, September-2020.

(b) It is to be determined in the field, by conducting one test every km, on top of each formation layer i.e., at top of compacted Blanket layer/Prepared subgrade layer/ Subgrade Top & Lower layer.

(c) Additionally, this test can also be done by third party (i.e., IIT, NIT, Govt. Labs or any NABL approve Lab) having testing facilities, to cross check the results achieved at site.

Frequency of testing in this case shall be decided/approved at the level of Chief Engineer (Con.). In PSUs, frequency of such tests shall be decided as per existing delegations for testing.

(5) Checks on Finished Formation

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

(ii) Cross Slope: Cross slope should be within 1 in 28 to 1 in 30.

(iii) Side Slopes: Side slope should be 2H:1V or flatter as per design.

(iv) Formation Width: Formation width should not be less than the specified width.

710 QUALITY CONTROL RECORDS

At least, following records of quality control needs to be maintained.

(i) Characteristics of borrow materials as per format in **Table 7.08** (placed at the end of chapter).

(ii) Quality of blanket material as per format in **Table 7.09** (placed at the end of chapter).

(iii) Field compaction trial computation sheet as per format in **Table 7.07** (placed at the end of chapter).

(iv) Quality of compaction of earthwork including blanket material as per format in **Table 7.10** for core cutter method and format in **Table 7.11** for sand replacement method.

(v) Quality of material and its compaction for backfill behind bridge approaches etc. as per format in **Table 7.08**, **Table 7.09**, **Table 7.10** and **Table 7.11** (placed at the end of chapter).

(vi) Details of machineries engaged in execution of earthwork including their output as per format decided by the field engineers.

711 CERTIFICATION FOR QUALITY OF EARTHWORK

(i) Certification of earthwork in formation in new lines, gauge conversion and doubling projects etc. will be done by Executive authority at SAG level (i.e., CE/C of respective projects). CE/C will submit details for certification of quality of earthwork to CRS as per the RDSO checklist.

(ii) Checklist for certification of quality of earthwork in Railway projects was issued by RDSO vide letter no. RS/G/95/Main dated 11.06.2004. This check list has been revised and placed at Appendix-M of RDSO Specification No. RDSO/2002/GE: IRS-004, September-2020.

712 SPECIAL DESIGN/CONSTRUCTION PROBLEMS

Any special design problem relayed with construction of formations may be referred to RDSO for guidance and advice, if required.

713 PERMANENT RECORDS

It would be desirable to prepare completion drawing of embankments and cuttings indicating details of special construction features like toe walls, breast wall, catch water drains, side drains,

cross section of embankment/cutting, type & depth of soil in subgrade/prepared subgrade/ blanketing, other geological features etc. These permanent records need to be handed over to open line at the time of handing over of the section for maintenance.

Table 7.01

Tests on Borrow Material, at site, before laying

Parameter to be tested	Test Code Ref.	Frequency of test	Acceptance Criteria
(i) Soil Classification	IS:1498	At least one test at every change of material subject to a minimum of one test for every 5000 cum	Soil should not be "unsuitable type" as given in Para 610(i) and should conform to the Specifications given in Para 614(6) and 614(7) of Chapter-6
(ii) CBR	IS:2720 (Part-16)		
(iii) Plasticity Index (for Prepared Subgrade only)	IS:2720 (Part-5)		

Table 7.02

Tests on Blanket Material, at site, before laying

Parameter to be tested	Test Code Ref.	Frequency of test	Acceptance Criteria
(i) Gradation	IS:2720 (Part-4)	At least one test at every change of material subject to a minimum of one test for every 500 cum	Should conform to the Specifications given in Para 614(2) of Chapter-6
(ii) Cc and Cu			
(iii) Fines (passing 75 µ)			
(iv) Abrasion value	IS:2386 (Part-4)		
(v) CBR	IS:2720 (Part-16)		
(vi) Filter criteria	IS:2720 (Part-4)		

Table 7.03

Compaction Equipment Data

Project: ……..

Location: ……

Date:……..

Item		Roller-1	Roller-2	Roller-3
Type of roller				
Gross weight				
Drum dimension (Roller type)	Width (mm)			
	Diameter (mm)			
Foot (Sheep Foot type)	Type			
	Number			
	Length (mm)			
	Area (mm2)			

Contact area (cm2) (Sheep Foot/ Pneumatic type/ Vibrator Plate type)			
Tyre inflation pressure (kg/cm2)			
Nominal Amplitude (mm)			
Frequency (Hz)			
Dynamic force (kg)			
Operational Speed (kmph)			
Static linear loads (kg/cm)			
Contact Pressure (kg/cm2)			

Table 7.04

List of Equipment for Field Trial / Monitoring

SN	Equipment	No. Required	No. Available
1	Field density apparatus complete: (a) Sand replacement (b) Core cutter with dolly and hammer (c) Nuclear moisture density gauge	 4 sets 4 sets 1 set	
2	Balance (a) Electronic balance – 20 kg capacity (with 2.0 gm least count) (b) Electronic balance – 500 gm capacity (with 0.1 gm least count)	 1 Set 1 Set	
3	Straight edge 300mm long	4 Nos.	
4	Frying Pan	1 No.	
5	Container plastic (about 500g capacity)	8 Nos.	
6	Enamel plates: 6-inch dia. 8-inch dia. 10-inch dia.	10 Nos. 3 Nos. 3 Nos.	
7	Uniform clean sand (Ottawa sand) (bags of 50 kg)	10 Bags	
8	Measuring Tape (3M/ 5M)	1 No.	
9	Measuring Tape (15M/ 30M)	1 No.	
10	Kerosene oil stove	1 No.	

Signature of
Monitoring Official ……

Name……..

Designation……..

Signature of
Project Official……

Name ……..

Designation……..

Table 7.05

Field Compaction Trial observation

Project…… Date: …….

Location……

Strip No.	Location on the ramp	Moisture content before watering				Moisture content after watering			
		Container no.	Wt. of wet soil (gm)	Wt. of dry soil (gm)	Moisture content (%)	Container no.	Wt. of wet soil (gm)	Wt. of dry soil (gm)	Moisture content (%)
1	2	3	4	5	6	7	8	9	10
J	1								
	2								
	3								
	4								
K	1								
	2								
	3								
	4								
L	1								
	2								
	3								
	4								
M	1								
	2								
	3								
	4								

Signature of
Monitoring Official……
Name……..
Designation……..

Signature of
Project Official……
Name……
Designation……

Table 7.06

Field Compaction Trial observation

Project…… Location……. Date…….

Strip No. …… OMC……% MDD……gms/cc Volume of core cutter……..cc

No. of roller passes	Location of the ramp	In-situ bulk density					Moisture Content				Dry density (gm/ cc)	% of MDD	Remarks
		Core cutter No.	Wt. of empty core cutter (gm)	Wt. of wet soil with core cutter (gm)	Wt. of wet soil (gm)	Bulk density of soil (gm/ cc)	Container No.	Wt. of wet soil (gm)	Wt. of dry soil (gm)	Moisture Content (%)			
1	2	3	4	5	6	7	8	9	10	11	12	13	14
4	1												
	2												
	3												
	4												
6	1												
	2												
	3												
	4												
8	1												
	2												
	3												
	4												
10	1												
	2												
	3												
	4												
12	1												
	2												
	3												
	4												
14	1												
	2												
	3												
	4												

Signature of
Monitoring Official……
Name……..
Designation……..

Signature of
Project Official……
Name……
Designation……..

Table 7.07

Field Compaction Trial – Computation Sheet

SN	Lift thickness (mm)	Moisture content %	Dry Density of Soil (gm/cc)						Remarks
			Nos of the roller passes						
			4	6	8	10	12	14	
1	225								
2	300								
3	375								
4	450								

Computed by……
Name……
Designation……
Date……

Checked by……
Name……
Designation……
Date……

Table 7.08

Details of Borrow Soil/ Formation subgrade/ Prepared subgrade

SN	Date of taking sample	Location layer Ch./ Km	Soil type				Soil classification	LL	PL	PI
			Gravel %	Sand %	Silt %	Clay %				
1	2	3	4	5	6	7	8	9	10	11

CBR value	Whether of dispersive nature	Suitable/ non suitable	Signature and name of Engineer's representative	Signature and name of contractor representative	Remarks
12	13	14	15	16	17

Table 7.09

Quality of Blanket Material

1. Type of Material : Manufactured / Naturally available

2. Source Location :

SN	Date of taking sample	Location of Laying	Soil type			Cu	Cc	Abrasion value	CBR value
			Gravel %	Sand %	Fines passing 75-micron sieve %				
1	2	3	4	5	6	7	8	9	10

Signature and name of Railway official	Signature and name of contractor	Remarks
11	12	13

Table 7.10

Field Compaction Records

Chainage/ km from…….. to ……..

Soil Classification……Height of bank:…… OMC……

Type of roller being used:…… Lab MDD/ field trial MDD:……

CORE CUTTER METHOD

S N	Date of Laying	Layer No.	Location coordinate of check	Placement moisture content	No. of passes	Wt. of core cutter + soil (ws) (g)	Wt. of core cutter (wc) (g)	Wt. of wet soil (ws-wc) (g)	Volume of core cutter (vc) (cc)
1	2	3	4	5	6	7	8	9	10

Bulk density $\gamma_b = (w_s-w_c)/ V_c$ (g/cc)	Moisture content of compacted layer (w) (%)	Dry density $\gamma_d = \gamma_b / (1+w)$ (g/ cc)	Degree of compaction (%)	Sig. and name of railway officer	Sig. and name of contractor	Remarks
11	12	13	14	15	16	17

Note:

1. In case of compaction of blanket material, percentage of fines should be mentioned in column.
2. Determination of Dry Density (γ_d) of soil in above table is done as per IS:2720 Part-29 titled as "Determination of Dry Density of Soils In-place by the Core Cutter Method".

Table 7.11

Field Compaction Records

Chainage/ km from ……. To …….

Soil Classification: ……. Height of bank: …….

SAND REPLACEMENT METHOD

Location	Bulk density of sand γ_s (g/cc)	Wt. of soil from hole W_w (g)	Wt, of Cylinder + sand before pouring W_1 (g)	Wt. of Cylinder + sand after pouring W_2 (g)	Mean weight of sand in cone W_3 (g)	Wt. of sand in hole $W_b = W_1 - W_2 - W_3$ (g)
1	2	3	4	5	6	7

Bulk density of soil $\gamma_b = (W_w / W_b) * \gamma_s$ (g/cc)	Moisture content (w) %	Dry density of soil $\gamma_d = \gamma_b / (1+w)$ (g/cc)	Relative density 1_D	Sig. and name of Railway officer	Sig. and name of contractor	Remarks
8	9	10	11	12	13	14

Ref.: IS:2720 (part 28) 1974 (latest version)

(Determination of dry density of soils in-place, by the sand replacement method)

Note:

1. Density Index (Relative Density) shall be found out as per IS: 2720 (Parr-14) 1963 (latest version).
2. The Density Index I_D (Relative Density) expressed as a percentage should be calculated as following:

Relative Density $(I_D) = \gamma_{max} (\gamma_d - \gamma_{min}) / \gamma_d (\gamma_{max} - \gamma_{min}) \times 100$

γ_{max} (from lab as per IS:2720 Part-14) …….

γ_{min} (from lab as per IS:2720 Part-14) …….

γ_d determined in field as shown in above table by the sand replacement method

***

CHAPTER 8
PLANNING FOR BALLAST PROCUREMENT

801 INTRODUCTION

Ballast is the granular material, usually crushed stone, placed and packed below and around the sleepers to transmit all the load coming over it, whether it is from the train load or the track structure above the ballast. The ballast bed provides resiliency and drainage to the track, apart from providing lateral or longitudinal resistance. The track is stable because of the ballast.

Ballast is a heterogeneous material that can vary in its properties even in the same quarry. Thus, the field engineers have to be alert all the time while procuring ballast. If a weaker ballast is put in the track, it is a permanent source of trouble, like weak formation, and it becomes a costly affair to deal with it.

Requirements of good Ballast :

a) It should be tough and wear-resistant.

b) It should be hard without getting crushed under the moving loads.

c) It should generally be cubical with sharp edges.

d) It should be non-porous and non-absorbent of water.

e) It should resist attrition.

f) It should be durable and not get pulverized under the weather conditions.

g) It should provide good drainage of water.

h) It should be cheap and economical in price.

802 MINIMUM DEPTH OF BALLAST CUSHION

As per Para 212(2) of IRPWM-2020 for **Broad Gauge-**

(1) The minimum depth of the ballast cushion below the bottom of the sleepers at the rail seat for BG should be as under –

In Case of	**Min depth of all BG routes (mm)**
Track Renewals (Complete Track Renewals and Through Sleeper Renewals)	300*
All Doubling, Gauge conversions and new line construction works	350
Loop line	250

*Where possible a depth of 350mm may be provided

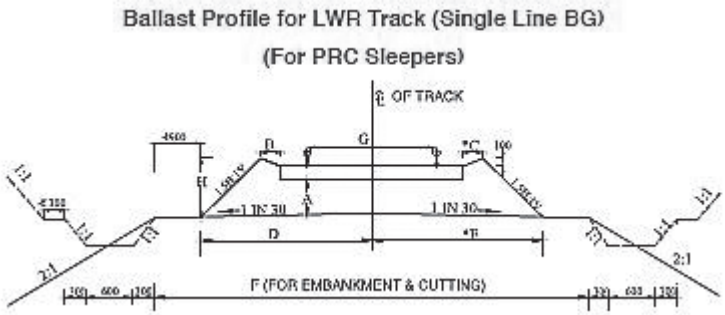
(2) Sidings –

Private and Other Sidings	For permissible speed up to 50 Kmph.	300 mm
	For permissible speed more than 50 Kmph	350 mm

Note – Minimum depth of clean ballast cushion at all times for mechanised maintenance under the rail seat of the PSC sleepers shall not be less than 150 mm.

803 CALCULATION OF QUANTITY OF BALLAST PER METER IN TRACK

As per Annexure – 2/2 (A) para 212 of IRPWM-2020



Gauge	Type of Sleeper	A	B	C*	D	E*	F	H	Quantity of Ballast per meter in	
									Straight Track (m3)	Curved Track (m3)
1676 mm	PRC	250	350	500	2693	2851	7850	646	2.030	2.120
		300	350	500	2772	2930	7850	698	2.304	2.401
		350	350	500	2851	3009	7850	751	2.585	2.690

*On outer side of curves only

Note:

1. The quantity of ballast is calculated considering PSC sleepers RT-2496 @ 60cm c/c. In case, any other type of sleeper or any other sleeper spacing is used, the quantity shall be calculated accordingly.
2. The quantity of ballast to be procured should be increased, from that shown above, on account of the following reasons -
   a) Super elevation has not been considered in the calculation of ballast quantity for curved track. The ballast quantity may thus be increased as per Cant.
   b) The quantity shown above is the compacted ballast quantity. Since the ballast is measured in loose stacks, Shrinkage/compaction allowance of around 8% should be taken, and the ballast quantity should accordingly be increased for procurement.
   c) Additional ballast required for points & crossings in running lines and crossovers, cut and connection locations should also be added up.

804 SPECIFICATION OF TRACK BALLAST

As per RDSO Specifications for Track Ballast IS/RDSO-GE/0001: 2023, February 2023, the following specifications for ballast should be followed -

(1) Basic quality: Ballast should be hard durable and as far as possible angular edges/corners, free from weathered portions of parent rock, organic impurities and inorganic residues.

(2) Particle shape: Ballast should be cubical in shape as far as possible. Individual pieces should not be flaky and should have generally flat faces, not more than two rounded/sub rounded

faces.

(3) Mode of manufacture: To ensure uniformity of supply, ballast for all BG main lines and running lines shall be machine crushed. Hand broken ballast can be used in exceptional cases with prior approval of Chief Track Engineer or CAO(C) in open line/Construction respectively. Such approval shall be obtained prior to invitation of tenders.

(4) Physical Properties: Ballast sample should satisfy the following physical properties in accordance with IS: 2386 Pt IV 1963 when tested as per procedure given in Annexure-I & II of IS/RDSO-GE/0001: 2023, February, 2023.

Aggregate Abrasion value - 30% Max* (BG)

Aggregate Impact value - 20% Max* (BG)

*Relaxation up to 35% & 25% respectively, on techno-economic grounds by CTE/CAO(C) in open line/Construction projects before invitation of tenders.

(5) Water absorption: When tested as per IS: 2386 Part III-1963, following the procedure given in Annexure III of IS/RDSO-GE/0001: 2023, February 2023, water absorption should not be more than 1%.

The power of relaxing the water absorption limit should be delegated to CTE in open line/ CAO(C) on construction for specified areas. However, maximum water absorption in any case should not be allowed more than 2.5%, as per the Para 2.2.3.1 of the IS/RDSO-GE/0001: 2023, February 2023.

(6) Size and Gradation:

Ballast should satisfy the following size gradation

a) Retained on 65 mm Sq. mesh sieve - 5% maximum

b) Retained on 40 mm Sq. mesh sieve - 40% to 60% (*for machine crushed)

c) Retained on 20 mm Sq. mesh sieve - Not less than 98% (for machine crushed)

Oversize ballast:

a) In case the ballast retained on the 65mm Sq. mesh sieve is at variance from 6 (a) specified above, the stack can be accepted with reduced payment as under:

A maximum of 5% ballast retained on 65 mm Sq. mesh sieve shall be allowed without deduction in payment. If the ballast retained on 65 mm Sq. mesh sieve exceeds 5% but does not exceed 10%, payment as a 5% deduction in the contract rate shall be made for the full stack. Stacks having more than 10% retention of ballast on 65 mm Sq. mesh sieve shall be rejected.

* As per IS/RDSO-GE/0001: 2023, February 2023

b) In case, the ballast retained on the 40mm square mesh sieve is above the 60% limit prescribed in 6 (b) above, payment at the following reduced rates shall be made for the full stack in addition to the reduction worked out in (i) above -

(i) 5% reduction in contracted rates if retention on 40mm square mesh sieve is between 60% (excluding) and 65% (including).

(ii) 10% reduction in contracted rates if retention on 40mm sq. mesh sieve is between 65% (excluding) and 70% (including).

c) In cases where the retention on 40mm Sq. mesh sieve exceeds 70%, the stacks

shall be rejected.

Undersize ballast:

The ballast shall be treated as undersized and shall be rejected if –

(i) Retention on 40mm square mesh sieve is less than 40%.

(ii) Retention on 20mm square mesh sieve is less than 98% (for machine crushed).

Note: Check Lists 812A, 812B and 812C provided at the end of this chapter shall be referred to for ensuring the quality of ballast as per the above specifications.

805 METHOD OF SIEVE ANALYSIS

(1) The screen for sieving of ballast will be of square mesh and shall not be less than 100 cm in length, 70cm in breath and 10cm in height on sides. The test sieves used for sieve analysis shall conform to the specification given in (Annexure IV) of IS/RDSO-GE/0001: 2023, February, 2023

(2) While carrying out sieve analysis the screen shall not kept inclined, but held horizontally and shaken vigorously. The piece of ballast retained on the screen shall not be pushed through the screen openings.

(3) The percentage passing through or retained on the sieve shall be weight only.

(4) Least count of weighing machine should not be more than 100gms.

806 CONDITIONS FOR SUBMISSION OF TENDER

(1) Each tenderer at the time of tendering shall submit the test report of Impact value, Abrasion value, Water Absorption Value from approved Laboratories and the list of these laboratories shall be mentioned in the tender documents.

(2) The tenderer shall also furnish an undertaking incorporated in the tender document that the ballast supply at all times will conform to Specifications for Track Ballast as specified by Railway.

(3) Tenderer/Contractor shall visit the area thoroughly and get himself acquainted with the topography, roads, availability of transport, raw material, climatic conditions etc. All factors affecting the market rates of labour, materials, laws, rules and regulations of State/Central Governments in respect of mines, minerals, forest and other departments, Specification and special conditions of the contract, and General Conditions Contract and other possibilities / aspects should be considered before quoting the rates. He should also note and confirm himself the availability of stone ballast confirming to railway specification for supply under this tender.

(4) Contractor will, at his own expense obtain requisite permits/licenses/ parwana for quarrying or for any other purpose as may be necessary to enable him to perform his part of the contract. Railway will not under any circumstances be liable to obtain any permit /licenses/ parwana whatsoever.

(5) Contractor shall be responsible to follow the provisions of Mining Act and other relevant acts and the Railway will not be responsible for infringement of any of their provisions.

(6) The contractor will ensure free access to quarry premises where stone is being quarried and

crushed, to the Engineer–in-charge or his representative at all times.

(7) In no case and under no circumstances, crossing of track by vehicles shall be allowed at unauthorized locations and contractor is solely responsible for all the consequences if he indulges into such unauthorized acts.

(8) For movement of vehicles along the side of track or across, Contractor shall arrange necessary protection including watchman, protective measures and infringement to running trains shall entail heavy penalty on the contractor at the discretion of the Railway.

807 COLLECTION AND TRAINING OUT OF BALLAST

The collection and training out of ballast can be done by either of the following methods:

a) By collection at ballast depots and training them out in ballast trains.

b) By collection of ballast along the cess and putting the same in the track directly.

The mode of collection will have to be decided taking into account proximity of quarry, availability of good stone ballast, service roads alongside the railway line for carriage of ballast, the availability of ballast train, the turnaround of ballast train, and the availability of traffic block for unloading. However, in general, the ballast quantity on cess should be so procured that a compacted ballast bed of 150 – 200mm in depth and 3-5m in width is achieved before laying the track and deploying departmental trains/machines like ballast rake, tamping machines etc. This gives better track stability for receiving these trains/machines as well as the required minimum ballast cushion for working of tamping machines.

Whatever is the mode of collection (depot or on cess) of ballast, stacking shall be done on a neat, plain and firm ground with good drainage in Railway land only. Care should be taken that the ballast does not get inundated or submerged in water during monsoon, if the stacks are to be continued during monsoon period.

The site for stacking the ballast is to be developed by Contractor with his own labour at locations as specified by the Engineer in charge or his supervisors by making approach roads, leveling, dressing of uneven and undulating ground and drainage arrangement, cleaning the plots off the rubbles/weeds, grass, organic matter, bushes, etc., at contractor's own cost

(1) Collection at ballast depots

At all ballast depots, the following procedure should normally be followed:

(a) The space along the sides of the Railway siding meant for stacking should be divided into convenient number of sub-depots in case training out capacity more than 50,000 cum. Separate contracts may be awarded for each sub-depot. These sub-depots may be physically separated from each other. Each sub-depot shall be further divided into zones for the purpose of segregation of stacking and loading areas. Zones may be further divided into plots. Approval of Dy CE/C shall be obtained for the depot diagram which are indicating the zones.

(b) For each depot, diagram should be maintained, which should indicate the site details of all the measured stacks.

(c) Each stack in each plot or zone should be serially numbered. In each plot there should only be one stack.

(d) The operations of collecting and training out materials should not be carried out at the

same time in any zone. The ground on which the stack are made should be selected and leveled.

(e) Measurements should be taken of complete stacks. The measured stacks should be identified suitably by lime sprinkling or any other method.

(f) The details of the measured ballast stacks shall be entered in a stack measurement or ballast passing register, which should have columns for measurement as well as test check by AXEN/XEN(C) and Dy CE(C). The register should have machine numbered pages similar to measurement Book.

(g) As soon as each stack is lifted, this should be recorded on the depot diagram which should always be kept up to date. Challans should be prepared after loading the ballast into wagons.

(h) There should be a buffer of at least one zone between zone of collection and training out for segregation of collection and training simultaneously.

(2) Collection of ballast along the cess

a) In case of collection of ballast alongside the cess, the Inspector in charge should maintain a separate register showing the measurement of stacks as well as its disposition (between KM to KM). The Stacks should be serially numbered between the successive posts. An entry should be made in register whenever the stacks are removed and ballast put into the track, record should show the place where the removed ballast has been used as well as the date of removal of the ballast.

b) The stacking area should be level, firm with good drainage. The plot for the ballast stacks should be selected by SE/JE in-charge and approved by AXEN/XEN(C) and should be level ground and at such locations where lifting and leading of the ballast into the track requires minimum effort.

c) The quantity of ballast required in a TP (Telegraph post or hectometer post) length should be as per the requirement in that length to avoid unnecessary lead for training out.

d) There should generally be a buffer of at least one km between the location of collection and training out of ballast in case both are to be done simultaneously. Specific approval of Dy. CE/C shall be taken for any deviation to this.

(3) Training out of Ballast

a) The commencement of training out of ballast or loading into hoppers should start at least 7 days after the date of measurement/test check of ballast by AXEN/XEN(C). Dy.CE/C should carry out his test check during this period of 7 days. In case Dy. CE/C does not intend to carry out his prescribed test check for the particular measurement, he should record the same in Measurement book (MB) and permit the training out of the ballast after passing the bill.

b) Supply of ballast on a plot shall start only after certification by AXEN/XEN (C) in the ballast passing register that the all the ballast supplied earlier in the plot has been trained out.

c) There should be Ground Balance register containing the quantity of ballast in each plot. After subsequent training out of ballast from a plot, the successive reducing balances should be reflected date-wise. For the quantities loaded, the reference of challan No. should be shown. Next stacking should be done in the plot only after Ground Balance

reduces to zero and after certification by AXEN/XEN(C) as per sub-para (b) above.

808 MEASUREMENT

(1) Stack Measurement:

The height of stack shall not be less than 1 m except hilly areas where it may be 0.50 m and the height shall not be more than 2.0 m. Top width of stack shall not be less than1.0m. Top of stack shall be kept parallel to the ground plane. The side slope of stack should not be flatter than 1.5:1 (Horizontal: Vertical). Cubical content of each stack shall normally be not less than 30 cum in plain areas and 15 cum in hilly areas.

Note: Refer Check list 812E

(2) Wagon Measurement:

In case of ballast taken by directly into wagons, a continuous white line should be painted inside the wagon to indicate the level to which ballast should be loaded. The cubical content in cubic metre corresponding to white line should also be painted on both sides outside the wagon.

In addition to painted line, mentioned in above paragraph, short pieces of flats (cut pieces of tie bars or otherwise) with cubical contents punched shall be welded at the centre of all the four sides as permanent reference (Refer para 4.2.2 of IS/RDSO-GE/0001: 2023, February, 2023). In case the supply is taken in general service wagon, actual measurements shall be taken.

Note: refer Check List 812F

(3) Shrinkage Allowance:

Payment shall be made for the gross measurement either in stack or in wagon without any deduction of shrinkage / voids. However, when ballast supply is made in wagons, shrinkage up to 8% shall be permitted at destination while verifying the booked quantity by the consignee as per IS/RDSO-GE/0001: 2023, February, 2023.

(4) Sampling and Testing:

(a) General

(i) The sample shall be drawn with due diligence and adequate precautions so that they represent the true nature and condition of the ballast.

(ii) Being a heterogeneous material, the gradation of ballast loaded in wagon and /or dumped/ inserted in the track may not remain same as that initially checked in stacks due to lifting, loading, transportation, unloading etc. Similarly, in case of direct loading in wagon, the gradation of ballast at destination may not remain same as that at source, due to loading, transportation etc. Therefore, the sample from wagon and track are not representative samples as far as gradation is concerned. Even in the same track, results of two checks may not be same.

(iii) The samples from a stack taken after lapse of a long period of stacking are not representative samples of the ballast supplied in the stack, due to settling down of smaller size of particles in voids underneath, dirt/dust getting accumulated in the stack, rains etc.

809 SAMPLING FREQUENCY

In order to ensure supply of uniform quality of ballast, the following norms shall be followed in respect of sampling testing and acceptance-

(1) On supply of the first 100cum, the tests for Size & Gradation, Abrasion Value, Impact Value, and Water Absorption (if prescribed) shall be carried out by Railway. Further supply shall be accepted only after this ballast satisfies the specification for these tests. Railway reserve the right to terminate the contract as per GCC at this stage itself in case the ballast supply fails to confirm with any of these specifications.

(2) Subsequent tests shall be carried out as follows: -

SN	Test	Supply in Stacks	Supply in Wagons
a	Size & Gradation	One for each 100 cum or part thereof in any stack	One for each 100 cum or part thereof for quantity to be loaded in wagons.
b	Abrasion Value, Impact Value, & Water Absorption Value (*)	One test for every 2000 cum	

(*) These tests shall be done for the purpose of monitoring quality during supply. In case of the test results not being as per the prescribed specification at any stage, further supplies shall be suspended till suitable corrective action is taken and supplies ensured as per specifications.

Note-

a) The above tests may be carried out more frequently if warranted at the discretion of Railway.

b) All tests for Abrasion Value, Impact Value and Water Absorption should be got done through approved laboratories or Railway's own laboratories (list of these laboratories shall be mentioned in the tender document). These tests, subsequent to award of contract, shall be done at Railway's cost.

810 SUPPLY OF BALLAST IN STACKS

(1) Sampling Procedure

(a) At the time of stacks formation, sufficient care should be taken to ensure that there is sufficient space around the stack to facilitate movement of JCB/Power Equipment. The length and width of each stack shall be kept in such a way that every part of the stack is accessible to the JCB or Power Equipment, to be deployed for drawing "Samples".

(b) In case of ballast supply in stacks, three "Samples" each of 0.3 - 0.5 cum volume, one sample each from two sides and one sample from top after removing outer layer (150-200 mm) should be collected from stack for every 100 cum or part thereof, by JCB or other suitable Power Equipment.

(c) The location (in plan) and depths of sampling points shall be varied for different "Samples" and different stacks in a lot.

(d) Gross "Sample" should be prepared by thoroughly mixing the three "Samples" collected as in (b) above, using JCB bucket or any other suitable Power Equipment, on a clean, flat and hard surface.

(e) Note: In exceptional cases of site-specific constraints, approval of Competent Authority

(Engineer-in-charge) shall be taken prior to invitation of tender, for using manual means for collection and mixing of "Samples" and this should be incorporated in the Tender Document.

(f) A "Test Sample" of volume 0.027 cum shall be drawn from each of the "Gross sample, by the method described under item (f) below for carrying out Size and Gradation tests.

(g) Method of drawing "Test Samples"- The ballast in "Gross Sample" shall be scooped into a cone shaped pile by taking care to drop each scoop full exactly over the same spot. After the cone is formed, it shall be flattened by pressing the top of the cone with a smooth surface. Then it is cut into quarters by two lines which intersect at right angles at the centre of the cone. The bulk of the samples is reduced by rejecting any two diagonally opposite quarters. The remaining ballast shall be mixed and "test sample" shall be drawn for testing. After drawing "test samples", the left-over ballast of "Gross Samples" shall be dumped back in the stack.

(h) In case clean, flat and hard surface is not available then a tarpaulin or any other suitable sheet may be used on a flat surface for mixing, drawing and sieve analysis of samples.

(i) In case of stacks of volume more than 100 cum, more than one "Test Samples" will be tested for size and gradation. In such cases the sieve analysis results of all the" Test Samples" shall individually conform to following gradation, for acceptance/rejection of the whole stack:

(i) Retention on 20mm Sq. Mesh Sieve shall not be less than 98% for machine crushed ballast (not less than 95% for hand broken ballast).

(ii) Retention on 40mm Sq. Mesh Sieve shall be between 40 to 70% (with reduced payment, as per para 804, for retention more than 60%).

(iii) Retention on 65mm Sq. Mesh Sieve shall not be more than 10% (with reduced payment, as per para 804, for retention more than 5%).

The full payment/reduced payment for the whole stack, as given in Para 804(6), shall be decided based on the average of the sieve analysis results of all the "Test Samples" for a stack.

811 SUPPLY OF BALLAST IN HEAPS FOR LOADING DIRECTLY IN WAGONS

(1) Sampling Procedure

(a) Samples of ballast shall be collected from heaps of ballast proposed to be loaded in to the wagons. For this, the contractor shall inform AXEN in-charge in writing sufficiently in advance before placement of rake, about the location of ballast heaps from where it is to be loaded into wagons. AXEN in-charge shall decide the location of heaps from which sampling is to be done, judiciously covering the entire quantity of ballast to be loaded in the rake.

Type of Tests	Supply of stacks	Supply in Wagons	Size of Test sample
Size and Gradation Test	One for each 100 cum or part thereof, in any stack	One for each 100 cum or part thereof for quantity to be loaded in wagons	0.027 cum for every 100 cum or part, thereof

Abrasive Value, Impact Value and Water Absorption Value	One Test for every 2000 cum	(Based on IS:2386 Part-III & IV of 1963)

The above tests may be carried out more frequently if warranted at the discretion of Railway.

(b) Based on the approx. quantity of ballast to be loaded in the rake, methodology for sampling of ballast to be followed shall be the same as in Para- 810 above.

Note: Refer Check List 812D for Ballast Sampling and 812G for Good practices.

812 CHECK LISTS FOR BALLAST SUPPLY

812A. Check List for General Requirements of Ballast

SN	Item to be Checked	Remarks
1	Whether ballast is hard, durable and free from weathered portions of parent rock	Yes/No
2	Whether ballast is free from organic and inorganic residue	Yes/No
3	Whether ballast is not flaky or elongated	Yes/No
4	Whether ballast is machine crushed	Yes/No
5	If hand broken, approval of CTE or CAO(C) has been taken before inviting tender and incorporated in tender document	Yes/No

812B. Check List for Physical Properties of Ballast

SN	Item to be Checked	Remarks
1	Whether the abrasion value of ballast is not more than 30%*	Yes/No
2	Whether the Impact Value of ballast is not more than 20%*	Yes/No
3	Whether Water absorption value is not more than 1%*	Yes/No
4	Whether test done from nominated lab available in Tender document	Yes/No

Note: * For relaxation in accordance with para 804, approval of CAO/C for Construction and CTE for open line is required.

812C. Check list for Size and Gradation of Ballast

SN	Item to be Checked	Remarks
1	Whether Retention on 65 mm sieve is within 5%**	Yes/No
2	Whether reduction in payment done for retention between 5% to 10% on 65 mm sieve	Yes/No
3	If retention on 65mm sieve is more than 10%, stack is rejected.	Yes/No
4	Whether retention on 40mm sieve is between 40% to 60%	Yes/No
5	Whether reduced payment processed for whole stack for retention* up to 70% **in accordance with para 804	Yes/No
6	Whether retention on 40mm sieve is more than 70%, stack is rejected	Yes/No

7	Whether retention on 40mm sieve is less than 40%, stack is rejected	Yes/No
8	Whether retention on 20mm sieve is less than 98% for machine crushed and 95% for hand crushed ballast, stack is rejected	Yes/No

Note: * Greater than 60% and

** 40 mm sieve

812D. Check List for Ballast Sampling

SN	Item to be Checked	Remarks
1	Whether sample collected and mixed by power equipment	Yes/No
2	Whether sampling done as per procedure given in para 810 above	Yes/No
3	Whether sample taken by box of size 0.3 x 0.3 x 0.3 m (0.027cum)	Yes/No
4	Whether separate sampling done immediately on change in the quarry for ensuring quality of ballast	Yes/No

812E Check List for Stack Measurement

SN	Item to be checked	Remarks
1	Whether location for stacks, its diagram etc. is approved by Dy. CE/C or as described in tender document	Yes/No
2	Whether certificate of levelness given by AXEN/XEN (C)	Yes/No
3	Whether plots are on neat and firm ground	Yes/No
4	Whether height of stack is as per specification	Yes/No
5	Whether top width, side slope and cubical content of stack are as per specifications	Yes/No
6	Whether ballast register is maintained and signed jointly by contractor and Engineer's representative	Yes/No
7	Whether measurement is done by nominated Supervisor and 100% test checked by AXEN/XEN (C)	Yes/No
8	Whether length, width and height is measured at least at four places and average done.	Yes/No
9	Whether lime is sprinkled along the edges on measured stack	Yes/No

812F. Check List for Wagon Measurement

SN	Item to be checked	Remarks
1	Whether continuous white line is painted at predetermined level	Yes/No
2	Whether cubical content of wagon is painted	Yes/No
3	Whether wagon/hopper is loaded up to the predetermined/marked level	Yes/No
4	Whether wagon/hopper is completely empty	Yes/No

812G. Check list for Good Practices (Vigilance Suggestions)

SN	Item to be checked	Remarks
1	Whether Unique transit pass or material memo is submitted by the supplier	Yes/No
2	Whether Permission for training out of ballast is given only after passing the bill	Yes/No
3	Whether sieve analysis is recorded in MB while recording measurement	Yes/No
4	Whether the information about the measurement of ballast is conveyed to Vigilance immediately by AXEN/XEN immediately after the test check	Yes/No

***

CHAPTER 9
PLANNING OF BRIDGES

901 INTRODUCTION

A bridge is a structure built to span physical obstructions without closing the way underneath, e.g., body of water, valley, road, etc. for the purpose of providing passage over the obstacle. There are various designs of bridges with each serving a particular purpose and suitable to given situation. There is no single solution for deciding type of bridge and designs of bridges vary depending on the function of the bridge, the nature of the terrain and it's hydrological & geotechnical characteristics, location of the bridge, proposed material of construction, aesthetics required etc.

902 MINOR, MAJOR AND IMPORTANT RAILWAY BRIDGES (Ref. IRBM Para 1103.3)

(1) IMPORTANT RAILWAY BRIDGES

Important bridges are those having a linear waterway of 300 metres or a total waterway of 1000 Sqm or more and those classified as important by the Chief Engineer / Chief Bridge Engineer, depending on considerations such as depth of waterway, extent of river training works and maintenance problems.

(2) MAJOR RAILWAY BRIDGES

A major bridge is one which has a total water way of 18 linear metres or more or which has a clear opening of 12 linear metres or more in any one span.

(3) MINOR RAILWAY BRIDGES

Bridges which do not fall in these classifications are termed as minor bridges.

903 BRIDGE PLANNING

(1) Bridge structures are essential component of any Railway network. Planning of bridge is an important activity and needs to be carried out carefully. Guidelines for this are available in various codes, manuals and instructions etc., so that, planning is done properly and decisions taken accordingly. Planning of Bridge project involves a chain of activities such as:

(a) Investigations and topographical survey,

(b) Survey of water bodies such as RAT, RAW and Rivers

(c) Plans and cross sections of Rivers

(d) Hydrological investigations

(e) Factors governing the choice of site

(f) Design discharge (Q)

(g) Design discharge for foundations (Qf)

(h) Design of waterways

(i) Vertical Clearance (C)

(j) Free board (F)

(k) Standard of substructure for new Railway lines

(l) Geotechnical investigations

(m) Choice of foundations for bridges

(n) Preparation of Design Basis Report (DBR)

(o) Preparation of drawings

(p) Quality Assurance Plan

904 INVESTIGATIONS AND SURVEY

(1) Investigation for Minor Bridges (Ref. IRBM Para 301)

(a) Minor bridges are generally provided on local drainage crossings, field channels and at canal crossings.

(b) Pipes are normally proposed where sufficient cushion below the sleeper is available.

(c) Where a skew crossing is unavoidable, it is advisable to restrict the skew to 30°.

(d) The investigation should cover the particulars of catchment area, the soil characteristics, and the anticipated flood level.

(e) Other relevant hydraulic particulars.

(2) Investigations for Major Bridges (Ref. IRBM Para 302)

The investigation is mostly confined to one particular site and should cover the following aspects:

(a) Topographical details.

(b) Catchment area with its characteristics from the Survey of India maps.

(c) Hydrological particulars such as low water level, high flood level, discharge data, flood velocity and surface slope from local gauging stations of irrigation and flood control departments and local enquiries.

(d) Geo-technical investigations to get the soil particulars as necessary for the design of foundations.

(e) Geology and Seismology of the area wherever necessary.

(f) Navigational requirements from concerned authorities to determine the clearance.

(g) Construction resources like labour, materials, accommodation, water and power, transport and communication infrastructure, etc.

(h) Important details of close by bridges across the same river or stream.

(3) Investigation for Important Bridges

(a) Investigation for important bridges may be carried out in following stages as stipulated in Railway Board's Letter No.2021/W-I/Genl./Gati Shakti dated.28.10.2022 **(Ref. 9.01)**, IRBM Para 303 may also be referred:

(i) Feasibility studies (includes Reconnaissance and Preliminary Engineering Survey)

(ii) Detailed survey and project report (Final Location Survey)

(b) After study of maps and a few visits to the possible sites and aerial reconnaissance as necessary, the investigation is mostly confined to one particular site, and should cover the aspects mentioned in para 904(2) above.

(c) In case of the meandering course in alluvial and quasi alluvial rivers and rivers having tortuous flows in submontane and mountainous regions, number of alternative sites may be available for locating a bridge. Investigations as detailed in above para (a) & (b) may be carried out for each one of the alternative sites.

905 GEOGRAPHICAL SURVEYS

(1) For planning of new bridges/extension of bridges, detailed geographical survey of site is required. The survey should cover the following features falling up 200 m on either side of bridge:

(a) Borrow pits.

(b) Rivers, streams, drains, sullage and sewer drains and their sizes with direction of flow.

(c) Pipelines with direction of flow.

(d) Temples, mosques, and graves.

(e) LC, ROB, FOB with Roads and footpaths with the names of towns or villages they lead to.

(f) Obligatory points such as Turnouts, electric crossings etc.

(g) Mining activity in the river bed, especially on the downstream side.

(2) The planning of bridges requires detailed analysis of data acquired during the various type of surveys. The purpose is to plan the bridge in such a way that it is suitable to the requirements and can be constructed most economically within the given site constraints. Therefore, each parameter requires the due deliberation.

906 SURVEYS OF RIVERS IN CONNECTION WITH THE LOCATION OF AN IMPORTANT BRIDGE (Ref. IRBM Para 305)

(1) The river should be surveyed for a distance of 8 Km upstream and 2 Km downstream of the location of the bridge, all spill-channels on the up-stream to be shown on the plan. These distances of 8 Km and 2 Km are to be taken as measured at right angles to the center line of the proposed Railway line and not along the course of the river.

(2) Cross section of the river bed should be taken at suitable points and positions marked on the plan. The level of the highest known flood and ordinary low water should be noted on each cross section. The average slope of the river bed is to be determined from a point about 2 Km upstream to a point 2 Km downstream of the Railway crossing. In case there are sharp changes in the bed slopes, the local bed slope should be determined over a shorter length.

(3) Reliable information of High Flood Levels (HFL) should be obtained and noted. This information is required for deciding the formation level.

(4) Should the diversion of river/ stream be considered desirable, the best method of doing so be examined, carry out the necessary surveys and the diversion shall be shown on the plan.

(5) Required protection works for following purposes shall be carefully considered and the position and the extent of such works surveyed and determined. High flood marks of the spill water should be carefully located and recorded on the plans and sections.

(a) to prevent encroachment by rivers

(b) to mitigate the effect of bursting of tanks

(c) scour in the vicinity of the railway line

(d) for proposed diversion etc.

(6) In case of the meandering rivers and rivers having tortuous flows, investigations as detailed in para 904 (3)(c) may be followed.

907 PLAN AND CROSS SECTION OF RIVERS

For all important bridges, plan and cross sections showing the following particulars should be furnished subject to the provision that the Engineer may exercise his discretion as to the necessity for these plans and sections in mountainous country **(Ref. IRBM Para 307)**.

(a) The plan should be drawn to a scale of 50 m : 1 cm of such portion of the river and its tributaries as may lie within a distance of about 2 Km from the proposed bridge site or such further distance as the Engineer may consider necessary. The direction of the flow should be indicated by arrows.

(b) Three cross sections for the river bed are required to be plotted to a natural scale of 5 m:1 cm. Where the width of the river in flood exceeds 1000 metres, the scale may be reduced. For river width greater than 500 metres, the cross section should be plotted in two halves. The cross sections should be taken at typical points selected at intervals of about 2 Km. On each cross section, the levels of the highest known flood, ordinary flood and ordinary low water should be indicated by lines with reduced levels. On the cross section taken on the centre line of railway, an elevation of the proposed bridge should be drawn to a scale in its proper position. The chainage should be indicated on the cross section. Where borings or trial pits have been made, their position, with a note on results should also be given.

908 HYDROLOGICAL INVESTIGATIONS

(1) Hydrological investigations to the extent necessary depending on the type and importance of the bridge shall be carried out. The following data should be collected (**Ref.** Para 4.1 & Appendix-I of IRS 'Code of practice for the design of sub-structures and foundations of bridges' and IRBM Para 306):

(a) Area of the catchment

(b) Shape of catchment (Oblong, fan etc.)

(c) Details of the course of the main stream and its tributaries

(d) Longitudinal slope of the main stream and average land slope of the catchment from the contours

(e) Nature of soil in the catchment (rocky, sandy, loamy or clay etc.)

(f) Extent of vegetation (forest, pasture, cultivated, barren, etc.). The details can be obtained from the following records:

(i) Survey of India Topographical sheets to a scale of 1:50,000.

(ii) Aerial photographs/Satellite imagery.

(iii) Aerial survey of the catchment may also be necessary for appropriate decision.

(g) Probable changes that may occur in the catchment characteristics assessed by enquiries from the right sources.

(h) Information from the rainfall records of local or nearby rain-gauges.

(i) Other climatic conditions (like temperature, humidity, snow accumulation etc.) assessed either from map issued by or from the India Meteorological Department.

(j) Changes in the course of the channel.

(k) The nature of the material through which the channel flows (whether it consists of boulder, gravel, sand, clay or alluvium). The description should be based also on actual bore hole particulars.

(l) Bank erosion and bed scour observed at the bridge site in the case of alluvial rivers and the nature of the material transported.

(m) The maximum observed scour depth in the vicinity of the proposed bridge crossing.

(n) Full description of bridges (as given below) existing both upstream and downstream from proposed crossing including relief and overflow structures.

  (i) Type of bridge including span lengths and pier orientation.

  (ii) Cross section near the structure, including vertical clearance from water level to soffit of super structures and direction of the current during floods.

  (iii) All available flood history- high water marks with dates of occurrence, nature of flooding, afflux observed, damages caused with sources of information.

  (iv) Photographs of existing bridges, past floods, main channels, and flood plains and information as to the nature of drift, stream bed and stability of banks.

(o) Factors affecting water stage at the proposed bridge site such as:

  (i) High flood levels of other streams joining.

  (ii) Particulars of reservoirs and tanks existing or proposed to be constructed and approximate date of construction.

  (iii) Flood control projects on the stream or other structures which affect the flow in the stream such as weirs, barrages, training works, spurs etc.

  (iv) Tides or back flow due to a confluence downstream.

  (v) Character of floods - whether steady, flashy or eddy forming, etc.

(2) A detailed map showing flood flowing patterns, location of proposed bridge, spill openings, if any and alignment of piers, should be prepared to a suitable scale. The map should indicate:

(a) Contours at 1m intervals, stream meander, vegetation, and man-made changes, if any.

(b) Three cross sections together with HFL, one on the centre line of the proposed bridge, one upstream and one downstream at 100 to 300m intervals.

(3) In the case of minor bridges, the scope of data collection may be reduced to above para 908(1) (a) to (h), (o) (i), (ii), (iii) and 908(2).

(4) Method Statement for Calculation of Catchment Properties using Geographic Information System as per guidelines given in RDSO Letter No. RBF/GIS dated.11.03.2022 **(Ref. 9.02)**.

909 FACTORS GOVERNING THE SELECTION OF A BRIDGE SITE

(1) The following factors should be considered in the selection of a bridge site (**Ref.** IRBM Para 308):

(a) The reach of the river, especially the upstream should be straight.

(b) The river in the reach should have a regime flow, free of whirls, eddies, and excess currents.

(c) The site should have a firm high bank that are fairly unerodable.

(d) In the case of a meandering river, the site should be located near a nodal point. A nodal point is defined as the location where the river regime does not normally shift and the location serves as a fulcrum about which the river channels swing laterally (both upstream and downstream).

(e) The site should have suitable strata at a reasonable and workable depth for founding piers and abutments.

(f) The bridge is normally located where the river section has minimum width and the bridge should be aligned normal to the river as far as possible.

(g) Wide Khadir for bridge location should be avoided. Location of bridge with respect to Khadir width should be carefully decided. If the bridge is located near one end of the Khadir width and the Khadir bank is non-erodible clay, one guide bund can be saved. However, longer length of approach at other end gets exposed and becomes vulnerable to river attack in this case. On the other hand, the central location of the bridge reduces length of approach open to river attack, minimizes obliquity of approach, but requires provision of two guide bunds.

(h) The bridge should not normally be located where frequent changes occur in the river course, tendency for aggradation or degradation is manifest and there is problem of bank erosion.

(i) The approach bank should be secure and not be liable to flash floods or major spills during floods.

(j) If the approach passes over braided channels which have connections with the main river upstream, there is possibility of dangerous situation where these channels get activated. If the spill is wide, the bank formed across will cause development of a parallel flow, which at times may become so large and swift as to cause erosion, bank slips or even breaches.

(k) The approach bank should not pass through a heavy hilly terrain or marshy land nor cut across a major drainage so as to avoid expensive construction works.

(l) Approach banks in the case of constricted bridges should avoid curvature.

910 SUB-SURFACE INVESTIGATION

(1) During sub-surface investigations, the following relevant information will be obtained (**Ref.** para 6.2.1.6 & 6.2.3 of IRS Code of practice for the design of sub-structures and foundations of bridges):

(a) Site plan – showing the location of foundations and abutments, etc.

(b) Cross sections – Cross Sections along the proposed bridge, indicating rail level, top of super-structure, High Flood Level (HFL), Low Water Level (LWL), founding levels etc.

(c) Load conditions – Load conditions shown on a schematic plan, indicating design combination of loads transmitted to the foundation.

(d) Environmental factors – Information relating to the geological history of the area, seismicity of the region, hydrological information, etc.

(e) Geotechnical information – Giving subsurface profile with stratification details, engineering properties of the founding strata, e.g., index properties, effective shear parameters, determined under appropriate drainage conditions, compressibility &, swelling characteristics, results of field tests, like static and dynamic penetration tests.

(f) Modulus of Elasticity and Modulus of Subgrade Reaction.

(g) A review of the performance of a similar structure, if any, in the locality.

(h) Information necessary to assess the possible effects of the new structure on the existing structures in the neighbourhood.

(2) Exploratory bore holes shall be driven by deep boring equipment and samples collected at every 1.5m or at change of strata, using special techniques of sampling. Often, in case of cohesion less soil, undisturbed samples cannot be taken and recourse must be made to in-situ field tests.

(3) Normally, the depth of boring will extend to 1.5 to 2 times the width of footing below foundation level. The first boring at each foundation shall extend to a depth sufficient to disclose deep problem layers. Soft strata shall be penetrated completely even when covered with a surface layer of higher bearing capacity. (**Ref.** para 6.2.3 of IRS 'Code of practice for the design of sub-structures and foundations of bridges')

(4) Chapter 10- Part C of this manual may be referred for further information.

911 SEISMIC SURVEYS

(1) When deciding the location of railway bridges, several seismic factors need to be considered to ensure their structural integrity and safety during seismic events. These may include- Seismic Hazard Assessment, Peak Ground Acceleration, Seismic Site Conditions, Fault Proximity and Liquefaction Potential.

(2) The general principles for seismic consideration are as follows (**Ref.** para 4.1 of IRS code for Earthquake resistant design of railway bridges):

(a) All components of the bridge, that is, superstructure, sub-structure, bearing, foundation and soil are susceptible to damage in the event of strong ground shaking. The earthquake resistant design shall consider the effect of earthquake motions on each component of the bridge following the provisions of Indian Railway Standard code for earthquake resistant design of railway bridges.

(b) The design shall ensure that seismic resistance of the bridge and its components are adequate to meet the specified design requirement so that emergency communication after an earthquake shall be maintained for the design basis earthquake.

(c) Masonry or plain cement concrete arches shall not be constructed in Zone V. Masonry or plain cement concrete arches shall not be constructed with spans exceeding 6m in Zone

IV and 10m in Zone Ill, Fig.1A Seismic Zone Map of India (IS: 1893 (Part-1): 2016).

(d) Box, pipe and slab culverts need not be designed for earthquake forces. Bridges of total length not more than 60 m and individual span not more than 15 m need not be designed for earthquake forces other than in Zones IV and V.

(e) Seismic forces on aqueduct structures and flyover bridges shall be calculated as for any other bridge. The effect of inertia force of flowing water mass in aqueduct shall be calculated on the basis of assumptions in (Para 6(e) of IRS 'Code for earthquake resistant design of railway bridges')

(f) Hydrodynamic pressure on walls of water trough in case of aqueduct shall be considered on the basis of provision of IS 1893 (Part 2).

(g) The liquefaction potential of foundation soil shall be investigated where necessary.

(h) When relative movement between two adjacent units of a bridge are designed to occur at a separation/expansion joint, sufficient clearance shall be provided between them, to permit the relative movement under design earthquake conditions to freely occur without inducing damage. Where the two units may be out of phase, the clearance to be provided may be estimated as the square root of the sum of squares of the calculated displacements of the two units under maximum elastic seismic forces.

(i) Special design studies shall be called for the following cases:

(i) Consideration of asynchronous ground motion when,

i. Geological discontinuities or marked topographical features are present; and

ii. Single span is greater than 600 m, even if there are no geological discontinuities.

(ii) In case of bridges over potentially active tectonic faults, the probable discontinuity of the ground displacement shall be estimated and accommodated either by adequate flexibility of the structure or by provision of suitable movement of joints.

(iii) Bridge located in near-field, that is, within 10 km near fault area of known active tectonic fault.

912 UTILITY SURVEY

(1) Most of the utilities, e.g., electric cables, telephone wires, optical fibers, gas pipe lines, oil pipe line, water pipe lines, sewers etc. are provided under ground. These underground utilities cause hindrance in works and need due care during execution for safety of both utilities and workmen.

(2) All utilities which infringe in execution of the work should be got shifted prior to work if possible. If it is not possible to shift some of the utilities, a detailed scheme for their protection or relocation should be prepared in consultation with owner of respective utilities and implemented at site for ensuring the safety.

(3) Utility survey is required to identify services at site. Besides site tell-tale/ markers, information may also be obtained from existing plans, registers, records etc. Cable layout plans for S&T and electrical shall be obtained from respective department.

(4) Damage to some utilities may lead only disruption of service to related facility e.g., telephone wires, optical fibre etc., whereas damage to other sensitive utilities may be catastrophic, e.g., gas or oil pipe line.

(5) Utilities identified during survey may be classified as-

(a) Utilities to be shifted and

(b) Utilities to be supported during construction

(6) Appropriate methods such as GPR (Ground Penetrating Redar), remote sensing, cable locator, trenching etc. may be done for locating underground utilities in the area.

913 OVERALL LENGTH OF BRIDGE

(1) SELECTION OF WATERWAY

The economy and safety of the bridge requires judicious selection of appropriate water way to be provided which in turn decides overall length of the bridge. As far as possible, bridges should be planned perpendicular to stream (especially for important bridges). Besides avoiding the skew designs, this helps in reducing overall length of the bridge also. For deciding the water way to be provided, following factors need to be considered:

(a) Discharge of the stream

(b) Type of terrain

(c) Bed material

(d) Water way of the bridges in upstream and down stream

(e) River training works in approaches.

(2) DESIGN DISCHARGE FOR WATERWAY (Q)

(a) The estimation of design discharge for waterway shall be based on-

(i) actual hydro-meteorological observations of the same or similar catchments

(ii) the computed flood with probable recurrence intervals of 50 years.

(b) The recurrence interval can be modified at the discretion of Chief Bridge Engineer based on the importance of the line. For further details reference may be made to para 4.2 and 4.3 of IRS 'Code of practice for the design of sub-structures and foundations of bridges.'

(3) DESIGN DISCHARGE FOR FOUNDATION (Qf)

To provide for an adequate margin of safety against any abnormal flood exceeding the design discharge (Q) the foundations, protection works and training works except free board, shall be designed for a higher flood discharge. This discharge shall be computed by Increasing the design discharge (Q) estimated according to para 4.4 of IRS 'Code of practice for the design of sub-structures and foundations of bridges.'

(4) DESIGN OF WATERWAYS

(a) In the case of a river which flows between stable high banks and which has the whole of the bank-to-bank width functioning actively in a flood of magnitude Q, the waterway provided shall be practically equal to the width of the water spread between the stable banks for such discharge. If, however, a river spills over its banks and the depth of spill is appreciable, the waterway shall be suitably increased beyond the bank-to-bank width in order to carry the spill discharge as well. The waterway shall be designed as per para 4.5 of IRS 'Code of practice for the design of sub-structures and foundations of bridges.'

(b) Minimum clear span of 1m should be provided in new bridges and rebuilding of bridges on existing lines. Minimum headroom of 1.2 m should be provided in new bridges

for proper inspection and maintenance. However, while constructing/rebuilding new bridges on existing lines, efforts should be made to provide minimum headroom of 1.2 m duly exploring the possibility of lowering of bed level etc. Principal Chief Engineer/ Chief Bridge Engineer may permit relaxation in minimum headroom provisions in cases where adoption of 1.2 m height results in heavy expenditure, heavy re-grading of track and difficulties in construction. (**Ref.** IRBM Para 311(3))

(5) VERTICAL CLEARANCE (C) (**Ref.** para 4.8 of IRS 'Code of practice for the design of sub-structures and foundations of bridges')

(a) The minimum clearance for bridges excluding arch bridges, syphons, pipe culverts and box culverts from the water level of design discharge (Q) including afflux shall be as under:

Discharge (Cumecs)	Vertical clearance (mm)
0-30	600
31-300	600-1200 (pro rata)
301-3000	1500
Above-3000	1800

(b) In the case of arch bridges, minimum clearance measured to the crown of the intrados of the arch shall be as under:

Span of arch	Clearance
Less than 4 m	Rise or 1200 mm. whichever is more.
4.0m to 7.0m	2/3 rise or 1500 mm whichever is more.
7.1m to 20.0m	2/3 rise or 1800 mm whichever is more
Above 20.0 m.	2/3 rise

(c) Syphons, pipe and box culverts are designed as pressure conduits therefore no clearance is considered necessary for these structures.

(d) While rebuilding bridges on existing line or building new bridges on these or new lines, the clearance stipulated above can be relaxed by Principal Chief Engineer/Chief Bridge Engineer as per para 4.8.3 to 4.8.5 of IRS 'Code of practice for the design of sub-structures and foundations of bridges.'

(6) FREE BOARD (F) (**Ref.** para 4.9 of IRS 'Code of practice for the design of sub structures and foundations of bridges')

(a) The free board from the water level of the design discharge (Q) to the formation level of the Railway embankment or the top of guide bund including afflux shall not be less than 1m. In cases where heavy wave action is expected, free board shall be increased suitably.

(b) In special circumstances, where the free-board can be safely reduced and where adoption of the prescribed values would result in heavy expenditure and / or serious difficulties in construction, the free-board may be relaxed at the discretion of the Principal Chief Engineer / Chief Bridge Engineer as indicated below after taking measures for safety as considered necessary by Principal Chief Engineer / Chief Bridge Engineer:

Discharge in (cumecs)	Vertical clearance (mm)
Less than 3	600
3 to 30	750
More than 30	No relaxation is permissible

(c) After taking measures for safety as considered necessary by Principal Chief Engineer / Chief Bridge Engineer, existing Free Board may be retained in following cases:

(i) Works other than rebuilding a bridge such as re-girdering, strengthening/ rehabilitation of substructure/ superstructure, replacement of bed blocks/bearings etc.

(ii) Extension of existing bridge for doubling/multi-tracking

(d) However, in case of syphon bridges the provision for free board as per para 6(a) above need not be considered where a spillway is provided on one bank of the channel at a suitable point upstream within or outside the Railway Boundary so that as and when the channel rises over the danger mark, the water from the channel will flow out. A small drain also has to be provided from the point of spillway to the nearest bridge to lead the water from the channel in case of overflow from the spillway.

(7) SPAN ARRANGEMENT

(a) The span arrangement and requisite waterway of these bridges are being decided based on hydrological parameters, economy in design, ease of construction etc. Selection of spans should be carefully planned to ensure that vertical profile is maintained to ensure smooth running of trains. Also, track centre to be generally maintained so that reverse curves are not introduced on the bridge approaches. This can be achieved by constructing foundation by adopting adequate safety measures and modern construction methods to enable safe train operation on the adjacent track. Adequate waterway is very important parameter in the design of new bridges, Railway Board's Letter No.2014/CE-III/BR/ Bridge Policy dated 21.04.2015 may be referred for detail **(Ref. 9.03)**.

(b) Following factors should be given due consideration while deciding span configuration:

(i) Height of bridge (bed level to formation level)

(ii) Nature of stream (perennial/ intermittent/ seasonal) and past history

(iii) Hydrological characteristics like topography, catchment area, run of coefficient etc.

(iv) Scour depth

(v) Type of foundation

(vi) Suitability of structure (Steel/ PSC/ RCC/ Composite etc.)

(vii) Superstructure Construction methodology (In-situ construction, cantilever construction, precast and launched etc.)

(viii) Availability of materials

(8) Following may be ensured to avoid excessive scour as stipulated in Railway Board's Letter No.2017/29/CEIII/BR/ Br. 588/ECoR dated 03.08.2017 **(Ref. 9.04)**.

(a) The piers of new bridge are in alignment of the piers of existing bridge. The span arrangement should be decided in such a way that there is free flow of water through spans of old bridge and there is no staggering of piers in water flow area.

(b) There should be adequate distance between new bridge and old bridge to ensure that there is no damage to existing bridge structure.

(9) In case of doubling, the track centre of second line may be reduced if founding strata is rocky or shallow foundation is provided on existing bridge. Provision of one additional short span on either side may avoid damage to the wing walls of existing bridge. The abutments in such cases are spill through type with elevated pile cap cum abutment having butter fly type wing walls.

(10) The decision on span length depends upon the ratio of the cost of substructure including the foundation to the cost of superstructure. Generally, it is most economical when this ratio is one (**Ref.** IRBM Para 316).

(11) In case of important bridges, due consideration to alternative launching schemes vs. site feasibility shall also be given.

(12) Techno-economic analysis shall be done to finalise the span configuration and material for construction, i.e., Steel/PSC. The economic evaluation of different alternatives of the bridge shall be carried out to determine its relative viability.

914 BRIDGE FOUNDATIONS

(1) Foundation is the lowest part of bridge structure which transfers all the loads falling over it to the ground. It distributes the loads over a large bearing area of soil/rock to provide stability of bridge against settlement and tilting.

(2) FACTORS AFFECTING ADOPTION OF PARTICULAR TYPE OF FOUNDATIONS

The selection of a particular type of foundation is based on a number of factors such as (**Ref.** BS: 127-R1):

(a) Adequate depth - The foundation must have an adequate depth to prevent undermining by scour.

(b) Bearing capacity failure- The foundation must be safe against a bearing capacity failure.

(c) Settlement- The foundation must not settle to such an extent that it damages the structure.

(d) Quality- The foundation must be of adequate quality from safety and durability point of view.

(e) Adequate strength- The foundation must be designed with sufficient strength that it does not fracture or break apart under the applied loads. The foundation must also be properly constructed in conformity with the design specifications.

(f) Adverse soil changes- The foundation must be able to resist long-term adverse soil changes. An example is expansive soil, which could expand or shrink causing movement of the foundation and damage to the structure.

(g) Seismic force- The foundation must be able to support the structure during an earthquake without excessive settlement or lateral movement.

Based on an analysis of all of the factors listed above, a specific type of foundation to be adopted subjected to techno-economic justification.

(3) SUITABILITY AND CHOICE OF FOUNDATIONS

Often the choice of the type of foundation is arrived at by the process of elimination, based on detailed analysis and relative economy studied before arriving at the final decision. The main criteria governing the choice of foundation for a structure comprise of (**Ref.** BS: 127-R1):

(a) Function of bridge

(b) Loads, the foundation will be required to support

(c) Subsoil condition

(d) Cost of the foundation in relation to the cost of the superstructure

(4) SELECTION OF FOUNDATIONS FOR BRIDGES

The following types of foundations are normally provided for railway bridges, depending on the site conditions (**Ref.** IRBM Para 316):

(a) Shallow Foundations

  (i) Isolated Open foundations

  (ii) Raft Foundation

  (iii) Open foundation for bridges like pipe and box culverts

(b) Deep Foundations

  (i) Pile foundations.

  (ii) Well Foundations.

  Preferably open foundation shall be planned. If Open Foundation is not technically suitable, other type of foundation shall be planned, in later case approval of SAG officer / CBE shall be obtained, such decision should be based on comparative analysis and techno-economic consideration (**Ref.** 9.03). Chapter 10-part C of this manual and RDSO report no. BS-127 R1 (Guidelines on Type of Foundations for Railway Bridges) may be followed for deciding the type of foundation.

(5) OPEN FOUNDATION

(a) Open foundation is suitable for bridges where rock or firm subsoil is available at shallow depth and there is not much scour and flowing water in the stream (**Ref.** IRBM Para 316). Open foundations must rest on a stratum with adequate bearing capacity. In order to reduce the bearing pressure, the base can be sufficiently widened by providing footings. The footings will rest on a lean concrete bed of adequate thickness. The foundation should be taken to a depth not less than 1.75 meters below the lowest anticipated scoured bed level/original ground level in ordinary soil (**Ref.** IRBM Para 403 & BS Report 127R1)).

(b) In rocky soil, it will be adequate if it is properly keyed into the rock for a minimum of 0.3 m in case of hard rock and 1.5 m in case of soft rock subject to the Codal provisions. Sloping rock may be suitably benched. Fissures and weathered rocks should be avoided (**Ref.** BS: 127-R1).

(c) Isolated open foundations are generally adopted where the Safe Bearing Capacity (SBC) is 150 KN/m2 or more at shallow depths. However, if subsoil is porous and water table is high this type of foundation would be generally feasible only up to 3 m to 4 m below the bed (**Ref.** IRC SP:82-2008).

(d) Raft foundations is adopted when good founding strata is not available within reasonable depth or Safe Bearing Capacity (SBC) of top stratum is generally less than 100 KN/m2. Rafts should be protected by means of suitable aprons and cut off walls or launching aprons, both on the upstream and downstream sides to prevent undermining of the foundations (**Ref.** IRBM Para 403).

(6) DEEP FOUNDATIONS

(a) Deep foundations become necessary when rock level is not available up to a depth of say 6 m or there is availability of substantial depth of water and large scour depth (Ref. IRC SP:82-2008). For river bridges where discharge is high, i.e., more scouring of bed is expected and load on the sub-structure is too high to be carried by top soil layers, in such cases, execution of open foundation and the bed protection works become difficult and it is advisable to adopt deep foundation.

(i) Cast-in-situ piles can be constructed of any desired length. The length of driven piles normally does not exceed 25 to 30 m depending on the capacity of driving equipment (**Ref.** IRBM Para 408 (4)).

(ii) For more depths, well foundation should be adopted. In case of lesser depths (say less than 20 m), techno-economic analysis should be done for adopting pile/ well foundation.

(b) Well foundation

(i) Well foundation is one of the most popular types of deep foundations in India, due to various reasons like simplicity, requirements of very little equipment for execution and adaptability to different subsoil conditions/ difficult site conditions like deep standing water and availability of good founding strata at large depths etc. (**Ref.** IRC SP: 82-2008)

(ii) Well foundation provides a solid and massive foundation for heavy loads and large horizontal forces. This has a larger cross-sectional area and hence the total foundation bearing capacity is much larger than what may be offered by a cluster of piles. The well provides a very good grip when taken sufficiently deep and hence is most suited for river beds subjected to heavy scour.

(iii) However, a well foundation should not be constructed in close vicinity to existing structures as construction of well foundation may affect the existing foundation.

(iv) The selection of type & shape of well foundation depends upon the soil type, the size and shape of pier or abutment, depth of foundation and available construction material. Where major obstructions such as uneven rocky strata are likely to be encountered, provision for pneumatic sinking may be made. Small obstructions can be removed either with the help of divers or by chiseling.

(v) Shape and Cross-Section of Wells can be decided based on dredging requirement, steining thickness, size of the base of substructure, obstruction to the flow of water and the overall size should be sufficient to transmit the loads safely to the soil without exceeding its allowable bearing pressure.

(vi) To cover for the risk of inclined rock bed and unforeseen situations, suitable provisions shall be made in the contract document.

(c) Pile foundation

(i) A pile is a vertical structural element of a deep foundation, driven or drilled deep into the ground. Broadly, piles transfer axial loads either substantially by friction along its shaft and/or by end bearing. Piles are used where either of the above load transfer mechanism is possible depending upon the sub-soil stratification at a particular site, IRC: 78 may be referred for detailed information with regard to various types of pile foundations and their suitability. (**Ref.** IRC SP:82-2008)

(ii) Pile foundation can be quite economical, particularly where the foundations have to be built very deep or taken through deep layers of soil subjected to little scour. Larger diameter piles can be provided to take care of large horizontal forces when the foundations are deep. Larger diameter piles can also be provided for foundation depths beyond the limit of pneumatic operations.

(iii) Piles should also be considered where right-of-way or other space limitations do not allow the use of spread footings, or where existing soil is contaminated by hazardous materials and removal for construction of shallow foundations is not desirable.

(iv) Piles should also be considered where an unacceptable amount of settlement of spread footings may occur.

(7) DISTANCE BETWEEN DEEP FOUNDATIONS

(a) The distance between the deep foundations should be decided based on detailed technical studies. In case, detailed technical study is not carried out, the following guidelines may be followed while finalizing the distance between the well foundations as stipulated in RDSO Letter No. CBS/DWF dated 15.07.2019 **(Ref.9.05)**.

(i) It is a good practice to propose the piers of new bridge in the same alignment as that of the piers of the existing bridge.

(ii) The desirable minimum clear distance between the existing and new foundations from the consideration of interaction of scour regions is 6D (where D is diameter of well).

(iii) There should be no interference in the pressure bulb zone of foundations of existing and proposed bridge.

(iv) There should be no reduction in passive earth pressure due to excavation of new foundation in close vicinity of the existing foundation.

(v) Sufficient space is required for easy operation of machinery and equipment for construction of proposed bridge to avoid any chance of interference to the train movement on the existing bridge.

(vi) Effect of extra load of excavated material, machinery, equipment etc. on the surrounding soil mass and foundation of existing bridge.

(b) Only after detailed investigations, CBE may decide whether reduction in distance between the existing and new foundations from the prescribed distance as per above guidelines is warranted. Accordingly, CBE may finally decide the distance between the deep foundations keeping in view the above guidelines and site-specific requirements.

915 SUBSTRUCTURES

(1) Substructure type and location shall be decided on techno-economical and ease of construction. Chapter 10-part C of this manual and IRS Code of practice for the design of sub-structures and foundations of bridges, shall be referred for further information.

(2) STANDARD OF SUBSTRUCTURE FOR NEW RAILWAY LINES (**Ref.** IRBM Para 314)

(a) For bridges built on new lines involving either spans of 24.4 m. and above or waterways of 304.8m.and above, or well foundations, a decision should be taken whether the substructures should be built:

(i) In the case of Meter Gauge bridge to suit broad gauge loading, or

(ii) In the case of Broad-Gauge single line bridge to allow for future doubling.

(b) In the survey report, the additional cost of building the substructures as stated above should be furnished.

(c) In case of multi-tracking works, dimension of pier across the track alignment increases substantially; decision to adopt single pier or pier with multiple columns will be taken with due consideration of type of foundation.

(3) RAIL STRUCTURE INTERACTION

(a) All the new bridges shall be designed to carry LWR/CWR track and for this Rail Structure Interaction (RSI) study shall be done as per clause 2.8.2.4.3 of Bridge Rules. The clause 2.8.2.4.3 of Bridge Rules refers to UIC 774-3R for carrying out RSI till the forces due to continuation of LWR/CWR on bridges in Indian conditions are finalized. BS: 114 version-2 explains methodology to be adopted to use UIC 774-3R for Indian Railways specific scenario. This should be done at initial design stage itself.

(b) The Rail Structure Interaction (RSI) is the interplay of stiffnesses of different components namely track, girders, bearings, sub-structure and foundations. Due to RSI extra stresses in the rail are induced by thermal expansion/ contraction of bridge deck(s)/ tracks, deflection of sub-structure under tractive/ braking forces from the trains and the end rotations caused by vertical bending under vertical train loads.

The RSI is nonlinear and its analysis can be done by an iterative procedure to get a solution that satisfies all boundary conditions. There can be no formula to be directly used to determine the stresses or deformations.

(c) Parameters affecting RSI

(i) Expansion Length

(ii) Span Length

(iii) Bending Stiffness of Deck

(iv) Deck Height & Rotation Distance

(v) Support Stiffness

(vi) Design Track Stiffness (**Ref.** clause 2.8.2.4.3 (d) of Bridge Rules)

(vii) Sectional Properties of Rails

(viii) Temperature variations

(d) Parameters to be verified during RSI studies- The RSI studies shall be carried out as per BS114 version-2 and the following parameters shall be verified:

(i) Additional Stresses in Rails shall be within limit as specified in IR Bridge Rule (**Ref.** clause 2.8.2.4.3 (b) of Bridge Rules).

(ii) Displacements of Bridge Elements shall be such that the following checks on rotation/ deflection specified in UIC-774-3R are satisfied (**Ref.** clause 2.8.2.4.3 (c) of Bridge Rules):

i. Absolute Longitudinal displacement of deck due to tractive effort/ breaking force shall not exceed

- 5 mm in case CWR runs through one or both ends of the bridge, or
- 30 mm in case of bridge with jointed track/ expansion devices.

ii. Longitudinal displacement of deck due to rotation of deck due to vertical load shall not exceed 8 mm.

iii. Relative displacement between rail and deck or between rail and embankment due to tractive effort/ breaking force shall not exceed 4 mm.

(e) Controlling RSI effects- In certain cases, deflection of the substructure and longitudinal displacement of bearing may require to be controlled from RSI point of view. RSI effects can be controlled by adopting any of the following measures individually or in combination. The decision in this regard shall be taken on techno-economic considerations, which shall be a joint decision of track and viaduct design engineers. If required special arrangement as mention in para 917 of this manual may also be considered.

(i) The RSI effects can be controlled by redesigning the bridge elements to make the girder or substructure stiffer. However, if this is not required from other structural reasons, making structure stiffer only for RSI effects might be uneconomical.

(ii) Modification of bearing arrangement- If additional rail stresses due to RSI exceed the limits options like changing the expansion length, relocating the fixed bearing in case of continuous spans, changing the bearing type, their stiffnesses and their locations etc. helps in controlling bridge deflections as well as track stresses.

(iii) Providing switch expansion joint (SEJ)- If LWR is allowed to move, it will reduce stresses in rails. This may be a possible solution in locations with longer spans/ taller piers where the rail-stresses are beyond permissible limits. Due to the SEJ(s), the horizontal deck forces are not transferred to approaches but to the fixed bearings, alleviating the effects on the rail. These provide relief in the desired stiffness of the sub-structure, as the allowable movement of decks for locations where SEJ is provided is 30 mm as against 5 mm where LWR/CWR is continued through. The decision of providing SEJ in track shall be approved by Principal Chief Engineer of the zonal railway as per clause 2.8.2.4.4 of Bridge Rules.

916 BRIDGE SUPERSTRUCTURES

(1) It is preferable to adopt RDSO standard span; if unavoidable non-standard span (with due justification and approval from CAO(C)/PCE) may be used. The following types of superstructures (Table 9.01) are normally provided for Railway Bridges, depending on the site conditions:

(a) RCC Box- (RB Letter No.2015/CE-III/BR/Structure Code dt 19.01.2022 **(Ref. 9.06)**)

(i) RCC boxes shall not be constructed for major bridges on new lines/gauge conversion/ doubling works. In exceptional cases on feasibility consideration (like insufficient vertical clearance, restricted land availability, to avoid damage to existing wing wall etc.), RCC box may be constructed for major bridges with adequate cushion (on replaceability consideration to accommodate suitable temporary girder) duly considering the strata underneath the bridge with approval of CAO(C)/CBE on case-to-case basis.

(ii) RCC boxes may be constructed for minor bridges on new lines/gauge conversion/ doubling works up to a span of 3 m with provision of adequate cushion (on replaceability consideration to accommodate suitable temporary girder) duly considering the strata underneath the bridge with approval of CE(C). In case it is not found feasible to provide desired cushion and/or RCC box of span more than 3 m is to be provided, approval of CAO(C)/CBE shall be taken.

(iii) Use of multiple RCC boxes shall not be permitted. However, standard RDSO design/ specially designed multi-cell RCC boxes may be permitted on feasibility consideration with approval of CAO(C)/CBE.

(v) Segmental RCC boxes for construction of railway bridges (carrying waterway) shall not be generally permitted. However, in exceptional cases on feasibility consideration, segmental RCC boxes may be permitted for railway bridges with approval of CBE. Adequate precautions shall be taken to ensure that there is no seepage through joints.

(vi) For construction of RUB/LHS, RCC boxes may be provided. Use of segmental RCC boxes may also be permitted with approval of the CBE.

(vii) For building/rebuilding of bridges on existing lines, efforts should be made to provide girder/slab bridges as far as possible and RCC boxes shall be provided only as last resort with approval of CBE.

(viii) In all cases where RCC boxes have been constructed or planned to be constructed, properly designed protection works such as drop wall, curtain wall, flooring etc. duly considering the scour criteria and approved by CBE or CE/C shall be provided, IRBM para 204 Annexure 204 and 818 may also be referred. The provisions shall also be incorporated in the GAD and approved by competent authority.

(ix) Only standard RDSO design RCC boxes shall be constructed at all locations. In exceptional cases where it is not feasible to adopt RDSO designs, specially designed RCC boxes may be constructed with the approval of PCE or CAO/C. It shall be ensured that provisions of para 13.4.1 of “Concrete Bridge Code - Reprint 2014” are duly complied while designing the non-RDSO standards RCC boxes.

(b) RCC slabs-They may be provided for bridges of small opening (less than 3 m spans) and used for culverts, services etc.

(c) PSC Slabs- They may be used for more than 3 m spans and up to 12.2 m spans.

(d) PSC I-Girders/ U-Slabs/ Box Girders- They may be used for more than 12.2 m; the maximum span length of PSC girder has been restricted to 24.4 m. On all new bridge works being planned for spans more than 24.4m, steel girder should be used as stipulated in Railway Board's Letter No. 2005/CE-I/BR-11/8 dated 28.05.2009 **(Ref. 9.07)**.

(e) Steel Plate Girders (I-section)- Steel girders may be used for 12.2m to 24.4mspans.

(f) Composite Girders- Composite Girders 18.3m to 30.5m spans may be adopted for continuing ballasted deck and LWR/CWR over bridges. However, to ensure composite action, construction and casting method statements shall be provided by the consultant and shall be approved by Chief Engineer before actual construction.

(g) Steel Open Web Girders- Steel open web girders may be used for 30.5 m and longer spans. Open web girders use steel more effectively than l-girders and hence require less steel than l-girder for same span. However, these require more sophisticated equipment and higher level of precision in fabrication. These are also provided with camber to counter deflections. Earlier only riveted field connections were permitted in Railway girders. Now HSFG bolts can only be used in connections, making their erection easier.

TABLE 9.01

TYPES OF SUPERSTRUCTURES AND PREFERABLE SPANS

Types of super-structures	RCC Box	RCC Slabs	PSC Slabs	PSC I-Girders/U-slabs/Box Girders	Steel Plate Girders (I-Section)	Composite girders	Steel open web girders
	(a)	(b)	(c)	(d)	(e)	(f)	(g)
Preferable spans (m)	To be avoided	Less than 3m	3m to 12.2m	More than 12.2m& restricted to 24.4m	12.2m to 24.4m	18.3m to 30.5m	30.5m and above

(2) (a) All types of steel/ composite girders shall be fabricated in RDSO approved workshop/ Railway Bridge workshop under good quality control and then assembled and erected/ launched at site.

(b) As far as feasible, standard drawings for superstructure shall be used in all the cases. List of RDSO standard drawings of above types of superstructures for 25T and DFC loading is extracted from BS: 28 Version 1.4 dated 30/08/2023 and shown in Table 9.02, below BS:28 may be referred for other loading. However, in case nonstandard drawings are unavoidable then railway may use the same with the specific approval of concerned CAO(C)/PCE while according approval of the same, CAO(C)/PCE should record the specific reasons/justification for using nonstandard drawing. A copy of the drawing along with related design/details may be furnished to RDSO [RB No. 2013/CE-III/BR/RDSO/Misc. dated 11.08.2014, **(Ref. 9.08)**].

TABLE 9.02

RDSO STANDARD DRAWING OF DIFFERENT TYPES OF SUPERSTRUCTURES

SN	Span	Skew Angle	RDSO Drawing No	Remark
(a) RCC Box				
(i)	Single box	-	M-00004	RCC box culvert
(ii)	Double box	-	M-00005	RCC box culvert
(iii)	Single box culvert	-	B-10151/R to 10151/9R	DFC Loading
(iv)	Single box culvert structural design	-	B-10152R to 10152/9R	25t loading
(v)	Segmental RCC BOX for limited height subway	-	B-10153 to 10153/3A	
(vi)	Standard drawing of double box culvert	-	B-10154/R to 10154/9R	DFC loading
(vii)	Single box culvert	-	B-10155 to 10155/10	25t loading for double track
(viii)	Segmental RCC Box culvert limited height Subway	-	B-10156 to 10156/2	DFC loading
(ix)	Single box culvert	-	B-10157 to 10157/4	DFC loading double line 4°
(x)	Double Box Culvert	-	B-10158 to 10158/2A	25t Loading for double line track
(xi)	RCC segmental box	-	B-10159 to 10159/2	25t Loading for RUB with footpath
(xii)	RUB/Subway	-	B-10160	25t Loading
(xiii)	RCC Box pushing	-	B-10161 to 10161/1	Using protection Plate arrangement
(b) RCC Slab				
(i)	0.61m, 0.915m, 1.22m, 1.83m & 2.44m	-	BA-10063	25t loading (M-25)
(ii)		-	BA-10063/1	25t loading (M-35)
(iii)		-	BA-10063/2	
(iv)		-	BA-10062	DFC loading (M-30)
(v)		-	BA-10062/1	DFC loading (M-35)
(c) PSC Slab				
(i)	3.05m	-	BA-10259	25t loading 2 units
(ii)			B-10277	
(iii)		-	B-10266	DFC loading 2 units

(iv)	3.66m	-	BA-10260	25t loading 2 units
(v)			B-10278	
(vi)		-	B-10267	DFC loading 2 units
(vii)	4.57m	-	BA-10261	25t loading 2 units
(viii)			B-10280	25t loading 2 units post tensioned slab in M45
(ix)		-	B-10268	DFC loading 3 units
(x)	6.1m	-	BA-10257	25t loading 2 units
(xi)		-	B-10274	
(xii)	9.15m	-	BA-10263	25t loading 3 units
(xiii)		-	B-10272/R	25t loading 2 units
(xiv)		-	B-10279	25t loading 2 units post tensioned slab in M60
(xv)	9.15m	-	B-10269	DFC loading 3 units
(xvi)	12.2m	-	B-10271 to 10271/1	25t loading 4 units
(xvii)	12.2m	-	B-10281 to 10281/2	25t loading post tensioned U-slab in M60
(d) PSC Girder				
(i)	12.2m	-	B-10256 to 10256/3	25t loading 4 I-girder for restricted height
(ii)		-	B-10258 to 10258/3	25t loading I-girder for straight track
(iii)		-	B-10265 to 10265/3	25t loading I-girder (post tensioned type)
(iv)		-	B-10275/R to 10275-4	25t loading PSC U-girder
(v)		-	B-10282 to 10282/7	DFC loading
(vi)		-	B-10285 to 10285/4	25t loading 2CI-girder with footpath

(vii)	18.3m	-	B-1519	Suitable for MBG
(viii)		-	B-10273 to 10273/4	25t loading 2eI girder up to seismic zone-V
(ix)		-	B-10276/R to 10276/4/R	U girder (post tensioned type)
(x)		-	B-10284 to 10284/7	DFC loading
(xi)	24.4m	-	B-10270 to 10270/4	25t loading box girder
(xii)		-	B-10283 to 10283/7	DFC loading
(xiii)	45.1m	-	BA-10232 to 10232/6	DFC loading box girder
(e) Plate Girder				
(i)	12.2m	-	B-16014/R2 to 16014/2R2, 16014/3R1, 16014/4R1 & 16014/5R2	25t loading welded
(ii)	12.2m	-	B-16017 to 16017/3	DFC loading welded
(iii)	18.3m	-	B-16015/R1 to 16015/4R1	25t loading welded
(iv)	18.3m	-	B-16018 to 16018/4	DFC loading welded
(v)	24.4m	-	B-16016R1 to 16016/5R1	25t loading welded
(vi)	24.4m	-	B-16019 to 16019/4	DFC loading welded
(f) Open Web Girder				
(i)	30.5m	-	B-17161 to 17178	25t loading welded through
(ii)		-	B-17061 to 17078	DFC loading welded through
(iii)		-	B-17141 to 17155	25t Loading Underslung Welded
(iv)	45.7m	-	B-17181/R to 17181/19	25t loading welded through
(v)		-	17081 to 17098	DFC loading welded through

(vi)	61.0m	-	B-17182/R to 17182/17	25t loading welded through
(vii)		-	B-17121 to 17138	DFC loading Welded through
(viii)	76.2m	-	B-17183R to 17183/17	25t loading welded through
(ix)		-	B-17101 to 17118	DFC loading welded through type
(x)	91.4m	-	B-17184 to 17184/18R	25t loading welded through
(xi)	106.70m	-	B-17185R to 17185-17	25t loading welded through
(g) Composite Girder				
(i)	12.2m	-	B-11752/R1 to 11752/4R1, 11752/5 & 11752/6R1	25t loading welded type (Up to 4° curve)
(ii)		-	B-11764 TO 11764/7	DFC loading for straight track
(iii)	18.3m	-	B-11753/R2 to 11753/5R2 & 11753/6R1	25t loading welded (up to 4° curve)
(iv)		-	B-11763 To 11763/7	DFC loading for straight track
(v)	24.4m	-	B-11751/R2 to 11751/3R2 & 11751/4R3, 11751/5R2 & 11751/8	25t loading new fatigue criteria
(vi)		-	B-11761 to 11761/7	DFC Loading for straight track
(vii)	30.5m	-	B-11754/R2 to 11754/5R2 & 11754/6	25t loading welded type (up to 4° curve)
(viii)		-	B-11762 to 11762/7	DFC Loading For straight track

917 BRIDGE BEARINGS

(1) The bearing transfers the vertical, lateral/longitudinal forces coming from the superstructure to the substructure. It allows for rotation of superstructure. It may permit/prevent certain movements. The following types of bearings are generally used:

(a) Steel Bearings- Sliding bearing and Rocker & Roller Bearing

(b) Steel Reinforced Elastomeric Bearing

(c) Pot-PTFE Bearing

(d) Spherical Bearings with PTFE or high-density polymer at sliding interface

(2) Lateral/ Longitudinal movement restrainers, shock transmission units (STU), bridge expansion devices etc. are special purpose add-on arrangements for supplementing the bearings to achieve desired end conditions. Special literature, manufacturers' guidelines etc. may suitably be consulted before designing and adopting.

(3) SELECTION OF BEARING

(a) While selecting the bearings for a particular type of bridge span the following requirements should be considered:

(i) Load and movement performance values- Load, Rotation, Movement, Directional movement/rotational capability

(ii) Durability factors- Ability to accommodate cyclic loads and movement, Resistance to corrosive environment, Resistance to production/operation defects

(iii) Avoidance or mitigation requirements

(iv) Life-cycle costs- Relative initial cost, Relative maintenance cost

(v) Service life potential

(vi) Performance during seismic activity in Zone-IV & V.

(b) Suitability of bearing according to functions- Important aspects required to be considered while choosing a bearing type are, environment conditions, its reliability & quality, low maintenance, life compatibility with superstructure, etc. The bearing chosen should be compatible with the design loads, horizontal movement and rotation. Table 9.03 shall be referred while deciding the suitability of bearings. (**Ref.** BS-131, Guidelines for selection of Bridge Bearings for Railway Bridges & ROBs).

(c) Suggested bearing types- Suggested bearing types vis a vis girder type is given in Table 9.04 (**Ref.** BS-131, Guidelines for selection of Bridge Bearings for Railway Bridges & ROBs).

(d) It is advisable that, for major and important bridges, the bearings are designed and manufactured by the approved supplier. It is a good practice that installation of bearing is done under the supervision of manufacturer of bearing as per the design parameters for the bearings.

TABLE 9.03

SUITABILITY OF BEARINGS

Factors		Bearing type			
		Fabricated steel (Pin fixed, rocker or roller)	Steel reinforced elastomeric pad	Pot-PTFE Bearing	Spherical
Load and Movement Performance Values	Load# (T)	Low to medium (Upto 265)	Low to medium (30 to 220)	High (20 to 1780)	High (20 to 1780)
	Rotation@ (radians)	High No limit	Medium 0.02	High Upto 0.04	High No limit
	Movement$ (mm)	High No limit	Low to medium (60)	High No limit	High No limit
	Multi directional Rotation/ Movement Capability	No	Yes	Yes	Yes
Durability factors	Relative Ability to Accommodate Cyclic loads and Movement	High	High	Low due to wear of sliding surface	Low due to wear of sliding surface
	Resistance to Corrosive Environment	Low for all elements	High	Moderate for exposed sides of POT and Piston	Moderate for exposed sides of steel elements
Durability factors	Resistance to Production/ Operation Defects	High	High	Moderate- Internal sealing ring wear and elastomer leakage	Moderate. PTFE Wear. Surfaces not mating properly

(To be contd. on next page)

(To Contd. from previous pages)

Avoidance or Mitigation Requirements		Use stainless steel or mitigate with galvanizing or metalizing Or use oil bath	Proper quality control to avoid manufacturing defects and ensure proper installation	Ensure proper quality control during manufacturing, improved sliding surface and metalized surfaces for corrosion protect on of exposed surfaces	Proper design and construction. Improved sliding surfaces Metalized surfaces.
Life cycle Cost	Relative initial Cost	Low to Moderate	Low	Moderate to High	High
	Relative maintenance cost	Moderate however Low with SS	Low	Moderate	Moderate
Service Life Potential		High for corrosion prone areas Moderate for corrosion prone areas	High	Moderate	Moderate

The load capacity mentioned is indicative and for general cases. The load capacity of the bearings is basically determined by the strength of the constituent materials of tile bearing, structure of the bearing and the load bearing capacity of the interfaces with superstructure and sub-structure. There may be incidences where this limit may exceed for specially designed bearings for special type of bridges.

@, $ The rotation and movement capacity of bearings mentioned above is also indicative and for general cases. There may be incidences where this limit may exceed for specially designed bearings for special type of bridge.

TABLE 9.04

SUGGESTED BEARING TYPES FOR PARTICULAR GIRDER TYPES

SN	Girder Type	Suggested Bearing Types
1.	Steel Plate Girder (Railway Bridge) for spans up to 24.4 m.	1. Steel sliding bearing. Regular oiling and greasing shall be resorted to protect the bearings from corrosion.
2	PSC Girder (Railway Bridge) for spans up to 24.4 m	1. Steel reinforced elastomeric bearing 2. POT-PTFE bearing
3	Steel Concrete Composite I-Girder (Railway Bridge) for spans up to 30.5 m.	1. Steel reinforced elastomeric bearing.
4	Steel Open Web Girder open deck type (Through as well as underslung girder) for spans 30.5 m and above.	1. Steel Rocker and Roller bearings. Regular oiling and greasing shall be resorted to protect the bearings from corrosion. 2. Spherical Bearings with PTFE or similar material at sliding interface. Suitable corrosion mitigation measures for exposed portion of bearing should be done.
5.	Rail cum Road Bridges	1. Spherical Bearings with PTFE or similar material at sliding interface. Suitable corrosion mitigation measures for exposed portion of bearing should be done.
6.	Steel Concrete Composite I-Girder (ROB) for spans up to 36 m.	1. Steel reinforced elastomeric bearing 2. POT-PTFE bearing. Suitable corrosion mitigation measures for exposed portion of bearing should be done.
7.	Bow String Girder (ROB) for spans 42 m or more.	1. Spherical Bearings with PTFE or similar material at sliding interface. Suitable corrosion mitigation measures for exposed portion of bearing should be done. 2. POT-PTFE bearing. Suitable corrosion mitigation measures for exposed portion of bearing should be done.

(i) The bearing chosen should be compatible with the design loads, horizontal movement and rotation. The above suggestion is indicative only and decision regarding the use of particular bearing should be done on the basis of site and design requirements and ability of a particular bearing to fulfil those requirements.

(ii) The type of girders given in Table 9.04 above are based on types which are typically being used for a particular span length in standard drawings of RDSO at present. There might be instances when other type of girder might be used for span length range indicated in above table due to site requirement or any other requirement. In such cases the decision of suitable bearing should be done accordingly.

(iii) Steel sliding bearing should not be replaced by elastomeric bearing in existing spans

where already sliding bearing is there. Elastomeric bearing should be provided in cases of construction/replacement of superstructure.

(iv) The life of POT-PTFE and Spherical bearings depend upon the life of sliding materials which is stipulated in terms of Accumulated Sliding Path (ASP). ASP can be calculated based upon current and projected traffic, and the life of bearing can be assessed accordingly. This issue is likely to govern selection of bearings for long span bridges.

(v) Above suggestions are recommendatory. Due diligence shall be carried out for selection of suitable type of bearing for a particular bridge.

918 RIVER TRAINING WORKS

(1) These works shall be planned based on technical and site-specific requirements as per IRBM Chapter- VIII.

919 PROVISION OF OHE ARRANGEMENTS

(1) In case of new construction, the bridge work must have provisions for OHE Masts, irrespective of whether Electrification is sanctioned or not. The bridge scheme shall be decided carefully to avoid OHE mast on superstructure of the bridge. The OHE Masts may be located on bridge piers only, if unavoidable otherwise.

(2) The implantation of OHE mast on bridges shall be decided by CBE on case-to-case basis, keeping in view inspection, maintenance & replacement requirements, adequate clearance between bearing plates edge & side of base plate of OHE mast and adequate margin for providing seismic restrainers (if required) etc. subject to adherence to IRSOD as stipulated in RDSO Letter No. CBS/DPA dtd-09.07.2020 **(Ref. 9.09)**.

(3) For further detail RDSO Report No. BS: 121 (Guidelines for Provisions of OHE MAST for Electrification at New and Existing Bridge Pier/Abutment) may be referred.

920 PROVISION OF INSPECTION ARRANGEMENTS FOR NEW BRIDGES

For every major / important bridge, the executing agency (construction wing of Zonal Railway, RVNL, etc.) should provide inspection cum maintenance system for all major / important bridges at the time of handing over the section. PCE/CBE should satisfy themselves that the system provided for inspection and maintenance for newly constructed bridge as per IRBM is in place for all new bridges being constructed as stipulated in Railway Board's Letter No.2014/CEIII/BR/Bridge Policy dated 09.10.2014 **(Ref. 9.10)** and BS:113 (Guidelines for Providing Arrangements for Bridge Inspection) may also be referred for details.

921 PREPARATION AND APPROVAL OF DRAWINGS

Preparation and approval of drawing shall be done as per Chapter 4 of this manual.

922 PREPARATION OF DESIGN BASIS REPORT (DBR)

(1) Design Basis Report (DBR) of any bridge is a planning document which contains the major design criteria along with the General Arrangement Drawing (GAD) based on which the

detailed design and drawings of the bridge are prepared.

(2) The DBR shall be prepared as per guidelines contained in BS-122(R1) (Guidelines for Approval of Design Basis Report for Important Bridges) by the executing agency (e.g., CAO/C unit or PSU or any other) and shall be examined and approved by CBE.

(3) The Design Basis Report shall contain span configuration, selection of materials and methods of construction etc. The basic field data on ecological conditions, environmental conditions etc. shall also be enumerated in the design basis note so that the design basis for the bridge can be approved. This will also include waterway planning including choice of location of bridge, computations for waterway and flood etc.

(4) In case of important bridges, sometimes launching scheme requires modifications/ alterations/ in design and provision of additional/ redundant members. Therefore, it is necessary to give due consideration to launching scheme at this stage and incorporate provision for launching/ erection scheme in DBR.

(5) The DBR shall be self-explanatory, annexure etc. shall be properly indexed wherever required.

(6) In case of doubling/ GC or multiple line projects, GAD/ completion plan of existing bridge shall also be annexed. Para wise change sheet should also be provided in case, DBR is resubmitted after observations.

(7) Following documents may further be referred:

(a) RB Letter No. 2013/CE-III/BR/RDSO/Misc. dated 04.06.2014 **(Ref. 9.11)**

(b) RB Letter No. 2014/CE-III/BR/Bridge Policy dated 10.03.2017 **(Ref. 9.12)**

(c) RB Letter No. 2014/CE-III/BR/Bridge Policy dated 11.11.2019 **(Ref. 9.13)**

(d) RB Letter No. 2014/CE-III/BR/Bridge Policy dated 12.02.2020 **(Ref. 9.14**)

(e) RB Letter No. 2014/CE-III/BR/Bridge Policy dated 20.04.2023 **(Ref. 9.15)**

(8) Approval of DBR of Important Bridge:

(a) RDSO may not be associated for approval of DBR of all such cases of new important bridges where standard RDSO spans are proposed and where waterway is being provided following provisions of IRS Sub-structure and Foundation Code and other IRS Codes (**Ref.** 9.12).

(b) RDSO may be associated in planning and clearance of DBR in all cases of new important bridges and rebuilding/ rehabilitation/ retro fitment of major/important bridges specially where use of special type of span/use of new technology/unconventional solution is envisaged and which warrants expert advice/input or warrants use of codes other than Indian Railway Codes due to peculiarity of the bridge. Following steps may be followed **(Ref. 9.15)**:

(i) For new important bridges & rebuilding of important/ major bridge:

i. DBR should be prepared (as per BS: 122) for important bridges by the executing agency (e.g., CAO/C unit or PSU or any other) and should be approved by CBE.

ii. DBR should be submitted to RDSO, if RDSO's association is required. In cases, where requirement of opinion from outside experts is felt, RDSO will recommend formation of TAG/TAC to Zonal Railway.

iii. CAO/C or PCE (for PSUs or any other organization/ unit) of the concerned

Zonal Railway will approve formation of TAG/TAC, its members and Terms of reference, keeping ED/B&S/RDSO and CBE of concerned Zonal Railways as standing members of the TAG/TAC.

iv. Modified DBR including final TAG/TAC recommendations shall be further examined by PCE/ CAO (executing agency) and forwarded to RDSO with their concluding recommendations.

v. Modified DBR including final TAG/TAC recommendations duly recommended/ modified by PCE (for PSUs or any other organization/ unit) /CAO-C (executing agency) shall be examined & accepted/modified/approved by PED/Infra/II/ RDSO (looking after B&S Die.). This should be informed to Railway Board on conclusion.

(ii) For Rehabilitation/ retro fitment of Important/ Major bridges:

i. Proposal including design concept, technical challenge/ justification including other details and also DBR (if required) should be prepared by the executing agency (e.g., CAO/C unit or PSU or any other) and should be approved by CBE.

ii. Step ii to step v as mentioned in above para (b)(i) should be followed in all cases, where RDSO association is required.

iii. In all other cases not requiring RDSO's association following shall be adopted:

- Proposal by executing agency should be submitted to CBE, who will recommend the formation of TAC/TAG to Executing agency.
- CAO/C or PCE (for PSUs or any other organization/ unit) of the concerned Zonal Railway will approve formation of TAG/TAC, its members and Terms of reference, keeping CBE of concerned Zonal Railways as standing member of the TAG/TAC.
- Final TAG/TAC recommendations along with final recommendations of executing agency (CAO/C, CBE for others) shall be accepted/approved/ modified by PCE. This should be informed to RDSO, Railway Board on conclusion.

(9) A checklist for approval of DBR of important bridges given in following Table 9.05 may be referred.

TABLE 9.05

CHECK LIST FOR APPROVAL OF DBR OF IMPORTANT BRIDGE

SN	Items descriptions	Availability (Y/N/NA)	Remarks
1	Whether association of RDSO is required as per **(Ref.9.12)**?		
2	Whether DBR has been examined and approved by CBE?		
3	Whether CBE recommended for formation of TAG/TAC?		
4	Whether opinion from outside expertise is required and whether RDSO recommended for formation of TAG/ TAC?		

5	Whether modified DBR including final TAG/TAC recommendation is examined by PCE/CAO (executing agency) before forwarding to RDSO?		
6	Whether PED/Infra/II/RDSO examined and accepted/ modified/ approved DBR?		
7	Whether clearance from Inland Waterways Authority of India/ concerned Authority for navigational requirement both vertical and horizontal clearances for proposed bridge is taken, wherever required?		
8	Whether GAD of proposed bridge and completion plan are submitted along with DBR?		
9	Whether latest checklist for preparation of GAD for Railway Bridges issued by RDSO has been followed while preparing GAD?		
10	Whether computation of waterway design discharge and scour depth submitted?		
11	Scour considerations especially, in case of doubling/multiple line taken into account		
12	Whether RAT/RAW is situated at upstream of bridge. Discharge due to RAT/RAW in upstream has also been taken into account?		
13	Whether waterway assessed as per **(Ref.9.03)**?		
14	Whether most economical option has been considered after comparisons of two or more types of spans? Proper and adequate justification for selection of span to be mentioned.		
15	Whether the latest guidelines of Board are followed for selecting the type of super-structure? If not, whether Board's approval has been taken for any deviations?		
16	Whether RDSO standard drawing is followed? If not, whether approval from PCE/CAO(C) for using nonstandard drawing has been taken with proper justification as per **(Ref.9.08)**		
17	Whether river-training and protection works are required and shown in GAD?		
18	Whether open foundation has been adopted? If not, whether approval of CBE/SAG officer has been obtained?		
19	Whether side pathway is provided?		
20	Whether provision for electrification is provided?		
21	Whether provision of RSI analysis is stipulated?		
22	Whether launching/erection scheme envisaged in DBR?		
23	Whether provision for bridge inspection arrangement envisaged **(Ref.9.10)**?		

923 APPROVAL OF STRUCTURAL DRAWING

Approval of structural drawings shall be given by the officers as mentioned in Table 9.06.

TABLE 9.06

APPROVAL FOR STRUCTURAL DRAWINGS OF RAILWAY BRIDGES AND ROBS

SN	Executing Agency	Railway Bridges	ROB Composite I-Girder	ROB Bow String Girder	Reference
1.	DFCCIL	CBE of DFCCIL	CBE of DFCCIL	CBE of DFCCIL	1. Para 318 of IRBM
2.	RVNL	1. By centralized design cell of RVNL headed by ED/CGM except for important, major and other typical bridges which shall be further submitted to Zonal Railways for approvals by CBE and CE/C for further certifications during submission of opening documents to CRS	CBE or CE/ Constn. (Nodal)	CBE or CE/ Constn. (Nodal)	1. RB letter No. 2021/2/CE-III/ BR/1/Bridge Policy dated 28.10.2021 **(Ref. 9.16)**
3.	PSUs	1. For railway bridges being executed by open line – By bridge branch at HQ level of Zonal Railway 2. For railway bridges being executed by construction organization By Construction organization	1. Bridge works executed by open line – By Bridge Branch at HQ Level of Zonal Railways. 2. Bridge works executed by Construction Organization – By Construction Organization	1. Bridge works executed by open line – By Bridge Branch at HQ Level of Zonal Railways. 2. Bridge works executed by Construction Organization-By Construction Organization	1. Para 317 of IRBM 2. RB letter no. 2021/2/CE-III/ BR/1/Bridge Policy dated 17.05.2021 & 19.07.2021 (**Ref.9.17 & Ref. 9.18** resp.)
4	Zonal Railways	1. For railway bridges being executed by open line – By bridge branch at HQ level of Zonal Railway	1. Bridge works executed by open line – By Bridge Branch at HQ Level of Zonal Railways.	1. Bridge works executed by open line – By Bridge Branch at HQ Level of Zonal Railways.	Para 317 of IRBM

		2. For railway bridges being executed by construction organization- By Construction organization	2. Bridge works executed by Construction Organization – By Construction Organization	2. Bridge works executed by Construction Organization-By Construction Organization	

924 CODES, MANUALS AND SPECIFICATIONS REFERRED

(1) REFERRED BS REPORTS, IRC REPORTS AND IS REPORTS- For Referred BS reports, IRC reports and IS reports refer to **Table 9.07**.

TABLE 9.07

REFERRED BS REPORTS, IRC REPORTS AND IS REPORTS

SN	Para No	Reference Document details
1	914(2), (3), (4)(b), (5)(b)	BS:127 R1 Guidelines on type of foundations for Railway Bridges
2	915(3)(a) & (d)	BS:114 version-2 Guidelines for Carrying out Rail-Structure Interaction for Railway Bridges (Revision 2)
3	916(2)	BS:28 Master List of Drawings of Bridges and Structures Directorate (R)
4	917(3)(b)	BS:131 Guidelines for selection of Bridge Bearings for Railway Bridges & ROBs
5	919(3)	BS:121 Guidelines for Provisions of OHE MAST for Electrification at New and Existing Bridge Pier/Abutment
6	920	BS:113 Guidelines for Providing Arrangements for Bridge Inspection
7	922(2)	BS:122(R1) Guidelines for Approval of Design Basis Report for Important Bridges
8	914(5)(c), (6) (a) & (b) & (c)	IRC SP:82-2008
9	911(2)(c)	IS:1893 (Part 1).
10	911(2)(f)	IS:1893 (Part 2).

(2) REFERRED DOCUMENTS- For Referred documents from Railway Board & RDSO refer to **Table 9.08**.

TABLE 9.08

REFERENCE DOCUMENTS

SN	Para No	Ref. document details	
1	904(3)(a)	9.01	Railway Board's Letter No.2021/W-I/Genl./Gati Shakti dated.28.10.2022
2	908(4)	9.02	RDSO Letter No RBF/GIS dated. 11.03.2022
3.	913(7)(a) 914(4)(b)	9.03	Railway Board's Letter No.2014/CE-III/BR/ Bridge Policy dated 21.04.2015
4.	913(8) 914(7)(a)	9.04	Railway Board's Letter No.2017/29/CEIII/BR/ Br. 588/ECoR dated 03.08.2017
5.	915(7)(a)	9.05	RDSO Letter No. CBS/DWF dated 15.07.2019
6.	916(1)(a)	9.06	Railway Board Letter No.2015/CE-III/BR/Structure Code dated 19.01.2022
7.	916(1)(d)	9.07	Railway Board's Letter No. 2005/CE-I/BR-11/8 dated 28.05.2009
8.	916(2)	9.08	Railway Board No. 2013/CE-III/BR/RDSO/Misc. dated 11.08.2014
9.	919(2)	9.09	RDSO Letter No. CBS/DPA dtd-09.07.2020
10.	920	9.10	Railway Board's Letter No. 2014/CEIII/BR/Bridge Policy dated 09.10.2014
11.	922(7)	9.11	Railway Board's Letter No.2013/CE-III/BR/RDSO/Misc. dated 04.06.2014
12.	922(7), 922(8)(a)	9.12	Railway Board's Letter No 2014/CE- III/BR/Bridge Policy dated 10.03.2017
13.	922(7)	9.13	Railway Board's Letter No 2014/CE- III/BR/Bridge Policy dated 11.11.2019
14.	922(7)	9.14	Railway Board's Letter No 2014/CE- III/BR/Bridge Policy dated 12.02.2020
15.	922(7), 922(8)(b)	9.15	Railway Board's Letter No. 2014/CE-III/BR/Bridge Policy dated 20.4.23
16.	923	9.16	Railway Board's Letter No. 2021/2/CE-III/BR/1/Bridge Policy dated 28.10.2021
17.	923	9.17	Railway Board's Letter No. 2021/2/CE-III/BR/1/Bridge Policy dated 17.05.2021
18.	923	9.18	Railway Board's Letter No. 2021/2/CE-III/BR/1/Bridge Policy dated 19.07.2021.

***

CHAPTER 10
EXECUTION OF BRIDGE WORKS

PART A
GENERAL

1001 INTRODUCTION

(1) Execution of bridge requires close supervision and periodic inspection for its successful completion. Chapter 4 of Indian Railway Bridge Manual may further be referred.

1002 SETTING OUT A BRIDGE

(1) The bridge layout shall be done after the center line of track has been marked in the field. The reference marks shall be outside the construction zone and duly protected against damage.

(2) All measurements should be done either using calibrated steel tape (all corrections should be applied appropriately, viz., tension, temperature and slope) or preferably using electronic measuring devices, e.g., Total Station or Electronic Distance Measurement device (EDM), LASER distance meter.

(3) First, the center of all piers and abutments shall be marked and cross checked. Thereafter, layout of individual footings shall be marked. In case of curved bridges, shift in center line of curve due to transitions shall be considered and marked. Usually, pier centers deviate outward in radial direction. This shall be incorporated by applying necessary correction to pier center.

1003 SETTING OUT BRIDGES WITHOUT A BASE LINE (Ref. IRBM Para 401)

(1) Where deep excavations are not involved and where there is no water flow in the river during the working season, setting out primarily involves fixing the alignment correctly using a Theodolite or Total Station. The distance between the abutment at either end and the nearest pier and the pier-to-pier distance can be set out by directly measuring and marking the centers using a good calibrated steel tape or LASER distance meter.

(2) The center points of each structure (pier or abutment) shall be punch marked on a flat or angle iron piece fixed flush with the top of a concrete block at the correct location.

1004 SETTING OUT BRIDGES WITH THE HELP OF A BASE LINE (Ref. IRBM Para 401)

(1) Where deep excavation, pile driving or well sinking is involved, and where there is standing water, base lines are set out at right angle to the center line of the bridge, one on either end on the high banks, or on one side of the bridge or anywhere between the abutments where level ground is available.

(2) The actual position of the piers/abutments is determined by the intersection of three sight

lines, one along the alignment sighted from stations located on either end, a second from a station on the base line on the downstream side and a third from a point on the base line on the upstream side. Theoretically all these three lines should intersect at one point. Normally a triangle of error gets formed and the correct center is fixed by judgment within this triangle.

1005 UTILITIES SHIFTING

(1) Utilities requiring shifting (normally wires, cables, and small diameter pipes are easy to shift) should be shifted prior to excavation to avoid any damage to services.

(2) For those requiring support (usually larger diameter pipes, gas pipes etc. are difficult and costly to shift and foundation is planned with them as it is) during construction, support system should be planned well in advance with a sequence of execution. All material required for support should be available at site before start of execution.

1006 SELECTION OF MATERIAL SOURCE

(1) Source for all construction materials (RMC, aggregate etc.) should be identified for ensuring their supply during the work. This helps in maintaining quality and speed of construction. Following factors need deliberation while selecting source:

  (a) Reasonable distance from source to site

  (b) Quality of aggregate available

  (c) Quantity of material required

  (d) Rate of supply (cum/hr. etc.) required

  (e) Capacity of source

  (f) Backup arrangements in case of failure

(2) Experience w.r.t. source, i.e., quality, quantity and reliability and variation over the time & season, variation along the different strata and area etc., may be obtained from previous projects executed around the project under consideration.

PART B
REINFORCED CEMENT CONCRETE

1007 CEMENT

The cement selected should be appropriate for the intended use, as provided in the specifications. Different types of cement should not be mixed. If more than one cement type is used (e.g., OPC 53 Grade, OPC 43 Grade, PPC, or others), a record shall be kept showing the location of use.

(1) The mixing of 50% blast furnace slag conforming to IS: 16714 with OPC cement at the 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 PCE/CE (Coordination) or CAO (Con).

(2) Portland Pozzolana cement shall not be used for PSC works. When Portland Pozzolana cement is used in plain and reinforced concrete, it is to be ensured that proper damp curing of the concrete is done for at least 14 days, and supporting formwork shall not be removed until the concrete attains at least 75% of the design strength.

(3) The sulphate-resistant cement conforming to IS: 12330 shall be used only in such conditions where the concrete is exposed to the risk of excessive sulphate attack, e.g., concrete in contact with soil or groundwater containing an excessive amount of sulphate. It shall not be used under such conditions where concrete is exposed to the risk of excessive chlorides and sulphate attacks.

(4) Compatibility of chemical admixtures and super plasticizers with Portland Pozzolana cement and Portland blast furnace slag cement shall be ensured by trials before use.

(5) Low heat Portland cement conforming to IS 12600 shall be used with adequate precautions with regard to removal of formwork, etc.

1008 AGGREGATES

Aggregates shall comply with the requirements of IS:383. Where required by the engineer, aggregates shall be subjected to the tests specified in IS:383. These tests shall be done in accordance with IS: 2386 (Part I) to IS: 2386 (Part VIII). As far as possible, preference should be given to natural aggregates.

(1) SIZE OF AGGREGATE

(a) For most works, 20 mm nominal size aggregate is suitable. Where there is no restriction to the flow of concrete into sections, 40 mm or larger sizes may be permitted, but in no case greater than one fourth of the minimum thickness of the member, provided that the concrete can be placed without difficulty.

(b) For heavily reinforced concrete members like the ribs of main beams, the nominal maximum size of the aggregate should usually be restricted to 5 mm less than the minimum clear distance between the main bars or 5 mm less than the minimum cover to the reinforcement, whichever is smaller.

(c) In general, marine aggregate shall not be used for reinforced concrete and Prestressed concrete bridges. However, in special cases, the use of marine aggregates may be permitted if it fulfils the requirements mentioned in the IRS concrete Bridge Code.

1009 WATER (Natural or Treated)

(1) Potable water is generally considered satisfactory for washing of aggregates and mixing and curing of concrete. As a guide the following concentrations represent the maximum permissible values:

(2) To neutralize 100 ml sample of water, using phenolphthalein as an indicator, it should not require more than 5 ml of 0.02 normal NaOH. The details of test are given in para clause 8.1 of IS 3025 (Part 22).

(3) To neutralize 100 ml sample of water, using mixed indicator, it should not require more than 25 ml of 0.02 normal H_2SO_4. The details of test shall be as given in para clause 8 of IS 3025 (Part 23).

(4) Average 28 days compressive strength of at least three 150 mm 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 IS:516

(5) The pH value of water shall be not less than 6.

(6) Permissible limits for solids shall be as given in Table 10.01 below:

TABLE 10.01

PERMISSIBLE LIMIT FOR SOLIDS

SN		Tested as per	Permissible Limit, Max
1	Organic	IS 3025 (Part 18)	200 mg/l
2	Inorganic	IS 3025 (Part 18)	3000 mg/l
3	Sulphates (as SO_3)	IS 3025 (Part 24)	500 mg/l
4	Chlorides (as CI)	IS 3025 (Part 32)	500 mg/ l for Pre-stressed Concrete Work, 1000 mg/ l for Reinforced Concrete work and 2000 mg/ l for Plain Concrete Work.
5	Suspended Matter	IS 3025 (Part 17)	2000 mg/l

(7) Water found satisfactory for mixing is also suitable for curing concrete. However, the water used for curing should not produce any objectionable stain or unsightly deposit on the concrete surface. The presence of tannic acid or iron compounds is objectionable.

1010 ADMIXTURE

Admixtures may be mineral or chemical which can be used for getting the desired properties of mix. The Chief Engineer may permit the use of admixtures for imparting special characteristics to the concrete or mortar on satisfactory evidence that the use of such admixtures does not adversely affect the properties of concrete or mortar particularly with respect to strength, volume change, and durability and has no deleterious effect on reinforcement.

(1) Mineral Admixtures:

Any of the following mineral admixtures may be used along with Ordinary Portland Cement. Uniform blending of the mineral admixtures with the cement should be ensured by having dedicated facility and complete mechanized process control at the site to achieve specified quality.

(1) Fly ash: Fly ash when permitted, shall conform to IS: 3812 (Part-1).

(2) Metakaoline: Metakaoline conforming to IS: 16354 when permitted may be used as part replacement of Ordinary Portland Cement.

(3) Silica Fume: Silica fume when permitted shall conform to IS: 15388.

(4) Ground Granulated Blast furnace Slag: Granulated Blast furnace Slag (GGBS) conforming to IS: 16714 when permitted may be used as part replacement of Ordinary Portland Cement.

(5) For High Strength Mixes the recommended percentage of Mineral Admixture Materials shall be in accordance with IS: 10262.-2019.

PRECAUTIONS:

(a) For concrete made with mineral admixtures, the setting time and rate of gain of strength may be different from those of concrete made with ordinary Portland cement alone. Cognizance of such modified properties shall be taken into account in deciding de-shuttering time, rate of movement of formwork in slipform construction, initial time of prestressing, longer curing period and for early age loading. The compatibility of chemical admixtures and cementitious materials should be ensured by trials.

(b) Concrete containing mineral admixtures may exhibit an increase in plastic shrinkage cracking because of its low bleeding characteristics. The problem may be avoided by ensuring that such concrete is protected against drying, both during and after finishing

(c) 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 adopt the same values as those used for concrete made with ordinary Portland cement alone.

(d) Mixes that contain very fine mineral admixtures such as silica fume, can be sticky and difficult to finish.

(e) Concrete made using blended cements such as Portland pozzolana cement and Portland slag cement shall also adhere to (a), (b) and (c) above.

2. Chemical Admixtures

(1) Chemical Admixtures, if used, shall comply with IS: 9103.

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

(3) Calcium chloride or admixtures containing calcium chloride shall not be used in structural concrete containing reinforcement, prestressing tendons, or other embedded metal.

(4) The admixture containing Cl and SO_3 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.

(A) PLASTICIZERS

(1) Water-reducing agents, workability agents, or plasticizers, as they are commonly called, are agents that maintain workability without increasing the water content. These are the most commonly used chemical admixtures and can reduce water content by 12–20%.

(2) There are three possible improvements that can be achieved, which are as follows:

(a) Increase workability without increasing water content to facilitate placement and compaction.

(b) Increase strength without affecting workability by reducing the water-cement ratio.

(c) Achieve economics by reducing consumption of cement without any detrimental effect on workability or strength.

(3) The dosage of plasticizers is normally limited to 1% of the weight of cementitious material.

(B) SUPER PLASTICIZERS

(1) They are high-range water reducers (HRWR) and perform the same functions as plasticizers.

(2) Super plasticizers can produce flowing concrete with a slump as high as 200 mm, which is pumpable and can be used in congested girders or in the casting of piles. A water reduction of over 30% is possible without any workability loss. This produces very strong and durable concrete. The dosage of superplasticizers is normally limited to 2% of the weight of cementitious material.

(C) MECHANISM

(1) Plasticizers and superplasticizers reduce the interparticle force that exists between the cement particles by imparting similar charges to the particles, which then repel each other and prevent floc formation. As flocculation of cement particles is avoided, water, which otherwise gets trapped in the flocs, is available to impart fluidity. Superplasticizers, while plasticizing, do not significantly offset the surface tension of water and hence can be used in higher dosages without air entrainment.

(2) Most commonly used plasticizers:

(a) Lignosulphonic based.

(b) Hydroxynated carboxylic-based.

(c) Sulphonated melamine-based: most suitable for cold regions.

(d) Sulphonated naphthalene-based

(3) New-generation superplasticizers with superior performance have been developed. Polycarboxylate ether, or simply polycarboxylate (PC)-based super-plasticizers that fall into this category, perform better than the traditional sulphonated polymers in terms of either a higher reduction in the water-cement ratio at a given workability or a higher slump level of the given mixture composition and a lower slump loss.

(4) Water reductions of up to 40% have been possible with PC-based superplasticizers. Dosages of PC based superplasticizer shall not normally exceed one percent.

(5) SIDE EFFECTS:

(a) Retardation in setting time

(b) Air entrainment.

(6) APPLICATIONS:

(a) PSC box/I girders require high strength as well as slump.

(b) In RCC, piles, walls, piers, and abutments

(c) For making flowing concrete when it is required to be pumped.

(d) When concrete is laid in large piers to avoid handling requirements.

(e) For large construction projects.

(7) PRECAUTIONS:

(a) Selection of an adequate dosage and time of addition

(b) Dosage depends on the cement types to be fixed after trials.

(c) Batch testing to ensure uniformity in properties.

(d) Low temperatures and less windy conditions are favorable.

(8) ASPECTS TO BE VERIFIED BEFORE APPROVAL OF AN ADMIXTURE:

(a) Dosage as a percentage by weight of cement, point of application, mode of application, and time of application

(b) Guidelines for selection of appropriate water reducing admixture shall be done as per annexure G of IS 10262.

(c) Side effects of admixtures

(d) Chemical names of the main ingredients

(e) percentage of chlorides or sulphates

(f) Effect of adding an excess or lesser quantity of admixture

(g) Transportation time is required.

1011 STEEL REINFORCEMENT

The reinforcement shall be any of the following:

(1) Grade-I mild steel and medium-tensile steel bars conforming to IS: 432 (Part-I)

(2) High-strength deformed steel bars conforming to IS: 1786

(3) Thermo-mechanically treated (TMT) bars satisfy the requirements of IS: 1786.

(4) Rolled steel made from structural steel conforming to IS: 2062 Gr. A and Gr. B

(5) High-strength deformed stainless steel bars and wires for concrete reinforcement satisfy the requirements of Indian Standard Code “IS: 16651”. (ACS-7 dt. 26.06.18)

Note:

(a) For seismic zones III, IV, and V, HSD (High Strength Deformed) /TMT steel bars having a minimum elongation of 14.5 percent and conforming to other requirements of IS: 1786 shall be used.

(b) An independent test on the quality of steel drawn from each lot should be conducted.

(c) Lab tests for physical properties (tensile tests and bend tests) as well as chemical properties

are to be conducted in a NABL-approved lab.

(d) Steel for reinforcement must be stored in a way to prevent distortion and corrosion. If required, cement wash is to be given for long storage.

(e) Steel should be free of mill scales, dust, loose foreign matter, rust, and coats of paint, oil, or other materials.

1012 CONCRETE

Production, Mixing, transportation, placement, compaction and curing.

(1) PRODUCTION

(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. A competent person shall supervise all stages of the production of concrete. A competent person is one who is issued a competency certificate by DEN/Sr. DEN/Dy. CE/XEN for executing and supervising the relevant aspects of concreting. The preparation of the test specimens and tests conducted on site shall be properly supervised.

(b) The engineer shall be afforded all reasonable opportunities and facilities to inspect the materials and the manufacture of concrete, to take any samples, and to make any tests.

(2) BATCHING

(a) In proportioning concrete, the quantity of both cement and aggregate should be determined by mass. Water can be measured by mass or by volume. Solid admixtures may be measured by mass and liquid/paste admixtures by volume/mass. Batching plant, wherever used, should conform to IS: 4925. All measuring equipment should be calibrated and be maintained in clean and serviceable condition, and their accuracy checked periodically. Coarse/Fine aggregate to be batched separately. Grading of fine/ coarse aggregate to be checked as per the frequency specified by the engineer. The grading of course and fine aggregates shall confirm to IS: 383.

(b) If material uniformity has been established, volume batching can be used for production of concrete up to M-20. Where weigh batching is not practicable, volume batching can be adopted for fine/coarse aggregates (not cement) for concrete grade up to M25, but allowance should be made for bulking of fine aggregates in accordance with IS: 2386 (part -III).

(c) 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 condition. The amount of the added water shall be adjusted to compensate for any observed variations in the moisture contents. For the determination of moisture content in the aggregates, IS: 2386 (Part-III) may be referred to.

(d) No additions/alterations in materials used on the work should be made without additional tests to show that the quality/strength of concrete is satisfactory.

(e) The accuracy of the measuring equipment shall be within ±2 percent of the quantity of cement and mineral admixtures being measured and within ±3 percent of the quantity

of aggregate, chemical admixtures and water being measured.

(3) MIXING

(a) Concrete shall be mixed in a mechanical mixer. The mixer should comply with IS: 1791. It shall be ensured that stationary or central mixers and truck mixers shall comply with the performance criteria of mixing efficiency as per IS: 4634. Mixing efficiency test shall be performed at least once in a year. The mixing shall be continued until there is a uniform distribution of the materials in the mass is uniform in colour and consistency. If, there is segregation after unloading from the mixer, the concrete should be remixed.

(b) Note:

(i) For guidance, the mixing time may be taken as 1.5 to 2 minutes for normal mixer and 45 to 60 seconds for high rated batching plant.

(ii) In hot weathers, Ice is added in the water to maintain the temperature below 35^{o}C.

(iii) Workability of the concrete should be controlled by direct measurement of water content with/without admixtures. Workability should be checked at frequent intervals (refer to IS: 1199).

(4) TRANSPORTATION

(a) Mixed concrete shall be transported from the place of mixing to the place of final deposition as rapidly as practicable by methods which will prevent the segregation/loss of ingredients.

(b) When concrete is conveyed by chute, there should be continuous flow in the chute. 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 formwork.

(c) During hot/cold weather, concrete shall be transported in deep containers.

(5) PLACING

(a) The concrete shall be deposited as nearly as practicable to its final position to avoid rehandling. The concrete shall be placed before initial setting of concrete has commenced and shall not be subsequently disturbed. Concrete shall be placed so as to avoid segregation of material or displacement of reinforcement. Concrete should not be dropped from a height more than 1.5m.

(b) No Concrete shall be placed in any part of the structure until the approval of the Engineer has been obtained. A record should be kept of the time and date of placing the concrete in each portion of the structure.

(c) 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. Concrete shall be deposited in horizontal layers to a compacted depth of not more than 450 mm when internal vibrators are used and not exceeding 300 mm in all other cases

(d) Precast concrete cover blocks of the same strength and density as parent concrete shall be used.

(e) The range of ideal temperatures to pour concrete would be around 10 to 30^{o} C. Concreting

close to freezing temperature should be avoided.

(6) COMPACTION

(a) No concrete shall be allowed without vibration except under-water concreting or tremie concreting or in specific cases. Concrete shall be thoroughly compacted and fully worked around the reinforcement, around embedded fixtures and into corners of the formwork.

(b) Concrete shall be compacted in its final position within 30 minutes of its discharge from the mixer, unless carried in properly designed agitators, operating continuously, when this time shall be within 1 hour of the addition of cement to the mix and within 30 minutes of its discharge from the agitator.

(c) 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.

(7) MECHANICAL VIBRATORS (Type depending on the shape & size of the Members)

(a) Internal Vibrators

(i) Shall be used vertically to the full depth of layer being placed and shall penetrate into the layer below while it is still plastic to the extent of 100 mm.

(ii) It shall be kept in place till air bubbles cease to escape from the surface and then withdrawn slowly to ensure that no hole is left in the concrete, care being taken to see that it remains in continued operation while being withdrawn.

(iii) Vibrator should not be used to move the concrete as it can cause honey-combing.

(iv) Distance between insertions should be 1.5 times the radius of the area visibly affected by vibration.

(b) External vibrators

(i) Form vibrators can be used in addition to internal vibrator in case of PSC girders/ slabs.

(ii) Special attention to be given to the design of form work and disposition of vibrators should receive special consideration to ensure efficient compaction and to avoid surface blemishes.

(iii) Over vibration and under vibration of concrete are harmful and should be avoided.

(8) CURING OF CONCRETE

(a) Moist Curing

(i) The concrete should be kept constantly wet for a minimum period of 14 (fourteen) days. Water should be applied on unformed surfaces as soon as it can be done without marring the surface and on formed surfaces immediately after the forms are stripped.

(ii) The concrete shall be kept constantly wet by ponding or covering with a layer of sacking, canvas, hessian or a similar absorbent material.

(iii) When air temperature is expected to drop below 5°C during the curing period, additional covering of cotton/gunny bags, straw or other suitable blanketing material shall be provided so that concrete temperature at surface does not fall below 10°C.

(iv) Curing Compound: Approved curing compounds can be used in lieu of moist curing with the permission of the Engineer. Such compounds shall be applied to all exposed surfaces of the concrete along with stripping of form work.

(v) Test shall be done to ascertain:

i Loss of moisture content in concrete with/without curing compound.

ii Cube strength of concrete with/without curing compound.

iii Permeability of concrete.

(b) Steam Curing-Steam curing can be used advantageously along with moist curing of concrete for transfer of pre-stress. Optimum steam curing cycle to be determined by trial. However, it has been found satisfactory to use a pre-steaming period of 4 to 5 hours or rate of temperature rise between 22-33^{o}C per hour and a maximum curing temperature of 66-82^{o}C for a period such that entire curing cycle does not exceed 18 hours.

1013 CONCRETING UNDER SPECIAL CONDITIONS

(1) WORK IN EXTREME WEATHER CONDITIONS

During hot or cold weather, the concreting should be done as per the procedure set out in IS: 7861 (Part I) or IS: 7861 (Part II) with the approval of the engineer. However, calcium chloride or admixtures containing calcium chloride shall not be used.

(2) UNDER-WATER CONCRETING

(a) When it is necessary to deposit concrete under water, Tremie method shall be used. The equipment materials and proportions of the mix to be used shall be submitted to and approved by the engineer before the work is started. The volume or mass of the coarse aggregate shall be not less than one and a half times, not more than twice that of the fine aggregate.

(b) Coffer-dams or forms 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. Coffer-dams 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.

(c) 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. In the exceptional cases of interruption of concreting which can be resumed within 2 hours, the tremie shall not be taken out of the concrete. Instead it shall be raised and lowered slowly from time to time to prevent the concrete around tremie from setting. Concreting should be resumed by introducing a little richer concrete with a slump of about 200mm for easy displacement of partly set concrete. All tremie tubes shall be properly cleaned before and after use.

1014 TREMIE

The concrete should be coherent and slump shall be more than 150mm but it should not exceed 180mm. When concrete is carried out under water a temporary casing should be installed to the full depth of bore hole or 2m in to non-collapsible stratum, so that fragments of ground cannot drop from the sides of the hole in 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 tremie shall be a hopper large enough to hold one entire batch of the mix or the entire contents of the transporting bucket if any. The tremie pipe shall be not less than 200mm in diameter and shall be large enough to allow a 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 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 before delivering the concrete to the tremie pipe through the hopper, so that when the concrete is forced down from the hopper to the pipe, it will force the plug (and along with it any water in the pipe) down the pipe and out of the bottom end, thus establishing a continuous stream of concrete. It will be necessary to raise the tremie pipe by 25cm to 30cm slowly in order to cause a uniform flow of the concrete, but the tremie shall not be emptied to avoid flow of water into the pipe. At all times even while changing/adding pipes to tremie, the bottom of tremie pipe shall be at least 600mm below the top of concrete as ascertained by sounding. This will cause the concrete to build up from below instead of flowing out over the surface, and thus 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 value, it shall be re-plugged at the top end, as at the beginning, before refilling for depositing concrete.

To minimise the formation of laitance, great care shall be exercised not to disturb the concrete as far as possible while it is being deposited.

1015 STRENGTH OF CONCRETE

(1) The characteristic strength is defined as the strength of material below which not more than 5 % of the test results are expected to fall.

TABLE 10.02

GRADES OF CONCRETE

Group	Grade designation	Specified characteristic compressive strength of 150 mm cube at 28 days in N/mm²
1	2	3
Ordinary Concrete	M10	10
	M15	15
	M20	20
Standard Concrete	M25	25
	M30	30
	M35	35

	M40	40
	M45	45
	M50	50
	M55	55
	M60	60
High Strength Concrete	M65	65
	M70	70
	M75	75
	M80	80
	M85	85
	M90	90
	M95	95
	M100	100

Notes:

(a) 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.

(b) For concrete of compressive strength greater than M60, design parameters given in the standard may not be applicable and the values may be obtained from specialized literatures and experimental results.

1016 WORKABILITY OF CONCRETE

he concrete mix proportions 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.

TABLE 10.03

DEGREE OF WORKABILITY (CLAUSE 5.3.1 OF IRS: CBC)

Placing Conditions	Degree of workability	Values of workability
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,
Concreting of lightly reinforced sections without vibrations, or heavily reinforced section with vibration	Medium	5-2 seconds, vee-bee time or 0.85-0.92, compacting factor or 25-75mm, slump for 20mm† aggregate
Concreting of heavily reinforced sections without vibration	High	Above 0.92 compacting factor or 75-125mm, slump for 20mm† aggregate

†For smaller aggregates, the values will be lower.

Note:-

i Suitable plasticizer/admixture may be used to achieve workability of the order of 150-

200mm. Plasticizer/Admixture should confirm to clause 4.4 of IRS CBC and Para 1010 above.

ii For building works, clause 7.1 of IS: 456 shall be followed.

1017 DURABILITY OF CONCRETE

(1) 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.

(2) The factors influencing durability include: -

(a) The environment.

(b) The cover to embedded steel.

(c) The type and quality of constituent materials.

(d) The cement content and water/cement ratio of the concrete.

(e) The shape and size of the member.

(f) Permeability of concrete

(g) Workmanship, to obtain full compaction and efficient curing.

(h) Environment exposure conditions

(3) The general environment to which the concrete is exposed during its working life is classified in three levels of severity that is, moderate, severe and extreme, as described in IR Concrete Bridge Code and mentioned below:

TABLE 10.04

DIFFERENT EXPOSURE CONDITIONS (CLAUSE 5.4.1 OF IRS: CBC)

Environment	Exposure Condition
Moderate	Concrete surface protected against weather or aggressive conditions. Concrete surface sheltered from severe rain or freezing whilst wet. Concrete exposed to condensation, concrete structure continuously under water. Concrete in contact with non-aggressive soil/ground water.
Severe	Concrete surface exposed to severe rain, alternate wetting and drying or occasional freezing or severe condensation. Concrete exposed to aggressive sub-soil/ groundwater or coastal environment.
Extreme	Concrete surface exposed to sea water spray, corrosive fumes or severe freezing conditions whilst wet. Concrete structure surfaces exposed to abrasive action, surfaces of members in tidal zone. All other exposure conditions which are adverse to exposure conditions covered above.

Note- For building works table 3 of IS 456 shall be followed.

1018 CLEAR COVER TO REINFORCEMENT

(1) Clear cover is the least distance from outer most surface of steel or binding wire or its end to the face of the concrete.

(2) Clear cover is the dimension used in design and indicated on the drawings. The clear cover shall not be less than the size of the bar or maximum aggregate size plus 5 mm; in the case of a bundle of bars, it shall be equal to or greater than the size of a single bar of equivalent area plus 5 mm. From durability consideration, minimum clear cover shall be as under:

TABLE 10.05

CLEAR COVER TO REINFORCEMENT (CLAUSE 15.9.2 OF IRS:CBC)

Type of Structure	Extreme Environment	Severe Environment	Moderate Environment
Slab	50	35	25
Beam/Girder	60	50	35
Column	75	75	50
Well, pile and footing	75	75	50

The clear cover shall not exceed 75mm in any type of structure.

Note- For building works, table 16 of IS: 456 shall be followed.

1019 TYPE AND QUALITY OF CONSTITUENT MATERIALS

For concrete to be durable, careful selection of the mix and materials is necessary, so that deleterious constituents do not exceed the limits.

(1) CHLORIDE CONTENT : The total chloride content by weight of cement shall not exceed the following values as given in table 10.06 below -(clause 5.4.6 of IRS: CBC)

TABLE10.06

CHLORIDE CONTENT

Limits of Chloride Content of Concrete	
(a) For prestressed concrete works –	
(i) Under extreme environment	0.06%
ii) Under severe and moderate environment	0.10%
(b) For RCC works	0.15%

(2) SULPHATE CONTENT

Sulphates are present in most cements and in some aggregates; excessive amounts of water-soluble sulphate from these or other mix constituents can cause expansion and disruption of concrete. To prevent this, the total water-soluble sulphate content of the concrete mix, expressed as SO_3 should not exceed 4 percent by mass of the cement in the mix. The 4 percent limit does not apply to concrete made with super-sulphated cement complying IS: 6909.

(3) MAXIMUM WATER CEMENT RATIO

The limits for maximum water cement ratio for design mix shall be based on environmental conditions as defined above. The limits for maximum water-cement ratio for different environmental conditions shall be as given in **Table 10.07**.

TABLE 10.07

MAXIMUM WATER CEMENT RATIO (CLAUSE 5.4.3 OF IRS:CBC)

Exposure condition	Maximum Water-Cement Ratio		
	Plain concrete (PCC)	Reinforced concrete (RCC)	Prestressed concrete (PSC)
Moderate	0.50	0.45	0.40
Severe	0.45	0.40	0.40
Extreme	0.40	0.35	0.35

Note- For building works, table 5 of IS 456 shall be followed.

(4) CEMENTITIOUS MATERIAL (Cement Mixed With Mineral Admixtures) CONTENT

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 10.08**. Maximum cement content not including fly ash and ground granulated blast furnace slag in excess of 450kg/m3 should not be used unless special consideration has been given in design to the increased risk of cracking due to drying shrinkage in thin sections, or to early thermal cracking and to the increased risk of damage due to alkali silica reactions (Clause 8.2.4.2 of IS: 456 shall be referred).

The ratio of water/cement (plus all cementitious materials) for high strength concrete made with high range water reducing admixtures (HRWRA) conforming to IS: 9103 shall be adopted as per clause 6.2.5 of IS: 10262:2019.

TABLE 10.08

MINIMUM CEMENT CONTENT (CLAUSE 5.4.5 OF IRS:CBC)

Exposure conditions	Minimum Cement content in Kg/m3		
	PCC	RCC	PSC
Moderate	240	300	400
Severe	250	350	430
Extreme	300	400	440

Note- for building works, table 5 of IS: 456 shall be followed.

(5) 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 in Table 10.09.

TABLE 10.09

MINIMUM GRADE OF CONCRETE (CLAUSE 5.4.4 OF IRS: CBC)

A) For Bridges in Pre-stressed Concrete and Important Bridges:

Structural Member	Moderate exposure	Severe exposure	Extreme Exposure
PCC Member	M-25	M-30	M-35

RCC Member	M-30	M-35	M-40
PSC Member	M-35	M-40	M-45

B) For Bridges other than mentioned above and sub-structure:

Structural Member	Moderate exposure	Severe exposure	Extreme Exposure
PCC Member	M-15	M-20	M-25
RCC Member	M-20	M-25	M-30
PSC Member	M-35	M-40	M-45

Concrete of grades lower than those given in Table 8 may be used for lean concrete, foundation for masonry walls or temporary reinforced concrete construction.

Note- For building works, table 5 of IS 456 shall be followed.

(6) PERMEABILITY OF CONCRETE

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 ensuring sufficiently low water-cement ratio, thorough compaction of the concrete as possible, and sufficient hydration of cement through proper curing methods.

The depth of penetration of moisture shall not exceed 25mm.

Permeability test

(i) Permeability test shall be mandatory for all RCC/ PSC bridges under severe and extreme environment;

(ii) Under moderate environment, permeability test shall be mandatory for all major bridges and for other bridges permeability test is desirable to the extent possible;

(iii) Permeability test is required for RCC/PSC structural element only.

(iv) Test to be done as per Appendix-G of IRS Concrete Bridge Code.

(v) For building works the test shall be done as per IS: 516 (part2/ Sec1).

1020 CONCRETE MIX PROPORTIONING

(1) The mix proportions 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.

(a) The determination of the proportions of cement aggregates and water to attain the required strengths shall be made as follows:-

(i) By designing the concrete mix, such concrete shall be called “Design mix concrete” or,

(ii) By adopting nominal concrete mix, such concrete shall be called “Nominal mix concrete”.

(b) Design mix concrete is preferred to nominal mix. If design mix concrete cannot be used for any reason on the work for grades of M20 or lower, nominal mixes may be used.

(2) DESIGN MIX CONCRETE

The mix shall be designed to produce the grade of concrete having the required workability, durability and a characteristic strength. The procedure given in IS: 10262 may be followed for mix design.

1) Standard deviation based on test strength of samples-The total number of test strength of samples required to constitute an acceptable record for calculation of standard deviation shall be not less than 30.

2) Assumed standard deviation- Where sufficient test results for a particular grade of concrete are not available, the value of standard deviation given in **Table 10.10** may be assumed.

TABLE 10.10

ASSUMED STANDARD DEVIATION (CLAUSE 8.7.5.3 OF IRS:CBC)

GRADE OF CONCRETE	ASSUMED STANDARD DEVIATION N/mm^2
M20	4.6
M25	5.3
M30	6.0
M35	6.3
M40	6.6
M45	7.0
M50	7.4
M55	7.6
M60	7.8

However, when adequate past records for a similar grade exist and justify to the designer a value of standard deviation different from that shown in Table 8, it shall be permissible to use that value.

Note- For building works table 8 of IS 456 shall be followed.

(3) Nominal mix concrete- Nominal mix concrete may be used for concrete of M20 or lower. The proportions of materials for nominal mix concrete shall be in accordance with **Table 10.11** below.

TABLE 10.11

PROPORTIONS FOR NOMINAL MIX CONCRETE (CLAUSE 5.5.3 OF IRS: CBC)

Grade of conc.	Total quantity of dry aggregates by mass per 50 kg of cement, to be taken as the sum of the individual masses of fine & coarse aggregates (kg)	Proportion of fine aggregate to coarse aggregates (By Mass)				Qty. of water per 50 kg of cement Max. (liters)
		Fine aggregates grading				
		Zone I	Zone II	Zone III	Zone IV	
(1)	(2)	(3)				(4)
M20	250	1:1.5	1:2	1:2.25	1:2.5	25

1021 REINFORCEMENT SPLICING

(1) Laps and Joints

Continuity of reinforcement may be achieved by a connection using any of the following jointing methods:

(a) lapping bars

(b) butt welding

(c) sleeving

(d) threading of bars

(2) Such connection shall occur, as far as possible, away from points of high stress and shall be staggered. It is recommended that splices in flexural members should not be at sections when the bending moment is more than 50 percent of the moment of resistance and not more than half the bars shall be spliced at a section.

(3) Where more than one-half of the bars are spliced at a section or where splices are made at points of maximum stress, special precautions shall be taken, such as, increasing the length of lap and/or using spirals or closely spaced stirrups around the length of the splice.

(4) The use of the joining methods given in (c) and (d) and any other method not listed shall be verified by test evidence.

(5) For Butt welding, clause 7.1.4 and 13.4 and for sleeving and threading of bars, clause 7.1.4.5 of IRS CBC shall be referred.

1022 LAP LENGTHS

(1) Lap splices shall not be used for bars larger than 32 mm. Bars larger than 32mm shall be welded or mechanically spliced. When bars are lapped, the length of the lap shall at least equal the anchorage length (derived from 15.9.6.2 of IRS CBC) required to develop the stress in the smaller of the two bars lapped. The length of the lap provided; however, shall neither be less than 25 times the smaller bar size plus 150 mm in tension reinforcement nor be less than 20 times the smaller bar size plus 150 mm in compression reinforcement.

(2) The lap length calculated in the preceding paragraph shall be increased by a factor of 1.4 if any of the following conditions apply:

(a) The nominal cover to the lapped bars from the top of the section as intended to bed cast is less than twice the bar size;

(b) The clear distance between the lap and another pair of lapped bars is less than 150 mm;

(c) A corner bar is being lapped and the nominal cover to either face is less than twice the bar size.

(3) Where conditions (a) and (b) or conditions (a) and (c) apply the lap length shall be increased by a factor of 2.0.

(4) Lap splices are considered to be staggered if the center-to-center distance of the splices is not less than 1.3 times the lap length calculated as described in 15.9.6.6.1 of IRS CBC.

(5) In case of bundled bars, lapped splices of bundled bars shall be made by splicing one bar at a time; such individual splices within a bundle shall be so staggered that in any cross-section there are not more than four bars in a bundle.

(6) Reinforcement couplers for mechanical splices of bars for concrete reinforcement, used, shall be in accordance with IS: 16172.

1023 REINFORCEMENT PLACING

(1) Reinforcement shall be bent and fixed in accordance with procedure specified in IS: 2502. The high strength deformed steel bars should not be re-bent or straightened without the approval of engineer-in charge. All reinforcement shall be bent cold.

(2) Bar bending schedules shall be prepared for all reinforcement work.

(3) All reinforcement shall be placed and maintained in the position shown in the drawings by providing proper cover blocks, spacers, supporting bars, etc.

(4) Congestion of reinforcement should be avoided during detailing, various methods such as choosing the diameter and grade of steel carefully and bundling of reinforcement, if required, are available.

(5) Rough handling, shock loading (prior to embedment) and the dropping of reinforcement from a height should be avoided. Reinforcement should he secured against displacement outside the specified limits.

(6) Unless otherwise specified by engineer-in-charge, the reinforcement shall be placed within the following tolerances:

   (a) for effective depth 200 mm or less ± 10mm

   (b) for effective depth more than 200 mm ± 15mm

(7) Sufficient spacers shall be provided to maintain specified concrete cover to the reinforcement and preventing displacement before and during the placement of the concrete. Spacers should be of such material and designs as should be durable, should not lead to the corrosion of reinforcement and should not cause spalling of the concrete cover. Spacer block made from cement, sand and small aggregates should match the mix proportion of the concrete as far as is practicable with a view to being comparable in strength, durability and appearance. The use of the pieces of wood, tile or porous material should not be allowed for this purpose.

(8) Concrete cover blocks used shall be of the same strength and density as parent concrete.

(9) At all intersections, reinforcing bars shall be securely bound together with 1.6mm dia. mild steel wire in accordance with IS:280 or with approved reinforcement clips. The free ends of the binding wire shall be bent inwards. For aggressive environment, galvanized binding wire shall be used.

(10) Maximum distance of spacers, chairs should not be more than one meter.

1024 FORMWORK AND SHUTTERING

(1) Formwork and shuttering should be designed for self-weight, weight of reinforcement, weight of fresh concrete and in addition to various live loads during the construction process (workmen, material and equipment).

(2) Shuttering should have sufficient stiffeners to avoid excessive deflection during placing and compaction of concrete.

(3) Shuttering Joints to be tightly butted to avoid leakage of slurry. If required, rubberized lining

to be provided.

(4) The shuttering should be provided in such a way that it maintains the tolerances on the shapes and dimensions of the structure.

(5) The tolerances for placement of shuttering for building works shall be as per clause 11 of IS: 456.

1025 STRIPPING TIME

(1) Forms shall not be struck until the concrete has reached a strength at least twice the stress to which the concrete may be subjected at the time of removal of formwork. The strength referred to shall be that of concrete using the same cement and aggregates, with the same propositions and cured under conditions of temperature and moisture similar to those existing on the work. Where possible, the formwork shall be left longer as it would assist the curing.

(2) In normal circumstances and where ordinary Portland cement is used, forms may generally be removed after the expiry of the following periods:

TABLE 10.12

FORMWORK STRIPPING TIME (CLAUSE 6.4.1 OF IRS:CBC)

(a)	Walls, columns & vertical faces of all structural members.	24 to 48 hrs. as may be decided by the Engineer.
(b)	Slabs (props left under)	3 days
(c)	Beam soffits (props left under)	7 days
(d)	Removal of props under slabs:	
	(i) Spanning up to 4.5m	7 days
	(ii) Spanning over 4.5m	14 days
(e)	Removal of props under beams:	
	(i) Spanning up to 6 m.	14 days
	(ii) Spanning over 6m	21 days

Note- Amendment No. 5 of IS 456 shall be referred for building works.

(a) For other cements, the stripping time recommended for ordinary Portland cement may be suitably modified.

(b) 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 or beam as the case may be together with any live load likely to occur during curing or further construction.

(c) Where the shape of the element is such that the formwork has re-entrant angles, the formwork shall be removed as soon as possible after the concrete has set, to avoid shrinkage cracking occurring due to the restraint imposed.

(d) The forms should be so constructed as to be removable in the sections without marring or damaging the surface of the concrete. Forms should be removed as soon as possible in order to make necessary repairs and finish the surface. As soon as forms are removed, list

of major/minor defects noticed in concrete should be prepared. Repairing methodology should be approved by Engineer- In charge. After making necessary repairs, the surface should be finished with wood float so as to free from streaks, discolorations or other imperfections. Plastering should not be permitted and a steel trowel should not be used to finish surfaces.

Table 10.13

Tolerances for Finished Concrete Bridge Structures (Clause 6.5 of IRS: CBC)

1	Shift from alignment	± 25mm
2	Deviation from plumb or specified, batter for face of exposed piers.	1 in 250, subjected to a maximum value of 0.05 times the least lateral dimension of pier.
3	Deviation from plumb or specified, batter for face of backfilled abutments	1 in 125
4	Cross-sectional dimensions of piers, abutments and girders	-5 mm +20mm
5	Thickness of deck slab of bridges	+6mm -3mm
6	Size and locations of openings	±12mm
7	Plan dimensions of footings (formed)	+50mm -25mm
8	Plan dimensions of footings (Unformed excavations)	+75mm -00mm
9	Thickness of footings	+No limit - 5%
10	Footing eccentricity	0.02 times the width of the footing in the direction of deviation but not more than 50mm.
11	Reduced level of top of footing/pier/bed block	±5mm
12	Centre to Centre distance of pier and abutments at pier top	±30mm
13	Centre to Centre distance of bearings along span	±5mm
14	Centre to Centre distance of bearings across span	±5mm

1026 SAMPLING, STRENGTH TESTING AND ACCEPTANCE CRITERIA OF CONCRETE

(1) 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.

(2) For 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 10.14 may be taken for general guidance in case of concrete made with ordinary Portland cement. However, in all cases, the 28 days compressive strength specified in table 2 shall alone be the criterion for acceptance or rejection of the concrete.

TABLE 10.14

OPTIONAL TESTS FOR CONCRETE (CLAUSE 8.7.1.1 OF IRS: CBC)

Grade of concrete	Compressive cube strength	Modulus of rupture	
	Min. at 7 days	Min. at 72±2h	Min. at 7 days
(1)	(2)	(3)	(4)
	N/mm²	N/mm²	N/mm²
M20	13.5	1.7	2.4
M25	17.0	1.9	2.7
M30	20.0	2.1	3.0
M35	23.5	2.3	3.2
M40	27.0	2.5	3.4
M45	30.0	2.7	3.6
M50	33.5	2.9	3.8
M55	37.0	3.1	4.0
M60	40.0	3.3	4.2

1027 FREQUENCY OF SAMPLING

(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.

(2) FREQUENCY: The minimum frequency of sampling of concrete of each grade shall be in accordance with the table 10.15

TABLE 10.15

CONCRETE SAMPLING FREQUENCY (CLAUSE 8.7.2.2 OF IRS:CBC)

Quantity of concrete in the work, m³	Number of samples
1-5	1
6-15	2
16-30	3
31-50	4
51 & above	4 plus one additional sample for each additional 50 m³ or part thereof.

Note- At least one sample comprising of 3 cubes shall be taken from each shift.

1028 TEST STRENGTH OF SAMPLE

The test strength 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.

(1) ACCEPTANCE CRITERIA

(a) Compressive Strength-The concrete shall be deemed to comply with the strength requirements when both the following condition are met:

(i) The mean strength determined from any group of four consecutive test results complies with the appropriate limits in col A of Table 10.16.

(ii) Any individual test result complies with the appropriate limits in col B of Table 10.16.

(b) Flexural Strength- When both the following conditions are met, the concrete complies with the specified flexural strength.

(i) The mean strength determined from any group of four consecutive test results exceeds the specified characteristic strength by at least 0.3 N/mm².

(ii) The strength determined from any test result is not less than the specified characteristic strength less 0.3N/mm².

TABLE 10.16

ACCEPTANCE CRITERIA (CLAUSE 8.7.6 OF IRS:CBC)

Specified Grade	Group of test results	A The mean of the group of test result exceeds the specified characteristic compressive strength by at least	B Any individual test result is not less than the characteristic compressive strength less
M 20 and above	Any consecutive 4	3 N/mm²	3 N/mm²

Note: For building works, table 11 of IS 456 shall be referred.

1029 QUALITY CONTROL FOR CONCRETE WORK

(1) Quality control of concrete involves ensuring that the concrete mix meets the required specifications, and that the finished product has the desired properties, such as strength, durability, workability, and appearance. This is achieved through testing and monitoring at various stages of production and construction.

(2) All concreting processes, including batching, mixing, transporting, laying, compacting, and curing, require close supervision during the manufacturing process. The following measures may be considered as guidance during making of concrete:-

(a) Concrete should be batched by weight as far as possible. If weight batching is not practicable, volume batching under adequate supervision in the presence of the engineer in charge may be approved.

(b) The mixer should be charged to its full capacity during mixing. The materials must be fed in the correct order to the mixer. The mixer's speed should be between 15 and 20 rotations per minute. In any event, the mixing duration should not be less than 2 minutes.

When dumping the concrete from the mixer, segregation should be prevented.

(c) Ready mixed concrete may be preferred for making good quality concrete.

(d) The workability of concrete is an important feature of concrete when it is fresh. As a result, a slump test or compaction factor test should be done to determine the workability of concrete.

(e) It is critical that no segregation occurs during the transportation of concrete.

(f) Concrete should not be dumped from a height greater than one meter. If the drop height is greater than one m, chutes should be employed.

(g) To avoid rehandling, concrete should be laid as close to its final position as possible.

(h) Concrete should be compacted using vibrators. Internal vibrator's insertion spacing should not exceed 0.6 m. It should be taken out slowly to avoid leaving any holes in the concrete.

(i) Curing should be done for prescribed amount of time so that the concrete obtains the necessary strength. As soon as the concrete hardens, it should be coated with hessian.

(j) The formwork should correspond to the structure's final shape. It should be examined before beginning the concrete work. The forms should be cleaned and lubricated with oil from the inside so that the concrete does not stick to its sides. Shuttering should be designed to take all anticipated load and should be approved from engineer in charge.

(k) Concrete should not be laid at temperatures below 4.5°C or above 40°C. Water and aggregates should be cooled in extremely hot temperatures. Retarders of acceptable grade may be utilised in hot weather concreting.

(l) Water and aggregates should be heated in extremely cold conditions. Quality-approved accelerators can also be employed in cold weather concreting.

(m) Proper lab should be established at site for quality control of concrete.

1030 PUMPABLE CONCRETE

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.

(1) PUMPING RATE AND RANGE

(a) Depending on the equipment, pumping rate should be 10 to 70m^3 per hour.

(b) Effective pumping range is up to 300 m horizontally and 90 m vertically.

(2) PROPORTIONING PUMPABLE CONCRETE

(a) Basic Consideration-

(i) More emphasis on quality control is essential to the proportioning. Concrete mixes for pumping must be plastic. Particular attention must be given to the mortar and to the amounts and sizes of coarse aggregates.

(ii) The maximum size of 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 screening or by careful selection of aggregates.

(iii) Pumping Operation

i Proper planning of concrete supply, pump locations, line layout, placing sequences and the entire pumping operation to be done.

ii The pump should be placed as near the placing area as practicable.

iii Lines from the pump to the placing area should be laid out with a minimum of bends.

iv The pipeline shall be rigidly supported.

v 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.

1031 READY MIXED CONCRETE

(1) USE OF READY MIXED CONCRETE

Ready mixed concrete may be used, wherever required. It shall conform to IS: 4926 (Specifications for Ready Mixed Concrete) may be referred.

(2) 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.

(3) 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, chemical admixtures should be tested for their suitability as per IS: 9103 at the time of finalizing mix design.

(4) RE-TEMPERING WITH CONCRETE

Under any circumstances, retempering i.e., addition of water after initial mixing, shall not be allowed, as it may affect the strength and other properties of the concrete.

(5) 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 finalising mix design.

(6) 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 not more than 6 revolutions per minute.

1032 HIGH PERFORMANCE CONCRETE (Ref. BS-89R)

High Performance Concrete (HPC) is one, whose ingredients, proportions and production methods are specially chosen to meet special performance and uniformity requirements that cannot be always achieved routinely by using only conventional materials, like, cement, aggregates, water and chemical admixtures, and adopting normal mixing, placing and curing practices. Use of mineral admixture is required. These performance requirements can be high strength, high early strength, high workability (including self-compacting concrete) low permeability and high durability for severe service environments, etc. or combinations thereof. Production and use of such concrete in the field necessitates high degree of uniformity between batches and very stringent quality control.

1033 SELF-COMPACTING CONCRETE (Ref. BS-89R, IS:456)

(1) SELF-COMPACTING CONCRETE (SCC)

SCC is concrete that does not require vibration for placing and compaction. It is able to flow under its own weight, completely filling every corner of formwork and achieving full compaction, even in the presence of congested reinforcement, whilst maintaining homogeneity.

(2) APPLICATION AREA

Self-compacting concrete may be used in precast concrete applications or for concrete placed on site. It may be manufactured in a site batching plant or in a ready-mixed concrete plant and delivered to site by truck mixer. It may then be placed either by pumping or pouring into horizontal or vertical forms. It is suitable in situations where;

(a) Reinforcement is very congested.

(b) Access to allow vibration is not available.

(c) Complicated geometry of the formwork.

(d) Pouring is possible only from a single point.

(e) Speedy placement is required.

(3) FEATURES OF FRESH SELF COMPACTING CONCRETE

The following are some of the features of self-compacting concrete

(a) Slump flow: minimum 600 mm

(b) Sufficient amount of fines (< 0.125 mm) preferably in the range of 400 kg/cum to 600 kg/cum. This can be achieved by having sand content more than 38 percent and using mineral admixture to the order of 25 percent to 50 percent by mass of cementitious materials.

(c) Use of high range water reducing (HRWR) admixture and viscosity modifying agent (VMA) in appropriate dosages.

1034 TESTS FOR CEMENT, AGGREGATES AND CONCRETE

(1) Various tests for quality control related to cement, concrete and coarse and fine aggregates shall be done as per table 10.17.

TABLE 10.17

TESTS ON CEMENT, CONCRETE AND AGGREGATES FOR CONCRETE

SN	Type of Test	Objective	Reference Code
1	Initial and final setting time of cement	Initial setting time of cement is regarded as the time elapsed between the moments that the water is added to the cement, to the time that the paste starts losing its plasticity. The final setting time is the time elapsed between the moment the water is added to the cement, and the time when the paste has completely lost its plasticity and has attained sufficient firmness to resist certain definite pressure.	IS:4031 (Part-5) Methods of Physical test for Hydraulic Cement: Determination of Initial and final setting times
2	Soundness test of cement	It is very important that the cement after setting shall not undergo any appreciable change of volume. Certain cements have been found to undergo a large expansion after setting causing disruption of the set and hardened mass. This will cause serious difficulties for the durability of structures when such cement is used. The unsoundness in cement is due to the presence of excess free lime that could be combined with acidic oxide at the kiln. It is also likely that too high a proportion of magnesium content or calcium sulphate content may cause unsoundness in cement. The soundness of cement may be determined by two methods, namely Le-Chatelier method and autoclave method.	IS: 4031 (Part-3) Methods of Physical Test for Hydraulic Cement: Determination of Soundness.
3	Fineness of cement	The fineness of cement has an important bearing on the rate of hydration and hence on the rate of gain of strength and on the rate of evolution of heat. Finer cement offers a greater surface area for hydration and hence faster the development of strength. The fineness of grinding has increased over the years. But now it has nearly stabilized. Different cements are ground to different fineness. The particle size fraction below 3 microns has been found to have the predominant effect on the strength at one day while 3–25-micron fraction has a major influence on the 28 days strength. Increase in fineness of cement is also found to increase the drying shrinkage of concrete.	IS: 4031 (Part-1) Methods of Physical Tests for Hydraulic Cement: Determination of Fineness by Dry Sieving.

4	Compressive strength of cement	The compressive strength of hardened cement is the most important among all the properties. Strength tests are not made on neat cement paste because of difficulties of excessive shrinkage and subsequent cracking of neat cement.	IS: 4031 (Part-6), Methods of Physical Tests for Hydraulic Cement-Determination of Compressive Strength of Hydraulic Cement other than Masonry Cement
5	Workability of concrete by Slump Cone Test	Workability is that property of freshly mixed concrete or mortar which determines the ease and homogeneity with which it can be mixed, placed, consolidated and finished. The factors helping concrete to have more lubricating effect to reduce internal friction for helping easy compaction are: (a) Water Content (b) Mix Proportions (c) Size of Aggregates (d) Shape of Aggregates (e) Surface Texture of Aggregate (f) Grading of Aggregate (g) Use of Admixtures. Slump test is the most commonly used method of measuring consistency of concrete which can be employed either in laboratory or at site of work. It is not a suitable method for very wet or very dry concrete.	IS: 1199 (Part-2), Fresh Concrete - Methods of Sampling, Testing Analysis. Determination of consistency of fresh concrete.
6	Workability of concrete by Compaction Factor Test	The compacting factor test is designed primarily for use in the laboratory but it can also be used in the field. It is more precise and sensitive than the slump test and is particularly useful for concrete mixes of very low workability and normally used when concrete is to be compacted by vibration. The method applies to plain and air-entrained concrete, made with lightweight, normal weight or heavy aggregates having a nominal maximum size of 38 mm or less but not to aerated concrete or no-fines concrete.	IS: 1199 (Part-2), Fresh Concrete - Methods of Sampling, Testing Analysis. Determination of consistency of fresh concrete

7	Workability of concrete by Vee-Bee Consistometer	The test measures the relative effort required to change a mass of concrete from one definite shape to another (i.e., from conical to cylindrical) by means of vibration. The amount of effort (called remolding effort) is taken as the time in seconds, required to complete the change. The results of this test are of value when studying the mobility of the masses of concrete made with varying amounts of water, cement and with various types of grading of aggregate. The time required for complete remolding in seconds is considered as a measure of workability and is expressed as the number of Vee-Bee seconds. The method is suitable for dry concrete. For concrete of slump in excess of 50mm, the remolding is so quick that the time cannot measured.	IS: 1199 (Part-2), Fresh Concrete - Methods of Sampling, Testing Analysis. Determination of consistency of fresh concrete.
8	Compressive strength of concrete	The compressive strength of concrete is given in terms of the characteristic compressive strength of 150 mm size cubes tested at 28 days as per Indian Standards. The characteristic strength is defined as the strength of the concrete below which not more than 5% of the test results are expected to fall. Characteristic strength of concrete is the strength of concrete specimens casted and tested as per given code of practice and cured for a period of 28 days.	IS: 516 (part 1/ sec 1) Hardened Concrete-Method of Test
9	Permeability of concrete	Permeability of cement mortar or concrete is of particular significance in structures which are intended to retain water, or which come into contact with water. Besides functional considerations, permeability is also intimately related to the durability of concrete, especially its resistance, against progressive deterioration under exposure to severe climate, and leaching due to prolonged seepage of water, particularly when it contains aggressive gases or minerals in solution. The determination of the permeability characteristics of mortar and concrete, therefore, assumes considerable importance.	IRS Concrete Bridge Code (Appendix-G), IS:516 (Part 2/Sec 1) hardened Concrete – Methods of Test

10	Aggregate crushing value	The aggregate crushing value gives a relative measure of the resistance of an aggregate to crushing under a gradually applied compressive load. With aggregate of aggregate crushing value 30 or higher, the result may be anomalous, and in such cases the ten percent fines value should be determined instead.	IS: 2386 (Part 4) Methods of Test for Aggregates for Concrete- Mechanical Properties.
11	Los Angeles abrasion value of aggregate	Abrasion test is carried out to test the hardness property of aggregates. The principle of Los Angeles abrasion test is to find the percentage wear due to relative rubbing action between the aggregate and steel balls used as abrasive charge.	IS: 2386 (Part-4) Methods of Test for Aggregates for Concrete- Mechanical Properties.
12	Impact value of aggregate	The aggregate impact value gives a relative measure of the resistance of an aggregate to sudden shock or impact, which in some aggregates differs from its resistance to a slow compressive load.	IS :2386(Part-4) Methods of Test for Aggregates for Concrete- Mechanical Properties.
13	Water absorption test on aggregate.	Water absorption gives an idea on the internal structure of aggregate. Aggregates having more absorption are more porous in nature and are generally considered unsuitable, unless found to be acceptable based on strength, impact and hardness tests.	IS: 2386 (Part-3) Methods of Test for Aggregates for concrete, Specific Gravity, Density, Voids, Absorption and Bulking
14	Specific gravity of aggregate	Specific Gravity is defined as the ratio of Weight of Aggregate to Weight of equal Volume of water. The specific gravity of an aggregate is a measure of strength or quality of the material. Aggregates having low specific gravity are generally weaker than those with high specific gravity. This property helps in a general identification of aggregates.	IS:2386 (Part-3) Methods of Test for Aggregates for concrete, Specific Gravity, Density, Voids, Absorption and Bulking
15	Size and grading of aggregates	The grading of aggregates in concrete is an important part of concrete design as the grading of the aggregates affects the workability of the fresh concrete, the cement content and therefore cost of the mix and shrinkage of the finished concrete.	IS: 383, Coarse and Fine Aggregates for Concrete -Specifications

1035 CHECK LIST FOR RCC WORK

TABLE NO 10.18

CHECKLIST FOR RCC WORK

SN	Description	Yes/ No/ N.A.
A. Cement		
1	Whether the Supplier/ Manufacturer as per approved list?	
2	Has the Cement got tested from approved laboratory (for Initial Setting Time, Final Setting Time, Soundness, Fineness, Chemical Tests) as per IS codal provisions?	
3.	Whether the above test certificates are attached?	
B. Coarse Aggregate		
1	Whether the Supply is from an approved source?	
2	Have the aggregates been got tested from reputed laboratory as per IS:383, IS:2386, IS:1760 and IS:2317 for Size & Gradation, Flakiness and Elongation Index, Deleterious Materials, Specific Gravity, Density, Moisture Content, Impact value, Crushing Value, Chloride and Sulphate Content, etc.	
3.	Whether the above test certificates are attached?	
C. Checklist for Fine Aggregate		
1	Whether the Supply is from an Approved Source?	
2	Have the aggregates been tested from reputed laboratory as per IS:383, IS:2386, IS:1760 and IS:2317 for Size & Gradation, Silt content, Deleterious Materials, Specific Gravity, Moisture Content, Chloride and Sulphate Content, etc.	
3	Whether the above test certificates are attached?	
D. Checklist for Water		
1	Whether the supply of water is from an approved source?	
2	Has the water been tested for pH value, Sulphate content, Chloride content, Organic Impurities, Inorganic Impurities, Suspended matter, etc. from reputed laboratory as per IS:3025.	
3	Whether the above test certificates attached?	
E. Checklist for Admixtures		
1	Whether the material is from approved Manufacturer/ Supplier:	
2	Whether the material satisfies the Test requirement as per IS:9103 for Relative Density, Chloride Content, Ash Content, pH value, Water Content, etc.	
3	Whether the above test certificates attached?	
F. Checklist for Reinforcement Steel		
1	Whether the material is from approved Manufacturer/ Supplier	

2	Whether the material satisfies the Test requirement as per IS:432(Part-1), IS:1786, IS:2062, IS:16651 for Diameter, Unit Weight, Ultimate Tensile Strength, Yield Strength, % Elongation, Bend & Rebend Test, Chemical Tests	
3	Whether the above test certificates attached?	
G. Checklist for Formwork		
1	Is the Shuttering material (Wood/ Steel) as approved?	
2	Are the Shuttering plates as approved?	
3	Is the thickness of Stiffener approved?	
4	Is the Preassembly of shuttering checked and elements of individual shuttering checked before use?	
5	Is the arrangement of Formwork as per approved dimensions?	
6	Has the alignment and levels of the shuttering/ form work checked?	
7	Is the verticality checked (Max limit- 1 in 1000)?	
8	Is shuttering watertight and weather foam and rubber sheet provided?	
9	Are shuttering plates suitable to give shutter finish of concrete i.e., free from dents, scales or pitting etc.?	
10	Is shuttering adequately supported and braced?	
11	Are shutter vibrators provided as approved?	
12	Are joints between panels flush (no steps/ lips)?	
13	Are spacers between shutters adequately provided wherever required?	
14	Are End Stoppers provided?	
15	Is the oiling of forms done with approved release oil?	
16	Are the Water stops fixed as required?	
H. Checklist for Staging		
1	Has the Staging been designed and got approved in advance?	
2	Is the base preparation done as per the approved methodology?	
3	Is the placing of Concrete block as per drawing?	
4	Is the erection of temporary Columns true to Plumb?	
5	Is the connection of Horizontal and Diagonal Bracings as per Drawings?	
6	Has all the Joints been properly made and Stiffened?	
7	Is the Placing of Longitudinal Girder and Transverse Girders as per Drawings?	
8	Has Staging been done as per approved design?	
9	Is the Spacing of temporary Column according to Approved design?	
I. Checklist for Concrete		
1	Are Construction Joints provided as approved?	
2	Has the old concrete surface been roughened?	
3	Is Batching plant calibration checked?	
4	Has the Concreting sequence been approved?	

5	Has the arrangement for protection from extreme weather during or after concreting been made?	
6	Are the Platforms and access for materials and labour movement provided?	
7	Is adequate illumination arrangement provided?	
8	Are safety measures as per Safety Assurance Record taken?	
9	Does the Slump of concrete meet the requirement?	
10	Are Cube specimens prepared as per Codal provisions?	
11	Is the previously placed layer of Concrete green to receive the succeeding layer of amalgamation?	
12	Is proper vibration done to ensure compaction?	
J. Checklist for Reinforcement		
1	Is Bar Bending Schedule approved?	
2	Is Bar bending and cutting satisfactory?	
3	Has corrosion treatment of bars been carried out in case of scaling of bars?	
4	Are Bar sizes correct as per Drawing?	
5	Are Bar spacing correct as per Drawing?	
6	Are Bar Lap lengths correct as per the structural drawing?	
7	Are Bar Lap at correct locations as per the structural drawing?	
8	Are all joints tied properly with binders using double knot?	
9	Is bar assembly rigid and adequately supported (including spacers/ chair supports)?	
10	Is the Concrete for cover blocks of the same grade as the main Concrete?	
	Are cover blocks of proper size and fixed at proper spacing?	
K. Checklist for Concrete Placing		
1	Has the temperature of Concrete before pouring been checked?	
2	Are the vibrators available for proper compaction of Concrete?	
3	Have precautions been taken for hot weather concreting as per IRS Concrete Bridge Code and IS: 7861 (part-1)?	
4	Have precautions been taken for cold weather concreting as per IRS Concrete Bridge Code and IS: 7861 (part-2)?	
L. Checklist for Post Concrete Inspection		
1	Is the alignment correct?	
2	Are the dimensions correct?	
3	Is there any honey combing?	
4	Are there any bubbles?	
5	Are there any cold joints?	
6	Is shutter finish obtained?	
M. Remarks of defects noticed		

PART C
BRIDGE FOUNDATION AND SUBSTRUCTURE

1036 FOUNDATION

(1) The following types of foundations are normally provided for Railway Bridges, depending on the site conditions:

(a) Open foundations.

(b) Pile foundations.

(c) Well Foundations.

(2) The decision on span length has to depend upon the ratio of the cost of the substructure including the foundation versus the cost of superstructure. Generally, it is most economical when this ratio is one.

(3) Open Foundation should be adopted as far as possible for new railway bridges. However, in special cases Zonal Railways were given a dispensation only with the approval of PCE/CAO(C), to opt for Well/Pile foundation over open foundation taking into account the site condition and other technical/ economic considerations.

Board has further allowed to Zonal railways that type of foundation to be adopted in case of new bridges may be decided at the level of concerned SAG officers/CBE to curtail the procedural delays. However, such decision should be based on comparative analysis and techno-economic considerations of Open/Well/Pile Foundations duly keeping in view the Project timelines. [Railway Board's letter No. No.2014/CE-III/BR/Bridge Policy dt 15.11.2016 **(Ref. 10.01)**.

(4) Open foundation is suitable for bridges where rock or firm subsoil is available at shallow depth and there is not much scour in the stream.

(5) Pile foundation can be used where the foundations have to be built very deep or taken through deep layers of soil subjected to little scour. Larger diameter piles can be provided to take care of large horizontal forces when the foundations are deep.

(6) Well foundation provides a solid and massive foundation for heavy loads and large horizontal forces. This has a larger cross-sectional area and hence the total foundation bearing capacity is much larger than what may be offered by a cluster of piles. The well provides a very good grip when taken sufficiently deep and hence is most suited for river beds subjected to heavy scour. Being cast above water level, good quality control can be exercised in construction of well foundation hence, these should be preferred over pile foundation.

(7) However, a well foundation should not be constructed in close vicinity to existing structures as construction of well foundation may affect the existing foundation, if constructed in close vicinity. Usually, a minimum clear distance equal to diameter of well-being constructed should be provided from existing structure for its safety.

(8) For setting the layout of Bridges [refer para 401 of IR Bridge Manual.]

OPEN FOUNDATION

1037 GENERAL

(1) As far as possible, foundations should be located on a firm ground having stable strata. This would not always be possible and, therefore, the foundations must be designed adequately against any expected failures.

(2) The settlement shall not normally exceed 25 mm after the end of the construction period for bridges with simply supported spans.

(3) Open foundations must rest on a stratum with adequate bearing capacity. The footings should rest on a lean concrete bed of adequate thickness. If required, a plate load test may be carried out to confirm the bearing capacity of foundation. In order to reduce the bearing pressure, the base can be sufficiently widened by providing footings.

(4) Pipe and box culverts can be constructed after removing the top soil in bed to the required depth and replacing it with a layer of lean concrete after the bed is levelled and well consolidated by ramming or rolling. Pipe and box culverts should not normally be provided where the bed is likely to be scoured.

1038 EXCAVATION

(1) Excavation should be done in such a way that the surrounding soil can stand by itself by suitably sloping the sides. When excavations have to be deep or when the side slopes are not stable, suitable shoring may be provided from top, using sheet piles, timber planks, walling pieces, and struts.

(2) The protective works shall be completed before the floods so that the foundation does not get undermined. Excavation on open foundations shall be done after taking necessary safety precautions for which guidance may be taken from IS 3764.

(3) Where blasting is required to be done for excavation in rock, and is likely to endanger adjoining foundations or other structures, necessary precautions, such as, controlled blasting, providing suitable mat cover to prevent flying of debris, etc. shall be taken to prevent any damage.

(4) In deep foundations and large-size excavations, where the seepage is there, suitable pumps may be used for dewatering. A small sump on the side or corners should be provided for the collection of the water to be pumped.

(5) After excavation up to desired level, excavated surface should be thoroughly inspected for any loose pocket of earth. If any loose pocked is noted it should be compacted before laying of PCC.

(6) Where excavation is required to be done under flowing or standing water, coffer dams of steel sheet pile, RCC, or timber may be constructed. Driving is done from a floating platform.

(7) In piers and abutments built on shallow open foundations on poor soil, a butt joint shall be provided between the tracks throughout the height of the structure, including the foundations, so as to permit differential settlements. Similar butt joints shall be provided also near the junction of the wing or return walls and the abutments.

1039 FOUNDING IN SOFT SOIL

(1) The foundation should be taken to a depth not less than 1.75 meters below the lowest anticipated scoured bed level in ordinary soil. Foundation shall not normally rest on compressible soils.

(2) In soft soils, rafts may be provided as a foundation. Such rafts should be protected by means of suitable aprons and cut-off walls or launching aprons, both on the upstream and downstream sides to prevent undermining of the foundations.

1040 FOUNDING IN ROCK

(1) Foundations resting on rocky strata shall be designed taking into consideration nature of rock formation, the dip and strike of the rock strata and presence of faults and fissures. Foundations shall not be allowed to rest on faulted strata likely to slip. Fissured strata shall be stabilised by grouting. Sloping rock may be suitably benched.

(2) In rocky soil, it will be adequate if it is properly keyed into the rock for a minimum of 0.3 meters in the case of hard rock and 1.5 meters in the case of soft rock.

PILE FOUNDATIONS

1041 GENERAL

(1) Pile foundation work shall be done in accordance with IS: 2911 Parts 1 to 4 and Manual on design and Construction of Well and Pile Foundation unless otherwise specified or mentioned in Drawings and Contract specifications. Under reamed piles shall not be used for Railway bridges.

(2) The Construction of pile foundations requires a careful choice of the piling system depending upon sub-soil conditions and load 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.

(3) The bottom of foundations shall be taken to such a depth as to provide adequate grip below the deepest anticipated scour. The depth of foundations below the water level for the design discharge for foundations shall not be less than 1.33 times of the max. depth of scour. In case, of unerodable strata, such as rock, occurring at higher levels, the structure may be founded at such higher level. The foundation shall not normally rest on sloping rock strata.

(4) Large diameter bored piles of more than one meter diameter are normally used for Railway bridge construction.

1042 SUB-SURFACE INVESTIGATIONS

(1) For the satisfactory design and construction of piles, detailed soil exploration to a depth generally not less than:

(a) 1.5 times estimated length of pile in soil or 10m below the proposed founding level.

(b) 15 times diameter of pile in ordinary / jointed rock but minimum 15 m in such rock.

(c) 4 times diameter of pile in hard rock but minimum 3 m in such rock. (MORTH para 1102.1)

(2) The following particulars are collected.

(a) Ground water table and its tidal and seasonal fluctuations;

(b) Soil profile and bore hole log;

(c) In-situ bulk and dry density;

(d) Index properties of soil;

(e) Shear properties of soil. If required Standard Penetration Test (SPT) may be done;

(f) Consolidation properties, in case of clays;

(g) Chemical analysis of soil and ground water to identify sulphate and chloride content or any other deleterious chemical content.

(h) Additional data such as high flood level, maximum scour depth, normal water level during working season, etc. should also be collected.

1043 CLASSIFICATION OF PILE FOUNDATIONS

Piles may be classified as under:

(1) Based on the manner of transfer of load.

(a) Friction piles: These piles transfer the load primarily by skin friction developed along their surface. They are used in soils not subjected to scour.

(b) Bearing piles: These piles transfer the load primarily by bearing resistance developed at the pile tip or base, without taking into account the frictional resistance. They are generally used in hard stratum.

(c) Bearing-cum-friction piles: These piles transfer the load both by bearing and friction

(2) Based on construction methods:

(a) Driven Pre-cast piles;

(b) Driven cast in-situ piles;

(c) Bored cast-in-situ piles.

1044 SELECTION OF TYPE OF PILES

The following factors are to be considered while selecting the type of piles:

(1) AVAILABILITY OF SPACE AND HEAD ROOM : Driven piles require large area and headroom since they need larger and heavier driving rigs. Bored piles, however, require comparatively smaller space.

(2) PROXIMITY TO THE STRUCTURE : Driving causes vibration of the ground which may damage nearby structures. Hence bored piles are preferred in these cases.

(3) RELIABILITY : Driven precast piles ensure good quality as they are cast under controlled condition. In cast in-situ piles, segregation of concrete is possible in water logged areas.

(4) LIMITATION OF LENGTH : Cast-in-situ piles can be formed to any desired length. The length of driven piles normally does not exceed 25 to 30 m depending on the capacity of the driving equipment.

1045 SPACING OF PILES

(1) The spacing of piles is determined based on the type of soil and empirical approach keeping in view the following aspects:

(a) Practical aspects of installing the piles.

(b) The nature of the load transfer to the soil and possible reduction in the bearing capacity of a group of piles thereby

(2) Where piles are found on a very hard stratum and derive their capacity mainly from end bearing, the spacing will be governed by the competency of the end bearing stratum. The minimum spacing in such cases shall be 2.5 times the diameter of the pile shaft.

(3) Piles deriving their bearing capacity mainly from friction shall be sufficiently apart to ensure that the zones of soil from which the piles derive support do not overlap to such an extent that their bearing values are reduced. Generally, the spacing in such cases shall not be less than 3 times the diameter of the pile shaft.

(4) In the case of loose sand or filling, closer spacing than in dense sand may be possible since displacement during filling may be absorbed by vertical and horizontal compaction of the strata. Minimum spacing in such strata may be twice the diameter of the pile shaft. This is applicable for driven piles only.

(5) Normally center to center spacing should not be more than 4d, where d is the diameter of pile shaft. In the case of piles of non-circular cross section, diameter of the circumscribing circle shall be adopted.

1046 TEST PILES

Test piles which are shown on the drawings or specified in the contract to determine the lengths of piles to be furnished, shall conform to the requirements for piling as indicated in specifications. Test piles which are used to arrive at the load carrying capacity shall not be incorporated in the structure.

All test piles 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 removed to at least 600 mm below the proposed soffit level of pile cap and the remaining hole so formed shall be backfilled with earth or other suitable material.

The piles shall be load tested in accordance with provisions laid down in as per IS: 2911 / Part 4.

1047 LOAD CARRYING CAPACITY OF A PILE / GROUP OF PILES

(1) Load carrying capacity of a single pile:

(a) The ultimate bearing capacity of a pile may be assessed by means of a dynamic pile formula, using the data obtained during driving of the piles or by a static formula on the basis of soil test results or by a load test. Reference may be made to IS: 2911-2010 for the details of dynamic and static formulae.

(b) For non-cohesive soils, Hiley's formula is more reliable than other formulae. Hiley's formula is not reliable in cohesive soils.

(c) Load test is most desirable. The load test on pile should be carried out four weeks after casting the pile

(d) Resistance due to skin friction will be available only below the scour line and this must be taken into account in all the three methods.

(2) Factor of safety for Pile Foundations:

(a) The factor of safety shall be judiciously chosen after considering the following:

(i) Reliability of the ultimate bearing capacity of pile;

(ii) Type of superstructure and type of loading;

(iii) Allowable total/differential settlement of the structure;

(iv) Experience of similar structures near the site.

(b) The minimum factor of safety with static or dynamic formula shall be 2.5. The value to be selected for the factor of safety shall, however, take into account, the allowable total settlement and differential settlement of the structure as a whole. The ultimate load capacity should be obtained, whenever practicable, from a load test (initial) (as per IS: 2911 / Part 4). Factor of safety for assessing safe load on piles from load test data should be increased in unfavorable conditions where:

(i) Settlement is to be limited or unequal settlement avoided as in the case of accurately aligned machinery or a superstructure with fragile finishing.

(ii) large impact or vibrating loads are expected

(iii) the properties of the soil may be expected to deteriorate with time, and

(iv) The live load on a structure carried by friction piles is a considerable portion of the total load and approximates to the dead load in its duration.

(3) Bearing capacity of a pile group: The bearing capacity of a pile group may be either of the following:

(a) Equal to the bearing capacity of individual piles multiplied by the number of piles in the group, or

(b) It may be less than the above.

The former holds true in the case of friction piles, cast or driven into progressively stiffer materials or in end bearing piles. In friction piles installed in soft and clayey soils, it is normally smaller. For driven piles in loose sandy soils the group value may be higher due to the effect of compaction. In such a case, a load test should be made on a pile from the group after all the piles in the group have been installed.

1048 CONSTRUCTION OF PILE FOUNDATION

(a) Driven precast piles: Piles can be driven either with a drop hammer or by the use of a single acting/double acting hammer. When the pile driving has to be done in water the equipment can be mounted on pontoons.

(b) Driven cast-in-situ piles: A steel casing pipe with a shoe at the bottom is driven first to the required depth. The reinforcement cage of the pile is then lowered inside the casing and the pile concreted. If possible, the concrete is tamped and compacted as it is poured, or a high slump concrete is poured through a tremie. As the concreting of the pile proceeds upwards,

the casing is withdrawn keeping a suitable over lapping length.

(c) Bored cast-in-situ piles: A guide casing of 3 to 4 m length is provided on top of the bore hole and is driven with the help of a bailer. Further boring below this casing is carried out by chiseling and the side walls are kept stable by circulating bentonite slurry inside the bore hole. The Bentonite clay used in the operation should conform to provisions made in IS: 2911 Part -1, section -2. After reaching the founding level, the chisel is removed, the bore hole flushed and the reinforcement cage lowered into the hole and held in position by tack welding it to the support bars at the top of the casing.

After this the concreting is carried out by using a "tremie" .The concreting is continued till a good quality concrete is seen at the top of the bore hole. The concrete used is a high slump mix (not leaner than M 20 grade). Cast-in-situ piles in which the steel shell is left in the ground ensures the quality of concrete and offers corrosion protection in soils containing chlorides and sulphates.

(1) For piles in streams, rivers, creeks, etc., the following criteria may be followed:

(i) Scour conditions are properly established.

(ii) Permanent steel liner should be provided at least up to maximum scour level. In case of marine clay or soft soil or soil having aggressive material, permanent steel liner of sufficient strength shall be used for the full depth of such strata. The minimum thickness of liner should be 6 mm.

(2) For bridges located in land, steel liners of minimum thickness of 6 mm shall be provided in cases given below. The liner shall be provided up to depth up to which following situations prevail.

(i) While constructing the pile foundation through very soft clay (N<3), very loose sandy strata (N<8), bouldery formation and artesian conditions, wherein the walls of boreholes cannot be stabilized by bentonite circulation.

(ii) Where sewage leakage is common phenomenon as well as sites with aggressive soil/ water environment.

1049 SOCKETING LENGTH IN ROCK

Minimum length of socket for preliminary design may be taken from following Table 10.19, although it should be estimated from static computations given in this standard and preferably verified by load test. Refer IS 14593: 2013 for detail guidelines on design and construction of Bored cast-in-situ piles founded on Rocks (end bearing pile).

TABLE 10.19

SOCKETING LENGTH IN ROCK

Rock type	Length of socket
Sound relatively homogenous rock including granite and gneiss	1 to 2D
Moderately weathered, closely jointed including, schist, slate	2 to 3D
Soft rock, sedimentary rocks, sandstones, siltstone, mudstone	3 to 4D

1050 PERMISSIBLE TOLERANCE WHILE DRIVING PILES

(1) CONTROL OF ALIGNMENT

Piles should be installed as accurately as possible as per the designs and drawings either vertically or to the specified batter. As a guide, for vertical piles a deviation of 1.5 percent (1 in 67) and for raker pile a deviation of 4 percent (1 in 25) should not normally be exceeded.

(2) Piles should not deviate more than 75mm or D/10 in case of bored cast-in-Situ piles having diameter more than 600mm whichever is more, from their designed position at the working level of the piling rig.

(3) In the case of a single pile in a column, positional tolerance should not be more than 50 mm (100mm in case of piles having diameter more than 600mm). Greater tolerance may be prescribed for piles driven over water and for raker piles.

(4) For piles to be cut-off at a substantial depth, the design should provide for the worst combination of the above tolerances in position and inclination. In case of piles deviating beyond these limits and to such extent that the resulting eccentricity cannot be taken care of by a redesign of the pile cap or pile ties, the piles should be replaced or supplemented by one or more additional piles.

NOTE: In the case of raker piles up to a rake of 1 in 6, there may be no reduction in the capacity of the pile unless otherwise stated.

(5) Any deviation 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.

1051 SEQUENCE OF PILING

(1) In a pile group the sequence of installation of piles shall normally be from the center to the periphery of the group or from one side to the other.

(2) Consideration should 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 in loose soils.

(3) Driving piles in loose sand tends to compact the sand which, in turn, increases the skin friction. Therefore, the order of installing of such a pile in a group should avoid creating a compacted block of ground into which further piles cannot be driven.

(4) In case where stiff clay or compact sand layers have to be penetrated, similar precautions need be taken. This may be overcome by driving the piles from the center to outward or by beginning at a selected edge and working across the group. However, in case of very soft soils, the driving may have to proceed from outside to inside so that the soil is restrained from flowing out during the operations.

1052 CONCRETE IN PILES

(1) Consistency of concrete to be used for piles shall be consistent with the method of installation of piles. Concrete shall be so designed or chosen as to have a homogeneous mix having a slump/workability consistent with the method of concreting under the given conditions of pile installation.

(2) Suitable and approved admixtures may be used in concrete mix where necessary.

(3) The clear cover for piles shall be 75 mm over all reinforcement including binding wire. In case of moderate environment clear cover may be reduced to 50 mm.

(4) From durability consideration, depending upon the environment to which the structure is likely to be exposed during its service life, minimum grade of concrete in pile shall be M-30 as given in Table 4(b) of IRS concrete bridge code para 5.4.4.

(5) 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.

1053 TREMIE CONCRETING

The following precautions are to be taken while doing the work:

(1) The concrete should be coherent, rich in cement (not less than 370 kg/m3) and of slump between 150 and 180 mm.

(2) When concreting is carried out under water, a temporary casing should be installed to the full depth of the bore hole or 2m into non collapsible stratum so that fragments of ground cannot drop from sides of the hole into concrete as it is placed. The temporary casing may not be required except near the top when concreting under drilling mud (Bentonite slurry.)

(3) The hopper and the tremie should be a closed system embedded in the placed concrete, through which water cannot pass.

(4) The tremie should be large enough with due regard to size of the aggregates. For 20 mm sized aggregate the tremie pipe should be of diameter not less than 200 mm. Aggregates more than 20 mm in size shall not be used.

(5) The first charge of concrete should be placed with a sliding plug pushed down the tube ahead of it or with a steel plate of adequate charge to prevent mixing of concrete and water. However, plug should not be left in the concrete as a lump.

(6) The tremie pipe should always penetrate well into the concrete with an adequate margin of safety against accidental withdrawal of the pipe surging to discharge the concrete.

(7) The pile should be concreted wholly by tremie and the method of deposition should not be changed part way up the pile, to prevent laitance from being entrapped within the pile.

(8) All tremie tubes should be scrupulously cleaned after use.

(9) Normally concreting of the piles should be uninterrupted. In an exceptional case of interruption of concreting, but which can be resumed within 1 or 2 hours, the tremie shall not be taken out of the concrete. Instead, it shall be raised and lowered slowly, from time to time to prevent the concrete around the tremie from setting. Concreting should be resumed by introducing a little richer concrete with a slump of about 200 mm for easy displacement of the partly set concrete. If the concreting cannot be resumed before final setting of concrete already placed the pile so cast may be rejected or accepted with modifications.

(10) In case of withdrawal of tremie out of the concrete either accidentally or to remove a choke in the tremie, the tremie may be reintroduced in the following manner to prevent impregnation of laitance or scum lying on top of the concrete deposited in the bore.

(11) The tremie shall be gently lowered on to the old concrete with very little penetration initially. A vermiculite plug should be introduced in the tremie.

(12) Fresh concrete of slump between 150 mm and 175 mm should be filled in the tremie which will push the plug forward and will emerge out of the tremie displacing the laitance/scum. The tremie will be pushed further in steps making fresh concrete sweep away the laitance/ scum in its way. When tremie is buried by about 60 to 100 cm, concreting may be resumed.

(13) In case of concreting through tremie or such tubes which are subsequently withdrawn, the concrete shall be placed in sufficient quantity to ensure that during withdrawal of the tube a sufficient head of concrete is maintained to prevent the in-flow of soil and water or bentonite slurry.

(14) The top of the concrete in a 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.

(15) The minimum embedment of cast in-situ concrete piles into pile cap shall not be less than 75mm.

1054 RECORDING OF DATA

A competent inspector shall be maintained at site to record necessary information during installation of piles and the data to be recorded shall essentially contain the following:

(1) Sequence of installation of piles in a group,

(2) Type and size of driving hammer and its stroke,

(3) Dimensions of the pile including the reinforcement details and mark of the pile,

(4) Cut-off level and working level,

(5) Depth driven,

(6) Time taken for driving and for concreting recorded separately, and

(7) Any other important observations, during driving, concreting and after withdrawal of casing tube.

1055 DEFECTIVE PILES

(1) In case defective piles are formed, they shall be removed or left in place whichever is convenient without affecting the performance of the adjacent piles or the group as a whole. Additional piles shall be provided to replace them as necessary.

(2) If there is a major variation between the depths at which adjacent 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 may be necessary to take all the piles to a level below the bottom of the zone which shows such pockets.

(3) Any deviation from the designed location, alignment or load- carrying capacity of any pile shall be noted and adequate measures taken to check well before the concreting of the pile cap and plinth beams.

(4) While removing excess concrete or laitance above cut-off level, manual chipping shall be

permitted after seven days of pile concreting. Pneumatic tools shall be permitted only after seven days after casting. Before chipping/breaking the pile top, a 40mm deep groove shall be formed all around the pile diameter at the required cut-off level.

(5) In case soft concrete or laitance is found below the cut-off level, entire portion of soft concrete or laitance shall be removed and pile shall be rebuilt, up to required level so that pile cap can be cast.

1056 LOAD TEST ON PILES

(1) For acceptance of piles, vertical and lateral load, testing of piles as required will be carried out as per procedure laid down in IS:2911 (Pt-IV) "Code of Practice for Design and Construction of Pile Foundation -Load test on piles".

(2) INITIAL TEST

This test is required for one or more of the following purposes.

(a) Determination of ultimate load capacity and arrival at safe load by application of factor of safety.

(b) To provide guidelines for setting up the limits of acceptance for routine tests,

(c) To get an idea of suitability of piling system, and

(d) To have a check on calculated load by dynamic or static approaches.

(i) The test load provision in the initial load test shall not be less than the estimated safe load multiplied by the minimum factor of safety of 2.5.

(ii) Initial pile load tests shall preferably be carried out prior to execution of piling job.

(3) ROUTINE TEST

This test is required for one or more of the following purposes:

(a) Checking the safe load as determined from static analysis.

(b) Detection of any unusual performance contrary to the findings of the initial test, if already done; and

(c) Workmanship.

The number of tests shall be 0.5 percent of the total number of piles, subject to a minimum of one (1) test. The number of tests may be increased up to 2 percent in particular cases depending upon the nature, type of structure and sub-strata condition.

(4) PULL-OUT TEST

This test shall be carried out preferably on initial test piles. In case it is found necessary to conduct pull out test on working piles the following considerations shall be made:

(a) To check that the pile shaft is designed to cater for such uplift load; and

(b) To limit the displacement within elastic deformation of pile beyond which the test should be discontinued.

1057 STANDARD TEST METHOD FOR LOW STRAIN PILE INTEGRITY TESTING

Pile Integrity Testing (PIT) is a Non-Destructive integrity test method for foundation piles. The method evaluates continuity of the pile shaft and provides information on any potential defects

due to honeycombs, necking, cross-section reduction, potential bulbs, sudden changes in soil stratum, concrete quality in terms of wave speed etc. It is known as "Low Strain" Method since it requires the impact of only a small hand-held hammer and the resultant strains are of extremely low magnitude. The test procedure is standardized as per ASTM D5882 and also forms part of various specifications and code provisions worldwide.

Various methods used to evaluate the integrity of the pile are briefly described below. The evaluation of PIT records can be described as follows.

(1) Pulse-Echo Method (or Sonic Echo - a time domain analysis)

(2) Force Velocity Approach

(3) Transient Response Procedure (Frequency Domain Analysis)

(4) Cross Hole Ultrasonic Method (CHUM)

The Force Velocity approach is sometimes used to evaluate defects near the pile top that maybe difficult to evaluate in Pulse Echo Method. The Pulse Echo is the most commonly used method and is described below.

Whereas it is essential to ensure integrity of Pile foundations for their performance, in addition to vertical and lateral load tests, Pile integrity test / NDT should also be conducted on all piles. The Cross Hole Ultrasonic Method (CHUM) as per ASTM D 6760 may be conducted. At least one pile under each pile cap to be selected randomly in advance by Engineer at site and other Low Strain Energy Method for all remaining piles as per IS:14893 & ASTM D 5882 to be conducted.

1058 PILE CAP

The minimum thickness of pile cap should be 1.5 times the diameter of pile. Such a pile can be considered as rigid.

The minimum embedment of cast-in-situ concrete piles into pile cap shall be 75mm. Any defective concrete (surplus during tremie concrete) at the head of the completed pile shall be cut away and made good with new concrete. Any length of pile surplus to that required for incorporation in the structure shall be cut off neatly and removed. During the process of cutting off, it shall be ensured that projecting reinforcement to be anchored into the pile cap.

In Marine conditions or in areas exposed to the action of harmful chemicals, the pile cap shall be protected with a suitable anti-corrosive paint (for detail refer Durability code BS14). High alumina cement i.e. quick setting cement shall not be used in marine constructions.

The reinforcement in the pile shall be exposed for full anchorage length to permit it to be adequately bonded into the pile cap. Exposing such length shall be done carefully so as to avoid damaging the rest of the pile.

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 neatly dressed levelling course of minimum 100mm thickness of M 15 or as specified nominal mix concrete shall be provided.

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.

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.

Top of pile cap should be usually 600 mm below the bed level to avoid obstruction of waterway. Cut-off level of pile cap should not change during construction stage. In case of change in cut-off level required during construction stage prior approval of alteration in GAD should be obtained with detailed justification.

WELL FOUNDATIONS

1059 TYPES OF WELL

(1) The types commonly used are:

(a) Circular

(b) Double - D

For bridges with single line circular wells are adequate. Where the pier length is larger as in the case of double line bridges, double- D wells may be used.

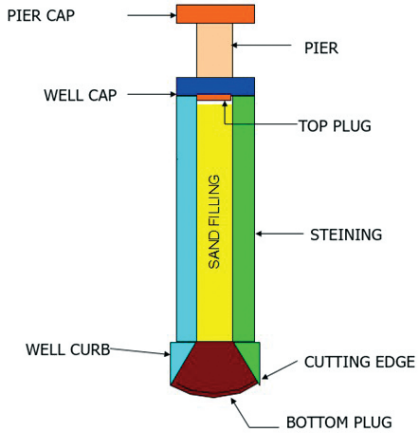
(2) The circular well is simple to construct, easy to sink and has uniform strength in all directions. It can be better controlled against tilt and tilt correction is also easier. The only disadvantage is the limitation in size which restricts its use to bridges with smaller piers.

(3) The shape of Double-D well facilitates easy casting and sinking due to presence of two dredge holes. The overall length of the well generally is restricted to twice the width.

(4) The desirable minimum clear distance between the existing and new foundations from the consideration of interaction of scour regions is 6D (where D is diameter of well). There should be no interference in the pressure bulb zone of foundations of existing and proposed bridge. There should be no reduction in passive earth pressure due to excavation of new foundation in close vicinity of the existing foundation. [RDSO letter No CBS/DWF dt 15.07.2019 (Ref. 10.02)].

1060 COMPONENTS OF WELLS

(1) The cross section of typical well foundation with its components shows as below.



Well curb including cutting edge: The bottom portion of the well is tapered and is called the well curb. It should be strong enough to transmit the design loads to the bottom plug. The inclination of the inner face of the curb should preferably be not more than 30 degree except in sandy strata, where it may go up to 45 degree. Reinforced well curbs with a minimum reinforcement of 72kg/m^3 excluding bond rods are suitable for depths up to 25 m. For depths more than 25 m, all steel well curbs are preferable. In case blasting is anticipated, the inner face of curb should be protected by steel plates or any other means to sufficient height.

The cutting edge, which is an integral part of the well curb, is usually made of rails or mild steel plates and angles and is fabricated in 3 or 4 parts.

The cutting edge should be properly anchored to the well curb. In the case of double-D wells the bottom of the cutting edge of the intermediate walls may be kept 300 mm above the outer cutting edges to prevent rocking. (IRBM)

Cutting edge and the top of the well curb shall be placed truly horizontal.

(3) WELL STEINING

(a) General- Well steining is built of mass concrete or reinforced concrete. Bond rods distributed uniformly on both the faces of the steining shall be provided at a rate not less than 9 kg /m^3 to bond the units of the steining during the process of construction. They shall be tied up by providing adequate horizontal hoop reinforcement which shall not be less than 9 kg/m^3. The cover for the rods shall not be less than 75 mm. (IRBM)

Well steining shall be built in lifts and the first lift shall be laid after sinking the curb at least partially for stability. The steining shall be built in one straight line from bottom to top and shall always be at right angle to the plane of the curb. In no case, it shall be built plumb in intermediate stages when the well is tilted.

(b) Thickness of steining of cement concrete wells-The well steining should be of sufficient thickness (Not less than 1000 mm) so that

(i) sinking is possible without excessive kentledge ;

(ii) the steining is strong enough to resist damage during sinking;

(iii) tilt correction is possible without damage to the well ;

(iv) the steining is strong enough to resist earth pressure in conditions like sand blow or sudden drop of well during sinking; and

(v) stresses developed during sinking and in service conditions are within permissible limits.

(4) BOTTOM PLUG

The dredge hole should be filled up with M-15 grade cement concrete under water. The bottom plug should fill up the entire portion of the cone and up to 300 mm above the top of curb. The bottom plug concreting should be done in one continues operation.

(5) TOP PLUG

A 300 mm or appropriate thick plug of cement concrete M-10 grade shall be provided over the hearting which shall normally be done with sand.

(6) WELL CAP

The bottom of the well cap shall, as far as possible, be located 300 mm above low water level.

All the longitudinal bars from the well steining shall be anchored into the well cap. The well cap shall be designed as a slab resting on the well steining.

1061 EQUIPMENT FOR CONSTRUCTION OF WELL FOUNDATION

Equipment shall be deployed for construction of well foundation as required and as directed by the Engineer. Generally, the following equipment may be required for the work:

(1) Crane with grab buckets – capacity 0.5 cum to 2.0 cum
(2) Submersible pumps
(3) Air compressors, air locks and other accessories where pneumatic sinking of well is anticipated
(4) Chisels of appropriate sizes
(5) aqua-header for cutting rocky strata
(6) Diving helmets and accessories
(7) Batching plants for concrete production
(8) Equipment for transportation, placing and compaction of concrete

1062 PITCHING OF THE CUTTING EDGE AND WELL CURB

The curb should be generally pitched at about 15 cm to 30 cm above the low water level. The pitching level may be kept higher if the water level in the river is subjected to greater fluctuations like in tidal areas. In case the site is dry, excavation should be carried out up to the level at which the well curb is proposed to be pitched and the center of the well curb carefully marked. The well curb should then be assembled on wooden blocks or sand bags placed at intervals of about 1.5 m.

In case the well has to be sunk in water, an island is formed, and the top of the island is levelled and compacted lightly and marking for setting the cutting edge is done on the level surface.

1063 CONCRETING OF STEINING

The well steining should be built up in stages initially 1.20 to 1.50 m at a time, as it is gradually sunk through the soil, keeping sufficient free board above the water level. Once well has acquired a grip of about 6 m, the steining can be raised 3 m at a time to obtain a better rate of progress. Inner shuttering and bracing should not be removed within 24 hours of casting.

1064 SINKING OF WELLS IN WATER

(1) The sinking of well is done by removing the soil with grabs or chiseling and drawing out the soil. Sinking of steining should not be done within 48 hours of casting.
(2) In stagnant water and in water with velocity up to about 2.0 m/s and of depth up to about 5 m, construction of island may be resorted to. In greater depths, the use of steel caissons would become unavoidable.
(3) The island should provide sufficient working space of about 2 to 3 m all-round the well. A minimum free board of 0.6 m should always be provided. For depths of water up to 1 m, an island may be constructed by laying a few rings of sand bags enclosing the area of the island and filling with sand

1065 FLOATING CAISSONS

(1) Floating caissons are generally fabricated at or near the banks on dry land or in dry docks and then towed into position.

(2) In deeper channels and swift rivers, caissons built of steel plates suitably strengthened by angle iron stiffeners and further strutted and tied together by MS angles may be used. Caissons are lowered through water and pitched in position before commencing the sinking.

(3) Caissons can be assembled at site itself and launched straight away using barges or can be assembled when the river bed is dry and launched when water level in the river rises.

1066 PROCESS OF OPEN SINKING OF WELLS

(1) For shallow depths, grabbing and removal of the earth can be done manually. For greater depths and where the sub soil water level is high, suitable dredger may be used. The grab cannot be operated in the blind area below the curb. Hence, these are suitable for the wells with thinner steining. Winches of suitable capacity can be used for operating the grabs or dredgers. For faster sinking of wells of 6 m dia and above, suitable cranes may be used.

(2) Well Sinking through clay and hard strata:

(a) In stiff clay strata or in strata with compact sand, shingle and boulders, the use of rail chisel may be required. Use of chisels can be avoided if hammer grabs are used.

(b) For sinking through stiff clay and other hard strata buoyancy effect of the soil may be reduced by dewatering the well to increase its effective weight.

(c) If due to heavy skin friction, the well is held in a floating condition, air or water jets may be used on the outer periphery of the well for reducing the friction. For this purpose, pipes of 4 to 5 cm. dia. fitted with nozzles can be incorporated in the well close to the outside periphery, particularly in the curb portion and also for some height of the steining above.

(3) Precautions to avoid blowing of sand and quick sand condition should be taken during well sinking as detailed in IRBM para 423. While sinking wells in deep water, divers with their equipment should be present for emergencies.

1067 TILT AND SHIFT OF THE WELL

(1) LIMITS OF TILT AND SHIFT

(a) As far as possible wells shall be sunk without any tilt and shift. A tilt of up to 1 in 100 (1%) and a shift of D/40 subject to a maximum of 150 mm can be permitted. (D is the width or diameter of well).

(b) Excessive tilt and shift, which cannot be corrected, should be taken into account for rechecking the design of the well and the resulting foundation pressure.

(c) The gauges marked at quarter points on the outer periphery of the steining starting from the bottom of the cutting edge mentioned earlier are used for checking the tilts. Water level readings on all the four gauges are observed frequently to get an idea of the direction and extent of tilt. Where the well is not sunk through water, plumb bobs are used on all four sides to judge the verticality of the well. It should be noted that plumb bobs are used only for checking for tilt during sinking and should never be used while building up the steining.

(2) TILT CORRECTION

Depending on the site conditions, any one of the following methods may be adopted either separately or in combination with others for the rectification of tilt which may occur due to the well encountering very soft material on one side and hard material on the other side or when there is a log of wood or a big boulder under the cutting edge on one side of the well.

(a) Eccentric dredging: The dredging is confined to the higher side and is done very close to the inside face of the steining and even a little under the steining.

(b) Eccentric loading: The side which is higher is loaded either by placing kentledges on the steining or by placing the load on a cantilevered platform. Eccentric dredging should also be carried out to aid the tilt correction.

(c) Applying pull to the well: Light pull can be applied to a well by taking a wire rope round the well and anchoring the tackle to a dead man anchorage or a large tree if available in the vicinity. The tackle is worked by a winch and tension is maintained as sinking progresses.

For applying heavy pull, wire ropes are taken round and fixed to a large dead man anchorage. Rails or other kentledges are then placed on the wire ropes to develop high tension and the tilt gets rectified as the well sinks.

(d) Applying push to the well: Light push can be applied by driving a strut between the well and the bank. The strut is made tight by driving wedges. For applying heavy push, two timbers or struts of steel of suitable section are tied together in the shape of a nut cracker with the handles spread apart and the load is placed at the hinge. Care should be taken to see that the push is not excessive.

(e) Packing the low side of the well with sand bags under the splayed portion : This can be adopted only when sinking is done under dewatered conditions either by pumping or using compressed air. The side which is lower is packed with sand bags and excavation is carried out only on the high side. This method should be used cautiously if the depth of the well is shallow and when the well is resting on a sloping rock surface.

(f) Use of divers for sinking: When dewatering is not possible and the use of pneumatic equipment for sinking is uneconomical, divers can be deployed for the removal of obstruction or clearing the strata.

1068 PNEUMATIC SINKING OF WELL

(1) Pneumatic sinking is used when other methods are not found feasible, particularly when the wells have to pass through considerable depths of intervening layers of rock or when the bed is full of large boulders or interlocked small boulders. This method may be employed for depths varying from 12 to 33 m.

(2) The inside of the well is made into a closed air tight box chamber and all water from this chamber is expelled out by letting in compressed air. The pressure of air inside the chamber should be maintained at approximately 0.12 kg/cm^2 above atmospheric pressure per meter depth below water level.

The dredging operation may be carried out inside the chamber in near dry condition. The compressed air arrangements are then removed and sand filling etc. of the well are completed

as for the open dredging.

The working chamber must be practically air and water tight and yet there must be an opening for men to enter and leave the chamber, as well as an inlet and outlet for materials. These opening are provided with vertical shafts and air locks.

(3) Precautions while working in air lock chamber should be taken as detailed in IRBM para 426.

1069 FOUNDING THE WELL

(1) SETTLING THE WELL BY BLASTING

After loading the well as specified a small charge of one or two gelignite sticks of 50 gm each is exploded at the center of the well at the level of straight portion of cutting edge. The well should not go down by more than 25mm. If it goes down, the necessity of further sinking should be examined.

(2) DRESSING THE BOTTOM OF THE WELL

(a) As far as possible, the well shall be evenly seated on sound rock devoid of fissures, cavities, etc.

(b) One or more cylindrical holes may be made in the base to give good anchorage to the well. Alternatively, anchorage can be provided by the rock itself which is allowed to remain projecting at the center.

(c) In shallow wells and wells resting on rock a few holes may be drilled and MS dowels fixed in them for providing a good bond between the base rock and the bottom plug.

(d) In case of sand overlaying steeply sloping rocky base below, it is preferable to bench the rock and take the well down to have a proper base. Where this is not feasible, a number of small wells or piles are sunk or driven through the sand till they penetrate into the base rock.

1070 BOTTOM PLUGGING OF THE WELL

Bottom plugging can be started immediately after the final sinking and dressing up of the bottom. Placing of concrete in plug can be perfectly done in dry condition or under compressed air. In either case the concrete is taken down in buckets or skip boxes whose bottom can be opened and closed by operating a wire rope from the winch. Another alternative is to place concrete through a tremie. When ingress of water is too heavy for pumping, concreting should be done first under dry condition (filled in gunny bags) all round below the cutting edge for plugging the water coming in, after which dewatering can be done and plug concrete placed in the middle.

1071 SAND HEARTING

Forty-eight hours after the completion of the concreting of the bottom plug, the well should be filled up with clean sand or sand and shingle or dredged sand not mixed with clay up to 1.5 to 1.75 m below the top of the well. It would be desirable to flood the sand with water for proper consolidation and then pump out the surplus water from the top.

1072 CONSTRUCTION OF THE TOP PLUG

The construction of the top plug should be started only after the sand filling has settled thoroughly and tested by ramming.

1073 SETTING OUT OF THE PIERS ON THE TOP OF WELL

The center line of the bridge as also of the well should be marked on the top plug of the well. Any shifting of the well should thus be ascertained and the capping slab built on the center line of the bridge.

SUBSTRUCTURE

1074 GENERAL

Though the main dimensions and choice of spans are largely determined by functional and economic considerations, proper proportioning of the various elements of a bridge (i.e. height, width and length of piers, length of spans etc.) is also important. Variations within reasonable limits should be allowed for in design to enable proper proportioning of the bridge.

The loading of substructure should be as per para 2.3.2 of Bridge Rule.

The size of piers and abutments depends on the construction materials used. For masonry abutments, a front batter of 1 in 12 to 1 in 10 is used. A flatter slope or stepping are provided in the rear as per design requirements.

When piers/ abutments are mass cement concrete or reinforced cement concrete, preference to RDSO standard drawing should be given.

When the ground is dry, construction of piers and abutments will not require any special arrangement. For their construction in water either coffer dams or temporary sheet piles may be used to divert the water.

Bearing areas for members shall be finished to true plane so as to give uniform bearing on the entire area. Bearing plane shall be horizontal even for the bridges on grades.

For concrete piers /abutments, horizontal construction joints shall be avoided as far as possible, by pouring the entire required concrete in one operation. Construction joints shall not be permitted in splash zones.

In case of tall piers and abutments, use of slip form 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 subjected to additional specifications as necessary. All specifications and arrangements for use of slip form and placing of concrete therein shall be subjected to the approval of the Engineer.

The top surface of foundation/well cap/pile cap over which new concrete is to be laid, 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.

1075 ABUTMENTS

The length of abutments at the top shall normally be equal to the formation width.

The width at the top shall be sufficient to accommodate not only the bearings, but also to carry ballast walls. It shall also be sufficient to provide adequate thickness of masonry or concrete beyond the bearings to resist diagonal shearing.

Where pier type abutments are provided without wing walls and return walls, the earth fill around the abutment shall be protected by providing properly designed stone-pitching on the slopes and apron at the toe of the fill.

For masonry abutments, a front batter of 1 in 12 to 1 in 10 is used: a flatter slope or stepping are provided in the rear as per design requirements.

In abutments, weep holes should be provided at vertical intervals of 1 m and horizontal intervals of 1 m in a staggered manner. Behind the abutment and wing walls boulder filling and back fill material should be provided for the full height. The boulder filling should not be less than 600 mm thickness. The back-fill material should consist of granular material of GW, GP, SW groups as per IS 1498 and should be free of clay and cement.

1076 PIERS

The length of piers shall be sufficient to provide proper seating for the girders. The width at the top shall be sufficient not only to accommodate the bearings of the girders, but shall also provide sufficient masonry or concrete on the outside of the bearings to resist diagonal shearing.

Where necessary, piers shall be provided at both ends with suitably shaped cut waters which shall extend up to at least 1 m above high flood level, including afflux.

Masonry piers are provided with a batter varying from 1 in 24 to 1 in 12. Their width at the top is determined keeping the minimum space required for seating of the bearings of girders as also to provide sufficient distance on the outside of the bearings to resist diagonal shearing.

1077 WING WALLS

The abutments can either be of the conventional type with the front face exposed or of the buried type when waterway requirement is not the main consideration. In the former case, wing walls are necessary to retain the slopes of the approach banks. Wing walls can be of the splayed, straight, square or 'box' type.

Butt joints should be provided between wing walls and abutment, wing walls and return walls and for the various tracks, when the bridge is for more than one track to cater for differential settlement in case of poor soils.

Wing and return walls also require provisions of weep holes as in abutments.

1078 BED BLOCKS FOR ABUTMENTS AND PIERS

In girder bridges where concentrated loads are transmitted to the substructure, bed blocks of proper design shall be provided on the top of the piers and abutments under the bearings to ensure proper distribution of the superimposed loads over the whole length of the abutment or pier. Such bed blocks may be reinforced cement concrete.

PART D
BRIDGE SUPERSTRUCTURE

1079 COMPONENTS OF PSC STRUCTURE

Critical items of PSC superstructure are prestressing steel/cable, sheathing, anchorage arrangement, these are dealt in detail in following para. PSC structures can be pretensioned or post tensioned. The main activities involved in posttensioned PSC construction are arrangement of soffit bed, placement of reinforcement, insertion and profiling of cable duct, erection of anchoring and shuttering arrangement, concreting, stressing and grouting.

1080 CONSTRUCTION SEQUENCE WITH TIME LINE

Construction activities in PSC may follow a defined timeline. Construction sequence along with time line may be shown in the approved drawing. A sample time line of activities is shown in Table 10.20

TABLE 10.20

CONSTRUCTION SEQUENCE WITH TIME LINE

SN	Description of Activities	Time (Days)
1.	Preparatory activities for casting of PSC work	
2.	Casting of girder (excluding end bracket, slab and diaphragm etc.) in situ or in casting yard.	
3.	Stressing and grouting of first stage cables.	
4.	Release of soffit shutter, transporting and launching of precast girders over piers, if required.	
5.	Casting of slab and diaphragms.	
6.	Stressing the second stage cables including emergency cables (if required) and grouting of second stage cables.	
7.	Casting of end bracket and sealing of anchorages with approved mix design concrete.	

1081 QUALITY ASSURANCE PLAN (QAP) FOR MATERIAL FOR PSC STRUCTURE

A sample QAP for materials required for construction of PSC structure are given in Table 10.21.

1082 CONSTRUCTION RECORDS FOR PSC STRUCTURE

Following record be maintained for PSC work in addition to records maintained for RCC work:

(1) Sheath passing and profile record

(2) Prestressing steel record

(3) Stressing record

(4) Anchor record

(5) Grouting record

1083 CONSTRUCTION MATERIAL FOR PSC

The provision of construction materials for RCC structures as mentioned in Para 4, 5 & 6 of Concrete Bridge Code (CBC) and Part-B of this chapter shall also be applicable for PSC works unless otherwise specified. Specific materials required for PSC work are dealt in the following para.

TABLE 10.21

QUALITY ASSURANCE PLAN (QAP) FOR MATERIAL FOR PSC STRUCTURE

SN	Process/Component Description	Characteristic to be checked	Frequency & Type of check	Reference document	Witnessing/ Inspecting Authority	Record Type	Acceptance Criteria	Remarks
1	2	3	4	5	6	7	8	9
(i)	HTS wire	(i) Tensile Test (ii) Test for Proof Stress (iii) Reverse Bend Test (iv) Elongation after Fracture (v) Test for Relaxation (vi) Chemical composition. (vii) Diameter tolerance	From each lot, number of coils to be selected as per Table 2 of IS 1785 Part-1 Cl-8. From each coil one sample to be selected for testing from NABL approved Lab.	(i) MTC (Manufacturer's Test Certificate) (ii) NABL Test Certificates	(i) Railway supervisor to conform Identification mark with MTC/Challan for each lot. (ii) Railway supervisor/ representative to witness the test to ensure that correct specimen is tested. (iii) Railway Supervisor/ representative to review the test results/ certificates.	(i) MTC (ii) NABL test report/ certificates (iii) Quality Control Check List	As specified in following or other specified codes. (i) IRS CBC (ii) IS: 1608 (iii) IS: 1785 (iv) IS:14268 (v) IS :1343	All material supplied should be supported by relevant MTC.
(ii)	Strands	(i) Tensile test (ii) Proof load test (iii) Elongation Test (iv) Relaxation test (v) Breaking strength	One sample from every 5 coils. Sample Size should not be less than 2 from each lot. Additional one sample is to be taken for proof test. IS 14268 Cl-7.					
(iii)	Sheathing Ducts	(i) Workability Test (ii) Transverse Load Rating Test (iii) Tension Load Test (iv) Water Loss Test (v) Relaxation test (vi) Breaking strength	As per IS: 1343 B.-3.1 Sample Size should not be less than 3 from each lot (length Not exceeding 7000 m) Test should be conducted as per Appendix B of IRS-CBC	Test Reports	(i) Railway to depute representative to witness the test to ensure that correct specimen is tested. (ii) Railway Supervisor to review the test results/ certificates.		As specified in following or other specified codes. (i) IRS CBC (ii) IS :1343	
(iv)	Mechanical anchorages	**A-Static load Test** (i) Relative force and time dependent displacement. (ii) Deformation of the anchorage components. (iii) Elongation of the tendon on free length up to failure. (iv) Measured ultimate force.	One complete set of Tendon anchorage assembly (C-1.1 & C-2.1 IS 1343)					

SN	Process/Component Description	Characteristic to be checked	Frequency & Type of check	Reference document	Witnessing/ Inspecting Authority	Record Type	Acceptance Criteria	Remarks
1	2	3	4	5	6	7	8	9
		(v) Location and mode of failure. **B-Dynamic Load Test** (i) Longitudinal and transverse concrete strains (ii) Formation, width and propagation of cracks (iii) Measurement of (iv) deformation of anchorage components (v) Location and mode of failure.						
v)	Grouting Material	(i) Material Test on – (a) Water (b)Cement (c)Sand (d) Admixture (ii) Compressive strength (iii) Mixing of Grout	(i) Sample selection of each material to be done in accordance to RCC in reference to IS 456, IS 1343 and IRS CBC.	(i) MTC/ Challan (ii) Test Report	(i) Railway to depute representative to witness the test to ensure that correct specimen is tested. (ii) Railway Supervisor to witness the test and get it reviewed by executive. (iii) Mixing of grout should be done in accordance to Annexure D of IRS CBC witnessed by Railway Supervisor.	(i) TC/challan (ii) Material passing register for each item in separate. (iii) Cube test register for compressive Strength.	As specified in following or other specified codes. (i) IRS CBC (ii) IS: 456 (iii) IS: 1343	(i)All material supplied should be supported by relevant MTC. (ii) Annex. D of IRS CBC to be referred for grouting operation.

1084 PRESTRESSING STEEL

The prestressing steel shall be any of the following:-

(a) Plain hard-drawn steel wire conforming to IS: 1785 (Part-I).

(b) Indented wire conforming to IS 6003.

(c) Uncoated stress-relieved strand conforming to IS: 6006.

(d) High tensile steel bars conforming to IS: 2090.

(e) Uncoated stress relieved low relaxation seven ply strands conforming to IS: 14268.

Note:

All prestressing steel shall be free from splits, harmful scratches, surface flaws, rough, jagged and imperfect edges and other defects likely to impair its use in prestressed concrete. (Clause 4.6.1.1 of IRS: CBC)

(1) Use of high-capacity tendons shall be preferred to avoid grouping and to reduce the number of cables. The prestressing steel and the suggested modulus of elasticity of steel used for the design of Prestressed concrete members shall as per **Table 10.22** (Ref. IRS-CBC Para 4.6):

TABLE 10.22

SUGGESTED MODULUS OF ELASTICITY FOR PRESTRESSING STEEL

Type of Steel	Modulus of Elasticity Es (KN/mm2)
Plain cold-drawn wires Conforming to IS:1785 (Part-I)	210
High tensile alloy steel bars Conforming to IS: 2090	200
Strands conforming to IS: 6006	195
Strands conforming to IS: 14268	195

(2) TESTING OF PRE-STRESSING STEEL

(a) All specified testing shall be done well in advance of the anticipated time of use.

(b) All strands to be transported to the site shall be assigned a lot number and tagged for identification purposes.

(c) All samples shall be representative of the lot and in the case of strand it shall be taken from the same master roll.

(d) At least 5 m long sample is selected from each lot for testing.

(e) Load vs. elongations of strand/ tendon will be required while stressing, therefore, the modulus of elasticity of each size and type of strand/ tendon shall be to determine prior to initial stressing.

(f) The modulus of elasticity shall preferably be determined by testing the samples of steel to be used for the construction. For details, para 4.6 of CBC may be referred.

(g) The test specimen shall be tensioned to 80 percent of ultimate, starting from 0 in 10 increments.

(h) For each increment, the gauge pressure, elongation and load cell force shall be recorded.

The data shall be furnished to the Engineer.

(i) The theoretical elongations shown on the post-tensioning working drawings shall be evaluated by the Contractor using the results of the tests and corrected as necessary.

(j) Revisions to the theoretical elongations shall be submitted to the Engineer for approval.

(k) Apparatus and methods used to perform the tests shall be proposed by the Contractor and be subject to the approval of the Engineer.

(l) Prestressing steel should confirm to quality control as per Table 10.21 and Table 10.23

TABLE 10.23

CHECKLIST FOR QUALITY CONTROL FOR PRESTRESSING STEEL

Name of work:

Name of Contractor / Agency:

Agreement No:

Span No:

Date of Inspection:

Location:

SN	Description	Yes/ No/NA	Action Taken	Remarks
(a)	Whether the reel of packaging is having proper marking, i.e., coil number, manufacturer, class, nominal diameter, etc.?			
(b)	Is the prestressing steel free from rough, jagged and imperfect edge?			
(c)	Is the prestressing steel free from loose rust, oil, grease, tar, paint, mud or any other deleterious substance?			
(d)	Is the steel supplied free from harmful scratches?			
(e)	Is the prestressing steel free from splits and surface flaws?			
(f)	Is the type (Plain, Strand) & nominal diameter etc. conforming to the approved drawing?			
(g)	Are the Breaking load & elongation within tolerances as per IS 1785?			
(h)	Is the chemical composition of Prestressing steel within acceptable limits?			
(i)	Is the storage of prestressing steel done at proper location so as to avoid direct contact with ground surface and away from damp walls?			
(j)	Is the Test certificate from manufacturer for each coil available?			
(k)	Are the wires supplied are self-straightening when uncoiled?			
(l)	Whether all the prestressing steel are cut to appropriate length and trimmed at the ends, by suitable mechanical means?			

Contractor Representative Railway Representative

(3) SUPPLY AND STORAGE OF PRESTRESSING STEEL

(a) The packing of prestressing strand shall be removed only just prior to making of cable for placement.

(b) Suitable stands shall be provided to facilitate uncoiling of strands without damage to steel. Care shall be taken to avoid the possibility of steel coming into contact with the ground.

(c) All prestressing steel shall be free from splits, harmful scratches, surface flaws, rough, jagged and imperfect edges and other defects likely to impair its use in prestressed concrete.

(d) The prestressing steel shall be supplied in coils of sufficiently large diameter and shall be self-straightening when uncoiled.

(e) For straightening/ bending (if required) bar-bending machine shall be used and temperature shall not be less than 10°C. Bars bent in threaded portion shall be rejected.

(f) In no case, heat shall be applied to facilitate straightening or bending of prestressing steel.

(g) Tendons of any type that are damaged, kinked or bent shall not be used.

(4) HANDLING THE PRESTRESSING STEEL

(a) Prestressing steel 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.

(b) All cutting to length and trimming of the ends of prestressing steel shall be done by suitable mechanical cutters.

(c) Prestressing steel shall be continuous over the entire length of the tendon. However, for joining, couplings may be used. Welding shall not be permitted in prestressing steel.

(d) Prestressing tendons shall be accurately located and maintained in position as per drawings. The permissible tolerance in the location of the prestressing tendon shall be ±5mm.

(e) Tendons shall be so arranged that they have a smooth profile without sudden bends or kinks. In all prestressed members there shall be sufficient gaps between the tendons or bars to allow movement of the largest size of aggregate during compaction by vibration.

(f) Para 7.2 of CBC may be referred for details related to prestressing tendons.

1085 SHEATHING

(1) The sheaths shall be in as long lengths as practical so as not to be dented or deformed during handling and transporting. The sheathings shall be in mild steel however, as an alternative, HDPE sheathings may be used subject to its being cost effective as compared to metal sheathing.

(2) TESTING OF SHEATHING

(a) All specified testing shall be done well in advance of the anticipated time of use.

(b) The manufacturer shall furnish a test certificate conforming the sheath supplied having

the requirements as per tests specified in Appendix-B and B1 of IRS CBC.

(c) Additional acceptance tests for the prestressing systems employing corrugated HDPE sheathing shall cover tests as per IRS CBC Appendix-B-1.

(d) Sheaths should confirm to quality control as per Table 10.21 and Table 10.24.

TABLE 10.24

CHECK LIST FOR QUALITY CONTROL FOR SHEATHING

Name of work:		Name of Contractor / Agency:		
Agreement No:		Span No:		
Date of Inspection:		Location:		
SN	**Description**	**Yes/ No/NA**	**Action Taken**	**Remarks**
(a)	Whether the sheaths supplied are dented or deformed during handling and transporting?			
(b)	Whether the diameter of the sheathing is confirming to approve drawing?			
(c)	Whether the Test certificate from the manufacturer for each coil kept in record?			
(d)	Are the suitable spacers provided at 1.0 m c/c to maintain cable profile?			
(e)	Whether joints of all sheathings are water-tight?			
(f)	Whether all the temporary openings in the sheathing are satisfactorily plugged?			
(g)	Is the tensile load test as per B-6 of IRS-CBC done and results are satisfactory and acceptable?			
(h)	Is the Water Loss Test – as per B-7 of IRS-CBC done and results are satisfactory and acceptable?			
(i)	Is the Bond Test – as per B-1-1 of IRS-CBC done and results are satisfactory and acceptable?			
(j)	Is transverse load rating test as per B-5 of IRS-CBC done and results are satisfactory and acceptable?			
(k)	Is Workability test as per B-4 of IRS –CBC done and results are satisfactory and acceptable?			

(3) SUPPLY AND STORAGE OF SHEATHING

(a) The sheathings shall preferable be HDPE sheathing.

(b) Unless otherwise specified high-density polyethylene (HDPE) sheathing shall have the properties as Cl 7.2.6.4.2.4.1 of IRS CBC.

(c) Tolerances for duct diameter and its thickness is given in Table 10.25.

(d) The sheaths shall be in as long lengths as practical so as not to be dented or deformed

during handling and transporting.

(e) Sheathing shall confirm to the quality requirements as per Table 10.21 and **Table 10.25**

TABLE 10.25

TOLERANCES FOR HDPE DUCT

SN	Internal Diameter of Duct (mm)	Minimum Wall Thickness of Duct (mm)	Tolerance for Duct Diameter (mm)	Tolerance for Wall Thickness (mm)
1	50	2.0	±1 % or ± 1 mm, whichever is greater	-0/+0.5 mm
2	85	2.5		
3	100	3.0		
4	125	4.0		

(4) HANDLING OF SHEATHING

(a) Sheathing shall be placed in correct position and profile by providing suitable ladders and spacers.

(b) Suitable spacers should be provided at 1.0 m c/c to maintain cable profile.

(c) The method of supporting and fixing shall be such that profile of cables is not disturbed during vibrations, by pressure of wet concrete, by workmen or by construction traffic.

(d) Sheathing shall be tied rigidly with such ladders/spacer bars so that they do not get disturbed/ lifted up during concreting.

(e) The joints of all sheathings shall be water-tight. Special attention shall be paid to the junction at the anchorage end, where the sheathing must tightly fit on the protruding trumpet end of anchorage and thereafter sealed preferably with adhesive water proof tape as per approved manufacturer. The sheathing and all joints shall be water tight.

(f) 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.

(g) Sheathing shall be neatly fitted at joints without internal projection or reduction of diameter.

(h) Type of sheathing to be used may be noted from reference drawing and only the same type of sheathing should be used.

1086 ANCHORAGES

(1) The anchorage system in general comprises the anchorage itself and the arrangement of tendons and reinforcement designed to act with the anchorage.

(2) TESTING OF ANCHORAGES

(a) Anchorage shall conform to quality assurance as per Table 10.21 and Table 10.26.

(b) The anchorage should be verified before putting in use for its compliance with the requirements laid down in Cl: 7.2.6.4.3.2 to Cl: 7.2.6.4.3.6 of IRS CBC.

TABLE 10.26

CHECK LIST FOR QUALITY CONTROL FOR ANCHORAGE ASSEMBLY

Name of work:		Name of Contractor / Agency:		
Agreement No:		Span No:		
Date of Inspection:		Location:		
SN	**Description**	**Yes/ No/NA**	**Action Taken**	**Remarks**
(a)	Whether all bearing surfaces of the anchorages cleaned prior to concreting and tensioning?			
(b)	Is the anchoring device capable of holding more than nominal slip?			
(c)	Whether the anchor cones, blocks, and plates are securely positioned and fastened for concreting?			
(d)	Is the anchoring device strong enough to resist in all respects a force equal to at least the breaking strength of the pre-stressing tendon it anchors?			
(e)	Whether the anchorages have provision for the introduction of a suitable protective medium, such as cement grout, for the protection of the pre-stressing steel?			
(f)	Whether the anchorages are safe and secure against all possible loads?			
Contractor Representative		Railway Representative		

(3) SUPPLY & STORAGE OF ANCHORAGES

(a) The anchorage system in general comprises the anchorage itself and the arrangement of tendons and reinforcement designed to act with the anchorage. All bearing surfaces of the anchorages shall be cleaned prior to concreting and tensioning.

(b) The anchoring device shall be strong enough to resist in all respects force equal to at least the breaking strength of the prestressing tendon it anchors.

(4) HANDLING OF ANCHORAGE

(a) Anchorages shall be handled and used strictly in accordance with the manufacturer's instructions and recommendations. Anchor cones, blocks, and plates shall be securely positioned and maintained during concreting such that the center line of the duct passes axially through the anchorage assembly.

(b) Where embedded anchorage is provided, its spacing, reinforcement details, concrete strength, cover, and other dimensions shall conform to the manufacturer's specification/ specialized literature.

(c) The anchorages shall be recessed from the concrete surface as per drawings.

1087 GROUT

(1) Purpose of grouting is to provide permanent protection to the post-tensioned steel against corrosion and to develop a bond between the prestressing steel and the surrounding structural concrete via sheathing.

(2) TESTING FOR GROUT

(a) Grout shall conform to quality assurance as per Table 10.21 and Table 10.27.

(b) Tests on material i.e., Water, cement, sand, and admixture should be done as per guidelines stipulated in IRS CBC.

TABLE 10.27

CHECKLIST FOR QUALITY CONTROL FOR GROUTING

Name of work:		Name of Contractor / Agency:		
Agreement No:		Span No:		
Date of Inspection: Location:				
SN	**Description**	**Yes/ No/NA**	**Action Taken**	**Remarks**
(a)	Is the water being used free from impurities & conforming to clause 4.3 of IRC-CBC?			
(b)	Whether the duly approved Ordinary Portland Cement used for preparation of the grout?			
(c)	Is the internal diameter of duct more than 150mm?			
(d)	Is sand used only for the case where the internal diameter of the ducts exceeded 150 mm?			
(e)	Is the sand used conforming to IS: 383?			
(f)	Whether approval of the engineer- in- charge taken for the use of admixture?			
(g)	Whether acceptable admixtures conforming to IS: 9103 and clause 4.4 of IRS CBC are used?			
(h)	Whether there are any traces of oil applied to steel for preventing corrosion removed before grouting operation?			
(i)	Whether the Grout Agitator, Water Pump & Grout Pump available at site are in working condition? Whether the hand-mixing of grout permitted?			
(j)	Is compressive strength test of grout sample conducted in advance to ascertain the suitability of the mix?			
(k)	Is Grout Screen available at site?			
(l)	Whether grouting activity is taken up at moderate temperature timing and temperature is below 40 degrees Celsius?			

(m)	Whether the care is taken to avoid leaks from one duct to another at joints of precast members?			
(n)	Whether the projecting portion of vents is cut off after completion of grouting and the face is protected to prevent corrosion?			
(o)	Whether in case of stage prestressing, cables tensioned in the first stage did not remain un grouted till all cables are stressed?			
(p)	Whether Appendix D of IRS CBC referred before commencing grouting operation?			
Contractor Representative		Railway Representative		

(3) HANDLING AND APPLICATION OF GROUT

(a) It is not recommended to use sand for grouting of prestressing tendons. In case the internal diameter of the ducts exceeds 150 mm, use of sand may be considered.

(b) Chemical Admixtures conforming to IS: 9103 and Cl: 4.4 of IRS Concrete Bridge Code may be used with the approval of the engineer- in- charge.

(c) Grout pump, water pump and grout screen shall be available at site before commencing grouting activity. Hand mixing shall not be allowed in any case.

(d) Grouting shall be carried out as early as possible, but not later than one week of stressing a tendon.

(e) Any traces of oil if applied to steel for preventing corrosion shall be removed before grouting operation.

(f) All outlet points including vent openings shall be kept open prior to the commencement of injection of grout.

(g) Grouting activity should be carried out as per recommendations given in Cl: 9.0 of IRS-CBC.

1088 STAGE-WISE CONSTRUCTION ACTIVITIES IN PSC WORK

(1) PREPARATORY ACTIVITIES FOR CASTING OF PSC WORK

(a) Preparation of pre-stressing bed/ soffit shutter -

(b) Prestressing steel shall be used carefully as per in para 1085. Prestressing steel shall be of adequate quality and Quality Control Proforma for prestressing steel Table 10.23 shall be complied with before using it.

(c) Providing Jacking end/anchorage end on both sides of the pre-stressing bed.

(d) Reinforcement fixing and placing.

(e) The high-strength steel tendons are pulled between two end abutments prior to the casting of concrete.

(f) Quality Check for any loose tendons, cable profiling, anchorage zone, etc.

(g) Fabrication and fixing of shutters.

(2) ACTIVITIES DURING CONCRETING OF PSC WORK

(a) All activities of concreting shall be done as per Part B of this Chapter or as specified.

(b) Care is to be taken to avoid both honeycombing as well as bleeding of concrete. Concrete shall be thoroughly compacted, para: 8.3 of IRS CBC should be referred for compaction of concrete.

(c) Curing should be done in accordance with para: 8.4 of IRS CBC.

(3) STRESSING AND GROUTING OF CABLES

(a) Steps for Pre-stressing of cables is given in Para 4 below.

(b) Apply zero correction and check the required pressure and elongation.

(c) After stressing is over lock the wedges with a wedge seating device.

(d) Release the pressure in the jack slowly.

(e) Grouting activity shall be done carefully as per para 1088 above. Grout shall be of adequate quality and Table 10.21 and 10.27 shall be complied with, before using it.

(4) STRESSING OF CABLES (Ref. IRS Concrete Bridge Code Cl: 7.2.6.5)

Stressing of cables is a specialized activity requiring site calculations & decisions and therefore shall be carried out in supervision of experienced technical personal only. Stressing activity can be elaborated in following steps:

(a) Preparatory Activities for Prestressing

(i) Noting down data from drawing

i. Note elongation of each cable for both ends along with pulling force (usually both ends have equal elongation but in special layouts, these may be different).

ii. Note diameter & modulus of elasticity of prestressing steel being used.

iii. Note actual Grip length of cable.

iv. Note down jack efficiency, ram area of jack, theoretical jack force.

v. Sometimes, ram area of jack is given along with pressure. If a jack of different ram area is to be used, corresponding pressure need to be worked out.

(ii) Working out correction

i. Correction for Area and Modulus of elasticity of strand.

ii. Correction for change in grip length.

iii. Correction for change in ram area of jack.

(iii) Fixing of bearing plate and wedges.

(iv) Fixing of jacks at each end of cable.

(v) Fixing of master wedges.

(vi) Removal of slackness

i. Any slack in the prestressing tendon shall first be removed by applying a small initial tension.

ii. This shall be taken as the starting point for measuring the elongation and a correction shall be applied to the total required elongation to compensate for

the initial tensioning of the wire.

iii. The extent of correction shall be arrived at by plotting on a graph the gauge reading as abscissae and extensions as ordinates; the intersection of the curve with the Y axis, when extended, shall be taken to give the effective elongation during initial tensioning and this effective elongation shall be added to the measured elongation.

(vii) Re-fix master wedges after removal of slack.

(viii) Calculation of theoretical modified elongation:

i. Calculate modified elongation of cable and jack pressure

ii. Calculate elongation at 20%, 40%, 60%, 80%, 90%, 95%, 100% and 105% of jack pressure.

(b) Activities during Prestressing

(i) Jack pressure to be applied in incremental stages to apply prestressing force. Both elongation and jack pressure shall be measured during prestressing. The variation between the two measurements should be within 5%. If the variation of two measurements exceeds 5% then:

i. the cause shall be ascertained

ii. the cable should be released and re-stressed.

iii. even then, if the variation does not come within 5% then the cable is to be rejected.

(ii) Para 7.2.6.5 of IR Concrete Bridge Code shall be followed for further detail.

(iii) After prestressing is achieved, the cable is locked and release the jacks, note down cable retraction giving wedge set. This should not be more than wedge set specified in drawing.

(c) Activities after Prestressing

(i) Observe cable for slow slip for next 24 hours.

(ii) If no slip is observed, grout the cable. Grouting shall be done as per para 1088 above.

(iii) Complete with trimming of strands using grinder followed by capping of end cones.

(5) TRANSPORTATION AND STORAGE OF PSC UNIT

(a) Members shall be transported in an upright position.

(b) Points of support and the direction of reactions with respect to the girder shall approximately be the same during transportation, and storage as when the girder is placed in final position.

(c) 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.

(d) Further, inclined side supports shall be provided at the ends and along the length of a precast girder to prevent lateral movements or instability.

(e) Care shall be taken during storage, hoisting and handling of the precast units to prevent their cracking or being damaged.

1089 STEEL SUPERSTRUCTURE

(1) In IR steel superstructure used are:

(a) Plate girders for span up to 30.5m,

(b) Open web girders for 30.5m and above and

(c) Steel composite girders.

Only Railway superstructures have been mentioned.

Fabrication of these structures is done in RDSO approved workshops to ensure good quality of the welded structure as per para 1214 of this manual.

(2) For ensuring quality in fabrication Quality Assurance Plan (QAP) is prepared by the Fabricating Agency as per para 1203 of this manual stating the details of raw material and testing, details of welding procedures, welders and testing requirements to ascertain the quality of welds, sequence of activities that will be carried out during fabrication, and submitted to Executing Agency.

(3) The QAP document also contains the details of role and responsibilities of the officials of the agencies involved in the fabrication of the girder and ensuring the quality of the fabricated components. This QAP shall be approved as per para 1203 of this manual.

(4) After the QAP is approved the Fabricating Agency prepares Welding Procedure Specification Sheet (WPSS) containing the parameters for achieving required weld size and quality. Similarly, Welding Procedure Qualification Record (WPQR) is also prepared for approval of welder. Both the documents (WPSS & WPQR) shall be prepared and approved as per para 1214 of this manual. The fabrication must be carried out as per the approved WPSS involving only the qualified welders as per WPQR.

(5) The internal quality control team of the fabricator is responsible for inspection of various activities on day-to-day basis and maintaining the record in the inspection registers for various stage inspections involved in fabrication as detailed in Chapter 12 of this manual.

(6) After inspection of a fabricated component by the internal quality team and carrying out the rectification as required, the Inspecting Agency is invited for final inspection duly submitting the 'four points' certificate as mentioned in Chapter 12 of this manual.

(7) After detailed inspection of the superstructure and its components for the quality the Inspecting Agency clear it for dispatched for erection at site.

(8) The details of fabrication process and related document are available in Chapter 12 of this manual.

1090 LOAD TEST (Ref. IRS Concrete Bridge Code Cl: 18.1)

(1) The load deflection testing for RCC and PSC are intended as a check where there is doubt regarding serviceability or strength. Load deflection test to be done as per provision mentioned in para 18 of IRS concrete bridge code.

(2) If steel plate, open web girder and composite girders is fabricated for the first time in Zonal Railway, then to validate the design and drawing the load deflection testing may be done as per "BS:128 (R2) Guidelines for carrying out load deflection test of steel plate & open web and steel-concrete composite girders". If the span is already being used in any Zonal Railway (i.e., span being used for the second or subsequent time) and fabrication work is inspected

and passed by RDSO, FIU of Zonal Railway or any other third-party inspecting agency engaged with the approval of CBE of Zonal Railway, load deflection testing is not required.

PART E
BRIDGE BEARINGS

1091 BRIDGE BEARINGS

(1) MANUFACTURE AND QUALITY CONTROL

(a) Provision of jacking points shall be made during the design/ construction of the superstructure.

(b) Consultation with the bearing manufacture shall be done at an early stage of the bridge design to avoid the hassles of reinforcement fouling with bearing dowels.

(c) Provision of the bearings in the structure shall be so made so as to have the least chances of dust & dirt accumulation and also spoilage from rain water seepage that may affect their performance.

(d) Quality assurance plan (QAP): Standard QAP for elastomeric, POT-PTFE bearing and suggested QAP of spherical bearings are given at Table 10.33, 10.34 & 10.35 respectively.

(e) QAP of rocker & roller bearings: Open Web Girder's drawing sets should include the drawings of Rocker & Roller bearings. Quality assurance plan and manufacturing activities of these bearings are as follows:

(i) Procurement of raw material

i. Plates- Steel shall be Grade B0 quality conforming to IS: 2062-2011.

ii. Roller- The steel for pins and rollers shall be conforming to IS: 2004 (Class 3 steel) and USFD test shall be conducted to ensure freeness from internal flaw, as per in para 9 of IRS B1.

iii. While ordering the steel, allowances for machining and distortion correction shall be considered for thickness of plates in addition to negative rolling tolerance as per IS:1852.

(ii) Cutting: Cutting can be done with oxy- acetylene flame with PUG cutting machine or any other suitable semi-automatic/ automatic machine. Cutting edges shall be at right angles. Cutting and machining allowances shall be considered while cutting plates.

(iii) Machining: Before fitment of components- Fix end Ribs, bottom plates and Knuckle plates shall be machined for proper fitment.

(iv) Manufacturing of Knuckle: Knuckles are shape as semi-circular solid and are turned out of plates. Two plates are rough machined in nearly semi- circular shapes. These two halves are tacked together and turned to perfect cylindrical shape as a unit. When end tacks are removed by grinding, it gives two knuckles. Saddles are rectangular solid having semicircular bore.

RPM of lathe machine during knuckle turning and saddle boring shall be kept within limit to avoid separation of plates while working on it.

(v) Manufacturing of Saddle: Saddles are also manufactured out of plates. Two plates are machined with rough semi-circular bore. They are fastened as a single unit with

clamping fixture. This pair is bored on lathe machine as a single unit. After removing the clamping fixture, it gives two saddles.

(vi) Manufacturing of Rollers: Rollers are manufactured by turning on lathe machine with finishing cut by emery paper for smooth surface.

(vii) Dimensions of link bar is important for limiting excessive movement of rollers.

(viii) Welding: Fixtures are used to align and hold parts in position during fitment. Root gap is eliminated before tack welding is done in fitment fixture. Welding is multi-pass runs and of short length. Manipulator is a must for this type of welding as it gives flat position for SMAW welding. Pre-heating and inter-pass temperatures shall be maintained during welding. Welding sequence is paramount important to minimize distortion. Electrodes of low hydrogen type are used to avoid hydrogen embrittlement. DPT of welds is carried out for tack weld and each pass of welds. Every effort shall be made to minimise welding distortion.

Post welding machining is must to eliminate distortion due to welding, such as, fixed end bottom plate may warp up due to welding. Smooth level surface can be obtained by removing excess material from bottom side of bottom plate by machining. Knuckle plate of expansion end may also be corrected similarly. Saddle and knuckles may also get distorted while welding of knuckle with knuckle slab and saddle with saddle plate. The surface matching of knuckle and saddle is ensured by 'blue matching' method. In this method contact points are identified by wet colour patches and eliminated by hand scrapper till more than 90% of surfaces are in contact. Blue matching/ machining is time-consuming but an essential manual process that requires skilled manpower. Therefore, necessity of surface matching by 'blue matching' method shall be written in drawing.

Overall height of bearing is a critical dimension. It is maintained by removing excess material from saddle plate by machining after all fabrication activities are completed.

(ix) Drilling: Holes for turned bolts and anchor bolts shall be made as per para 18.3 of IRS B-1. It should be 1mm under drilled in shop and reamed at site to suit the diameter of turned bolt and anchor bolts. This shall be given in drawing. Drilling shall be done after welding to cope up with shrinkage. It shall be ensured that holes are at right angles to bottom of bottom plates and top of saddle plates.

(2) INSTALLATION OF BEARING (Ref. IRC 83)

(a) Handling and storage

(i) Upon receipt of the bearings at site, there shall have a visual examination of the bearings to ensure that no damage or displacement of the bearing components is taken place during the transportation.

(ii) The transportation clamps shall be intact when bearing is received and shall not be removed until bearing is placed in position and fixed.

(iii) Bearing should be stored properly giving due care to save it from dust and rain.

(iv) Lifting and handling should be done taking proper protection and avoiding any unnecessary damage to the bearings.

(v) Care should be taken to avoid any rectification or re-assembly, if situation so arrived it shall be done strictly in the presence of the manufacturer's representative or in their plant.

(b) Installation at site

(i) Bearings shall preferably be installed at annual mean temperature (tm), truly horizontal with top and bottom components of the bearings parallel to each other, unless otherwise stated. Bearing may be preset, so that it will not shear at tm, if installation temperature is other than tm as per advice of OEM or bearing designer.

(ii) A joint inspection of client, contractor and representative of bearing manufacturer should be done prior to installation of bearing. It is preferable to install bearing in the presence of representative of OEM.

(iii) Location marking on pedestals/ bed blocks

i. Bearing locations shall be marked along/ across relative to the center line of girder.

ii. Special care is to be exercised if the bridge is in curve or in skew, to cater for the eccentricity.

(c) Level, slope and dressing of pedestals/ bed block surface

(i) The level of pedestals/ bed blocks shall all be as per approved drawing and within ±1.5 mm, otherwise suitable rectification shall be done.

(ii) It is desirable to have smooth surface finish for better seating of bearings.

(iii) The pedestal shall be perfectly level under the bearing within variation of 1 in 500.

(iv) Slope of pedestals/ bed blocks shall be as per the design, variation up to 1 in 1000.

(v) The portion of surface projected above, the required top level of bed block/ pedestal, shall be ground and finished to the required level, care shall be taken that the reinforcement cover is not affected.

(vi) The portion of surface below the top level of bed block/ pedestal shall be made good by appropriate bedding material.

(vii) It is preferable to place bearing on thin bedding material instead of directly placing on matured concrete, however, selection of bedding material depends on type and size of bearing, loading on bearing, method of installation of bearing, construction sequence, early loading, strength and setting time of bedding material, gap to be made good, friction requirements, access to the bearing, condition of surface around the bearing area, shrinkage of the bedding material etc. as appropriate.

(viii) To ensure even loading on bearings and the supporting structures, it is essential that any bedding material whether above and below the bearing, extend over the whole area of the bearing. Improper application of bedding material, below and above the bearing, i.e., voids, gaps, impurity etc. may attribute to failure of the bearing irrespective of the quality of the product.

(d) Checking holes for holding down bolts

(i) The location of the holes left in concrete shall be checked for position with template matching holes in bearing to ensure that the holding down bolts can be inserted with sufficient gap all around.

(ii) Proper care shall be ensured to avoid any fouling of reinforcement in the pedestal with holding down bolts.

(iii) Adequate space should be available above a pedestal during lowering process of bearings, enabling physical inspection and easy insertion of holding down bolts into designated holes, to ensure secure attachment and proper alignment.

(iv) Holding down bolts, initially separate from the bearing, can be positioned and fixed before lowering of bearing and subsequently fastened together with the bearing.

(e) Preparation of underside of girder

(i) The checking of undulations on underside of girder shall be done with 200 mm long straight edge and any variation beyond ±1 mm shall be rectified similar to rectification of bed block/ pedestal as above.

(ii) The holes/ bolts provided in girders for providing bearings shall be checked with suitable templates to verify their positions

(iii) If girder is proposed to be cast in situ, the shuttering plates for geometry and scaffolds for support need to be inspected carefully to ensure that the final girder profile matches that of bearings.

(f) Placing of bearings

(i) Each Bearing should be specifically and distinctly marked indicating its movement direction relative to traffic direction and each bearing pedestal too should be similarly marked and cross checked before placing the bearing.

(ii) The hard wood packing shall be removed and bearings shall be inserted at proper position. The center lines in either direction shall be marked on the bearing as well as on bed block to serve as guide. Accuracy of marking shall be within ±1.5 mm with respect to drawings. Bearings must be placed at true plan position of their control lines marked on receiving surfaces (max. Tolerance ±3 mm).

(iii) After the bearing is aligned at proper location, bolts connecting the bearing to the girder shall be provided/ tightened duly confirming the sliding direction with drawing.

(iv) The marking along and across the central line of the girder shall be clearly done at the respective center of side faces of bearing top/bottom with paint or suitably engraved to serve as reference for inspections. Similar marking shall be made on the soffit of the girder as well as top of the bed block/ pedestal.

(v) Bearings and its components shall be checked for any dust, dirt or cement slurry deposit etc. and the surrounding area shall be cleaned thoroughly once the process of bearing installation is finished.

(vi) The temporary/ transportation clamps attached to the bearing must remain in place until the bearings are correctly installed, anchored and grouted. The clamps shall be removed just before the girders are subjected to service load.

(vii) Drainage shall be ensured by providing slope away from bearing in all directions. (Bearing shall rest on flat horizontal surface).

(viii) When replacing bearings in existing girders, all bearings in one line of support shall be replaced together.

PART F
LAUNCHING OF SUPERSTRUCTURE

1092 LAUNCHING / ERECTION OF SUPERSTRUCTURE

(1) FACTORS INFLUENCING LAUNCHING/ ERECTION METHOD

(a) The following factors generally influence the suitability of a particular launching/ erection method:

(i) Particulars of Bridge and Spans

i. Length, width, height, & weight of girder

ii. Number and type of spans

iii. Height and width of piers and abutments

iv. Skew or square span

(ii) Site Conditions

i. Type of gap, wet, dry or partly dry

ii. Height of gap

iii. Depth of water, velocity and liability of river to spates or floods

iv. Condition of approaches- high or low banks or cuttings

(iii) Access to Site

i. Road, rail or water access

ii. Availability of bridging equipment and bridging materials

(2) COMMON LAUNCHING/ ERECTION METHODS

(a) The following common methods and/or their combinations can be adopted for launching/ erection of new span and regirdering of existing bridges. The launching scheme shall be approved by concerned Chief Engineer of the project (ref. para 20.5 of IRS-B1).

(i) Launching with the help of derricks

(ii) Launching by side slewing method

(iii) Launching by use of crane

(iv) Launching by gantries

(v) End launching without/ with launching nose

(vi) Erection by cantilever method

(b) Launching/erection scheme of bridges having special methods such as using beam launcher, tidal energy/barge, ropeway etc. Shall be finalised in consultation with expert consultants/RDSO.

(3) PRELIMINARY ARRANGEMENTS BEFORE LAUNCHING

(a) Collection of site particulars-

(i) Site conditions should be studied and relevant facts such as cross sections of the rivers, HFL, LWL, bed level, bank level, history of flash flood and weather conditions, available approach length etc.

(ii) In case of rail over rail (rail flyover) requirement of block vis-à-vis normal availability should also be assessed. A good launching scheme is one which is easily implementable.

(b) Development of launching scheme

(i) Each launching/erection scheme is to be designed for each work separately based on the actual site conditions.

(ii) Relevant codal provisions for Dead load, SIDL, Wind load, Crane loads and Dynamic effect of crane/trolley etc. shall be considered. The scheme shall define method statement for site fabrication, erection sequences, weight & location of erection equipment. Design of falsework & other temporary components, erection stresses & strengthening of the permanent steelwork, erection stability & bracing of critical components, erection check measurements that may be needed, span closing and swinging operations etc. design of all the temporary foundations for erection/ launching shall be done for all anticipated loads. The design and drawing details of each structural component or permanent member affected due to erection/ launching scheme should also be approved.

(iii) It is important to note that the design provisions contained in IR Steel Bridge Code are intended to be applied to the superstructure of simply supported span up to 100m between center of the bearings. Therefore, the provisions of these codes shall be adopted with care for larger spans and for fixity at supports/ continuity and other intermediate or special conditions. For cantilever launching/ erection schemes involving handling of multiple spans supported on numerous points, the deflection of cantilever is substantially higher compared to simply supported conditions and may induce large secondary forces. These schemes also change the level of stresses & their nature during erection/launching as compares to stresses during normal loading. Special erection methods will require approved erection drawings (ref. para 34.6 of IRS-B1).

(iv) The erection/ launching scheme shall be based on detailed stage-wise, member-wise, joint-wise stress-strain analysis versus capacity and demand calculation for structural integrity. Correct estimation of handing & erection loads shall be made and accuracy shall be ensured in the design, manufacture, and erection of every part of the work to ensure proper fitment (ref. para 13.1 of IRS-B1).

(v) In addition to erection/ launching scheme, Lifting and slinging methods shall be designed and submitted by the agency and approved by the engineer (ref. para 21.8 of IRS-B1).

(vi) The erection/ launching scheme should introduce sufficient degree of redundancy in the structure to withstand failure of a few members/ joints during erection/ launching without causing catastrophic collapse of the structure.

(vii) The design and scheme of erection/ launching method should be revalidated/ proof checked by engaging a third-party designer/ consultant having excellent experience in this field, then approved by competent authority. The proof-checking shall be based on the drawings/ methodology but without access to the design calculations submitted by initial agency for designing of the launching/ erection scheme.

(viii) Continuous monitoring through instrumentation shall be incorporated in the scheme to ensure the correct degree of fixity/ movement of structure as a whole in longitudinal/lateral direction. Support reactions and rotation along the longitudinal axis shall also be monitored. The launching scheme shall indicate the limits to raise alarms to alert/stop any further activity of launching. The scheme shall also stipulate required rectification thereafter.

(ix) Temporary Arrangement Drawing (TAD) shall be approved based on the conceived erection/ launching scheme and after confirming the feasibility as per actual site conditions. The reduced level of top of the bearing should be as per GAD and clearly mentioned in the TAD. All the structural load bearing components like stools and its connections with each other and with bed block and with bearing to be properly checked at site. The approved design and drawings shall be in conformity with proposed erection/ launching scheme.

(c) Selection of crane for erection [Railway Board's Letter No. 2015/CE-IV/RUB/206 dated 15.02.2016 (Ref. 10.03)].

(i) No machine shall be selected to do any lifting on a specific job until its size and characteristics are considered against the weights, dimensions and lift radii of the heaviest and largest loads. A factor of safety of 1.5 shall be ensured at the most adverse lifting situation with respect to heaviest load proposed to be lifted.

(i) The contractor shall ensure that a valid Certificate of Fitness is available before use of Road Cranes. Contractors can utilize the services of any competent person as defined in Factories Act, 1948 and approved by Chief Inspector of Factories.

(ii) The laminated photocopies of fitness certificate of crane issued by competent person, manufacturer's load chart, the operators' photo and competency certificate for crane shall always be either kept in the operator cabin or pasted on the visible surface of the lifting appliances.

(iii) All lifting appliances including all parts and gears thereof, whether fixed or movable shall be thoroughly tested and examined by a competent person once at least in every six months or after it has undergone any alterations or repairs which may affect its strength or stability.

(iv) Fitness certificate of crane and authorization certificate of crane operator should be ensured before commencement of work. Installation of Crane track shall be as per approved drawings and inspected & certified by a competent official.

d) General precautions while launching/ erection

(i) Foundations of temporary staging to be kept on firm ground without any water logging.

(ii) Fabrication inspection of all the temporary members, link members, link props, pins etc. being used in the erection/ launching scheme shall be ensured by engaging suitable third-party fabrication inspection agency like RITES/ CEIL/ WRI/ KRCL based upon the approved structural drawings of these members.

(iii) Only parallel barrel drifts shall be used in erection. No reaming is allowed without written authority. Oversized rivets may be used only after approval (ref. para 20.2 of IRS-B1).

(iv) Cylindrical drifts and turned bolts shall be used to withstand stresses arising from the special method of erection, no reliance is to be placed on service bolts (ref. para 20.4 of IRS-B1). However, once joint/ member is erected and likely to take load, no holes shall be left without bolt whether needed or not, must filled with turned bolts and fully tightened.

(v) The responsibility for the execution of the work in all respects lies with the contractor (ref. para 2.1 of IRS-B1).

(vi) The contractor must ensure that the parts at the site are available in sequence (ref. para 6.1 of IRS-B1).

(vii) All lines and levels provided by the engineer shall be carefully preserved by the contractor (ref. para 7.1 of IRS-B1).

(viii) All concerned must be advised about the method to be followed and the equipment to be used before the start of the work (ref. para 21.3 of IRS-B1).

(ix) Periodical inspection of erection accessories and machinery shall be conducted by the contractor (ref. para 21.5 of IRS-B1). It is desirable that the representative of executing agency shall be associated.

(x) Frequent checking of deflection of nodes and recording shall be maintained in a register (ref. para 34.8 of IRS-B1).

(xi) Lifting gear/slings/ropes with evidence of cuts, excessive wear, distortion or kinks shall be discarded. Avoid using wooden blocks with round surfaces.

(xii) Ensure moving path of girder/heavy members shall be clear of any obstructions.

(xiii) Avoid use of heavily corroded perforated/ pitted C. C. Cribs trestles for staging.

(xiv) There should be adequate surveillance 24 X 7 by CCTV in different angles so as to capture each and every activity along with the time-stamping. The designer of launching scheme shall keep a vigil on the launching operations to ensure its conformity w.r.t. approved method statement.

(xv) Drones should be utilized to capture the image of all the joints and connections which are normally not reachable by the supervisors or engineers. These images shall be time-stamped, submitted by the fabrication/ erection/ contracting agency's authorized engineers and scrutinized and commented by authorized representative of Railway.

(xvi) Any rectification shall again be captured and matched with the comments as above. These footages shall be preserved in soft copy as well as in hard copy till the erection/ launching activities are completed.

(xvii) The executing agency and their site staff shall periodically be sensitized about violating the prescribed methodology & precautions and adverse implications of violations.

(xviii) Periodic safety drills for using safety gears such as helmets, waist slings, industrial boots, gloves etc. shall be carried out/planned.

1093 LAUNCHING WITH THE HELP OF DERRICKS

(1) SUITABILITY

(a) Substructure of low height

(b) Less number of spans

(c) Smaller spans

(d) Low girder weight

(2) METHOD

Derrick is erected for lifting/ lowering of girder, its stability is ensured by attaching sufficient number of wire rope guys.

(3) PRECAUTIONS

(a) Sufficient number of wire rope guys are tightened from the crown plate to anchorages

(b) The winch is located and anchored at a suitable place.

(c) One girder at a time to be handled duly positioning and slinging with the help of suitable winch and wire rope pulleys or chain pulley block.

(d) Rigidity of anchorages and capacity of lifting tackles, knots and fixtures, etc. should be ensured.

1094 LAUNCHING BY SIDE SLEWING METHOD

(1) SUITABILITY

(a) Height of bridge is up to 4-5m

(b) Firm ground support

(c) Sufficient gap between the adjacent lines

(2) METHOD

Temporary staging is provided on both the sides of old girder for supporting & slew in of new girder and slew out of old girder.

(3) PRECAUTIONS

(a) Place girder safely on temporary staging on wooden support with proper level to avoid any movement due to vibrations.

(b) Check & ensure proper functioning of:

(i) Pulling equipments like rope pulley, chain pulley, tirfor etc. for pulling activity.

(ii) Rolling/ sliding arrangement for slewing activity. Sliding surfaces should be smooth, properly greased & free from rust.

(iii) Jacking arrangement for lifting & lowering operations.

(c) To control movement/ stopping the girder, a rope may be tied at the rear end of the girder and released gradually as it moves in the desired direction.

(d) Roller alignment shall carefully be maintained during rolling operation to prevent deviation in girder movement.

(e) Avoid placing of steel girders directly on metal surfaces to prevent slippage.

(f) Avoid placing the first layer of C.C. Cribs directly on the ground else it will result in

settlement/ tilting of temporary staging.

(g) Avoid using rusted/ pitted rails and fish plates for sliding to minimize friction.

(3) CHECKLIST FOR LAUNCHING BY SIDE SLEWING METHOD

TABLE 10.28

Name of work:	Name of Contractor / Agency:			
Agreement No:	Span No:			
Date of Inspection:	Location:			
SN	**Description**	**Yes/ No/NA**	**Action Taken**	**Remarks**
1	Approved launching scheme is in place.			
2	Necessary testing of cables, ropes, pulleys, tirfor, jacks etc. done.			
3	Rolling/sliding arrangements checked and found satisfactory.			
4	Fixing of rope to arrest uncontrolled movement of girder during sliding is in place.			
5	Arrangement to monitor roller alignment during launching is in place.			
6	All the sliding surfaces are smooth, properly greased and free from rust.			
Contractor Representative		Railway Representative		

1095 LAUNCHING BY USE OF CRANE

(1) SUITABILITY

(a) This method is suitable for launching of steel plate/ PSC girders

(b) Substructure height around 10m

(c) Site accessibility for crane

(d) Firm and stable ground to support the crane

(e) Sufficient space for placement of crane,

(2) METHOD

Crane is used for lifting, placement and lowering of girders.

(3) PRECAUTIONS

(a) A detailed plan indicating crane and girder positions for erection shall be prepared and used to mark the final position of girder. Capacity of the crane shall be calculated duly considering obstruction to free movement of hanging girder as per the plan. Maximum lifting (working) radius of the crane shall be worked out from the plan. The lifting points on the load (girder or a dismantled piece) should be stipulated on the drawing. Required boom length and angle shall be worked out from sectional details e.g., level of crane and girders.

(b) Girder weight shall be worked out from the approved drawings. Total weight to be handled by crane can be calculated by adding weight of track structure if any and weight of lifting accessories e.g., sling, lifting girder etc. to girder weight.

(c) Consider factor of safety for load calculation i.e., 1.5 times the actual load to be handled at site. [RBs Letter No. 2015/CE-IV/RUB/206 dtd. 11.08.2016 (Ref. 10.04)].

(d) Select suitable crane out of available crane in the market based on above data, i.e., working radius, boom length, boom angle and weight to be lifted, factor of safety etc. as above.

(e) After finalizing the crane, again check the plan for its placement in detail ensuring grounding of its outriggers on firm ground. Grounding on weak soil or on slope will cause settlement of outrigger and it may result in tilting/ toppling of crane.

(f) If due to any reason the selected crane is needed to be place at different location, then all the earlier calculations for working radius, boom length shall be re-checked to ensure that revised load carrying capacity of the crane is 1.5 times of the load to be handled at required working radius and boom length.

(g) Crane shall have load chart indicating safe working load at various radius of operations (Load Chart), Limiting switch, Boom light, swing horn, flashing beacon. Safe Working Load (SWL) prominently displayed on the crane body. This SWL shall never be exceeded.

(h) Operators shall not leave Cranes/ lifting equipment unattended with power on or with a load suspended.

(i) When more than one crane is required to lift or lower the load, the Lifting shall be in tandem and arrangements shall be such that none of the cranes be loaded beyond its SWL or be rendered unstable in the process of lifting or lowering the load. A competent person shall be specially appointed to co-ordinate the operation of the cranes working together.

(j) Before actually commencing the work near the track, trial at site shall be done by actually lifting the heaviest segment to be tackled with required boom length and required operating radius. Once, the trial is successful, then only the crane shall be brought to the site of actual work.

(k) It should also be ensured that there is no obstacle in the swing area of the crane.

(l) No crane or any lifting equipment should be loaded beyond safe working load (SWL).

(m) Crane should not be used for lifting of materials during heavy winds, rains and/or bad weather which may endanger its stability.

(n) Crane should not be used in proximity of live OHE or live electric power supply lines

(o) Crane should not be used to pull out fixed objects.

(p) Once a girder leaf is lifted and placed over pedestal location, immediate arrangements to secure the girder from toppling should be made.

(q) Once second adjacent girder is also launched, the two girders should be tied together with the help of Cross Bracings etc. in sufficient numbers to ensure that both leaves can act as one unit and can restrain each other from toppling.

(r) This process should be repeated till the last leaf and every subsequent girder should be secured as described above.

(4) CHECKLIST FOR LAUNCHING BY USE OF CRANE

TABLE 10.29

Name of work:	Name of Contractor / Agency:			
Agreement No:	Span No:			
Date of Inspection:	Location:			
SN	**Description**	**Yes/ No/NA**	**Action Taken**	**Remarks**
1	Approved launching scheme is in place.			
2	Necessary certifications regarding crane carrying capacity, load charts calibration etc. available.			
3	Valid competency certificate for the train operator is available.			
4	Necessary testing for cables, ropes, pulley and other arrangement done.			
5	Ground locations marked for placement of crane, props etc. are firm. In case of weak ground necessary ground improvements have been done.			
6	Person to coordinate the operation of multiple cranes has been identified and informed to all concerned.			
7	Before commencing of work trial lifting done.			
8	It has been ensured that there are no physical obstructions in the swing area of the crane.			
9	Non-occurrence of heavy rains, heavy winds, bad weather etc. checked.			
10	Proper scheme of securing the already erected girder from toppling is in place.			
11	Arrangements for fixing cross bracings etc. with the adjacent leaf are in place.			
12	It has been checked that crane is not working in the vicinity of OHE, live electric power line or transformer etc.			
Contractor Representative		Railway Representative		

1096 LAUNCHING BY GANTRIES

(1) SUITABILITY

(a) Re-girdering of steel plate girders and open web underslung type girders.

(b) Sufficient space is required on pier/ abutment for erection of gantry portal.

(c) When staging on river bed is not feasible due to excessive pier height or river bed cannot support the temporary staging and/ or water is flowing with high current.

(2) METHOD

In this method, the gantry portal is taken up to the pier/ abutment location by plying material lorry on existing track. The portals are erected on pier/ abutments. New girder along with track is taken to the location on span by material lorry. The new girder is lifted and hanged on the portals. Now material lorries, track structure and bracings of old girder are removed. Next the leaves of old girder are widened to make space for lowering of new girder. After lowering of new girder in this space track is linked and gantry portals are removed & shifted with the help of material lorries.

(3) PRECAUTIONS

(a) Track lifting may be required depending upon difference in combined height of track and girder of new and existing girder after girder replacement, necessary arrangements will be needed to provide suitable slope.

(b) Ensure firm ground support for new girders which are stacked adjacent to track.

(c) Girders should not be placed directly over metal surface. Metal to metal contact reduces friction and tends to slip.

(d) Place girder safely on material lorries. Keep the new girders ready with complete track structure and lifting bracket/ sling.

(e) Ensure firm support to gantry portal and fix it into pier/ abutment by suitable anchoring arrangements.

(f) Ensure proper fixing of lifting/lowering arrangement (i.e., chain pulley block) of appropriate capacity on gantry portal with the help of sling.

(g) Avoid contact of slings with sharp edges, by protecting it, with cut pieces of pipes etc.

(h) Check & ensure proper functioning of pulling and lifting/ lowering equipment's like rope pulley, chain pulley blocks etc. for pulling activity.

(i) Ensure smooth, rust-free contact surfaces of fish plates, rollers & rails etc. whichever is applicable for free movement of girder.

(4) CHECKLIST FOR LAUNCHING BY GANTRIES

TABLE 10.30

Name of work:	Name of Contractor / Agency:			
Agreement No:	Span No:			
Date of Inspection:	Location:			
SN	**Description**	**Yes/No /NA**	**Action Taken**	**Remarks**
1	Approved launching scheme is in place.			
2	Necessary checks to ensure of proper functioning of gantries, valid certificate of gantry and operator are ensured.			
3	Necessary checks to ensure of proper functioning of pulling and lifting/ lowering equipment's like rope, pulley, chain pulley blocks etc. is ensured.			
4	Test lift performed to assess the capacity of gantry and slings etc. before start of work.			
5	System for monitoring of gantry support during launching operations is in place.			
Contractor Representative		Railway Representative		

1097 END LAUNCHING WITHOUT / WITH LAUNCHING NOSE

(1) SUITABILITY

(i) New constructions

(ii) Open web through type steel girders

(iii) When staging is not feasible on river bed due to high pier height or the river bed cannot support the temporary staging or the water is flowing with high current.

(2) METHOD

This method is based on the principle of equilibrium of propped cantilever i.e., overturning moment is maintained less than restoration moment by suitable counter weight. In this method, three girders are tied together. The front girder acts as a launching nose and rear-most girder acts as counter weight. Launching will be carried out by pushing this entire assembly from bridge approach with the help of push/pull arrangements of winch and rollers for forward movement. If number of spans are less than three, then also the arrangement of launching nose and counter weight is necessary. Sometimes special arrangement may be required.

(3) PRECAUTIONS

(a) Wire ropes/cables/winch machines etc. should be tested and record regarding these should be kept before starting the launching operations

(b) Foundations of the trestles/winch machines, their fixing arrangements etc. should be well designed and approved.

(c) General arrangement and Structural drawings of trestles/ temporary arrangement

should be made and approved by the competent authority.

(d) Skidding Arrangement to be designed suitably as per the case and its anchoring with the longitudinal beams, should be ensured in all respect.

(e) Secure the girder safely on rolling points.

(f) Check & ensure proper functioning of:

(i) Pulling equipment like manual/ power winch.

(ii) Jacking arrangement for lifting & lowering operations.

(g) Ensure smooth, rust-free contact surfaces of fish plates, rollers & rails whichever applicable for free movement of girder.

(h) Maintain alignment of rollers during rolling operation to prevent deviation in girder movement.

(i) Ensure the girder moving path is clear of any obstacles.

(j) The rear end of girder shall be tied with a rope and gradually released as it moves in the desired direction to control unusual movement of the girder. The support to which rope is tied should be well anchored into the ground.

(k) Care should be taken while lowering these girders to their final positions. Lowering should be done at a slow pace and in steps. Jacks used should be tested. Any sudden jerk should be completely avoided.

(4) CHECKLIST FOR END LAUNCHING WITHOUT/ WITH LAUNCHING NOSE

TABLE 10.31

Name of work:	Name of Contractor / Agency:			
Agreement No:	Span No:			
Date of Inspection:	Location:			
SN	**Description**	**Yes/ No/NA**	**Action Taken**	**Remarks**
1	Approved launching scheme is in place.			
2	Necessary checks to ensure of proper functioning of rope, pulley, cables, jacks, winch machine, etc. are ensured.			
3	The fabrication and placement of all the temporary arrangements like trestles, stools, connection elements etc. is done as per approved structural drawing/scheme.			
4	Arrangement for securing the girder from uncontrolled movement is in place.			
5	All the sliding surfaces are smooth and free from rust.			
6	Arrangement to monitor roller alignment during launching is in place.			
7	Exact scheme for lowering of girder at slow pace and in steps is in place and a system to monitor the same is there.			
Contractor Representative			Railway Representative	

1098 ERECTION BY CANTILEVER METHOD

(1) SUITABILITY

(a) New constructions

(b) Open web through type steel girders.

(c) When staging on river bed is not feasible due to high pier height, river bed cannot support the temporary staging, water is flowing with high current.

(2) METHOD

This method is based on the principle of equilibrium of propped cantilever i.e., overturning moment is maintained less than restoration moment by suitable counter weight. An anchor span is first erected (Fig. 10.01) and with the support of it, subsequent spans are erected **(Fig. 10.02)**. The anchor span and cantilever span are connected with the help of temporary links and buffer blocks. Crane will be used to lift and hold the members for erection and joining with already erected members. The crane generally moves on a temporary track laid over the top chord.

Fig. 10.01 Erection of Anchor Span

Fig. 10.02 Cantilever erection of subsequent span

(3) PRECAUTIONS

(a) Planning of span arrangement/pedestals/seismic arrestors

(i) Launching of steel girders by cantilever method typically involves use of anchor spans supported over temporarily trestles etc. and terminating at a pier from where launching of cantilever span starts. Over such piers where last panel of anchor span and first panel of cantilever span is coming, planning of pedestal should be done in such a way that very high pedestals are avoided as it makes the whole temporary arrangement very vulnerable to even small unforeseen forces.

(ii) Careful planning is required specially where combination of composite girder/plate girder and open web girder is planned. As plate/composite girders have substantial depth in comparison to open web girder, there is substantial difference between the heights of pedestals below these two types of girders. Use of multilayer stools/ temporary arrangements is warranted in order to make up this difference.

(iii) If such an arrangement is unavoidable then casting of these pedestals should be planned after the launching of the intended girder in place. This will allow handling of these girders at much lower levels.

(iv) Similarly casting of seismic arrestors should be planned in such a way that it does not affect the launching operations and allows sufficient space for launching related

operations

(b) Launching and erection scheme

(i) Components and joints involve in anchor span/cantilever span should be checked for all incidental forces, wind forces etc. for each stage of launching. This applies to RDSO standard girders as well as non RDSO girders.

(ii) Launching and erection scheme should clearly contain various stages involved and such scheme should be approved by competent authority.

(iii) When there is high wind and heavy rain, work should be stopped.

(c) Temporary members

(i) Sometimes it becomes imperative to use temporary members in the launching and erection scheme. Detailed structural drawings of these members along with their connections should be made by the designer and approved by the component authority.

(ii) Fabrication inspection of these temporary members/connection elements should get done by engaging FIU (Fabrication Inspection Unit) or any specialized third-party fabrication inspection agency as already prescribed by Railway Board. Material used in fabrication of these temporary members should have proper record of material testing.

(d) Temporary elements

(i) A lot of temporary structural elements are used in the launching process like linking pins, link members, link props, buffer blocks, end bearing plates, temporary bearings, temporary top bracings connecting link members, stools etc.

(ii) Detailed structural drawings of these elements should be prepared and approved by the competent authority to avoid any ad-hoc arrangements in the field. In case of use of multi-tier stool arrangement, connection between different tiers should be properly designed and implemented.

(iii) Ultrasonic Flaw Detection Test (USFD) should be conducted for above mentioned temporary elements as many a times these are repeatedly used at multiple launching sites.

(e) Crane track

(i) Structurally stable crane track arrangement is a crucial part to achieve successful cantilever launching. Typically crane track is assembled with the help of temporary panels supported over the top chord of the girder.

(f) CRANE

(i) Necessary certifications regarding crane carrying capacity, load charts, calibration etc. should be arranged before deploying the crane for the work.

(ii) Necessary competency certificate for the crane operator should be ascertained before appointing operator to the job.

(iii) Necessary testing for cables, ropes, pulley and other arrangements should be done in advanced.

(g) Completeness of anchor span

(i) In order to achieve complete structural adequacy of the anchor span, it is necessary to fix all the secondary members like portal bracings, sway bracings, knee bracings, brackets, top lateral bracings, bottom lateral bracings along with their cover plates and connecting plates by providing full numbers of bolts as mentioned in approved structural drawings. Complete numbers of gusset plates and cover plates should be provided with complete numbers of bolts at all joints.

(ii) Any compromise in above mentioned item, may lead to compromise in torsional rigidity of the girder as a whole. This eventually reduces the capacity of the anchor span to handle unforeseen deflections, sways, differential settlement, if any etc.

(h) Temporary supports

(i) Design of all temporary supports like trestles and their foundations, stools etc. should be done and approval of the same should be obtained from the competent authority.

(ii) Foundations of temporary staging to be kept on firm ground without any water logging. The design of all the temporary foundations, involved during launching, is to be done with all anticipated loads and structural drawings of the same shall be approved by the competent authority.

(iii) Field check for ensuring that the erection of these temporary trestles is as per approved drawing, should be done at appropriate level.

(i) Connections

(i) During launching of a particular panel of the girder, preparation of joints to be made with maximum 40% of drift and rest with fitted turned bolts of grade, as specified in the design. Subsequently all the holes should be filled with Turn fitted bolts/HSFG bolts with same grade as specified in the design before going for launching of next panel. Drifts are used only for alignment of the holes and not for taking any load.

(ii) Mixing of types of bolts, at a joint and in girder as a whole, should be avoided. Provision of HSFG bolt, turn fitted bolts, drifts etc., in combination, should be avoided in all respects as their philosophy to carry the load are completely different. Before starting of the launching of cantilever span, it should be ensured that all the drifts from anchored span joints, have been replaced with bolts.

(iii) Erection scheme sequence and bolting sequence of each joint should be mentioned in the drawing by the designer. Grade of drift and bolts should be clearly mentioned in the drawing. Non/partial fixing of secondary members like bottom lateral bracing, top bracings, portal bracings, knee bracings and brackets/gusset plates/bolts/cover plates reduces the structural adequacy of the girder as-a-whole to resist accidental twists/wind effects and differential settlements at supports etc.

(j) Temporary bearings

(i) Top plate of temporary bearings should not be left unconnected with the bottom of girders.

(k) Records

(i) Each stage of the launching should be properly recorded in the form of documents,

videos, drone videos, high resolution photographs etc.

(ii) All the record related with material passing, fabrication inspection, approved drawings should be meticulously kept and maintained.

(iii) During the launching some control points should be earmarked on the girder and it is to be monitored using Total station. Any deviation from its proper location shall be captured and corrective action taken. Simultaneous monitoring through drones, should be carried out as it is not possible to see/inspect the top of the girders in position. High resolution photographs and videos should be made at each stage and preserved.

(l) Monitoring of deflections

(i) Designer should provide permissible values of deflections at each stage of launching at each panel point locations of anchor span as well as cantilever span.

(ii) The deflections should be monitored regularly and compared with design values. In case of discrepancy the same should be immediately reported to the higher authorities.

(iii) It is recommended that levels should be taken at three locations at every panel point, one in the middle of the cross girder and two at both ends.

(m) Monitoring the alignment

(i) Any misalignment of the girder with respect to center line of the bridge should be regularly monitored and kept in record.

(n) Lowering the girder in position

(i) Care should be taken while lowering these girders to their final positions. Lowering should be done at a slow pace and in steps. Jacks used should be tested. Any sudden jerk should be avoided at all cost.

(o) Certification to commence the work

(i) Design consultant of the launching scheme, site engineer of the company, SSE/ BRI and AXEN/ADEN should jointly certify that arrangements of the anchor span, bearings, stools, levels, structural members, number of bolts and its grade, joints, link members, pin, and buffer block are as per approved design and drawings of launching scheme before starting any launching operations.

(4) CHECKLIST FOR ERECTION BY CANTILEVER METHOD

TABLE 10.32

Name of work:
Name of Contractor / Agency:
Agreement No:
Span No:
Date of Inspection:
Location:

SN	Description	Yes/ No/NA	Action Taken	Remarks
1	Approved launching scheme is in place.			
2	Approved structural designs and drawings are available for all the structural elements involved like connecting pins, link members, buffer block, bearing plate, temporary bearings, temporary panel members etc. and the same are available at site in accordance with these approved drawings.			
3	USFD testing reports for temporary structural elements like linking pins, buffer block, bearing plate etc. are available.			
4	Structurally stable crane track arrangement as per approved drawing is in place.			
5	Necessary certifications regarding crane carrying capacity, load charts, calibration etc. are arranged.			
6	Necessary competency certificate for the crane operator is ascertained.			
7	Necessary testing for cables, ropes, pulley and other arrangements are done.			
8	All the primary as well as secondary members, all the necessary cover plates/gusset plates of anchor span are fixed as per approved drawings.			
9	All the joints of anchor span are prepared and completed as per approved structural drawings.			
10	Approved drawings are available for all the temporary structural elements like trestles, stools, temporary bearings etc. and the work has been executed as per these approved drawings.			
11	No drift is left anywhere in the anchor span before start of launching of next span.			
12	No mixing of turned fitted bolts and HSFG bolts is done at any joint of anchor span.			
13	If multiple layers of stools are used, fixing arrangement among them has been done as per approved drawings.			

14	Fixing of top plate of temporary bearing with the bottom of the girder has been done.			
15	System of recording successful completion of one stage of erection and clear orders for moving ahead to the next stage is in place.			
16	System of recording deflection of cantilever span regularly and its comparison with design values is in place.			
17	System of taking alignment along the center line of bridge regularly is in place.			
18	Approved scheme is available for systematic lowering of girder is in place.			
19	Necessary precautions with respect to working in electrified area have been taken.			
Contractor Representative			Railway Representative	

1099 SAFETY PRECAUTIONS IN ELECTRIFIED AREA

In case of electrified tracks, OHE is present requiring special safety precautions. Safety precautions in electrified area have been given in detail in para 282 to 290 of IRPWM. Some of the important precautions related to bridges are listed below for ready reference.

(a) No work shall be done within a distance of two meters from the live parts of the OHE without a 'permit-to-work'.

(b) No crane shall be worked except on the authorised 'permit-to-work'. In every case of working a crane, arrangement should be made for the presence of authorised overhead equipment staff to ensure that all safety precautions are taken.

(c) Steel tapes or metallic tapes with woven metal reinforcement shall not be used in electrified tracks. LASER distance meter and Linen tapes are safer and, therefore, shall be used.

(d) It is important to note that dangerous voltages may be induced in metallic masses such as fencing posts in the vicinity of traction conductors. To avoid possibility of shock due to such voltages, the metallic structures are required to be bonded and earthed.

(e) All electrical equipment, every power line or cable shall be regarded as being 'live' at all times.

(f) For work adjacent to overhead equipment the Engineering Inspector shall apply to the proper authority sufficiently in advance for sanctioning the traffic and power block required.

(g) Prior to issue 'permit-to-work' to the Engineering Inspector, The Traction Power Controller - through Traction Foreman - shall arrange to isolate and earth the concerned live electrified section.

TABLE 10.28
QUALITY ASSURANCE PLAN FOR ELASTOMERIC BEARINGS
(RDSO Letter no. CBS/PBEJ/Reg. Dated 28.02.2023) **(Ref. 10.05)**

1. Name of Manufacture: 2. Drawing. No.: .....
3. Name of Project/Railway: 4. Authority (CA No./LOA No./Order No.)

SN	Component Operation	Characteristic Checks & Tolerances	Frequency & Type of check	Reference Document	Fabricator's quality control	Inspection details		Type of Records	Acceptance criteria	Remarks
						Inspecting Agency	Extent of Inspection			
1	2	3	4	5	6	7	6	9	10	11
1.0	RAW MATERIAL Elastomer	Physical and Chemical Test	As per manufacturer certificate & test required by Authorized inspecting Official of Zonal Railway from Govt./ NABL approved lab	Manufacturer test certificate & Challan	Verification of Reference document.	Authorized inspecting Official from Zonal Railway	From patches at Random and at discretion of Inspecting official	Fabricators 'record.	IRC:83 (Part-II) & -referred documents	1. The elastomer used in the manufacture of Elastomeric Bearing should be either Natural Rubber (NR) or Chloroprene Rubber (CR) as the raw polymer. 2. Raw material must meet requirements given in Para 4 (Material) of IRC:83 (Part-II).
2.0	Mild Steel	Mechanical & Chemical Test UTS, Yield Stress, Elongation%, Bend test. Impact test at 0 degree centigrade or -20 degree for sub-zero zone, test for C, Mn, Si. P. S etc.	As per Mill TC & test required by Authorized inspecting official from of Zonal Railway from Govt./ NABL approved lab.	Mill TC and Challan	Verification of Reference document and Complete visual 'inspection	Authorized Inspecting official of Zonal Railway	One test niece per thickness per heat / at discretion of Inspecting official	Fabricators record Co-related with Quality Mill TC & test report.	IS:2062, E250. BO is generally used. However Quality C shall be used for subzero condition. (As specified in approved Drg.).	1. Laminates of mild steel conforming to IS:2062 / (a: 1079 or equivalent international grade shall be used. The yield stress of the material shall not be lesser than 250 Mpa 2. Uses of any other materials like fiberglass or similar fabric as laminates are not permitted. 3. Physical condition of raw material must be visually checked for Pitting.

									rusting, rolling defect etc. before use. 4. Corrosion protection of exposed steel surfaces, if any, shall conform to the requirement of relevant part covering corrosion protection of bearing plates. 5. 100 % Ultra Sonic Testing shall be conducted for 12mm & above thick plates as per provision of relevant specification (IS:4225 or ASTM A435) before processing the material for manufacturing.
								IRC 83 Part-II & as per approved drawing	1. All Bearing shall conform to the provisions in Clause 6 on manufacturing and workmanship and Table5: Manufacturing Tolerances of IRC:83 (Part-II) in all respects. 2. Internal reports shall be furnished which will be verified by Zonal Railway Inspector. However random check may be done by Zonal Railway inspector during Manufacturing. 3. Manufacturing process (any stage) shall be open to inspection by Railway inspecting official.
							Fabricators record.		
						At Discretion of Inspecting official			
					Manufacturer inspecting agency				
				Measurement of dimension					
			As per approved drawing						
		Visual & Measurement							
	Dimension and tolerances.								
	Manufacturing Process								
3.0									

4.0	Final inspection *(See Note below)*								
4.1	General Inspection	Dimensions of bearing as per specified tolerances.	Visual examination and dimensional check	As per relevant drg. & specificati on	Measuremen t of dimension	Authorize d inspecting officials from Zonal Railway	100%	Fabricato rs record & test report.	IRC 83 (Part-II) & referred documents	1. All Bearing shall conform to the provisions in Clause 7.9.1.1 of IRC:83 (Part-II) in all respects for Level 1 acceptance testing. 2. All Bearing shall conform to the provisions in Clause 7.9.2.1 of IRC:83 (Part-II) in all respects for Level 2 acceptance testing.
4.2	Chemical & Physical Test	Physical and Chemical Test.	As per manufacturer certificate & test required by Authorized inspecting Official of Zonal Railway from Govt./ NABL approved lab	Manufacturer Test Certificate & Challan	Verification of reference document.	Authorized Inspecting Official from Zonal Railway	From batches at Random/ Discretion of Inspecting official	Fabricators record.	IRC 83 (Part-II) & referred documents	1. Specially molded test pieces shall conform to the provisions in Clause 7.9.1.2 of IRC: 83 (Part-II) in all respects for Level 1 acceptance testing/ Level 2 acceptance testing. 2. Ozone resistance test shall be mandatory for all acceptance level. 3. Test certificate shall be furnished by manufacturers for level I acceptance/ Level II acceptance.
4.3	Load Test on complete bearings									
a)	Axial load test	Variation in stiffness	All bearing of the lot shall be tested.	As per relevant drg. and specification	Fabricators record.	Authorized Inspecting Official from Zonal Railway	100% In case of large lot	Fabricators record.	IRC 83 (Part-II) & referred documents	1. For both Acceptance Level 1 & Acceptance Level 2, all 100% bearings to be checked for axial load tests as per Clause 7.9.1.1 (C) of IRC:83 (Part-II)

b)	Shear Modulus test	Shear modulus by plotting shear stress strain curve	Load testing on test bearings.	As per relevant drg. and specification	Fabricators record.	Authorized Inspecting Official from Zonal Railway	Mandatory for Large lot and on discretion of Inspecting official for small lot	Fabricators record.	Referred documents (Ref. Para C.2.4 of IRC:83-2018 Pt-II)	1. Bearing to be checked as per Clause 7.9.2.3 of IRC:83 (Part-II) 2. The test result shall be deemed-satisfactory if shear modulus 'G' determined is within the tolerance limit of value specified in the main text in Table 2 of IRC:83-2018 Pt-II and provided there is no evidence of instability, defect or damage discovered by close inspection during the test.
c)	Compressive Stiffness Test	Compressive load deformation curve and compressive stiffness	Load testing on test bearings.	As per relevant drg. and specification	Fabricators record.	Authorized Inspecting Official from Zonal Railway	Mandatory for Large lot and on discretion of Inspecting official for small lot	Fabricators record.	Referred documents (Ref. Para C.3.4 of IRC:83-2018 Pt-II)	1. Bearing to be checked as per Clause 7.9.2.3 of IRC:83 (Part-II) 2. The test result shall be deemed satisfactory if the value of apparent compression stiffness determined from the deflection between 30 percent and 100 percent of the test load is within + 20 percent of the value specified by the manufacturer and no discernible defect is found by visual examination. The manufacturer should specify the value along with the submittal for acceptance testing program.

d)	Shear Test	Bond	Required adhesion between elastomer to steel laminate.	Load testing on test bearings for.	As per relevant drg. and specification	Fabricators record.	Authorized Inspecting Official from Zonal Railway	Mandatory for Large lot and on discretion of Inspecting official for small lot	Fabricators record.	Referred documents (Ref. Para C.4.4 of IRC:83-2018 Pt-II)	1. Bearing to be checked as per Clause 7.9.2.3 of IRC:83 (Part-II) 2. (a) Examine the test bearing for evidence of cracking or peeling both in the strained and unstrained state. After removal of the shear force the bearing should be examined visually, whilst still under the compressive load, and any bulges which could indicate bond failure should be noted. It may be necessary to cut the edge cover to confirm the presence of flaws arising from bond failure. (b) If neither of the test bearings shows evidence of peeling or separation at or near the interface between rubber and reinforcement layers and there is no sign of bond failure the test shall be deemed to be satisfactory.
4.4	Special Acceptance Inspection										
	TGA Method/ any other test as per Special Contract Agreement/ as per provisions in Clause 7.9.3 of IRC:83 (Part-II)		Special type of test (Other than test mentioned in clause 4.3)	As per manufacturer certificate & test required by Authorized inspecting Official of Zonal Railway from Govt./ NABL approved lab	As per special contract agreement	Fabricators record.	Authorized Inspecting Official from Zonal Railway	Discretion of Inspecting official	Test report from Govt./ NABL approve d lab	IRC 83 (Part-II) & referred documents	As per provisions in Clause 7.9.3 of IRC: 83 (Part-II)

Note:

1. For the purpose acceptance testing (Clause 7.9 of IRC:83- Part II), acceptance lots shall be classified as below: A lot size of 24 or larger number of bearings shall be defined as a large lot and a lot size of less than 24 bearings shall be defined as small lot. When the number of bearings for a project is large and phased production is permitted, bearing supplied in any one phase will be considered as a large lot.
2. The level of acceptance testing shall generally be graded into the following two levels depending on lot size: Level 1 acceptance testing and Level 2 acceptance testing. Acceptance testing level 1 is a higher-level inspection and shall be applicable to large lots. This level of inspection can be specified for small lots also as per the discretion of the Railway. This shall involve manufacture of extra bearings to be used as test bearing and eventually consumed in destructive testing. Acceptance testing level 2 shall be applicable in general for all lots, unless otherwise specified, and shall not involve any destructive testing of finished bearings.
3. Under load, bulging of the rubber layer between the reinforcing steel laminates on free exposed perimeter is a normal phenomenon and is not detrimental to the performance of the bearing unless any crack or evidence of bond failure is detected. (**Ref.** para 9.10 of IRC:83-2018 Pt-II)
4. Counter sunk bolts should not project beyond machined surfaces.
5. The bottom surface of the top plate and top surface of the bottom plate shall be vulcanized to elastomeric pad. Pasting/gluing of rubber to steel is not allowed.

TABLE 10.29

QUALITY ASSURANCE PLAN FOR POT-PTFE BEARINGS (Ref. 10.05)

1. Name of Manufacture: ..... 2. Drawing. No.: .....
3. Name of Project/Railway: ..... 4. Authority (CA No./LOA No./Order No.)

SN	Component Operation	Characteristic Checked	Frequency & Type of check	Reference Document	Fabricator's quality control	Inspection details		Type of Records	Acceptance criteria	Remarks
						Inspecting Agency	Extent of Inspection			
1	2	3	4	5	6	7	8	9	10	11
1.0 1.1	RAW MATERIAL: Cast Steel (CS)	Physical & Chemical Test UTS, Yield Stress, Elongation%, Reduction of Area, Impact test at 0 degree centigrade or -20 degree for sub-zero zone, Hardness test, Test for C, Mn, Si, P, S, Cr, Ni, Mo, Cu ,V etc.	As per manufacturer certificate & test required by Authorized inspecting Official of Zonal Railway from Govt./ NABL approved lab	Mill TC and Challan	1. Verification of reference document 2. Complete visual inspection 3. 100% Ultrasonic Testing before & after load Test.	Authorized Inspecting official of Zonal Railway	One integral Test piece per heat	Fabricator s record Co-related with Mill TC & test report.	Cast steel shall generally comply with Grade 340-570W of IS:1030/ (Grade/Class as per relevant approved Drg.).	1. Manufacturer's test certificate shall be furnished. 2. 100% UST shall be conducted before & after load test. Acceptance criteria shall be IS:9565 Level-III. 3. Cast Steel Material shall comply clause 4.1 and ANNEXURE-G of IRC:83 (Part-III) or Grade/Class mentioned in approved drawing.
1.2	Mild Steel	Mechanical & Chemical Test UTS, Yield Stress, Elongation%, Bend test , Impact test at 0 degree centigrade or -20 degree for sub-zero zone, test for C, Mn, Si, P, S, CE etc.	As per Mill TC & test required by Authorized inspecting official of Zonal Railway from Govt. Lab ./ NABL approved lab.	Mill TC and Challan.	Verification of Reference document and Complete visual inspection.	Authorized Inspecting official of Zonal Railway.	One test piece per thickness per heat/ at discretion of Inspecting official.	Fabricators record Co-related with Mill TC & test report.	Grade E350 BR (min.) of IS: 2062, shall generally be used. However Quality C of IS:2062 shall be used for subzero condition/ As specified in approved Drawing.	1. Manufacturer's test certificate shall be furnished. 2. 100% UST shall be conducted for plates. Acceptance criteria shall be IS:4225 are ASTM A435. 3. Physical condition of raw material must be visually checked for Pitting, rusting, rolling defect etc before use. 4. Mild Steel Material shall comply clause 4.1 and ANNEXURE-G of IRC:83 5. (Part-III) or Grade/clause mentioned in approved drawing.

1.3	Stainless Steel (S.S.)	Physical & Chemical Test UTS, Yield Stress, Elongation %, Hardness, Test for C, Mn, Ni, Cr, P, S, Si, Mo etc.	As per Mill TC & test required by Authorized inspecting official of Zonal Railway from Govt. Lab/ NABL approved lab.	Mill TC and Challan.	Verification of Reference document and Complete visual inspection.	Authorized Inspecting official of Zonal Railway.	One test piece per thickness per heat / at discretion of Inspecting official.	Fabricators record Co-related with Mill TC & test report.	Stain less steel shall conform to AISI 316 or AISI316L Or (Grade/class as per relevant approved Drg.).	Manufacturer's test certificate shall be furnished. Sample from each lot of S.S shall be drawn by authorize inspecting official and tested in Govt./NABL approved laboratory. Stainless Steel Material shall comply clause 4.1 and ANNEXURE-G of IRC:83 (Part-III) or Grade/clause mentioned in approved drawing.
1.4	PTFE	Mechanical and Physical Properties 1. Mass density 2. Tensile strength 3. Elongation at break 4. Ball hardness	per Mill TC & test required by Authorized inspecting official of Zonal Railway from Govt. Lab./ NABL approved lab.	Manufacturer test certificate & Challan	Verification of refere nce document.	Authorized Inspecting official of Zonal Railway.	Sample from each lot of PTFE material/ at discretion of Inspecting official.	Fabricators record.	IRC:83 (Part-III) and referred documents or as per relevant specification / approved Drg.).	1. Material shall be either poly tetra fluoro ethylene (PTFE) free sintered without regenerated material or any other material having requisite material strength and low frictional properties. 2. Pattern of dimple shall be as per Fig. 4 of IRC:83 (Part- III). 3. Manufacturer's test certificate shall be furnished. 4. Sample from each lot of PTFE shall be drawn by authorize inspector and tested in Govt./NABL approved laboratory. 5. PTFE material must comply the parameters given in Clause 4.2 of IRC:83 (Part-III).

1.5	Elastomer	Physical properties	As per manufacturer certificate & test required by RDSO/Auth orized inspecting official from Govt. lab./ NABL approved lab.	Manufacturer test certificate & Challan.	Verification of reference document.	Authorized Inspecting official of Zonal Railway.	From each batch at Random.	Fabricators record.	IRC:83 (Part-III) & referred document/ as per relevant test procedure.	1. The elastomer to be used for the component of bearing shall be made of Natural Rubber (NR) or Chloroprene Rubber (CR). 2. Raw material must meet requirements given in Clause 4.4 and ANNEXURE-G of IRC:83 (Part-III). 3. Manufacturer's test certificate shall be furnished.
1.6	Brass sealing Ring	Physical & Chemical properties	As per manufacturer certificate & test required by RDSO/Authorized inspecting official from Govt. lab./ NABL approved lab.	Manufacturer test certificate & Challan.	Verification of reference document.	Authorized Inspecting official of Zonal Railway.	One test pc for full lot of supply/ discretion of Inspecting official.	Fabricators record.	CuZn37/Cu Zn 40 as per IS:410 or CuZn37 or CuZn39 Pb3 of EN12163 & EN12164 respectively or Grade/class As per relevant approved Drawing.	1. Test certificate shall be furnished by manufacturer. 2. One sample for full lot of sealing ring supply shall be drawn by Authorized Zonal Railway inspecting official for testing in Govt./NABL approved laboratory. 3. Material must meet requirements given in Clause 4.5 of IRC:83 (Part-III).
1.7	Bolts & Nuts	Physical & Chemical properties	As per manufacturer certificate & test required by RDSO/Authorized inspecting official from Govt. lab. / NABL approved lab.	Manufacturer test certificate & Challan.	Verification of reference document.	Authorized Inspecting official of Zonal Railway.	As per relevant specification	Fabricators record.	IRC83 (Part-III) & referred documents Or Grade/class as per relevant approved Drawing.	1. Test certificate shall be furnished by manufacturer. 2. One sample for each lot of Bolts & Nuts supply shall be drawn by authorize inspecting official of Zonal Railway for testing in Govt./NABL approved laboratory. 3. Fasteners must meet requirements given in Clause 4.8 and ANNEXURE-G of IRC: 83 (Part-III).

2.0	Manufacturing Process									
2.1	Process Inspection	Dimensional inspection, NDT and visual inspection	Visual & Measurement	As per approved drawing	Measurement of dimension & Verification of reference document.	Authorized Inspecting official of Zonal Railway.	100 %	Fabricators record.	IRC 83 Part- III & as per approved drawing	1. Internal report shall be furnished; however, check shall be done in presence of Zonal Railway inspecting official. 2. Manufacturing tolerances and Manufacturing method of bearing shall confirm Clause 6.1 & Clause 6.2 of IRC:83 (Part-III) respectively. 3. The manufacturer should be able to establish the traceability of all major raw material (Annexure G of IRC:83 (Part-III) with procurement and consumption record and Mill Test Certificate/ material test report 4. Major metallic components as specified in Annexure G, shall be ultrasonically tested for soundness as per Level: 3 of IS: 9565 prior to use in bearings. 5. All welding shall be done by qualified welder on the basis of applicable WPSS and shall be in accordance to Clause 6.2.10 of IRC:83 (Part-III). 6. All structural welds shall be visually checked for weld size and location as per drawing as well as controlled as per the following tests: - Visual test (all structural welds) - Liquid penetration test as per IS: 822 (all structural welds) - All full penetration butt welds shall be controlled through ultrasonic testing as per IS 4260 / AWS D1.5 / ASME Section VIII.

2.2	Tolerance of fit between different component of bearing	Dimensional Inspection	Visual and measurement	As per relevant Drg	Measurement of dimensions & surface roughness.	Authorized Inspecting official of Zonal Railway.	100%	Fabricators record	IRC 83 Part- III	1. Inspection records to be furnished. However random checking may be done in-presence of inspecting authority of Zonal Railway. 2. Tolerance of fit between different component of bearing shall comply clause 6.1.4 of IRC:83 (Part-III).
2.3	Corrosion Protection	Surface preparation & protective coating system	Visual and measurement	As per drawing and relevant specification	Fabricators record & check.	Authorized Inspecting official of Zonal Railway.	100%	Fabricators record.	IRC-83 Part-III & referred document.	1. Surface preparation & protective coating system must be in accordance to clause 6.3 of IRC-83 Part-III. 2. Internal report shall be furnished. However, total DFT shall be checked randomly by inspecting authority of Zonal Railway.
3.	Inspection on finish bearing									
3.1	Dimensional Inspection	Over all Dimensional check of finished bearing	Visual and measurement	As per drg. and relevant specification	Fabricators record & check.	Authorized Inspecting official of Zonal Railway.	100%	Fabricators record.	IRC-83 Part- III	1. All bearings of the lot shall be visually inspected for absence of any defects in surface finish, shape or any other discernible superficial defects. 2. All bearings shall be checked for overall dimensions as per manufacturing tolerances specified in Clause 6.1 of IRC:83 (Part-III). 3. All bearings must meet requirements given in Clause 7.4.3 of IRC:83 (Part-III).

3.2	Load Test (a) Proof Load Test (b) Friction test (c) Rotation test	Load Testing parameters as per Clause 7.4.3 of IRC-83 Part-III	At least one or a pair of bearings (depending on the requirement) of each type and different vertical load capacity selected at random shall be load tested	As per relevant Drawing.	Fabricators record.	Authorized Inspecting official of Zonal Railway.	At least one or a pair of bearings	Fabricators record.	IRC-83 Part- III	1. All bearings must meet requirements given in Clause 7.4.3 of IRC:83 (Part-III). 2. Proof Load Test of bearings shall be done as per Clause 7.4.3.3.1 of IRC:83 (Part-III). 3. Friction Test of bearings shall be done as per Clause 7.4.3.3.2 of IRC:83 (Part-III). 4. Rotation Test of bearings shall be done as per Clause 7.4.3.3.3 of IRC:83 (Part-III).
3.3	Final Clearance Inspection	After load test bearing must be checked for condition of components	Visual and measurement and testing	As per relevant Drg. & specification	Measurement of dimension	Zonal Railway.	100%	Fabricators record.	IRC 83 Part- III	After load testing DP test and ultrasonic testing of bearings to be done for checking any damage during testing before final clearance.

Note:

(i) Firm should maintain traceability of raw material used for fabrication of every POT-PTFE bearing and the record should be made available to the inspecting authority on demand.

(ii) Certificate of elastomeric should not be older than 6 months.

(iii) Certificate of PTFE should not be older than 1 year.

TABLE 10.30: QUALITY ASSURANCE PLAN FOR SPHERICAL BEARINGS

1. Name of Manufacture: ..... 2. Drawing. No.: .....
3. Name of Project/Railway: ..... 4. Authority (CA No./LOA No./Order No.)

SN	Component Operation	Characteristic Checked	Frequency & Type of check	Reference Document	Fabricator's quality control	Inspection details		Type of Records	Acceptance criteria	Remarks
						Inspecting Agency	Extent of Inspection			
1	2	3	4	5	6	7	8	9	10	11
1.0 1.1	RAW MATERIAL: Cast Steel (CS)	Physical & Chemical Test UTS, Yield Stress, Elongation%, Reduction of Area, Impact test at 0 degree centigrade or -20 degree for sub-zero zone, Hardness test, Test for C, Mn, Si, P, S, Cr, Ni, Mo, Cu ,V etc.	As per manufacturer certificate & test required by Authorized inspecting Official of Zonal Railway from Govt./ NABL approved lab	Mill TC and Challan	4. Verification of reference document 5. Complete visual inspection 6. 100% Ultrasonic Testing before & after load Test.	Authorized Inspecting official of Zonal Railway	One integral Test piece per heat	Fabricator s record Co-related with Mill TC & test report.	Cast steel shall generally comply with Grade 340-570W of IS:1030/ (Grade/Class as per relevant approved Drg.).	4. Manufacturer's test certificate shall be furnished. 5. 100% UST shall be conducted before & after load test. Acceptance criteria shall be IS:9565 Level-III. 6. Cast Steel Material shall comply clause 4.1 of IRC:83 (Part-IV) or Grade/Class mentioned in approved drawing.
1.2	Mild Steel	Mechanical & Chemical Test UTS, Yield Stress, Elongation%, Bend test , Impact test at 0 degree centigrade or -20 degree for sub-zero zone, test for C, Mn, Si, P, S, CE etc.	As per Mill TC & test required by Authorized inspecting official of Zonal Railway from Govt. Lab ./ NABL approved lab.	Mill TC and Challan.	Verification of Reference document and Complete visual inspection.	Authorized Inspecting official of Zonal Railway.	One test piece per thickness per heat/ at discretion of Inspecting official.	Fabricato rs record Co-related with Mill TC & test report.	Grade E350 or above B0 quality of IS: 2062, shall generally be used. However Quality C of IS:2062 shall be used for subzero condition/ As specified in approved Drawing.	1. Manufacturer's test certificate shall be furnished. 2. 100% UST shall be conducted for plates. Acceptance criteria shall be IS:4225 are ASTM A435. 3. Physical condition of raw material must be visually checked for Pitting, rusting, rolling defect etc. before use. 4. Mild Steel Material shall comply clause 4.1 of IRC:83 (Part-IV) or Grade/clause mentioned in approved drawing.

1.3	Stainless Steel (S.S.)	Physical & Chemical Test UTS, Yield Stress, Elongation %, Hardness, Test for C, Mn, Ni, Cr, P, S, Si, Mo etc.	As per Mill TC & test required by Authorized inspecting official of Zonal Railway from Govt. Lab/ NABL approved lab.	Mill TC and Challan.	Verification of Reference document and Complete visual inspection.	Authorized Inspecting official of Zonal Railway.	One test piece per thickness per heat / at discretion of Inspecting official.	Fabricators record Co-related with Mill TC & test report.	Stain less steel shall conform to AISI 316 or AISI316L Or (Grade/class as per relevant approved Drg.).	6. Manufacturer's test certificate shall be furnished. 7. Sample from each lot of S.S shall be drawn by authorize inspecting official and tested in Govt./NABL approved laboratory. 8. Stainless Steel Material shall comply clause 4.1 & 4.4 of IRC:83 (Part-IV) or Grade/clause mentioned in approved drawing.
1.4	Sliding Material, e.g., PTFE etc.	Mechanical and Physical Properties 5. Mass density 6. Tensile strength 7. Elongation at break 8. Ball hardness 9. Static and Dynamic Coefficient of friction at relevant temperature	per Mill TC & test required by Authorized inspecting official of Zonal Railway from Govt. Lab./ NABL approved lab.	Manufacturer test certificate & Challan	Verification of refere nce document.	Authorized Inspecting official of Zonal Railway.	Sample from each lot of PTFE material/ at discretion of Inspecting official.	Fabricators record.	IRC:83 (Part-IV) and referred documents or as per relevant specification / approved Drg.).	6. Material shall be either poly tetra fluoro ethylene (PTFE) free sintered without regenerated material or any other material having requisite material strength and low frictional properties. 7. Manufacturer's test certificate shall be furnished. 8. Sample from each lot of PTFE shall be drawn by authorize inspector and tested in Govt./NABL approved laboratory. 9. PTFE material must comply the parameters given in Clause 4.3 of IRC:83 (Part- IV).

1.5	Fasteners Bolts & Nuts	Material Properties i)Mechanical Test: a) Proof Load b) Hardness ii)Chemical Test C,Mn,Si,S,P and others	One Sample of each size. As per manufacturer certificate & test required by RDSO/Authorized inspecting official from Govt. lab. / NABL approved lab.	Manufacturer test certificate & Challan.	100% Checking Verification of reference document.	Authorized Inspecting official of Zonal Railway.	From batches at Random and at discretion of Inspecting official. At least one sample against each size in NABL Lab.	Fabricators record.	IRC83 (Part-IV) & referred documents Or Grade/class as per relevant approved Drawing. For Bolts IS:4014, For Hex nut IS:4032, For Lock Nut IS:4035, For 3D Nut DIN:6334	1. Test certificate shall be furnished by manufacturer. 2. One sample for each lot of Bolts & Nuts supply shall be drawn by authorize inspecting official of Zonal Railway for testing in Govt./NABL approved laboratory.
1.6	Shear Studs	Material Properties i)Mechanical Test: a) Proof Load b) Hardness ii)Chemical Test C, Mn, Si, S, P and others	One Sample per procurement lot in NABL	Mill TC and Challan	100% Checking and Verification of MTC and NABL test report.	Authorized inspecting Official from Zonal Railway		j) MTC and NABL Report.	ISO 13918 S235-C450	1. Test certificate shall be furnished by manufacturer. 2. One sample for each lot of Bolts & Nuts supply shall be drawn by authorize inspecting official of Zonal Railway for testing in Govt./NABL approved laboratory.
2.0	Manufacturing Process									
2.1	Process Inspection	Dimensional inspection, NDT and visual inspection	Visual & Measurement	As per approved drawing	Measurement of dimension & Verification of reference document.	Authorized Inspecting official of Zonal Railway.	100 %	Fabricators record.	Para 6 and 7.3 of IRC 83 Part- IV & as per approved drawing	1. Internal report shall be furnished; however, check shall be done in presence of Zonal Railway inspecting official. 2. Manufacturing tolerances and Manufacturing method of bearing shall confirm Clause 6 of IRC:83 (Part-IV).

									3. The manufacturer should be able to establish the traceability of all major raw material with procurement and consumption record and Mill Test Certificate/ material test report 4. Major metallic components shall be ultrasonically tested for soundness as per Level: 3 of IS: 9565 prior to use in bearings. 5. All welding shall be done by qualified welder on the basis of applicable WPSS and shall be in accordance to Clause 6.8 of IRC:83 (Part-IV). 6. All structural welds shall be visually checked for weld size and location as per drawing as well as controlled as per the following tests: - Visual test (all structural welds) - Liquid penetration test as per IS: 822 (all structural welds) - All full penetration butt welds shall be controlled through ultrasonic testing as per IS 4260 / AWS D1.5 / ASME Section VIII.
2.2	Tolerance of fit between different component of bearing	Dimensional Inspection	Visual and measurement	As per relevant drawing	Measurement of dimensions & surface roughness.	Authorized Inspecting official of Zonal Railway.	100%	Fabricators record	IRC 83 Part- IV	1. Inspection records to be furnished. However random checking may be done in-presence of inspecting authority of Zonal Railway. 2. Tolerance of fit between different component of bearing shall comply clause 6 of IRC:83 (Part-IV).

2.3	Corrosion Protection	Surface preparation & protective coating system	Visual and measurement	As per drawing and relevant specification	Fabricators record & check.	Authorized Inspecting official of Zonal Railway.	100%	Fabricators record.	IRC-83 Part-IV para 4.10 & referred document.	3. Surface preparation & protective coating system must be in accordance to clause 4.10 of IRC-83 Part-IV. 4. Internal report shall be furnished. However, total DFT shall be checked randomly by inspecting authority of Zonal Railway.
3.	Inspection on finish bearing									
3.1	Dimensional Inspection	Over all Dimensional check of finished bearing	Visual and measurement	As per drg. and relevant specification	Fabricators record & check.	Authorized Inspecting official of Zonal Railway.	100%	Fabricators record.	IRC-83 Part-IV, para 6.1	1. All bearings of the lot shall be visually inspected for absence of any defects in surface finish, shape or any other discernible superficial defects. 2. All bearings shall be checked for overall dimensions as per manufacturing tolerances specified in Clause 6.1 of IRC:83 (Part-IV). 3. All bearings must meet requirements given in Clause 7 of IRC:83 (Part-IV).
2.3	Vertical Compression Test under SLS load	Bearing Capacity Load Test	Lot defined is as per Cl:7.2 of IRC-83 (Part IV)	Approved Drawing IRC 83 Part IV Cl:7.4.2(iii)	Internal Test Report	Authorized inspecting Official from Zonal Railway	Frequency as per IRC 83 (Part IV)	Internal Inspection Report	Cl: 7.4.2(iii) & 7.5 of IRC-83 (Part IV)	Internal Reports shall be furnished for review. Load Test to be witnessed on the randomly selected bearings by Inspecting Authority.*
2.4	Coefficient of Friction Test	Bearing Capacity Load Test	Lot defined is as per Cl:7.2 of IRC-83 (Part IV)	Approved Drawing IRC 83 Part IV Cl:7.4.2(iv)	Internal Test Report	Authorized inspecting Official from Zonal Railway	Frequency as per IRC 83 (Part IV)	Internal Inspection Report	Cl: 7.4.2(iv) & Cl:7.5 of IRC-83 (Part IV) #Coefficient of friction in lubricated condition should be <0.03	Internal Reports shall be furnished for review. Load Test to be witnessed on the randomly selected bearings by Inspecting Authority.

2.5	Combined Load Test (For Fixed and Guided type)	Bearing Capacity Load Test	Lot defined is as per Cl:7.2 of IRC-83 (Part IV)	Approved Drawing IRC 83 Part IV Cl:7.4.2(v)	Internal Test Report	Authorized inspecting Official from Zonal Railway	Frequency as per IRC 83 (Part IV)	Internal Inspection Report	Cl:7.5 of IRC-83 (Part IV)	Internal Reports shall be furnished for review. Load Test to be witnessed on the randomly selected bearings by Inspecting Authority.*
3.2	Load Test (d) Proof Load Test (e) Friction test (f) Rotation test	Load Testing parameters as per Clause 7.4.3 of IRC-83 Part-III	At least one or a pair of bearings (depending on the requirement) of each type and different vertical load capacity selected at random shall be load tested	As per relevant Drawing.	Fabricators record.	Authorized Inspecting official of Zonal Railway.	At least one or a pair of bearings	Fabricators record.	IRC-83 Part- III	1.All bearings must meet requirements given in Clause 7.4.3 of IRC:83 (Part-III). 2.Proof Load Test of bearings shall be done as per Clause 7.4.3.3.1 of IRC:83 (Part-III). 3.Friction Test of bearings shall be done as per Clause 7.4.3.3.2 of IRC:83 (Part-III). 4.Rotation Test of bearings shall be done as per Clause 7.4.3.3.3 of IRC:83 (Part-III).
3.3	Final Clearance Inspection	After load test bearing must be checked for condition of components	Visual and measurement and testing	As per relevant Drg. & specification	Measurement of dimension	Zonal Railway.	100%	Fabricators record.	IRC 83 Part- III	After load testing DP test and ultrasonic testing of bearings to be done for checking any damage during testing before final clearance.
2.6	Marking	Visual	100%	Approved Drawing	Visual	Authorized inspecting Official from Zonal Railway	100% Inspection before acceptance	NA	As per drawing and para 7.8 of IRC -83 Part IV	Marking should be done with suitable indelible ink and identification plate.

* After the tests are completed, the tested bearings shall be removed from the test machine, dismantled and the components shall be examined for and signs of distress, permanent deformation in the components especially the sliding surface. Warping, swelling, cracks or other permanent defects should be checked.

Reference IS Codes

SN	Para No	Ref. document details	
1	1007(3)	IS: 12330	Specification For Sulphate Resisting Portland Cement
2	1008	IS: 383	Specification For Coarse And Fine Aggregates From Natural Sources For Concrete
3	1008	IS: 2386 (Part I to Part VIII)	Methods Of Test For Aggregates For Concrete
4	1109(3)	IS: 3025	Methods Of Sampling And Test (Physical And Chemical) For Water And Wastewater
5	1109(4)	IS: 516	Method of Tests for Strength of Concrete
6	1010(1)	IS: 9103	Method Of Making, Curing And Determining Compressive Strength Of Accelerated-Cured Concrete Test Specimens
7	1010(8)(b)	IS: 10262	Concrete Mix Proportioning - Guidelines
8	1011(1)	IS: 432 (Part 1)	Mild Steel And Medium Tensile Steel Bars And Hard-Drawn Steel wire For Concrete Reinforcement Part I Mild Steel And Medium Tensile Steel
9	1011(2),(3)	IS: 1786	High Strength Deformed Steel Bars And Wires For Concrete reinforcement Specification
10	1011(5)	IS: 16651	High Strength Deformed Stainless Steel Bars and Wires for Concrete Reinforcement
11	1012(2)(a)	IS: 4925	Concrete Batching And Mixing Plant
12	1012(2)(a)	IS: 383	Coarse and Fine Aggregate for Concrete
13	1012(2)(b), (c)	IS: 2386 (III)	Methods of test for aggregates for concrete Part 3 Specific gravity, density, voids, absorption and bulking
14	1012	IS: 1791	General Requirements for Batch Type Concrete Mixers
15	1013(1)	IS: 7861 (I&II)	Code of practice for extreme weather concreting Part 1 Recommended practice for hot weather concreting, Code of practice for extreme weather concreting: Part 2 Recommended practice for cold weather concreting
16	1016, 1019(4), 1024(5)	IS: 456	Plain and Reinforced Concrete - Code of Practice
17	1019(2)	IS: 6906	
18	1019(4)	IS: 9103	Specification for Concrete Admixtures
19	1019(4)	Cl: 6.2.5 IS: 10262:2019	Concrete Mix Proportioning — Guidelines
20	1019 (6)(a)	IS: 516 (Part 2/ Sec1)	Method of Tests for Strength of Concrete Hardened Concrete — Methods of Test Part 2 Properties of Hardened Concrete other than Strength Section 1 Density of Hardened Concrete and Depth of Water Penetration Under Pressure

21	1022(6)	IS: 16172	Reinforcement Couplers for Mechanical Splices of Bars in Concrete
22	1022(8)	IS: 280	Mild Steel Wire for General Engineering Purposes
23	1023(1)	IS: 1199	Fresh Concrete — Methods of Sampling, Testing and Analysis
24	1023(1)	IS: 516	Method of Tests for Strength of Concrete
25	1031(1)	IS: 4926	Code of Practice Ready-Mixed Concrete
26	1031(6)	IS: 5892	Concrete Transit Mixer
27	1034 (1) Table 10.17	IS: 4031 (Part-1, 3, 5, 6),	Methods of physical tests for hydraulic cement
		IS: 1199 (Part 2)	Fresh Concrete— Methods of Sampling, Testing and Analysis Part 2 Determination of Consistency of Fresh Concrete
		IS: 516	Method of Tests for Strength of Concrete
		IS: 2386 (Part 3 & 4)	Methods of Test for Aggregates for Concrete Specific gravity, density, voids, absorption and bulking, Methods of test for aggregates for concrete Part 4 Mechanical properties
		IS: 383	Coarse and Fine Aggregate for Concrete - Specification
28	1041(1), 1047	IS: 2911 (Part 1 to 4)	Design And Construction Of Pile Foundations — Code Of Practice
29	1049	IS: 14593/ 2013	Design and construction of bored cast-in-situ piles founded on rocks - Guidelines
30	1056(1)	IS: 2911(PT IV)	Design and construction of pile foundations - Code of practice : Part 4 Load test on piles
31	1057(4)	IS: 14893	Low strain non-destructive integrity testing of piles - Guidelines
32	1081 Table 10.21	IS: 1343	Prestressed Concrete - Code Of Practice
33	1081 Table 10.21	IS: 1608	Metallic materials - Tensile testing
34	1081 Table 10.21	IS: 1785	Plain Hard-drawn Steel Wire For Prestressed Concrete
35	1081 Table 10.21	IS: 14268	Uncoated Stress Relieved Low Relaxation Seven-Wire (Ply) Strand for Prestressed Concrete-Specification
36	1084 (1), Table 10.22	IS: 6006	Uncoated Stress Relieved Strand For Prestressed Concrete - Specification
37	1084 (1), Table 10.22	IS: 14268	Uncoated Stress Relieved Low Relaxation Seven-Wire (Ply) Strand for Prestressed Concrete-Specification

38	1084 (1), Table 10.22	IS: 1785 (Part 1)	Plain Hard-drawn Steel Wire For Prestressed Concrete: Part 1 Cold Drawn Stress-relieved Wire
39	1084 (1), Table 10.22	IS: 2090	High tensile steel bars used in prestressed concrete
40	1087(2)	IS: 383	Coarse and Fine Aggregate for Concrete - Specification
41	1087(2), IS 1088(3)	IS: 9103	Specification for Concrete Admixtures
42	1091(1)(e)	IS: 2062	Hot Rolled Medium and High Tensile Structural Steel
43	1091(1)(e)	IS: 2004	Carbon steel forgings for general engineering purposes
44	1091(1)(e)	IS: 1852	Rolling and cutting tolerances for hot rolled steel products

Reference Books & BS Reports

SN	Para No	Ref. document details	
1	1091	BS:128 (R2)	Guidelines for carrying out load deflection test of steel plate & open web and steel-concrete composite girders
2	1032, 1033	BS:89R	Guidelines for the use of High-Performance Concrete including self-Compacting Concrete in Bridges

Reference Document

SN	Para No	Ref. document details	
1	1036 (3)	10.01	Railway Board's Letter No.2014/CE-III/BR/Bridge Policy dt. 15.11.2016
2	1059 (4)	10.02	RDSO Letter No CBS/DWF dt. 15.07.2019
3	1092 (3)(c)	10.03	Railway Board's Letter No. 2015/CE-IV/RUB/206 dated 15.02.2016
4	1095 (3)(c)	10.04	RBs Letter No. 2015/CE-IV/RUB/206 dt. 11.08.2016
5	1092 (1)(d)	10.05	RDSO Letter no. CBS/PBEJ/Reg. dated 28.02.2023

***

CHAPTER 11
GRADE SEPARATOR

1101 INTRODUCTION

Grade Separator:

Grade separation is a method of aligning a junction of two or more surface transport axes at various heights (grades) so that they do not disrupt traffic flow on other transit routes when they cross. The composition of such transportation axes does not have to be uniform; it can be a combination of roads, footpaths, trains, canals, or airport runways.

Roads with grade separation normally allow traffic to move freely, with fewer interruptions, and at higher overall speeds; this is why speed limits on grade-separated roads are typically higher. Furthermore, lowering the complexity of traffic movements minimizes the chance of accidents.

A grade separator in railway terminology is mainly of three types, as under

(1) Road Over Bridge: A road bridge constructed over the railway line is called a road over bridge (ROB) as the bridge passes over the railway line.

(2) Road Under Bridge: A road bridge constructed below the railway track is called a road under bridge (RUB) as the bridge passes under the railway track.

(3) Rail flyover: A Railway bridge constructed over another railway line is called a rail flyover (RFO) as the bridge passes over the railway line.

1102 PLANNING AND DESIGN

(1) Inherent features for planning of Grade Separator

Road-over or road-under bridges have their own inherent features that must be taken into consideration while making a choice between them. To sum up, a few of them are as follows:

(i) ROB requires a width of land equal to the full width of the road in the initial length of approaches but a very lesser width (sufficient for only a central pier) thereafter by adopting a cantilever type of construction. Whereas RUB requires a full width of land for the complete length of approaches. In urban areas where land is a scarcity and valuable resource, the choice between the two should be made judiciously.

(ii) The overall height requirement of ROBs is substantially greater than the overall depth requirement of RUBs. The reason is that the vertical clearance requirement of road vehicles is less than that of railway traffic and its overhead equipment. The higher depth of the girder further increases the overall vertical height of ROB.

(iii) The length of approaches is longer in the case of ROBs due to the reasons mentioned above.

(iv) Where the height of the embankment is sufficient, RUB can be a good option. ROB can be planned in the case of cuttings.

(v) If the RUB is constructed sufficiently below ground, drainage can pose problems. In such cases, ROB can be planned instead of RUB, or RUB can be planned with an effective

drainage arrangement.

(vi) For planning effective drainage, Railway Board's letter No. 2017/CE-IV/RUB/88 dated 20.04.2020 **(Ref. 11.01)**, 27.01.2022 **(Ref. 11.02)** and 18.02.21 **(Ref. 11.03)** shall be followed.

1103 SELECTION CRITERIA FOR ROB/RUB

The following factors must be considered while deciding on the selection of RUB/ROB.

(i) Railway Embankment Height: Where the railway embankment is significantly higher than the natural ground level, RUB may be a preferable option to ROB. A shorter approach length will be required.

(ii) Type of road traffic to be passed: The minimum vertical clearance shall be 5.0 m for non-urban areas and 5.5 m in case of urban areas. In case of RUB located over local or collector streets, where only light commercial vehicles are plying and where alternative routes for heavy commercial vehicles and fire tenders are available within a short distance, the authorities may relax the clearance requirements stated above. This gives RUB an advantage over ROB. The minimum desired vertical clearance for ROBs is 5870mm as per clause 10c (ii) of CH I and 7870/8250mm as per ACS1 of IRSOD 2022, independent of the kind of road traffic.

(iii) Any subsidiary lanes to be connected to the main road - Connecting any subsidiary roads to the main route is simple with RUBs. In the case of ROB, it might not be feasible. It is avoidable by providing RUB with shorter approaches.

(iv) Vertical clearance required- RUB has a lower vertical clearance requirement than ROB.

1104 PLANNING OF ROAD OVER BRIDGES AND ROAD UNDER BRIDGES

[BS112- RDSO guidelines for planning of ROB **(Ref 11.11)** & BS132- Compendium for Road Over Bridges on Indian Railways **(Ref 11.12)**].

While planning and designing roads over bridges and roads under bridges, policy circulars issued by the Ministry of Railway, RDSO, PCE/CAO/C or CBE offices related to the preparation of GAD, execution of work, safety-related instructions, use of non-standard spans, inspection of steel girders, and other miscellaneous instructions should be considered.

(1) Planning of ROB

(a) Planning of the Layout of Piers: The provision of piers on railway land shall be decided on techno-economic considerations. It may be noted that with small substructure heights, in most cases in ROBs, longer spans will in general be costlier than medium-length spans. However, the long-term interests of railways must be guarded while planning the pier locations. The following may be kept in mind in this respect:

(i) Piers shall not be planned where there is a possibility of current tracks shifting due to realignment, yard remodeling, etc. or where future tracks might come. Provision for future track(s) shall be considered for most locations outside yards. Since the alignment of the future track(s) is not always known, various possibilities for the same may be examined. If it is feasible, space for at least one track on either side of existing tracks may be kept. For terminals, major yards, and their approaches,

keeping land free from obstructions might be desirable, as the entire layout might get changed during remodeling or fresh planning.

(ii) Piers may be planned on railway land near the edges if no constrains for future tracks planning is needed.

(iii) Piers may be planned such that they are aligned with other structures already located on railway land, like piers of other bridges or major structures that are not likely to be removed in future.

(iv) Piers may be planned in railway land if the land available in adjoining locations are less so that the location of pier in railway land will not affect the future planning of tracks.

(v) While planning the location of piers and abutments, the location of existing masts and infringements should be kept in mind.

Railway Board's letter No. 2015/CE-IV/ROB/76 dated 01-03-2016 and 2015/CE/IV/ROB-RUB/Misc dated 15.02.23 can be referred for guidance **(Ref. 11.04)**.

For NHAI works, the Railway Board's Letter No 2015/CE/IV/ROB-RUB/Misc./49 dated 29.10.2019 should be referred **(Ref. 11.05)**

(b) Planning span lengths: The following aspects may be kept in mind while planning the span length of a bridge:

(i) Decisions on the span lengths shall be taken keeping railway operations in mind and, after that, as per techno-economic considerations.

(ii) Shorter spans will necessitate a larger number of piers and will require more land to be permanently occupied. Longer spans become costlier. Optimization between these two factors should be done.

(iii) As a general principle, a symmetrical arrangement of spans with respect to existing tracks is desirable.

(c) Foundation planning: Deep foundations are generally more expensive than open foundations. Because the ROBs are not surrounded by water, scouring is not an issue, and the foundation depth may be reduced. Deep foundations such as piles are used when soil conditions dictate or there is an advantage such as ease of construction, reduction in period of caution order, etc. If such constraints do not exist, open foundations must be used if bearing capacity considerations permit.

(d) Planning of girders: Wherever possible, RDSO's standard girders should be used for spans above railway tracks. If the site conditions require the use of girders other than those of the RDSO's standard drawings, the reasons for doing so must be recorded and approval obtained from the Chief Bridge Engineer. List of RDSO standard drawings is mentioned in annexure 11A.

Railway Board's letter No. 2015/CE-IV/ROB/78 Pt. dated 15.01.2020 shall be referred for guidance **(Ref. 11.06)**.

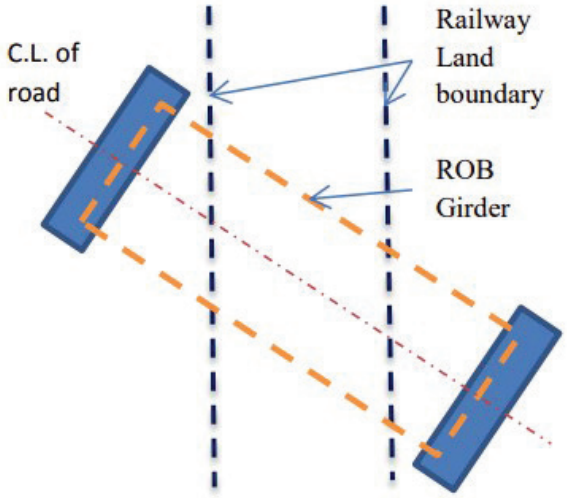
(e) Skew arrangement: Skew alignment of ROB to railway track is sometimes required, particularly on national and state highways with higher speed requirements. Sometimes a skew layout is also required in congested areas where alignment change is not possible. Higher skew angles are required to be adopted. Skew girders are not a desirable

configuration because they are susceptible to large torsional moments. Hence, efforts must be made to achieve square alignment or minimize skew angles to within acceptable limits (generally below 20 degrees).

Railway Board's letter No. 2017/CE-IV/ROB/164 (policy) dated 16-02-2021 shall be referred **(Ref. 11.07)**.

(f) Methods for reducing skew angles in Road Over Bridges: Various strategies can be tried individually or in combinations to reduce the skew angle as much as possible. Choice of strategy/ combination thereof will depend on site conditions. The strategies and constraints in adopting the same are discussed below:

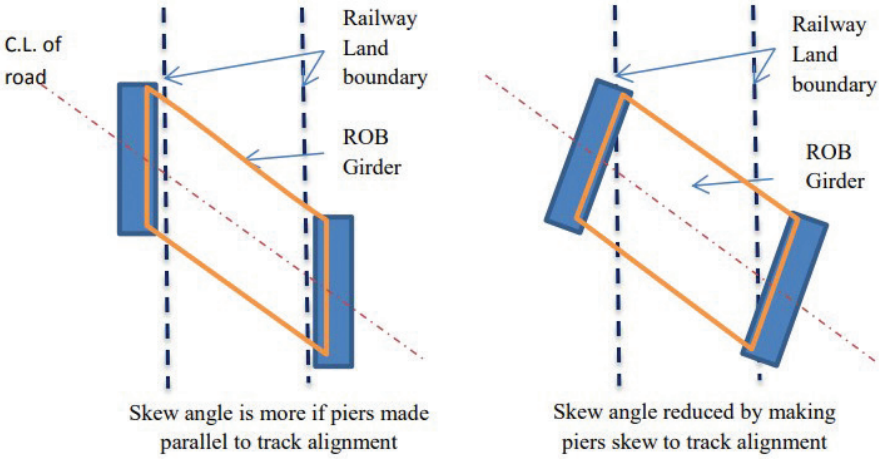
(i) Providing longer spans: If space constraint is not there, providing longer span can help in reducing or eliminating skew angle. In such a case, the substructure is skew to railway alignment but the ROB girders are square or at lesser skew angle.



Constraints:

- The span is longer, so the depth of girder will be slightly higher.
- The piers are not parallel to railway land boundary. So, if the piers are being built in railway land, the width of land rendered unusable for future is increased.

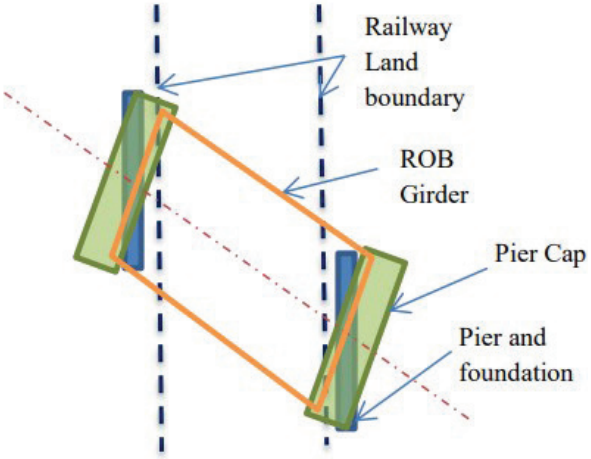
(ii) Constructing sub structure in skew to railway land boundary: It is not mandatory that the sub structure shall be parallel to railway land boundary even though it is desirable to reduce the railway land permanently rendered unusable. If the space constraint is not there, the sub structure can be constructed in skew to the railway land boundary, thus reducing the skew angle of the girders to within 20 degrees.



Constraints:

- The piers are not parallel to railway land boundary. So, if the piers are being built in railway land, the width of land rendered unusable for future is increased.
- The skew piers should not violate the Schedule of Dimensions of existing or future tracks. This needs to be checked.

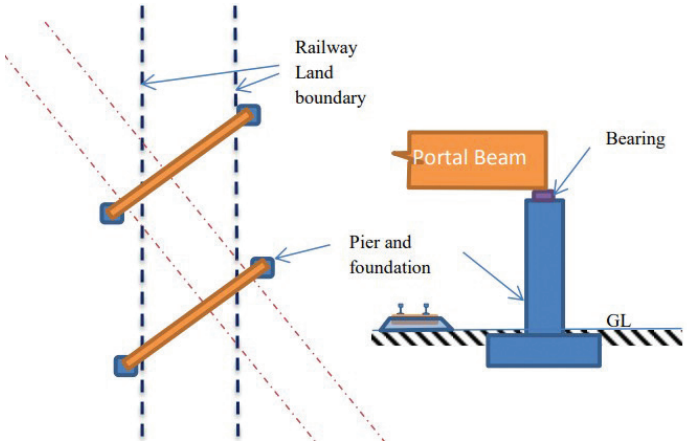
(iii) Constructing Skew pier Cap/Bed block: Land is a precious resource and at lots of locations, railways might require the entire railway land boundary for its current and future operations and the land on approaches might also not be available. In this situation, both the options (I) and (II) discussed above will not be feasible. Option (II) might not be desirable if the standard girder design is not available for the longer length contemplated. In such situations, an option can be to construct the foundation and the sub structure parallel to railway land boundary occupying minimum width, but to reduce the skew angle of the girder, pier cap/bed block can be made in skew. In this approach, the land is not wasted and the extra width in bed block is provided above the Schedule of Dimensions so that maximum space is usable, without affecting the train operations. In such cases, circular piers with skew pier caps may be an appropriate solution



Constraints:

- The cantilever length of pier cap is increased. The depth of pier cap can increase.
- The skew piers can violate the Schedule of Dimensions of existing or future tracks. This needs to be checked.
- If the height of pier is increases to keep the clearance below skew pier cap as per schedule of dimensions, the overall height of ROB will increase, result in increase in approach lengths.

(iv) Providing portal across the track: A very good method to reduce the skew angle is to rest the girders on portal provided across the track rather than on the piers directly. This method is used by Metros to cross the roads and other obstructions. Casting the beam of the portal over running track is very difficult and shall be avoided. To solve this issue and also to ensure that the road level is not increased unnecessarily, beam of the portal can be a steel beam and the girders of the road over bridge shall be connected to the web of this beam. This arrangement can utilize the standard RDSO girders by eliminating the bearing stiffener and the bearings under the girders. The bearings in this case shall be provided under the cross girder of the portal. The arrangement of the piers for the portal shall be as per the drawing



The portal beam shall be provided over the piers such that the beam is normal to the road alignment. Bearings (Spherical/POT-PTFE) shall be provided under the portal beam as shown in drawing.

(2) Planning of Road under bridge-

The various aspects of planning and construction of RUB/subways are as follows:

(a) Site Survey

(i) A suitable site with sufficient formation height and proper drainage feasibility should be selected for the construction of the RUB or subway. All relevant site details for the planning of RUB should be collected.

(ii) A detailed soil investigation should be conducted.

(iii) S&T cable, electrical cable, or any other cable or OHE wire, and other utilities should be surveyed, and planning for their shifting or diversion by the concerned department should be done.

(b) Design of RUB/ Subway:

The reinforced concrete BOX should be suitably designed, RDSO standard drawing shall be referred to for this purpose. The gradient of approaches, along with suitable curvature if required, should be decided. The gradient should not be steeper than the maximum restricted gradient. The height of the box should be decided depending on the class of road. In case of single lane subway, the approaches shall be widened for some stretch to facilitate crossing of vehicles.

(c) Design of Drainage arrangement:

The Drainage arrangement is also designed for efficient drainage of water away from the RUB or subway and to prevent any water logging inside it. The parameters to be considered are the relative levels of the road in the underpass, surrounding ground level, natural ground water table, annual rainfall, slope of the ground, permeability of the soil etc. An adequate drainage system shall be adopted to avoid inconveniences for road users. For efficient drainage arrangement following points may be considered.

For New RUB/Subway works

i Provide properly designed humps on approaches on either side. Preferably as part of road surface itself and enclosed with retaining wall to restrict ingress of outside water.

ii. Provide minimum joints in RCC box structure. Joints, if provided, should be designed with water-proofing details. New arrangements and technology for water-proofing joints may be considered.

iii. Sealing of joints between retaining wall and RCC box, and in retaining wall structure. U-trough type retaining walls may be usefully adopted.

iv. Retaining walls should be without weep holes and without gaps to restrict ingress of outside water.

v. Provision of cover shed on approaches as appropriate. Simpler cover sheds should be preferred.

vi. Properly designed arrangements of cross drains, drains, sump etc. and plan for pumping in the event of water logging.

vii. Use waterproof concrete for RCC works including use of appropriate admixture.

viii. Provision of footpaths, as appropriate.

ix. Properly finished road surface with wearing coat.

x. Suitable, internal waterproofing measures.

xi. Additional water proofing measures in construction stage itself.

xii. Suitable signages for road users for ease of movement, stopping the entry to RUB for road users in unsafe situations.

xiii. GADs to provide all these measures as part of drawing itself.

xiv. All new RUB work must be taken up with an overall detailed plan to address water-logging issues for each case.

For existing RUB/Subway works

i. Evaluate source of water ingress and devise solution accordingly.

ii. Provide suitably designed hump on approaches and enclose approaches with retaining

wall with no gap for water ingress.

iii. Provide cover shed on approaches as required.

iv. Seal all joints in RCC box and retaining walls by use of various methods and combination thereof. Some of these are internal waterproofing lining, cement canvas, grouting, shotcreting, water proofing painting etc. Innovative solutions may be considered and adopted.

v. Provide low height footpath where feasible.

vi. Provide road and signage for informing road users and also provide for stopping the RUB in case of unsafe situations.

vii. Overall plan for drainage system to take water away from RUB should be designed and provided accordingly.

viii. Provide wearing coat for good road surface.

ix. Provide additional small-sized opening for pedestrians, two wheelers etc. adjacent to full height RUB, in exceptional cases subject to land availability, if considered necessary.

The Railway Board's letter No. 2017/CE-IV/RUB/88 dated 20.04.2020 **(Ref.11.01)**, 27.01.2022 **(Ref. 11.02)** and 28.02.21 **(Ref. 11.03)** can be referred to for guidance.

Salient features of Guideline regarding Drainage Arrangements in RUB/ Subway

Table 11.01 - Guideline: Proposed solutions

Height of embankment	**Level of ground water table with respect to Ground Level**			
	Low		***High**	
	Annual Rainfall < 800mm	**Annual Rainfall > 800mm**	**Annual Rainfall<800mm**	**Annual Rainfall>800mm**
Track on embankment and Road level inside the RCC Box higher than the ground level	Minor works as per site Requirement to be decided by engineer-in-charge	Minor works as per site Requirement to be decided by engineer-in-charge	Minor works as per site requirement to be decided by engineer-in charge	Proper side drain sand crossed rains as per site requirement
Track on embankment and Road level inside the RCC Box lower than the ground level	Sump + open drains/ closed drains or Combination of both	Cover over the approaches + Subway + Sump + open drains/ closed drains or Combination of both (Pumping arrangements as Standby)	Lining of the Subway + coverover the approaches + Sump + pumping arrangement + surfaced drainage and suitable cross drainage wherever required	Lining of the Subway + cover over the approaches + sump + pumping arrangement + surface and suitable cross drainage ROB preferable over RUB

*High ground water table is considered as 2.0m below the lowest level of road in the RUB/Subways.

The above table is to be read with following notes:

a) The joints of segments of RCC Box, joints between box and the retaining walls and segments of retaining walls in approaches must be sealed. Weep holes should not be provided in new RUB/Subways. Sealing of weep holes, wherever provided, should be ensured in all cases.

b) Local arrangements such as catch water drains, raising of walls, and raised hump with reverse slope along with grating to prevent ingress of water, etc. to be provided as per site requirement.

c) Electrically operated sensor based pumping arrangements are preferable in built up and urban areas. Standby diesel operated pumps to be ensured.

d) Water harvesting may be planned where groundwater table is low and perviousstrata is available.

e) The proposed drainage arrangements for each group are considered minimum requirements and indicative only. These may be suitably augmented/ modified as per the site conditions.

(d) Preparation of general arrangement drawings

A general arrangement drawing (GAD) shall be prepared for each site considering the above requirements and a proper drainage arrangement fulfilling the site conditions.

(3) Construction methodology for construction of RUB/Subway

(a) RCC Box by cut and cover method.

In this method, the RUB/subway is constructed by blocking the rail traffic, excavating the existing formation, placing the precast box segments during traffic block and filling back the excavated earth and restoring the traffic with restricted speed after compacting the loose formation.

Advantages

- Fairly economical
- Faster execution

Disadvantages

- Larger block duration is required.
- Heavy machineries are required.
- Failure of machinery may lead to traffic disruption.
- Poor quality control, drainage issues and settlement of approaches due to inadequate compaction.

(b) Pushing of BOX with restricted height reliving girders

In this method, the restricted-height reliving girder is placed at the site to create a gap for box pushing and to allow rail traffic over it. The reliving girder is placed during traffic block and supported on temporary supports. Rail traffic is allowed over these girders at a restricted speed during construction. Once the work of insertion of BOX of adequate length is completed, the girders are removed, and rail traffic is allowed on the newly constructed RUB/Subway.

Advantages

- Improved quality control
- Lesser-duration traffic blocks are required.
- faster execution than BOX pushing method.
- Track disturbance is avoided.

Disadvantages

- Heavy machinery is required.
- More blocks are required.

(c) BOX pushing through embankment.

The method involves pushing of Box through the railway embankment with the rail traffic passing under suitable speed restriction. Precaution is required to avoid disturbance to the railway track during pushing of the Box. The method is time consuming.

Advantages

- Better quality control
- No traffic block is required

Disadvantages

- Changes of track disturbances
- Longer duration caution order is required
- Slow pace of construction

(d) Box pushing using Protection Plate Arrangement

The method involves for construction of RUB/Subway using box pushing technique by providing a steel protection plate arrangement at the formation level which has the advantage of faster progress and lesser distrurbances to the track during the box pushing operations.

RDSO standard drawing has been (drawing no. RDSO/B-10161-set of two drawings) referred for construction of RUB/Subway by box pushing using ptotection plate arrangement.

1105 INNOVATIVE DESIGNS

Innovative scheme and designs can be adopted to address some issues that are site-specific.

(i) RUB/Subway with a combination of openings with differential heights and levels: This can be a useful option for a few selected locations with a population residing nearby and where RUB is prone to water logging. Small openings can continue to cater to the mobility of pedestrians, two-wheelers, small vehicles, etc. Various configurations can be there, depending on the requirements.

(ii) RUB with subway/ramp: ROBs proposed in lieu of level crossings located in areas with habitation nearby may need provisions for pedestrians, two-wheelers, auto rickshaws, small vehicles, etc. to avoid the need to take a detour to go over the ROB to cross the railway track.

The Railway Board's letter No. 2017/CE-IV/88 dated 23.02.2023 **(Ref. 11.08)** may be referred to for guidance.

1106 LAUNCHING OF GIRDERS FOR ROAD OVER BRIDGE (ROB)

(1) Introduction:

Launching ROB girders basically involves all the operations involved in assembling, putting the assembled girders in position over pier caps, and lowering the girders to their final position over bearings.

Generally, space constraints are there for assembling the full girder, erecting temporary supports, and performing the related operations. Since neither track nor road can be blocked for the assembly of girders, it becomes very important to follow all possible safety measures while preparing the girder for launching and erecting temporary arrangements for launching. Any mistake can be fatal from a human safety point of view. Therefore, launching girders over railway tracks is a very challenging and complicated procedure involving many operations that are to be performed with the utmost precision so as to ensure the full safety of road users as well as railway passengers.

(2) General requirements for launching of ROB girders over railway tracks

i. PCE sanctions should be obtained for launching scheme of girder.

ii. Traffic and power blocks are to be arranged for erection of steel girder over Railway Track.

iii. Track is to be protected in accordance with relevant clauses of Indian Railways P. Way Manual.

iv. Pulling/ launching of the girder shall be stopped in case wind speed at site exceeds 15 kmph and it shall be made sure that weather conditions are normal and visibility is clear.

v. Level and compact the ground as per requirement for assembly of trestle, girder and movement of crane on launching end side.

vi. Arrange material, crane, cribs/ trestle, two pulling winches and two restraining winches of sufficient capacity, wire rope of suitable grade etc. for execution of work.

vii. Safety net shall be provided under the girders while fixing the bracing and shuttering work.

viii. Clearance from Railway Track to be maintained in accordance with Indian Railway Schedule of Dimensions for Broad Gauge.

ix. Protect the site of work for any trespass of any living beings.

x. Ground at the location of trestle pedestal should be compacted to attain safe bearing capacity of soil. Field engineer should certify that SBC of soil is more than foundation pressure at foundation level.

xi. Launching Track should be laid in correct alignment and level on trestles for longitudinal slewing of girder.

xii. Speed restriction of 20 kmph is to be imposed before start of work and shall be continued up to completion of work.

xiii. Skid plate surface for skidding arrangement shall be smoothened by lubrication. It shall be ensured by field engineer, that there should be no gaps in skid plate, which should be closed by welding and smoothened by grinding.

xiv. Before launching of girder, it must be ensured that fabrication of girder and its inspection

has been done as per approved QAP (Quality Assurance Plan) and WPSS (Welding Procedure Specification Sheets).

xv. All steel to steel members will be connected with tack weld to avoid any longitudinal and transverse movement.

xvi. Pulling arrangement shall be trial tested with actual load well before taking traffic and power block.

xvii. Fabrication of BSG shall be done after locking the skidding arrangement with suitable method. Locking shall also be done after each stage of pulling to prevent from skidding.

xviii. The condition of crane shall be strictly observed as given in Railway Board letter No. 2015/CE-IV/RUB/206 dated 15.02.2016 and 11.08.2016 (**Ref. 11.09** and **Ref. 11.10**) and other instructions issued from time to time.

xix. Any activity near or over existing railway track shall be performed under traffic and power block.

(3) Composite Steel Plate Girders:

(a) Assembly of girders at site

(i) General: Composite Plate girders are fabricated in convenient lengths to suit transportation and availability of plate lengths. In general, the length is restricted to about 12m to 13m so as to facilitate transport in single lengths.

(ii) Erection of composite plate girders. Assembly of pieces of girders transported to site should be done according to the camber provided in the drawing. Girders are erected on a level ground over the platform made up of compacted earth or concrete base. Over this, sleeper or timber pickings at suitable intervals are laid for laying the main members for assembly. After they are laid, levelled and aligned, splicing plates are fixed. Joint holes are partially filled with drifts for bringing them into proper alignment. Provision of HSFG bolts in the splice joints of composite girder should be done in accordance with the procedure given in IRS B1-2001 for this purpose. All girder leaves of composite girder span should be assembled in field according to the approved drawing as mentioned above. The concreting of deck may be done after propping the girders where the site condition allows.

(iii) In case of ROB use of non- corrosive permanent shuttering (corrosion resistance) may be adopted as safety of track under ROB is involved. For Railway bridge, use of permanent shuttering (corrosion resistance) may be allowed on case-to-case basis where safety considerations are involved e.g., in case of RORs and bridges with very high level of deck slab etc., Railway Board's letter No. 2017/07/CE-III/BR/Safety dated 27.09.2022 **(Ref. 11.13)** may be referred to.

(iv) Choice of a suitable method of girder erection: Several methods are available for girder erection. The following factors generally influence the suitability of a particular erection method:

Particulars of Bridge and spans:

- Length, width, height, and weight of girder.
- Number and type of spans.
- Height and width of piers and abutments

- Skew or square span.

Site conditions:

- Height of gap.
- Condition of approaches- high or low banks or cuttings.
- Access to site
- Availability of bridging equipment/ launching equipment such as cranes etc.

(b) Preliminary arrangements before girder erection: Site conditions should be carefully studied by visiting the site and noting all the relevant facts before preparing erection schemes. Cross sections of the site and various important levels should be taken. Before embarking on preparation of the scheme, a thorough knowledge of the site conditions as mentioned above should be known.

The following arrangements should be made before actual launching work is started:

(a) Plan the sequence of erection work.
(b) Move the girder materials to the site.
(c) Assembly of girders as per approved drawings
(d) Decision regarding capacity and number of cranes to be deployed according to various site conditions.
(e) Arrange the plant and equipment necessary to carry out the work along with spares.
(f) Preparation of ground for proper working of cranes being used in launching of girders.
(g) Test all the equipment to be used in the erection work.
(h) First Aid and communication arrangement at site.
(i) Arrange for consumable stores.
(j) Arrange for necessary traffic blocks.
(k) Arrange for a proper organisation with Supervisors, Skilled and Unskilled Staff.
(l) Provide facilities for the large labour force that will be employed at site.

1107 ERECTION BY USE OF CRANES

This is the most common method for launching of the composite plate girders of ROBs. Composite plate girders can be placed in position with the help of cranes. Tentative sequence of launching operations is given below:

(a) The assembled girders of ROBs, to be brought near the crane as near as possible.
(b) Lifting hooks as per approved launching scheme to be placed in leaves of girder prior to start of traffic block.
(c) Infringements/ obstacles in launching of girder to be removed before traffic block as far as possible e.g. overhead electrical wires to be grounded or lowered during power block.
(d) One or two cranes, as per approved launching scheme is used for lifting the leaf of assembled composite girder at site. Girder lifted by crane is then moved across the railway track and avoiding infringement/damage to overhead electrical wires. Lifted girder is gradually lowered in position on blocks placed for this purpose.

(e) The placed girder should be properly secured with adjacent girders or with some other suitable arrangement as per approved launching scheme. Securing of girder is one of the most important operations to ensure safety of girder and to avoid its toppling/ falling. Crane should not be removed from the girder unless it is properly secured.

(f) Girders should be placed in sequence as per the approved launching scheme. If launching of girder is planned from two places then middlemost girder is launched first and thereafter launching of girders from middle to end is done. If launching is done from one place then farthest side girder from crane is launched first and thereafter launching from farthest side girder to nearest side girder is done. However, this might change as per other site condition and sequence of launching should be decided beforehand in approved launching scheme.

(g) After completion of placing, lowering and securing of all girders in position, the cranes should be removed to avoid any infringement to track.

(h) To restore the position of the track, overhead electrical wires and any other facilities that were removed for the launching of the girder should be restored before clearing the block section for the movement of traffic.

1108 BOW STRING ARCH STEEL GIRDERS (BSG)

(a) Girder assembly at site:

(i) It shall be ensured that before starting launching of the BSG all the steel components of the girder are well assembled and welded. No launching is to start without ensuring that all the components are properly welded.

(ii) Such assembly of BSG is typically done over temporary arrangements like trestles, longitudinal beams, skidding arrangements and cranes etc.

(iii) Normally this activity is planned in such a way that it does not infringe the tracks and generally no traffic/ power blocks are required to complete this activity.

(b) Launching:

(i) Most preferred method of launching BSGs is service span and end Launching method with winch machines. In this method BSG is first assembled over temporary arrangements like trestles and longitudinal beams. Thereafter girder is pulled to its final location with the help of pulling and restraining winches. Thereafter girder is lowered gradually in steps over the bearings.

(ii) Bow String Girders are typically suitable for lifting also. Such information shall be clearly mentioned in the approved drawings. The lifting points should be clearly indicated and the member strength should be checked for forces acting during launching.

(i) For other cases of launching arrangement of BSG, all members shall be checked for their adequate strength for all temporary forces. The strength and stability of all temporary supports and BSG shall be properly checked. If there is overhang during launching, stability and strength of BSG shall be analyses and ensured. The overhang should be planned only after suitably confirming the overhang length for which BSG had been designed and checked. The launching scheme shall include all relevant steps and notes required for safety and stability for all temporary structures and BSG.

Annexure 11A

List of Standard RDSO Drawings of ROB

SN	Description of Drawing
1	18.0m (ROB) IRC-6 loading welded type
2	24.0 m (ROB) IRC-6 loading welded type
3	30.0 m (ROB) IRC6 loading welded type
4	36.0m (ROB) IRC-6 loading welded type
5	Skew arrangement for 18m, 24m, 30m and 36m span ROB
6	Bow string arch steel girder (30 m clear span)
7	Bow string steel girder (36 m clear span)
8	Bow string steel girder (42 m clear span)
9	Bow string steel girder (48 m clear span)
10	Bow string arch steel girder (54 m clear span)
11	Bow string arch steel girder (60 m clear span)
12	Bow string arch steel girder (72 m clear span)
13	Details of deck slab for 5- girder arrangement
14	Splicing arrangement for bending of cross girder of B.S.A.G.
15	18m span composite welded girder for NHAI configuration
16	24m span composite welded girder for NHAI configuration
17	30m span composite welded girder for NHAI configuration
18	36m span composite welded girder for NHAI configuration
19	18,24,30,36m span related ROB drawings for NHAI configuration
20	42 m clear span bow string girder for NHAI
21	48 m clear span bow string girder for NHAI
22	54m clear span bow string girder for NHAI
23	60m clear span bow string girder for NHAI
24	72m clear span bow string girder for NHAI
25	Bow string steel girder for zone v (48 m clear span)
26	Different launching scheme of bow string girder
27	Bow string steel girder for zone v (60m clear span)
28	54m clear span bow string girder for zone V
29	60m NHAI three lane Bow String Girder
30	72m clear span bow string girder for zone V
31	Typical plan for sacrificial shuttering arrangement
32	Bow string girder 42m clear span (NHAI) three lane one way
33	Bow string girder 48m clear span (NHAI) three lane one way
34	Bow string girder 56m clear span (NHAI) three lane one way
35	Bow string girder 60m clear span (NHAI) three lane one way

36	Bow string girder 72 m clear span (NHAI) three lane one way
37	N-type steel O.W.G. (102 m 3 lane 1way for N.H.A.I)
38	N-type steel O.W.G. (102 m 2 lane 1way for N.H.A.I)

Reference Documents

SN	Para No	Ref. document details	
1	1102(1) (vi), 1104(2)(c)	11.01	Railway Board's letter No. 2017/CE-IV/RUB/88 dated 20.04.2020.
2	1102(1) (vi), 1104(2)(c)	11.02	Railway Board's letter No. 2017/CE-IV/RUB/88 dated 27.01.2022.
3	1102(1) (vi), 1104(2)(c)	11.03	Railway Board's letter No. 2017/CE-IV/RUB/88 dated 18.02.2021
4	1104(1)	11.04	Railway Board's letter No. 2015/CE-IV/ROB/76 dated 01-03-2016 and No. 2015/CE-IV/ROB-RUB/Misc dated 15-02-23
5	1104(1)	11.05	Railway Board's Letter No 2015/CE/IV/ROB-RUB/Misc./49 dated 29.10.2019
6	1104(1)(d)	11.06	Railway Board's letter No. 2015/CE-IV/ROB/78 Pt. dated 15.01.2020
7	1104(1)(e)	11.07	Railway Board's letter No. 2017/CE-IV/ROB/164 (policy) dated 16-02-2021
8	1105	11.08	Railway Board's letter No. 2017/CE-IV/88 dated 23-02-2023
9	1106(2) (xviii)	11.09	Railway Board's letter No. 2015/CE-IV/RUB/206 dated 15.02.2016
10	1106(2) (xviii)	11.10	Railway Board's letter No. 2015/CE-IV/RUB/206 dated 11.08.2016
11	1104	11.11	BS 112- RDSO guidelines for planning of ROB
12	1104	11.12	BS132- Compendium for Road Over Bridges on Indian Railways
13	1106(3)(a) (iii)	11.13	Railway Board's letter No. 2017/07/CE-III/BR/Safety dated 27.09.2022

***

CHAPTER 12
STEEL GIRDER FABRICATION

1201 INTRODUCTION

(1) The bridge superstructures in the form of steel girders are either-

(a) Solid Web Girder

(i) Plate girders

(ii) Composite girders

(b) Open Web Girder

(i) Through girder

(ii) Semi-through girder

(iii) Underslung girder

(2) The Open line/Construction Organization shall get their fabrication requirement of steel structure for railway works met by primary or secondary sources as given in Table 12.01.

TABLE 12.01

PRIMARY AND SECONDARY SOURCE

SN	Railway	Primary source	Secondary source
1	CR, WCR & SECR	Manmad	Sabarmati
2	ER, ECoR & ECR	Mughalsarai	Lucknow
3	NCR, NR	Jalandhar & Lucknow	Mughalsarai
4	SWR, SR	Arakkonam	Manmad
5	NWR, WR	Sabarmati	Manmad
6	SCR	Lallaguda	Manmad
7	NFR	Bongaigaon	Mughalsarai
8	NER	Gorakhpur	Lucknow
9	SER	Sini	Mughalsarai

In case primary, and secondary sources are not able to complete the requirement within the realistically planned target date, concerned CBE shall advise the requisite railway, their ability/ inability to supply girders within the stipulated time. Only after obtaining the confirmation in writing from CBE of both the primary and secondary sources that they are not able to meet the request of the zonal railway, the concerned railways may go to the trade for fabrication/ supply of girders by meticulously stipulating the fabrication of bridge superstructure as eligibility criteria in the tenders. In such cases, zonal railway will have to ensure that the trader supplies the material within the target date originally stipulated by railway to the CBE of primary and secondary source as stipulated in RB No. 2014/CE-III/BR/Bridge Workshops Policy Dt 24.02.2014 **(Ref. 12.01)**.

(3) When railway goes to the trade for fabrication/supply of girders, the fabrication workshop shall be RDSO approved for the nature of the fabrication work it is supposed to carry out. The tendering firm should have valid approval throughout the execution process as per BS-S-7.5.3.1-4 Version 3.0 dated 12.07.2022 (Latest) on "Schedule of Technical Requirements for fabrication of Open Web, Composite and other Steel Plate Girders (Part-A) or BS-S-7.5.3.1-4 version 4.3 dated 28.06.2021 (Latest) on "Schedule of Technical Requirements for fabrication of Composite and other Steel Plate Girders(Part-B)" **(Ref. 12.02)**.

(4) In case the tendering firm is not in the list of RDSO approved firms for fabrication of Steel Bridge Girder, then it will have to get the Steel Girder manufactured through an RDSO approved firm in the RDSO approved premises only vide Railway Board Instruction No. 24/2019 vide RB No. 2016/54/CE-III/BR/RDSO Misc. Dt 15.07.2019 **(Ref.12.03)**. Before ordering sub-letting of work, the Contractor shall submit the names of the Sub-Contractors proposed for the approval of the Engineer and shall afterwards send a copy of the orders for the subletting work **(Ref. IRS B1 para 3)**. The Contractor shall be responsible for the entire sublet work. Such work shall be inspected and verified by the Inspecting Authority.

(5) For the Steel Girders of important bridges (para 902(1) of this manual), besides RDSO approved as mentioned in para (3) and (4) above, firm may also be permitted to set up a site fabrication workshop at site of work which meets the Schedule of Technical Requirements for steel bridge girder issued by RDSO. The approval of the site fabrication workshop will be done by RDSO only and not by any other organization vide Railway Board letter no 2016/54/CE-III/BR/RDSO/Misc. dated 09.05.2019 **(Ref.12.04)**.

1202 AUTHORITY FOR INSPECTION OF NEWLY FABRICATED STEEL GIRDERS

(1) Railways may carry out fabrication inspection of welded bridge girders carrying rail or rail-cum-road traffic whether completely welded type or partially welded type, on its own by open line/bridge organisation (FIU- Fabrication Inspection Unit), or may engage specialised third party (RDSO, KRCL, RITES, WRI or any other expert public sector undertaking e.g., CEIL etc.) for fabrication inspection of girders to ensure the quality of fabrication. The respective procuring entity shall nominate/select third party to ensure quality with the consent of CBE of the Railway.

(2) Fabrication Inspection Unit (FIU) of zonal railway headed by an officer not below JA grade under CBE of that Railway, shall inspect welded/partially welded type girder carrying rail or rail-cum-road traffic, and composite steel plate girder for ROB.

(3) For ROBs, an inspection of all standard as well as non-standard steel bow string girdersand non-standard composite-I as well as truss type steel girders shall only be done by RDSO.

TABLE 12.02

FABRICATION INSPECTION OF STEEL GIRDERS OF RAILWAY BRIDGES AND ROBS

Step No.	Fabrication Inspection Steps	Railway Bridges	Road Bridge (Composite I-Girder)		Bow String Girders (ROBs)
		Standard/ Non-Standard	Standard Composite Girders	Non-Standard Composite Girders	All Types of BSG
1.	Nominated Inspecting Agency	RDSO /CEIL/ RITES/ KRCL/ Fabrication Inspection unit (FIU) of Zonal Railway	RDSO/ CEIL/ RITES/ KRCL/ Fabrication Inspection unit (FIU) of Zonal Railway	RDSO Only	RDSO Only
2.	Approval of *QAP & **WPSS	Inspecting Agency	Inspecting Agency	RDSO	RDSO
3.	Approval of Welding Procedure Qualification Record (***WPQR)	Inspecting Agency	Inspecting Agency	RDSO	RDSO
4.	Material Inspection	Zonal Railway/ PSU	Zonal Railway/ PSU	Zonal Railway/ PSU	Zonal Railway/PSU
5.	Inspection of Master Plate & Layout	Inspecting Agency	Inspecting Agency	RDSO	Zonal Railway
6.	Inspection of Trial Assembly	Inspecting Agency	Inspecting Agency	RDSO	RDSO
7.	Inspection of Components/ Dismantled Components and Welding	Inspecting Agency	Inspecting Agency	RDSO	RDSO
8.	Components of next span	Inspecting Agency	Inspecting Agency	RDSO	RDSO
9.	Inspection Certificate	Inspecting Agency	Inspecting Agencysw	RDSO	RDSO 1. Component level (Interim IC) 2. At Assembly site (Final IC)

* QAP:Quality Assurance Plan

** WPSS: Welding Procedure Specification Sheet

*** WPQR: Welding Procedure Qualification Record

Note: Above table is a representative summary only. The actual stage inspections of fabrication as

enumerated above shall be governed by approved QAPs

(4) Fabrication Inspection of Steel Girders of Railway Bridges and ROBs can be sought out in Table 12.02. For further clarification **(Ref. 12.03)**, Railway Board letter No. 2016/54/CE-III/BR/RDSO/Misc. dated 09.05.2019 **(Ref. 12.04)**, Railway Board Letter No. 2017/16/CE-III/BR/Girder inspection Dt. 26.05.2017 **(Ref. 12.05)**, RDSO No. CBS/INSP/WBG Dt.13-08-2018 **(Ref. 12.06)**, Railway Board Letter No. 2017/16/CE-III/BR/Girder Inspection Dt.17-11-2022 **(Ref. 12.07)**, and Para 27.1 of WBC may be referred.

1203 FABRICATION WORKSHOP

Inspection of workshop: Inspection of workshop & records shall be done for availability of following facilities with respect to RDSO approval as per **Ref.12.02**:

(a) Covered Space for layout, fabrication, blasting & painting

(b) Various machines listed in **Ref. 12.02**.

(c) Material handling equipment, tools & tackles.

(d) Concrete surface for raw material stacking, trial assembly, storage for ready components.

(e) Testing facilities (In-house and NABL/ NABCB approved labs)

(f) Calibration of CNC machines with accuracy, validity.

(g) Staff competency (Engineers, Welders, Fabricators, Craftsmen and Painters etc.)

(h) Other certifications like ISO etc.

1204 QUALITY ASSURANCE PLAN (QAP) FOR FABRICATION

(1) PREPARATION AND APPROVAL OF QAP

(a) For ensuring quality fabrication, QAP prepared by fabricating agency and duly signed by fabricator, contractor and an officer (Railway JAG or equivalent rank) of project executing organization shall be put up for approval of the inspection agency **(Ref. 12.03 & Ref. 12.04)**.

(b) In all cases of fabrication of RDSO standard spans of steel girders where RDSO is chosen as the Inspecting Agency the procedure given in RDSO letter no. CBS/Bridge Insp/Genl Matters Dt 01.03.2023 **(Ref. 12.08)** is to be followed for approval of QAPs, i.e.,based upon the type of girder Model QAP is to be adopted and the top sheet is required to be filled and sent to RDSO for approval purpose.

(c) In all cases of fabrication of RDSO standard spans of steel girders where any other specialized third party is engaged as Inspecting Agency, it is advisable that QAP may be prepared based on model QAP suggested in **Ref. 12.08** and approved by the Inspecting Agency. If changes in the model QAP are envisaged then approval of CBE shall be obtained and RDSO shall be informed.

(d) In the case of a non-standard girder, it is advisable that the QAP be prepared based on BS:124 and counter-signed by CBE after scrutiny by the prime design consultant and approval by the Inspecting Agency.

(2) SCOPE OF QAP

(a) Quality Assurance Plan (QAP) will describe stage-wise procedure for quality controlling of activities such as acceptance of material, fabrication processes, testing and inspection, painting and metalizing, material stacking, dispatch etc. **(Ref. para 1 of BS:124)**. Inspection of fabrication workshop to ascertain facility, equipment, RDSO approval, capacity and competency of artisan etc.

(b) The Quality Assurance Plan shall cover the following activities:

(i) Raw Material Inspection: for details **refer para 1205**.

(ii) Inspection of consumables: for details **refer para 1206**.

(iii) Manufacturing Process: for details **refer para 1207**.

(iv) Welding: for details **refer para 1214**.

(v) Inspection of trial assembly: for details **refer para 1217**.

(vi) Dismantling of trial assembly: for details **refer para 1217 (4)**.

(vii) Surface protection: for details **refer para 1219**.

(viii) Final dispatch including packing, shipping mark and loading etc.: for details **refer para 1220**

The activities mentioned above are discussed in detail in the related paragraphs of this chapter. Each of the activities shall be inspected by internal quality inspector of fabricator on day-to-day basis to ensure quality and recorded in appropriate document/ register.

(c) The internal QC organization of fabricator shall be responsible for day-to-day adherence of QAP and stage inspection. It shall be responsible for collection of samples, witnessing, testing of samples and analysis of test results to satisfy QAP.

(d) Various records as given in this chapter are to be maintained for ensuring QAP and facilitating inspection by Inspecting Agency. These records should be verified by internal QC organization at every stage of fabrication.

(e) For the preparation of the QAP document para 11 (attachment on page 64) of BS:124, Annexure-I of BS:110(R), Annexure-I of BS:125, Annexure-I of BS:130, and the latest guidelines from Railway Board/ RDSO may be referred.

(f) Based on above para, stage of work/ component/ material-wise, rows can be added by the agency preparing QAP. Sample proforma given in Table 12.03 may be adopted for QAP.

TABLE 12.03

QUALITY ASSURANCE PLAN

SN	Components & Operations	Characteristic check	Type of Check	Reference document/ Specification	Formats & Records	Frequency of Inspecting/ Testing	Responsibility & Extent of Inspection			Remarks
							Fabricator	Inspecting Agency	Consignee	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)

1205 RAW MATERIAL INSPECTION

(1) Identification and correlation of material heat/cast no. from Mill Test Certificate (MTC) & invoice/challan. MTC shall contain the following information:

(a) All the steel sections used in the fabrication must have Mill Test Certificate (MTC) clearly indicating the specification to which the steel conforms and whether steel is UT tested, killed and normalized **(Ref. IRS B1 Para 8.12)**.

(b) All the cast mark numbers/ heat mark numbers, shall be matched with MTC and recorded along-with the number of plates/ rolled section in material receipt register as soon as the material are received in the workshop.

(c) Sampling and witnessing of lab tests shall be done in presence of representative of project executing agency. Reports of NABL/NABCB approved lab shall be correlated with MTC.

(d) Above details to be recorded in Table 12.12: Statement of material test certificates of this manual.

(2) STEEL PLATES AND ROLLED SECTION (Ref. IRS B1 para 8)

(a) The 'grade designation' and 'quality' of steel should conform to para 5 of IS: 2062 and para 8 of IRS B1. Table 1 & 2 of IS: 2062 categories steel in nine grades of steel. For grades E 250 to E 410 there are four sub-qualities (A, BR, B0 and C) and for grades E 450 to E 650 there are two sub-qualities (A and BR). Sub-qualities A, BR, B0 and C indicate requirement of impact test and mode of de-oxidation as indicated below:

(i) Quality 'A'- Impact test not required, semi-killed/killed

(ii) Quality 'BR'- Impact test optional; if required at room temperature; semi-killed/ killed

(iii) Quality 'B0'- Impact test mandatory at 0°C, semi-killed/ killed

(iv) Quality 'C'- Impact test mandatory at –20°C, killed

(b) In case 'Rolled Steel Section' conforming to IS:2062 Quality "B0" or "C" are not available in market, CAO(C)/CBE may permit use of steel conforming to IS:2062-2011 Quality "BR" on case-to-case basis by satisfying himself about non availability of quality "B0" or "C"

(c) In a 'Rolled Steel Section' conforming to IS:2062 Quality "BR" is also not available in market, CAO(C)/ CBE may permit use of steel conforming to IS:2062 Quality "A" case to case basis, by satisfying himself about non-availability of quality "BR", however, Quality "A" shall be used for foot-over bridges and other structures subjected to non-critical loading.

(d) Visual inspection and dimension check- In this inspection it shall be recorded that the steel is reasonably straight and free from surface flaws, lamination, pitting, rusting, rough/jagged and imperfect edges, rolling marks or other surface defects. Visual and Dimensional inspection details to be recorded as per Table 12.09: Material offering and inspection register of this manual.

(i) Steel Plates: Minor surface defects may be removed as specified in para 7.2 of IS: 2062-2011. Dimension Check to be done by measurement, conforming to IS: 1852-1985 para 7. Thickness tolerances is reproduced in Table 12.04.

TABLE 12.04

THICKNESS TOLERANCES OF PLATE

Thickness	Tolerance in % of nominal thickness
Less than 8 mm	+12.5 and -5%
From 8 mm up to and including 12 mm	+7.5 and -5%
Over 12mm	+5 and -5%

(ii) Rolled Section: The dimensions of all rolled sections must agree with the approved drawings. The rolling and cutting tolerances shall be in accordance with IS: 1852-1985 or closer tolerances as shown in the drawing **(Ref. IRS B1 Para 8.10 & 8.11)**. Rolling tolerances given in para 4 of IS:1852 to be ensured:

i Depth

ii Width of flange

iii Flange out-of-square or out-of- parallel

iv Off center of web

v Weight

vi Twist

vii Camber and sweep

viii Leg length (for angles)

ix Visual and Dimensional inspection details

(e) NDT inspection

(i) Ultrasonic testing shall be done for all the plates of 12 mm thickness & above for lamination check as per IS: 4225, ASTM SA-435/435M (BS: 124 page-64 item 1(1.1.1) and **Ref. 12.08**.

(ii) This requirement shall be highlighted at the time of ordering the material to the manufacturer of steel plates, so that inspection if any may be planned.

(iii) Certificate of ASN level-II operator, calibration certificate of ultrasonic machine and Lab test Reports are to be recorded.

(f) Destructive testing

(i) Tensile test: This test is for yield strength, tensile strength, and percentage elongation of steel. Two test samples per cast/heat and a class of steel product irrespective of cast/heat size from each supplied lot, on standard test pieces prepared in accordance with IS:1608.

(ii) Bend test: Two samples shall be tested for each cast/heat and a class of steel product irrespective of cast/heat size from each supplied lot as per IS: 1599.

(iii) Charpy impact test: This test is carried out using a V-notch test piece and test samples shall be taken from thickest plate per cast/heat. For details refer para 12 of IS:2062

(g) Acceptance of steel

(i) If any of the tests above do not give the specified results, two additional tests shall be carried out at random on the same lot. Both re-tests shall conform to the

requirements of IS: 2062; otherwise, the lot shall be rejected **(Ref. para 17.1 of IS: 2062)**.

(ii) If any heat-treated material fails to meet the mechanical requirements specified, the supplier may re-heat the material and, in that case, all mechanical properties shall be re-evaluated. (**Ref.** para 17. 2 of IS: 2062)

(3) SHEAR STUD

(a) The raw material inspection shall be done as per BS: 115.

(b) Chemical and Mechanical properties shall be tested as per BS: 115 (Revision 1), ISO: 13918 and applicable codes referred in these codes and guidelines.

(c) Visual inspection and dimension check

(i) Dimensional check of studs shall be as per BS: 115.

(ii) The studs shall have proper flux (aluminum ball) at the tip.

(iii) Studs shall not be corroded and shall not have any coating.

(iv) Tolerances in length: the length of loose studs shall be verified as per EN code provisions. For 25 mm dia. & 200 mm long studs commonly used in RDSO drawings, the length of loose studs shall be 205.5 mm, with the tolerance of +/- 1.5 mm.

(v) Mass of studs shall be as per table A.4 of ISO-13918 (2008) (E) **(Ref. para 6 of BS-115 Rev1)**.

(4) HSFG BOLTS, NUT & DTI WASHERS

(a) Chemical and Mechanical properties shall be tested as per IRS B1 and relevant EN: 14399 series codes referred in it.

(5) For inspection of raw materials, the Check List in Table 12.05 may be followed.

TABLE 12.05

CHECK LIST - INSPECTION OF RAW MATERIALS

SN	Description	Yes/ No/NA	If NO, Action Needed	Details of Record or Ref Doc No
(1)	Approval of QAP	YES		QAP No. Approval Letter No.
(2)	Raw Material			
(a)	Steel Plates, Structural Section conforming to Steel to IS: 2062 quality BO fully killed and normalized			
(i)	Identification and correlation with Mill Test Certificate	YES		Records available in Statement of Material Test certificate register Page No.
(ii)	Visual Inspection	YES		Inspection details available in Statement of Material Test certificate Register Page No.

(iii)	Sampling and Testing at NABL/NABCB Approved Lab in presence of representative of Executing Agency.	YES		Lab Test Reports (for Mechanical Test, Charpy test, Chemical Analysis) available in Statement of Material Test certificate Register Page No.
(iv)	Ultrasonic Test for 12mm & above plates (by ASNT Level-II Operator) done	YES		Lab Test Reports available in Statement of Material Test certificate Register Page No.
(v)	Dimension Inspection	YES		Inspection details available in Statement of Material Test certificate Register Page No.
(vi)	Whether material is passed?	YES		Details available in Statement of Material Test certificate Register Page No.
(b)	Stud			
(i)	Visual & Dimension Inspection	YES		Inspection details available in Statement of Material Test certificate Register Page No.
(ii)	Sampling and Testing at NABL/NABCB Approved Lab in presence of representative of Executing Agency.	YES		Lab Test Reports (for Mechanical Test, Chemical Analysis) available in Statement of Material Test certificate Register Page No.
(iii)	Whether material is passed?	YES		Details available in Statement of Material Test certificate Register Page No.
(c)	HSFG Bolts & Nuts	YES		Inspection details available in Statement of Material Test certificate Register Page No.
(i)	Dimension Inspection	YES		Inspection details available in Statement of Material Test certificate Register Page No.
(ii)	Sampling and Testing at NABL/NABCB Approved Lab in presence of representative of Executing Agency.	YES		Lab Test Reports (for Mechanical Test, Chemical Analysis) available in Statement of Material Test certificate Register Page No.
(iv)	Whether material is passed?	YES		Details available in Statement of Material Test certificate Register Page No.

1206 INSPECTION OF CONSUMABLES

(1) METALISING CONSUMABLES

(a) Abrasive material for blasting:

(i) The abrasive material shall be in accordance with Clause 4 of IS: 6586.

(ii) Visual and Dimensional inspection details to be recorded in Table 12.09: Material offering and Inspection Register of this manual.

(b) Aluminium wire for metalizing: The chemical composition of Aluminium to be sprayed shall be 99.5% aluminum conforming to IS: 2590.

(2) PAINTS

Paints shall be procured from reputed vendors. Reports of NABL/NABCB approved lab shall be correlated with MTC. Sampling and testing of paints shall conform to IS: 101 besides following:

(a) Etch/ wash primer conforming to IS: 5666.

(b) Zinc chrome primer conforming to IS: 104 with the additional proviso that zinc chrome to be used in the manufacture of primer shall conform to type 2 of IS: 51.

(c) Zinc chrome red oxide conforming to IS: 2074.

(d) Aluminium paint conforming to IS: 2339.

(3) WELDING CONSUMABLES

(a) SAW wire and flux: Lab testing as per IRS M-39 shall be carried out.

(b) GMAW wire: Lab testing as per IRS M-46 shall be carried out.

(c) MMAW Electrode: Lab testing as per IRS M-28 shall be carried out.

(4) For inspection of consumables, the Table 12.06 of the Check List may be followed.

TABLE 12.06

CHECK LIST - INSPECTION OF CONSUMABLES

SN	Description	Yes/ No/NA	If NO, Action Needed	Details of Record or Ref Doc No
(1)	Approval of QAP& WPSS	YES		QAP No. QAP Approval Letter No. WPSS No. WPSS Approval Letter No.
(a)	Paints and Primers			
(i)	Visual Inspection	YES		Inspection details available in Statement of Material Test certificate Register Page No.

(ii)	Sampling and Testing (as per approved QAP) at NABL/NABCB Approved Lab in presence of representative of Executing Agency.	YES		Lab Test Reports available in Statement of Material Test certificate Register Page No.
(iii)	Whether material is passed?	YES		Details available in Statement of Material Test certificate Register Page No.
(b)	Aluminium wire			
(i)	Sampling and Testing (as per approved QAP) at NABL/NABCB Approved Lab in presence of representative of Executing Agency.	YES		Lab Test Reports available in Statement of Material Test certificate Register Page No.
(ii)	Whether material is passed?	YES		Details available in Statement of Material Test certificate Register Page No.
(c)	Welding Consumables			
(i)	Sampling and Testing (as per approved QAP) at NABL/NABCB Approved Lab in presence of representative of Executing Agency.	YES		Lab Test Reports available in Statement of Material Test certificate Register Page No.
(ii)	Whether material is passed?	YES		Details available in Statement of Material Test certificate Register Page No.

1207 FABRICATION RECORDS

(1) FABRICATION DRAWING REGISTER

Fabrication drawing register shall contain component wise details of fabrication drawing, related master gusset and jigs, inspection and distance gauges etc. Fabrication drawings are prepared by the contractor based on the structural drawing of structure. These drawings shall be prepared accurately and correctly after verification of layout & templating, as these are basis of actual fabrication work such as, manufacturing of master gussets and jigs, cutting, drilling, welding, joint fit-up, assembly etc. it is advisable to follow para 1208 of this manual. Fabrication drawings are used to prepare cutting list for materials. These drawings shall be approved by the engineer before put into use (**Ref.** para 1.2 of IRS B1).

(2) JIGS REGISTER (Ref. Appendix I of IRS B1)

This register shall be maintained to keep a record of the details of jigs, including their approval and any modifications or rectifications made to the jigs. One page should be allotted for each jig, as outlined in Table 12.07. At the beginning of the Register, a statement of the jigs shall also be included, in accordance with Table 12.08.

TABLE 12.07

JIGS REGISTER

(i) Description of jig:_____

(ii) Jig No:_____

(iii) Shipping mark of the component for which jig is made:

(iv) Drawing No. for the component:_____

Date of inspection	Observation/ inspection notes	Compliance action	Initial of Supervisor In charge
1	2	3	4

TABLE 12.08

STATEMENT OF JIGS

Jig No.	Description of Jig.	Shipping mark of the component.	Drg. No. as per which jig is made/modified	Inspecting official's approval details
1	2	3	4	5

(3) MATERIAL OFFERING AND INSPECTION REGISTER (**Ref.** Appendix I of IRS B1)

This register shall be maintained separately for each work order for keeping record of material offered for inspection, inspection remarks and passing details. One page should be allotted for individual members or fittings. Proforma shall be as per Table 12.09.

TABLE 12.09

MATERIAL OFFERING AND INSPECTION REGISTER

(i) Description of component/fitting: _____

(ii) Shipping mark: _____

(iii) Quantity required per span: _____

Span No.	Initial of Supervisor offering material for inspection.	Inspecting officials Remarks	Compliance action	Seal & initial of Inspecting official	Dispatch & consignee details.
1	2	3	4	5	6

(4) INSPECTION NOTES AND COMPLIANCE REGISTER (**Ref.** Appendix I of IRS B1)

This register shall be maintained to record compliance actions taken on inspection notes. In this register, one copy of the inspection note received from inspecting officials shall be pasted, and compliance action recorded against each item.

(5) WELDING PROCEDURE DATA REGISTER (Ref. Appendix I of IRS B1)

The welding data record, to be submitted to the Inspecting Authority while offering the welded girder for inspection. In this register complete details of welding shall be maintained in the Proforma as per Table 12.10.

TABLE 12.10

WELDING PROCEDURE DATA REGISTER

(i) Name of work: _____

(ii) Contract/Work Order No. _____

(iii) Span No. _____

Date of welding	Girder component and its Sl. No.	Weld joint description	Name of welder/ Ticket No.	WPSS No. followed
1	2	3	4	5

Welding consumable used		Welding parameters			Weld repair details	Run on/ Run off tabs. No. if any	Ultrasonic Test/ Radiograph No. if any	Initial of Supervisor In-charge
Electrode/ wire	Flux	Current (amp.)	Arc Voltage (volt)	Travel Speed (m/ min)				
6	7	8	9	10	11	12	13	14

(6) NDT (RADIOGRAPHIC/ ULTRASONIC) TESTING REGISTER (Ref. Appendix I of IRS B1)

This register shall be maintained for testing of Butt welds. In addition, a register for all the NDT done on weld shall be maintained as per **Table 12.11**.

TABLE 12.11

NDT (RADIOGRAPHIC/ ULTRASONIC) TESTING REGISTER

Name of work	Span No.	Girder Part	Weld joint description	Date of radiographic inspection.	Radiograph No.	Observation	Result	Initial of Supervisor in-charge.
1	2	3	4	5	6	7	8	9

(7) STATEMENT OF MATERIAL TEST CERTIFICATES (Ref. Appendix I of IRS B1)

This register shall be maintained for material acceptance and traceability as given in Table 12.12. One page should be allotted for each span similar records with appropriate columns are to be maintained for other consumables etc.

TABLE 12.12

STATEMENT OF MATERIAL TEST CERTIFICATES

(i) Name of Work_____

(ii) Contract/Order No. _____

(iii) Span No. _____

Girder Component description and identification No.	Type and Size of rolled section	Material Test Certificate No.	Cast No.	Steel quantity as per the test certificate	Steel Manufacturer/ Supplier	Initial of Supervisor in charge
1	2	3	4	5	6	7

1208 LAYOUT AND TEMPLATING

Templating means setting out the drawing to-the-scale on the shop floor. Templating helps in the following:

(1) Preparation of complete detailed fabrication drawings and erection marking drawing based on the design drawings, required for all the permanent and temporary structures.

(2) To find out errors in drawings and to find out overlaps in members or obstructions which might hinder the girder assembly. This is especially required for locations where many members are meeting.

(3) To find out unknown length of any member which cannot be worked out from design drawings.

(4) To prepare cutting list for materials from working drawings.

(5) Position of holes in web & flange plate for field splice joint, top lateral bracing, and intermediate stiffeners.

(6) Profiles of gussets, cross bracing angle ends etc.

(7) Various gauges such as edge distance, profile gauge, pitch gauges, center gauge required for ensuring accurate dimensional tolerance.

(8) The measurements taken from the templating are used for manufacturing Master Gussets.

(9) Master gussets are not used for girder fabrication directly. These are stored carefully in workshop and used for fabrication and rectification of Working Gussets and Member Jigs.

(10) The correctness of CG of members, whether CG of member matches with CG of main gusset plates, accuracy of member lengths with respect to length given in camber drawings shall be checked during layout stage inspection.

(11) Accuracy in fabrication and getting effective pre-stressing of open web steel girder span depends solely on accuracy of holes and camber lengths of members, which in turn depends on quality of gussets/jigs.

(12) It is possible that templating may be done on computers, using any 3D modelling software. Fabrication drawings may be prepared by using 3D computer-aided drawing software that provides every detail of the components and joints. The 3D drawings can be viewed in exploded view to verify accuracy of drawings and hidden components.

(a) It is desirable that file format of soft copy of 3D drawing should be compatible with the CNC machine software so that drawings can be directly used as input.

(b) As these drawings, as approved, are meant to be replacing templates. Therefore, these drawings shall be preserved for record and future reference.

(c) Provision for 3D drawings using appropriate software may be made in QAP as well as in tender schedule so that the fabricator/contractor may have in-house team or engage specialized agency.

1209 FLATTENING AND STRAIGHTENING

All steel materials plates, bars and sections shall have straight edges, flat surfaces and be free from twist. If necessary, flattening and straightening shall be carried out as per para 15.1 & 15.2 of IRS B1.

1210 PLANNING, SHEARING AND CUTTING

Except where otherwise indicated, cutting of all plates and sections shall be affected by shearing or sawing as per para 16 of IRS B1 duly accounting the wastage in cutting and edge preparation, end milling requirement, distortion correction etc.

(1) Heat/Cast number must be transferred on components before taking up cutting operation and also to be recorded in cutting register. This register is useful for identification and traceability of raw material used. Sample format is given in Table 12.13:

TABLE 12.13

CUTTING REGISTER

Date of cutting	Size of plate	Plate No.	Heat No.	Thickness	Width	Length	Quantity	Sign. of internal QC	Sign. of Project executive agency
1	2	3	4	5	6	7	8	9	10

(2) Cutting by mechanically controlled torch/torches single/ multi-head flame cutting machine preferably oxyacetylene gas shall be used provided the edge is reasonably clean and straight. Use of multi-head is desirable for higher productivity and reducing the distortion. Plasma-arc cutting method can also be employed. This process offers less heat input causing less distortion. **(Ref. IRS B1 para 17)**

(3) After surface cleaning, cutting for requisite sizes shall be the first process to be carried out, this may be carried out by any of the CNC cutting machine viz. CNC Plasma Cutting Machine and CNC Multi-torch Flame cutting Machine or multi head pug cutting machine mounted on guide rail arrangement **(Ref. BS:124 Para 7.6.5)**. Valid calibration certificate of CNC machines for accuracy shall be ensured before carrying out cutting. All flame cut edges shall be cleaned square and true edges.

(4) Before cutting of plates, required nesting plan shall be prepared accordingly and Plate marking

by qualified artisan is done according to nesting plan or will be fed into CNC plasma cutting machine or CNC Multi-torch cutting Machine.

(5) Cutting shall be carried out in such a way that the requirements for geometrical tolerances, maximum hardness and smoothness of free edges are met (**Ref.** BS:124 Para 7.6.5).

(6) Draglines produced by cutting should be removed. Due cutting allowances shall be made to get the member slightly longer than required so that the final dimension of the member can be brought to the tolerances desired with minimum grinding/milling.

(7) Both the undercutting/ overcutting shall be avoided.

(8) When flame cutting is deployed on a plate of long length, suitable stitching method shall be followed to control the distortion **(Ref. BS: 124 Para 7.6.5)**.

(9) No shearing of sections or plates is permitted for plate thickness more than 12mm.

1211 EDGE PREPARATION / SCALLOPING, GRINDING & FINISHING (BS: 124 Para 7.6.7)

(1) BEVEL:

Wherever bevel is required, the edge preparation shall be done for welding process using Beveling Machine or using Pug Machine guided by railing arrangement for higher thickness plates.

(2) Scalloping shall be done only if the thickness difference between two plates is more than 3 mm and the scalloping ratio shall be 1:5.

(3) Edge Milling shall be used to maintain the pre camber requirement of all sections. Due cutting allowances shall be made to get the member slightly longer than required so that the final dimension of the member can be brought to the tolerances desired with minimum milling.

1212 DRILLING

(1) For making holes, working gussets and member jigs described in 1208(10) shall be used.

(2) The jig shall be clamped to fixture and the component for correct placement and levels to ensure no shifting during handling and drilling.

(3) Before fixing jig with member, all bushes (welded on holes) in jig shall be checked for accuracy by using go and no-go gauges. **(Ref. IRS B1 para 18.5)**

(4) When the bore diameter exceeds a tolerance of, -0mm, +0.4mm, the bushes shall be replaced. **(Ref. IRS B1 para 18.5)**

(5) Tolerances for checking jigs from master plates shall be +0mm, - 0.13mm.

(6) While drilling with CNC machine, it shall be ensured that the work piece is fixed firmly with help of suitably designed fixtures and does not shift during drilling due to vibrations.

(7) Valid calibration certificate of CNC machines for accuracy shall be ensured before carrying out drilling.

(8) The tolerance for holes shall be as per Appendix II of IRS B1.

(9) After drilling all burrs left by the drill and the sharp edges of all the rivet holes shall be removed completely. **(Ref. IRS B1 para 18.6)**

(10) No sub-punching shall be allowed in the main truss members of open-web girders. **(Ref. IRS B1 para 18.2)**

1213 TACK ASSEMBLY

(1) This activity is to be done carefully so that the final components/ girders that are being fabricated shall be of correct geometric shape and the size is within the tolerance specified.

(2) Size of tack welds shall be not less than the throat thickness or leg length of the root run to be used in the joint **(Ref. Para 24 of IR Welded Bridge Code)**.

(3) Length of the tack weld shall not be less than four times the thickness of the thicker part or 50 mm whichever is the smaller.

(4) Tack weld shall be done on both sides of member simultaneously in zigzag manner instead of opposite to each other to avoid distortion. The distance between tacks shall be 400 mm or as specified throughout.

(5) Tack welds shall not be made at extreme ends of joints.

(6) After the tack assembly is complete, the girder/ component shall be checked for dimensional accuracy as per clause 13 of IRS B1. Details to be recorded in Fit up register. This register is useful for verifying the fit-up tolerances before SAW/ GMAW is carried out, sample format is given in Table 12.14.

(7) After all pre-fabrication activities are completed, inspection shall be recorded as per format given in Table 12.15.

TABLE 12.14

FIT-UP REGISTER

Date	Component description	Dimension	Hole relation	Height	Length	Straightness	Sign. of internal QC	Sign. of Project executive agency
		Actual						
		Observed						

TABLE 12.15

INSPECTION OF PRE-FABRICATION ACTIVITIES

SN	Description	Yes/ No/NA	If NO, Action Needed	Details of Record or Ref Doc No
(1)	Manufacturing process			
(a)	Layout/ Templating			
(i)	Dimension check	YES		Inspection details available in Jig Register Page No.
(ii)	Preparatory work such as Cutting, Straightening, Edge Preparation, Marking, Drilling, Fit up, Pre-assembly, End finishing	YES		Day to day inspection details available in: i Cutting Register Page No. ii Fit up Register Page No.

1214 WELDING

(1) All welds should preferably be done by submerged-arc welding (SAW) process either fully automatic or semi-automatic. Flux cored Arc welding, Gas Metal Arc Welding (GMAW) or Manual Metal-Arc Welding (MMAW) may be done only for welds of very short runs or of minor importance or where access of the locations of weld do not permit automatic or semi-automatic welding **(Ref. IRWBC para 21.8 and IRS B1 para 26.2)**. Manual metal arc welding may be done taking adequate precautions as per IS: 9595 and under strict supervision. **(Ref. IRS B1 para 26.6)**. Check List in the **Table 12.16** may be used for welding.

(2) Site welding should not be undertaken except in special circumstances with the approval of the Chief Bridge Engineer. Site welding should be confined to connections having low stresses, secondary members, bracings etc. (**Ref.** IRS B1 para 26.5)

(3) The welds are to be examined radiographically/ultrasonically or by other non-destructive testing methods which are equally effective and present satisfactory evidence to the Engineer that welds are meeting the quality requirement. (IRS Welded Bridge Code para 14.3) Details of inspection shall be recorded in **Table 13.10**: NDT (Radiographic/ Ultrasonic) testing register.

TABLE 12.16

CHECK LIST- FABRICATION-INSPECTION OF WELDING

SN	Description	Yes/ No/NA	If NO, Action Needed	Details of Record or Ref Doc No
(1)	Welding			
(a)	WPSS	YES		WPSS No.
	WPSS Approval Letter No.			
(b)	WPQR	YES		WPQR No.
	WPQR Approval Letter No.			
(c)	Random Measurement of preheating Temperature	YES		Details available in welding procedure data register Page No.
(d)	Visual check of baking of Electrode, Flux	YES		Details available in welding procedure data register Page No.
(e)	Selection of correct electrodes & flux	YES		Details available in welding procedure data register Page No.
(f)	Current condition	YES		Details available in welding procedure data register Page No.
(g)	Sequence of welding	YES		Details available in welding procedure data register Page No.
(h)	Provision of Run-on & run-off plates	YES		Details available in welding procedure data register Page No.
(i)	Whether weld is passed?	YES		Details available in Statement of Material Test certificate Register Page No.

(2)	Inspection of welding			
(a)	For Fillet Welds- Visual, D.P. Test, Fillet Size, Penetration, Leg length, Throat thickness etc.	YES		Records available in DPT & Macro Etching register Page No.
(b)	For Butt Weld- Ultrasonic Test/ Radiography Test as applicable (as per approved QAP)	YES		Records available in NDT inspection register Page No.
(c)	Whether weld is passed?	YES		Details available in Statement of Material Test certificate Register Page No.
(3)	Stud Welding			
(a)	Visual & Dimensional Inspection	YES		Records available in Stud Welding Inspection register Page No.
(b)	Ring Test & Bend Test	YES		Records available in Stud Welding Inspection register Page No.
(c)	Whether material is passed?	YES		Details available in Statement of Material Test certificate Register Page No.

(4) PREPARATION OF SPECIFICATIONS FOR WELDING AND QUALIFICATION OF WELDERS

The first step in fabrication of girders by welding is to establish the parameters to be used for welding different type of joints involved in fabrication of girder and ascertaining if the welders are competent to make the welds of proper quality and strength. For this it is preferable to group the joints based on type, position, size, thickness of base plate etc. so that number of WPSS can be kept minimum. WPSS for tack welding shall also to be prepared (**Ref.** para 5.3 of Steel structure fabrication for Railways IRICEN publication). For approval and testing of welding procedures para 19 of IR Welded Bridge Code & para 26 of IRS B1, and for welder para 20 of IR Welded Bridge Code may be referred.

(a) Preparation of welding procedure specification sheet (WPSS): The latest version of IS: 7307 Part-I shall be referred for preparation of WPSS and testing. Welding procedure test shall be carried out to demonstrate by means of a specimen weld of adequate length on a steel representative of that to be used, so as to conform that satisfactory weld is achievable with the welding procedure to be used for fabrication (**Ref.** para 19 of IR Welded Bridge Code). Each page of WPSS shall be signed by fabricator, contractor, and an officer of project executing organization being minimum Railway JAG or equivalent rank.

(b) The welding procedure shall be such as to avoid distortion and minimize residual shrinkage stresses. Properly designed fixtures should be used for assembly. The welding techniques, quality, size of electrodes, required voltage and current shall be as prescribed by manufacturers of the material and welding equipment. The Contractor should submit

full details of welding procedure in Proforma as per IRS B1 para 26.4.

(c) For composite girder, WPSS for stud welding shall also be submitted.

(d) Approval of WPSS:

(i) The Inspecting Agency shall give approval of WPSS based upon scrutiny of submitted sheets with respect to the approved structural drawings of the girder.

(ii) In all cases of fabrication inspection where RDSO is chosen as the Inspecting Agency procedure given in RDSO letter no. CBS/Bridge Insp/Genl Matters Dt 08.06.2023 **(Ref. 12.09)** is to be followed for approval of WPSS.

(iii) In all other cases of fabrication inspection of steel girders,the following may be adopted for preparation and approval of WPSS by the Inspecting Agency.

(i) A statement of the results of assessing each test piece, including repeat tests for each welding procedure stating that no rejectable features or test results are found, and the test piece made according to the particular welding procedure satisfied the requirements of IS: 7307 in respect of that type of test piece from the approved lab will be the basis for approval of a particular WPSS (**Ref.** Para 8 of IS: 7307).

OR

(ii) The welding procedure tests carried out in accordance with IS:7307 and witnessed by an independent inspecting authority may be accepted by other inspecting authorities provided that all the provisions have been fulfilled subject to undertaking by fabricator and project executing agency that same welding machines will be used based on which earlier approval of WPSS was granted

(5) PREPARATION OF WELDING PROCEDURE QUALIFICATION RECORD (WPQR)

(a) Welder qualification test (WQT): The welders shall be trained in accordance with IS: 817. The welders shall be subjected to appropriate qualifying tests specified in IS: 7310 (Pt-I) as per IR WBC Para 21.1. In addition to the provisions of IS:7310 Part-I to qualify the welders for steel girder fabrication following must be ensured as stipulated in RB No. 2017/16/CE-III/BR/Girder Inspection Dt. 25.05.17 (**Ref. 12.10**)

(i) Welders to be engaged, in future, should at least be High School pass and preferably trained from ITI or a reputed Welder Training Institute. This provision of educational qualification shall not be applicable for the Welders already qualified & working satisfactorily.

(ii) Oral and written test to be made mandatory for qualifying new welders.

(iii) No welding by the fresh welders to be allowed till they pass and obtain the Welder Qualification Test (WQT) certificate. Nominated representative of Executing Agency shall witness WQT. If feasible, WQT certificate to be issued at site only.

(iv) In case of renewal of WQT certificate for the existing welders, the test procedure to be clearly specified. Besides the existing provisions, oral test and evaluation of records of welding be insisted upon.

(v) Welders giving consistently defective welds shall be re-tested & re-qualified.

(vi) Welders are allowed to weld only those type of welds for which they have WQT

certificate. Tack welders also need WQT certificate.

(vii) If same drawings and previously approved welders are to be used for new project then undertaking by fabricator shall be taken that the welder has worked within the range of qualification and to extend the validity of the qualification for a further six months period.

(b) Test Related to WPQR: Welding Procedure Qualification Record is maintained for each welder by the executing agency and approved by Inspecting Authority. As per IS: 7310 (part-I) visual, NDT and destructive test shall be carried out at premises of fabricator and it shall be the part of WPQR prepared by the executing agency as per Appendix V & para 26 of IRS B1 for each welder. Necessary arrangements of machines/ equipment to carry out these tests shall be made by the fabricator during WQT or these tests may be arranged by fabricator in approved Govt. labs/ NABL labs. WPQR for stud welding for composite girder, shall also be submitted as above.

(c) Approval of WPQR:

(i) Inspecting Agency shall consider the WQT report while approving the WPQR.

(ii) In all cases of fabrication inspection where RDSO is chosen as the Inspecting Agency; procedure is given in RDSO letter no. CBS/Bridge Insp/Genl Matters Dt.19.06.2023 **(Ref. 12.11)** is to be followed for approval and renewal of WPQR and its applicability for other similar projects.

(iii) In all other cases of fabrication inspection of steel girders, the Inspecting Agency shall give approval and renewal of WPQR preferably as per **Ref.12.11** or based on provisions of approved QAP and IS:7310 (part-I), 2019. The WPQR shall be renewed every six months.

(6) DISTORTION CONTROL MEASURES

(a) To minimize distortion during welding the sequence of welding and weld passes shall also be mentioned in the WPSS. Para 27 of IRS B1 and para 21 and 22 of IRS Welded Bridge Code may be referred. The following suitable methods may be used for fabrication of components for minimizing distortion (**Ref. BS: 124 Para 7.6.12.4**):

(i) Method of balanced (double sided) joint welding

(ii) Suitable welding process to reduce heat input

(iii) Reduced numbers of weld passes

(iv) Pre-set of the parts to be welded at suitable distance by clamping

(v) Controlled heating opposite to welding

(vi) Preheating of weld location by LPG flame thrower gun

(vii) Back-to-back tack weld of components for welding of 'C-built up' section and 'L-built up' section.

(b) All base plates and saddle plates of bearing should be perfectly machined and should be parallel to each other. When bearings are fixed to the bottom of girders any gap between bottom of girder and top of bearing plates may damage the bearing or in worst cases, cracks may be initiated from welding joint between bearing stiffener and bottom flange. This gap is generally due distortion of girder bottom flange left unattended. Further, shortening of the bearing stiffener due to welded connection of bearing stiffeners with

both web & flanges, pull and lock the bottom flange in distorted position. To ensure full contact between bearing top plate with girder bottom plate, distortion of girder bottom plate shall be fully rectified by 'blue matching' method after welding & finishing. For this necessary allowance to be provided for bottom flange material. This allowance can be capped within rolling tolerance by using distortion control fixtures at the time of welding bearing stiffener to girder bottom flange.

(7) WELDING PROCEDURES (Para 21 of IRS Welded Bridge Code)

(a) Welding work shall be given to a contractor who does produce satisfactory evidence of his ability to handle the work in a competent manner. The contractor shall employ a competent welder and supervisor to ensure that quality of materials and the standard of workmanship comply with the requirements laid down in WBC.

(b) Welds shall preferably be made in flat position.

(c) During the entire welding & cooling cycle, the joints shall not be subjected to any external forces or shocks.

(d) Freedom of movement of one member of a joint shall be allowed wherever possible. No butt joint shall be welded without allowing one component, freedom of movement of the order of 1.5 mm.

(8) SEQUENCE OF WELDING (Para 22 of IRS Welded Bridge Code)

(a) The sequence of welding shall be such that, when possible, the members, which offer the greatest resistance to compression, are welded first.

(b) The welding in the thinnest element of a section (usually the web in case of beams) shall be done prior to the welding of the thicker elements (usually the flanges in case of beams).

(9) RUN-ON AND RUN-OFF PIECES

Run-on and run-off pieces shall be provided in all cases of parent metal more than 20 mm thick or as per QAP, by extending the ends of the edges of the parts joined. These can be extra plates tack welded to the member being welded with similar joint preparation and of reasonable thickness, not less than the thickness of the part joined and not less than 40 mm long (**Ref.** Para 5.7 of WBC).

(a) If it is found convenient, the length of the member itself is increased so that the extra length is considered as run-on and run-off piece. Run-on and run-off pieces shall be removed afterwards by hacksaw or abrasive cutting. It should not be removed by hammering.

(b) The run on and run off pieces are very useful in quality control to check the welding quality by non-destructive as well as destructive tests.

(c) Run on/off pieces shall be duly marked and preserved till girder is finally cleared.

(10) PRECAUTIONS BEFORE WELDING

To get good quality weld by SAW process, the welder must ensure that:

(a) The SAW equipment is set properly as per WPQR with appropriate

(i) Current

(ii) Arc Voltage

(iii) Wire feed

(iv) Travel speed of equipment

(v) Electrode Stick out

(b) The flux and wire combination shall be conforming to IRS M-39, for submerged arc welding, as per approved WPSS.

(c) SAW electrode wire coil is fixed in machine after inspection to ensure no dent / bend or rust stain is there in the wire.

(d) On either side of the joint, 75mm width of flange and web plate should be properly cleaning.

(e) Flux is dried in oven to temperature 200-250°C for one hour before use.

(11) PRECAUTIONS DURING WELDING

(a) Full welding shall be carried out in flat/horizontal-vertical position with SAW process as per sequence mentioned in WPSS using manipulators or special welding fixtures. Welds in inaccessible locations or minor welds shall be made by GMAW welding, if approved in WPSS.

(b) Start welding on run-on piece from ends.

(c) Ensure that the flux lid is open and sufficient flux shall be poured ahead of welding nozzle.

(d) Welder shall ensure that variation of parameters during welding (over the WPSS) shall not exceed the following limits:

(i) Welding current±10%

(ii) Arc voltage ±7%

(iii) Speed travel ±15%

(12) PRECAUTIONS AFTER WELDING

(a) After completion of weld, welding is stopped on run-off piece.

(b) Entire flux is removed by suction after allowing 10 to 15 minutes cooling.

(c) Slag is removed carefully without any injury to the weld.

(d) The surface is cleaned with brush afterwards.

(e) Before shifting, run-on and run-off plates are removed by abrasive cut or hacksaw blade to avoid thermal stress **(Ref. Para 5.7 of WBC)**.

(f) Check any variation in shape of member during welding.

(13) TESTING OF WELDS

Welds shall be subjected to the following tests

(a) Visual examination: All welds shall be visually examined to ensure that the welds meet the specifications as given in Appendix C of WBC. This shall include:

(i) Surface defects visible at surface

(ii) Cracks have opening at surface

(iii) Damage to parent metal

(iv) Profile defects

(v) Incorrect finish

(b) Dimensional tolerances: All welds shall be checked for dimensional accuracy as per Appendix B of WBC. Suitable gauges shall be made and used to check the welds.

(c) Macro etching test shall be done on run on and run off pieces cut after welding to verify the fusion of the weld with parent metal and the complete profile of the weld and details shall be recorded in Macro etching test register.

(d) Non-destructive testing (NDT): Following NDT as applicable shall be done on the weld and details shall be recorded in relevant NDT register:

(i) Liquid/Dye Penetrant flaw detection Test (DPT)

(ii) Magnetic Particle flaw detection

(iii) Radiographic examination

(iv) Ultrasonic Testing

(v) Eddy current Testing

(vi) Ring test (for Studs) ref item 5.0 of Model QAP of BS-130

(e) Sample format for recording the test results is as under:

(i) DPT Register: Dye Penetrant Test (DPT) weld inspection identifies visual weld defects such as undercut, blow holes, cracks have opening at surface etc. If any defect id found it shall be rectified as per QAP and recorded. Format of this register is given in Table 12.17.

TABLE 12.17

DPT REGISTER

Date	Component description	Weld line No.	Porosity	Under cut	Crack	Grinding	Rectification date	Sign. of internal QC	Sign. of Project executive agency
1	2	3	4	5	6	7	8	9	10

(ii) Macro Etching Register: This weld inspection is carried out on the run on/off pieces for determining throat thickness and root penetration, format given in Table 12.18 may be used.

TABLE 12.18

MACRO ETCHING REGISTER

Date	Component description	Weld line No.	Vertical leg length	Horizontal leg length	Throat Thickness	Penetration	Sign. of internal QC	Sign. of Project executive agency
1	2	3	4	5	6	7	8	9

(f) Destructive testing (DT): The following destructive tests shall be done on a few run-on/ run-off piece of a welds as prescribed in QAP and recorded in destructive weld testing register as per Table 12.19. Balance run-off/ run-on pieces are to be preserved till girder is passed.

(i) Tensile test

(ii) Bend test

(iii) Impact test

(iv) Fracture Test

TABLE 12.19

DESTRUCTIVE WELD TESTING REGISTER

Date	Component description	Weld line No.	Tensile test	Bend test	Impact test	Sign. of internal QC	Sign. of Project executive agency
1	2	3	4	5	6	7	8

(14) SHEAR STUD WELDING FOR COMPOSITE GIRDER

(a) Precautions before welding: The welding parameters and the welder shall be qualified.

(i) For initial qualification, minimum two studs of each type being used shall be welded on sample plates having similar properties to the girder part on which these studs are to be provided.

(ii) The studs shall be welded in the same position as to be welded in the actual girder part.

(iii) If these studs are not found satisfactory, the welding parameters shall be adjusted or the welder shall be further trained and sample studs provided again till welding is found satisfactory.

(iv) After satisfactory qualification, certificates shall be issued by an officer of level Assistant Engineer or above, which shall be further governed as follows:

i. The welder shall be qualified for the approved welding parameters. For initial qualification, minimum two studs of each type being used.

ii. For any new position/quality/size of stud, the parameters to be used are required to be qualified only once.

iii. This need not be re verified as long as the quality of studs is satisfactory in field.

(v) The member surface shall be cleaned by light sand blasting or by scrapping with wire brushes such as to remove the mill scales.

(vi) If grease or other contaminants are present, the surface shall be cleaned with solvents also.

(vii) The prepared surface shall not be painted or metallised in any way. Where studs are to be welded to steel surface already painted, the welds surface should be brushed,

ground or scrapped to completely remove the paint from weld locations.

(viii) It is not adequate to remove enough paint to make electrical contact and allow the weld arc to get started, since the thickness and volatility of the remaining paint may still have a serious adverse effect on the welds.

(ix) The surface on which studs are to be welded shall be free from paints for a distance of minimum 50mm from the centre of any stud to be welded.

(x) Weld plate thickness: To develop full steel tensile and shear capacity of the stud, plate thickness shall normally be at least 0.5 times the stud shank diameter. For welding plates thinner than this, extra care is required to be exercised in distortion control.

(xi) Edge distance: Studs should be placed no closer to a base plate free edge than the stud diameter plus 1/8 inch (3mm) to the edge of the stud base. The distance should be at least 1 to 1.5 inch (25-38mm) from each free edge.

(b) Precautions during welding of shear studs:

(i) Visual inspection of ferrules for damage and dryness.

(ii) Proper Alignment: The machine shall be checked for proper alignment control by observing the movement of the chuck/stud before starting the work with a machine.

(iii) Visual inspection of shape of weld: Visual inspection of the profile of weld collar.

(iv) To overcome problems due to arc blow either a copper or steel plate larger than the base plate to be welded, with a center ground bolted to the bottom, can be provided temporarily below the base plate to increase the edge distance available. Or an open box shield shall be provided around the stud welding location. The bottom of this open box shall be properly machined so as to have good contact with the base plate. This will provide path to current and eliminate the grounding/ arc blow effects.

(v) Check List in the Table 12.20 for Quality Inspection of Automatic Stud Welding may be used.

TABLE 12.20

CHECK LIST - QUALITY INSPECTION OF AUTOMATIC STUD WELDING

Name of Inspector: _____		Date of Inspection: _____	
Fabricating Agency: _____		Workshop:_____	
Signed qualification certificate of operator	Name of machine operator: _____	Certificate number: _____	Date: _____ Whether Date < 2 years old: Yes/No
Drg. No. : _____	Span No. : _____	No. of studs per span: _____	
Approved QAP No. : ____	Dia. Of stud: _____		Length of stud: _____
Inspection Results (If answer to any question is NO, then the process needs to be checked and inspection to be repeated)			

SN	Description	Yes/No/NA	If No, Action Needed	Details of Record or Ref Doc No
1	Studs Material Inspection Report Nos, Satisfactory?			
2	Ferrules Material Inspection Report Nos, Satisfactory?			

Welding Machine brand/ serial No. : _____

Machine settings (As per approved QAP or approved qualification record):

Current	Duration	Cycles	Lift	Plunge	Special settings, if any

(c) Precautions after welding of shear studs

(i) Visual Inspection shall be done for hot weld, cold weld or hang up defects in the shape of the weld as per para 6 K (i) of BS: 115 rev 1.

(ii) Dimensions of 5% weld shall be measured and verified against the required dimension.

(iii) Any stud with cumulative weld defect length less than 10% of the circumference shall be considered acceptable and no action shall be taken.

(iv) Any stud with cumulative weld defect length within 10% and 20% of the circumference shall be considered repairable provided that clustering of such repaired studs does not exceed

i. 1 in 6 in end quarter

ii. 1 in 3 in middle half span

(v) Any studs with cumulative weld defect length more than 20% shall also be considered as defective and not repairable. Additional stud shall be provided to compensate defective studs by good quality stud of same dia/length.

(vi) Verticality of Studs: Studs shall generally be vertical. Slightly inclined studs having good welds as described above shall be considered acceptable.

(vii) Ring Test: 1 in 20 (5%) studs shall be tested by ring test. It involves striking the side of the head of the stud with a 2 Kg hammer. A ringing tone achieved after striking indicates good fusion whereas dull tone indicates a lack of fusion.

(viii) Bend Test: 1 in 100 (1%) studs shall be tested by bend test. The test consists of bending the studs after they are allowed to cool, to an angle of approximately 60° or as specified from their original axes by either striking the studs with a hammer on the unwelded end or placing a pipe or other suitable hollow device over the stud and manually or mechanically bending the stud.

(ix) Details of inspection as per BS: 115 shall be recorded in stud welding inspection register.

(x) Restriction on Galvanizing/ Other coatings on Studs: Zinc/ paints etc. may contaminate the weld metallurgy. No galvanized/coated studs shall be used on Indian Railways.

(xi) If required for corrosion protection, the steel surface duly fitted with studs shall be aluminum metallised after welding of studs and their inspection is over. However, the same shall not be painted as this would reduce the bond strength with concrete which is to be poured subsequently.

(xii) Rejection of Member: If the population of defective welds is excessive and providing additional studs and/or cutting of studs as specified above is not desirable from quality considerations, then the member shall be rejected.

(xiii) Stud welding register. Sample format of stud welding register given in Table 12.21 may be used.

TABLE 12.21

STUD WELDING REGISTER

Date	Component description	Nos. of stud welded	Visual	Ring test @ 100%	Bend test @ 1 in 50	Welded stud Height @ 5%	Details of rectification	Sign. of internal QC	Sign. of Project executive agency

(d) Check List for stud welding given in Table 12.22 may be used.

TABLE 12.22

CHECK LIST - STUD WELDING

SN	Description	Yes/No/NA	If NO, Action Needed	Details of Record or Ref Doc No
(1)	Surface preparation (100%)			
(a)	Is surface free from rust/mill scale etc.?			
(b)	Is surface free from grease/paints etc.?			

(c)	Is the surface being cleaned of weld splatter/ broken ferrules during welding?			
(2)	Visual Inspection of raw material (on random samples, ~2-4%) (Only summary to be given here, detailed record shall be entered in register as per Table 13.21			
(a)	Studs			
(i)	Is surface free from paint, galvanizing, grease and moisture			
(ii)	Is the flux intact at the tip of the stud			
(iii)	Is the length of stud as per requirement			
(b)	Ferrules			
(i)	Are ferrules broken?			
(ii)	Are the ferrules properly dry Yes / No(With Over drying/ Without Over Drying)			
(c)	General Remarks on storage/handling of materials etc.			
(3)	For following tests only summary to be given here, detailed record shall be entered in register as per Table 13.21			
(a)	Ring test (@5%):	No. of tests done_____	Nos: ___ OK	Nos: NOT OK
(b)	Bend Test (@1%):	No. of tests done_____	Nos: ___ OK	Nos: NOT OK
(4)	Visual Inspection of completed weld (@100%): (Only summary to be given here, detailed record shall be entered in register as per Table 13.21			
(a)	Is the surface of flash having a shiny bluish hue?			
(b)	No of studs with good weld shape?			
(c)	No of studs with defects within acceptable limits?			
(d)	No of studs with repairable defects?			
(e)	No of studs defective/with not repairable defects?			
(5)	Measurement of Welded Stud Height (@5%): (Only summary to be given here, detailed record shall be entered in register as per Table 12.22		Height of welded stud (mm)	Burn off length (mm)
(a)	Is the burn-off length proper?			
(6)	Is the member with studs acceptable?			
(7)	Changes required in welding process in light of defects observed, if any			

(8)	Repairs of Defects (If possible)	Total number of repairable studs	Date of repair	Quality of repairs
				OK / NOT OK
(9)	Replacement of Non-Repairable studs (If possible)			
(a)	No of Non-repairable studs			
(b)	No of additional studs provided			
(c)	No. of studs cut			
(d)	Additional studs provided (with 50mm gap all around)			
(e)	Quality of new studs		OK / NOT OK	

1215 HIGH STRENGTH FRICTION GRIP (HSFG) BOLTS (IRS B1 para 28.9.3)

(1) High strength Friction Grip (HSFG) bolts transfers force from one member to another through frictional resistance and the connection made using HSFG bolts is designed for no slip condition. Whereas, rivet or conventional bolted connection transfers force through bearing and shearing of bolts/ plates. Frictional force is product of normal force and coefficient of surface friction. Coefficient of friction is physical property of contact surfaces. To generate enough friction for given surface material high normal force is required, for which bolts having high tensile strength are used.

(2) Friction factor for common surface may be adopted from per IS:4000.

(3) The desirable/ undesirable activities while using HSFG bolts are given below for ready reference.

(4) DO'S

(a) Check class (8.8 or 10.9) of bolts from drawing carefully.

(b) Check bolt tension and type of surface preparation from drawing. If not available in drawing, then refer to design office.

(c) Check supply of bolt to ensure class.

(d) Obtain torque required to produce desired tension through lab test

(e) Re-assess torque through lab test if source of bolts changes

(f) Carryout surface preparation as mentioned in drawing using shot/ grit blasting only.

(g) Tighten bolts using torque wrench at specified torque only.

(h) Use nuts and bolts as supplied.

(5) DON'TS

(a) Don't use bolts of class lower than that specified in drawing.

(b) Don't carry out sand blasting for surface preparation.

(c) Don't use paint other than that specified for surface preparation.

(d) Don't tighten bolts using a normal spanner.

(e) Don't assume tightening torque.

(f) Don't use rusted bolts.

(6) Agency for fixing of HSFG bolts in workshop and at site (before launching) shall be an authorized agency form Supplier/Fabricator and shall be certified by AEN of Railway or equivalent official of the project executing agency.

(7) Complete HSFG bolting assembly including Direct Tension Indicator (DTI) washer, shall be supplied by same manufacturer who is responsible for the function of the assembly.

(8) The bolt length shall be chosen such that after tightening the following requirements are met for bolt end protrusion beyond the nut face and the thread length:

(a) The length of protrusion shall be at least the length of one thread pitch measured from outer face of the nut to the end of the bolt.

(b) For preloaded bolts at least four full threads (in addition to the thread run out) shall remain clear between the bearing surface of the nut and the unthreaded part of the shank.

(9) SURFACE FINISH & COATINGS

Property class 8.8 bolts shall be hot dip galvanized as per ISO: 10684. Property class 10.9 bolts shall not be hot dip galvanized since this may cause hydrogen embrittlement. These bolts should be coated with Zinc flakes as per ISO: 10683 (latest version). Use of Zinc flake spray coating as per ISO: 10683 (latest version) can be adopted even for property class 8.8 bolts as well.

(10) NUT (**Ref.** IRS B1 para 28.9.5)

(a) Nut/ bolt shall be adequately protected by coating of machine oil.

(b) Nuts shall run freely on their partnering bolt, which is easily checked during hand assembly.

(c) Any nut and bolt assembly where nut does not run freely shall be discarded.

(11) POSITION OF NUT IN BOLT

HSFG bolt cannot be easily opened out except by use of torque wrench. Still, as an additional precaution, it may be ensured that the nut is not easily accessible for opening out by anti-social elements, the same shall be provided preferably as follows:

(a) In girder web: Towards outside of the girder.

(b) In flanges: Towards bottom (Except when in composite construction).

(c) In composite construction: Towards inside of concrete.

(d) In bracing: Towards the rolled section side so that the space for rotation of the nut is not readily available.

(e) Where Tapered washer is used, the nut shall preferably be on the other side.

(12) PLAIN AND PLAIN CHAMFERED WASHER

(a) For 8.8 bolts a washer shall be used under the bolt head or the nut, whichever is to be rotated.

(b) For 10.9 bolts washers shall be used under both the bolts and the nut.

(c) One additional plate washer or up to three washers with a maximum combined thickness of 12 mm may be used in order to adjust the grip length of bolt assemblies.

(13) DIRECT TENSION INDICATORS (DTI) WASHERS

A specified feeler gauge shall be used to determine that the required bolt preload has been achieved by the assembly after it has been tightened as given in Table 12.23. To check full compression of the indicator, a 0.10 mm feeler gauge should not get inserted in the space between indicator positions on the DTI **(Ref. BS: 111 Rev 7)**.

TABLE 12.23

DIRECT TENSION INDICATORS

Direct tension indicator positions	Designation H8 and H10 Thickness of feeler gauge (mm)
Under bolt head, when nut is rotated	0.40
Under nut, when bolt is rotated	0.25
Under nut, when nut is rotated	
Under bolt head, when bolt is rotated	

(14) Fabrication and Assembly of High Strength Friction Grip (HSFG) bolting assemblies with Direct Tension Indicator washers:

(a) The steel interface between the plies which form a joint having HSFG bolts shall have special surface preparation so that sufficient slip factor is available. For details of surface preparation refer para 28.10 of IRS B1 and other codes mentioned therein.

(b) The interface between the plies which are connected together by the HSFG bolts shall be "Aluminium metallised without any over coating".

(c) HSFG bolts shall be fitted by the competent artisans trained/ certified by the supplier of HSFG bolt. It is good practice that, the supplier gets the HSFG bolts fitted under the supervision of his competent officials and issue a certificate about its proper fitting. HSFG bolt Tightening Register shall be maintained duly indicating the tight/loose condition and action taken along with signature of responsible officials.

1216 INITIAL ASSEMBLY

(1) The surfaces of hole should be ground by 'pencil grinding machine' to remove burrs formed during drilling, especially at mating surface to ensure dead contact. Care shall be taken not to reduce mating surface contact area by excessive grinding.

(2) Entire mating portion which are to be in contact permanently shall be cleaned of rust, mill scale and one coat of red oxide zinc chrome primer to IS: 2074 shall be applied when initial assembly is done by welding/ riveting. This is very important activity and will ensure sealing of mating parts and will prevent entry of water or moisture and help to prevent corrosion in hidden parts during entire life of the girder.

(3) When initial assembly is done with HSFG bolts, the metalized surface with Aluminium shall not be applied any overcoat paint. As overcoat paint film will change the Friction factor to unknown value contrary to design value. It is good practice to protect joint area suitably while overcoating adjoining areas.

(4) With help of assembly fixture members are formed to final shape. Provide 50% service bolts and drifts at alternate hole (in 4:1 ratio) to ensure the provision of clause 19 of IRS B1. Clamping force exerted by service bolts and alignment provided by drifts will ensure proper fabrication.

1217 INSPECTION OF TRIAL ASSEMBLY

(1) For the first span of any fabrication or the first span made with new jigs, trial assembly in workshop to ensure correctness of fabrication within tolerances is a must. As per clause 33.2 of IRS B1, the interchangeability of the members shall be established by trial assembly. Inspection of trial assembly shall include correctness of dimensions of components, Camber verification, inspection of dismantled trial assembly and Dimension Inspection (DI) after dismantling.

For subsequent spans, component inspection for OWGs will be done with respect to individual components and component inspection for plate/ composite-I girders shall be done in leaf-assembled condition. Component inspection of Bow String Girders shall be offered with assembly of at least one D shape.

Part spans are not to be offered for inspection.

(2) ITEMS TO BE CHECKED DURING TRIAL ASSEMBLY

(a) Correctness of dimension of components including end finishing is done before start of trial assembly.Following measurements should be taken using calibrated steel tape, gauges, and profiles as applicable:

(i) Overall length
(ii) Bearing centres
(iii) Height
(iv) Diagonal at either end of the assembled span
(v) Girder centres
(vi) Butting of compression members, Gap at Joints
(vii) Squareness
(viii) Straightness
(ix) Skew angle
(x) Verticality
(xi) Drift plan showing Drift &Temporary fasteners
(xii) Edge Distances
(xiii) Fairness of Holes
(xiv) Camber record on Jack
(xv) Dead Load deflection (Camber without Jack)
(xvi) Infringements
(xvii) Match marking of joint components for non-interchangeable fabrication
(xviii) Witness/ inspection by internal quality control unit of contractor.

(b) A sample format for dimension checking during trial assembly inspection is given in Table 12.24. This table is non-exhaustive and the relevant items as per IRS B1 para 13

& Appendix-II shall be included. Similar DI shall also be carried out for plate girder for suitable parameters.

TABLE 12.24

DIMENSION CHECK DURING TRIAL ASSEMBLY

Description	Required Dimension (mm)	Observations (mm)	Remarks
Overall length			
C / C bearing			
Truss center			
Height of girder at center			
C/C of panel point			
C/C of Stringer			
Alignment of girder			
Fairing of holes			
Verticality			
Infringement If any			

(c) In Workshop trial assembly of OWG/ Plate girder shall be done on level concrete platform of suitable size and strength. Assembly shall be done using sufficient numbers of drifts and service bolts. (**Ref.** Para 20.3 of IRS B1).

(3) CAMBER: (IRBM Para 612(3))

(a) Camber in open web girders

(i) Open web girders are designed based on the theory of truss where all joints are assumed to be pin joints and all members are considered to carry axial forces only. In practice, open web girders have rigid joints due to the connection size and number of rivets at a joint. Due to rigid connection, under load, the whole joint rotates rather than individual member and causes secondary stresses in members. Para 34 of IRS B1 stipulates provision of camber by pre-stressing the members in such a way that the girder will get upward deflection when it is not loaded but will assume nominal shape (i.e., bottom chord becomes horizontal) under the designed load. The length of the bottom chord remains same whether loaded or not loaded, to avoid additional stress in rails.

(ii) Standard steel OWG are generally designed as prestressed girder and member length for fabrication are designed accordingly and given in Camber drawing for respective span. The pre-stressing of girders is achieved by fabricating member length as per camber layout. The joint configuration is maintained as per nominal layout. As a result, under designed load, the members will be straight and joints will not have any rotation, thus fulfilling the assumption of pin jointed truss. Detailed procedure for providing camber is given in Appendix-III of IRS B1 and Appendix-A of Steel Bridge Code.

(iii) The Dos and Don'ts for achieving camber are as under

Do's

i. Keep all the camber jacks at level.

ii. In case, the girders are erected on yielding supports such as a service spans, provide due allowance for the anticipated yield when the camber blocks are set out.

iii. Check camber frequently during erection.

iv. Drift number of holes simultaneously, if drifting is unavoidable.

v. While fixing top chord, the process shall be commenced at the centre, progressing outwards.

vi. Vertical and horizontal members to be aligned first then align diagonal members, complete the process bay by bay.

vii. Fix upper end of end raker first

viii. Re-tight service bolts frequently as the bolting progresses.

Don'ts

i. Don't provide camber till all bottom chord, verticals and diagonals have been erected.

ii. Don't drift joints as far as possible.

iii. Don't use hammers exceeding 1 kg (2 lb) to drive in parallel barrel drifts.

iv. Don't carry out reaming of holes. Align holes by pushing/ pulling members.

v. Don't insert wires in holes for pushing/pulling members.

vi. Don't fix lower end of end raker first.

vii. Don't start riveting until the Engineer has personally satisfied himself that the alignment of the girders is correct, the verticals plumb laterally, the camber is set as per camber diagram with camber jacks screwed tight, all the joints and cover plates well up, service bolts tight and field rivet holes coinciding.

(iv) Formats for camber measurement record for OWG for shop and site are same and given below:

i. Camber on Jack: The format to assess the Design value, LHS and RHS of the camber on jack is given in Table 12.25.

TABLE 12.25

CAMBER ON JACK

Panel point	Design value	Observed value (LHS)	Observed value (RHS)
L0			
L1			
L2			
L3			
L4			
L5			
L6			
L7			

L8			
L9			
L10			
L11			
L12			
L13			

ii. Residual camber: The format to assess the residual camber of LHS and RHS leaves has been given in Table 12.26.

TABLE 13.26

RESIDUAL CAMBER

Panel point	Design value	Observed value (LHS)	Observed value (RHS)
L0			
L1			
L2			
L3			
L4			
L5			
L6			
L7			
L8			
L9			
L10			
L11			
L12			
L13			

(b) Camber of plate girder: The provision of camber and its retention in plate girders till launching is critical for fabricators. Due care is to be taken for drilling and matching holes for cambered plate girders. The following methods are employed to provide camber in steel plate girder.

(i) Providing camber before fitment and welding- In this method web is cut in camber profile on CNC cutting machine and flange fitment is done in camber profile. Semi-automatic SAW in flat position can be used while carefully positioning the welding head in this condition in lateral/ vertical direction along longitudinal movement. Due allowance shall be considered for distortion in cutting of web plates. Welding sequence shall be adhered to. It is good practice to prop the plate girders suitably at the joint location so that the cambered shape is maintained. The splice joint is now free from any stress. Fully tightened HSFG bolts, duly observing the butting of the

compression flange.

(ii) For measurement of camber, of complete trial assembly of first span and for leaf assembly of second span onwards at fabricators premises, or at site for leaf assembled plate girder, format given in Table 12.27 shall be used. However, span-wise, girder-wise, separate tables shall be made duly indicating girder identification number.

TABLE 12.27

CAMBER WITH SUPPORTS AT ENDS ONLY

Date	Component description	Leaf detail	A-End	Center	B-End	Final camber	Sign. of internal QC	Sign. of Project executive agency

(4) DISMANTLING OF TRIAL ASSEMBLY AND DIMENSION INSPECTION

(a) Detailed Inspection of dismantled components of trial assembly shall be carried out to see the integrity of components. (**Ref.** Para 13 of BS: 125)

(b) Components are checked for handling damage, oval holes, bulging of plates at drifting locations etc.

(c) Any corrective action suggested based on trial assembly to be completed. Before final assembly inspection. If such corrections are required to be done in Jigs, then the same shall be reflected in the Jig register and the corrected Jigs shall be used henceforth.

(d) Dimension Inspection (FDI) of components including end finishing is done.

(e) In case of interchangeable component, second span onwards inspection is to be done using stage clearance record and other visual and dimensional measurements by inspecting agency. For second and subsequent spans, each girder to be offered in leaf assembled condition for inspection. Part spans shall not be offered for inspection of inspecting agency.

(f) Check List for fabrication-inspection of trial assembly given in Table 12.28 may be used.

TABLE 12.28

CHECKLIST- FABRICATION-INSPECTION OF TRIAL ASSEMBLY

SN	Description	Yes/No/ NA	If NO, Action Needed	Details of Record or Ref Doc No
(1)	First Span Inspection (at fabricators premises)			
(a)	Trial Assembly for 1st span	YES		Records available in Trial Assembly Inspection register Page No.

(b)	Dismantled component Inspection	YES		Records available in Trial Assembly Inspection register Page No.
(c)	Any correction is suggested and whether carried out?	YES		Records available in Trial Assembly Inspection register Page No. and in Jig register Page No.
(2)	2nd span inspection and onwards (at fabricators premises)			
(a)	Whether corrections suggested at Trial assembly stage complied with?	YES		Records available in Trial Assembly Inspection register Page No.
(b)	Inspection of components 2nd span and onwards	YES		Records available in Component Inspection register Page No.
(c)	Whether components are passed?	YES		Details available in Statement of Material Test certificate Register Page No.

1218 FINAL INSPECTION

In order to ensure the quality of steel Bridge Girders while offering the girder to Inspecting Agency for final inspection a four-point cerificate mentioning following shall be submitted by the executing agency (minimum Railway JA Grade Officer or equivalent) vide RDSO No. CBS/INSP/ WBG Dt. 10.04.2015 **(Ref. 12.12)**.

(1) Steel used for welded Bridge Girders components is of weldable quality of IS:2062 Gr B0/C as the case may be fully killed and fully normalized, which has been inspected and approved by the Railways/ executing agency.

(2) Fabrication has been done with the help of approved Jigs/CNC machines, as per approved QAP.

(3) Entire welding is done by approved welders using approved welding procedures and welding consumables (as per WPSS).

(4) Fabrication work is inspected by internal quality control/inspection organization including the welding and riveting. All significant defects are rectified and final dimensions are within tolerances.

1219 SURFACE PROTECTION (**Ref.** para 39 of IRS B1)

(1) All painting to be carried out in covered shed. Humidity, curing time & temperature to be maintained as per paint specification. No part of the work shall be painted or coated, packed or dispatched, until it has been finally inspected and approved by the Inspecting Officer.

(2) The protective coating by metalizing with sprayed aluminum shall be applied for all types of New Steel Girder Bridges (including all components), for all locations, as given in the para 39.2.1 of IRS B1. Dry Film Thickness shall be measured by 'elcometer' or any other approved

method.

(3) Prior to the application of protective coating the surface of work shall be carefully prepared removing mill- scale, rust, etc. using wire brushes, sand or grit blasting as stipulated in QAP.

(4) Surfaces which are inaccessible for cleaning and painting after fabrication shall be applied one heavy coat of zinc chrome red oxide priming to IS: 2074 before being assembled for riveting/welding.

(5) During fabrication, only one layer of the top coat shall be applied in workshop. The second layer of the top coat shall be applied at site after the portions of paint affected by the wear/ abrasion during assembly/ launching of girders have been touched and repaired.

(6) METALLISING

(a) Surface preparation- Surface preparation shall be started only after final clearance of girder. Blasting shall be done in covered sheds and surface roughness shall be ensured by visually comparing with roughness comparator of Sa 2½ (Ref IRS B1 Appendix-VII, IS: 5905).

(b) Metalizing shall be started within 4 hours and completed within 8 hours after blasting.

(c) Dry Film Thickness (DFT) shall be checked by taking minimum one reading per square meter of painted surface. Adhesion test shall be done as per IRS B1 Appendix-VII. Format for DFT records of Metalizing may be as given in **Table 12.29**.

TABLE 12.29

DRY FILM THICKNESS CHECKING

Date	Component description	Blasting	Metalizing DFT @ 1 reading per Sq. meter	Etch primer	Zinc chrome yellow primer	1st coat of aluminum (at fabricators premises)	2nd coat of aluminum (at site after launching)	Sign. of internal QC	Sign. of Project executive agency

(d) After metalizing is completed apply:

(i) One coat of etch primer conforming to IS: 5666.

(ii) One coat of zinc chrome primer to IS: 104 with the additional provision that zinc chrome to be used in the manufacture of primer shall conform to type 2 of IS: 51.

(iii) Two coats of aluminium paint to IS: 2339 brushing or spraying as required. One coat shall be applied before the fabricated steel work leaves the shop.

(iv) After the steel work is erected at site, the second finishing coat shall be applied after touching up the primer and the finishing coat if damaged in transit.

(7) PAINTING AND METALIZING OF COMPOSITE GIRDER

(a) Restriction on Galvanizing/ Other coatings on Studs: Zinc/ paints etc. may contaminate the weld metallurgy. No galvanized/coated studs shall be used on Indian railways.

(b) If required for corrosion protection, the steel surface duly fitted with studs shall be aluminium metallised after welding of studs and their inspection is over. However, the same shall not be painted as this would reduce the bond strength with concrete which is to be poured subsequently.

(8) Check List for fabrication-inspection of painting and metalising given in Table 12.30 may be used.

TABLE 12.30

CHECK LIST- FABRICATION-INSPECTION OF PAINTING AND METALISING

SN	Description	Yes/ No/NA	If NO, Action Needed	Details of Record or Ref Doc No
1	Surface Preparation by shot blasting and metalizing	YES		Records available in Metalising & Painting register Page No.
2	Cleaning and painting			
2.1	Surface condition before painting	YES		
2.2	Surface finish after Painting	YES		
2.3	DFT Checking	YES		Records available in Metalising & Painting register Page No.

1220 DISPATCH

While dispatching a girder/ component it shall be marked as per the approved shipping and erection drawing. Hard Punching for marking shall not be used. The shipping list shall indicate the parts, numbers and the identification markings on the members for the guidance of the field engineers during assembly. The following shall be ensured during dispatch:

(1) Shipping mark on all Components as per erection drawings & shipping list.

(2) Fixing of Inscription Plate

(3) Packing

(4) Loading

1221 ASSEMBLY AT SITE

(1) AT SITE UNLOADING AND STACKING

Care shall be taken to ensure that no damage is done to the finished component during unloading and stacking. Interchangeable components shall be stacked together. All damaged components shall be suggested and listed out for recoupment.

(2) Check List for fabrication-inspection of dispatch activities given in Table 12.31 may be used.

(3) Competency of personnel for applying torque to tighten HSFG bolt should be as per para 1215 (14) of this manual. Competency Certificate shall be issued by an engineer not below the rank of ADEN or equivalent **(Ref. BS-111 para 11(iii))**.

(4) Assembly of girder parts shall be done on level surface.

(5) Proper drifting and service bolting shall be done as per para 1217 (3) of this manual.

(6) After ensuring camber values as required, HSFG bolt shall be fixed as per para 1215 of this manual.

(7) Onsite Inspection details/measurements for following shall be recorded for:

(a) Inspection of HSFG bolt fitment. For assembly at site, HSFG bolt fitment record shall be maintained as per format given in **Table 12.32**.

(b) Camber measurement details for girder supported on end support and intermediate support shall be maintained depending upon the type of girder as given in para 1217.

TABLE 12.31

CHECKLIST- FABRICATION-INSPECTION OF ASSEMBLED STRUCTURE AT SITE

SN	Description	Yes/No/ NA	If NO, Action Needed	Details of Record or Ref Doc No
(1)	Verification of received material and components with shipping list and erection drawing.	YES		
(2)	Assembly at site before launching (By fabricator or their authorised agency)	YES		
(a)	HSFG Bolts fitment	YES		Records available in HSFG bolt fitment register Page No.
(b)	Camber measurement (On End support and intermediate supports)	YES		Records available in camber measurement register Page No.
(c)	Camber measurement (On End support only)	YES		Records available in camber measurement register Page No.

TABLE 12.32

HSFG BOLT FITMENT REGISTER

Date	Component description	Joint details	Location	Applied torque	DTI location	DTI feeler gauge inspection	Torquing done by	Sign. of internal QC	Sign. of Project executive agency

(c) Camber measurement details for girder supported on end support only in dead load condition shall be maintained depending upon the type of girder as given in para 1217.

(d) **Refer to para 1217(3)** for the detailed process of erection aimed at achieving the design camber.

1222 CODES, MANUALS AND SPECIFICATIONS REFERRED

For Steel fabrication reference to the specifications in the following order shall be preferred- Indian Railway standard, RDSO's Specifications, Metro Railway Specifications, Bureau of Indian Standards, Indian Road Congress (IRC) Specifications and other International/ National Specifications.

Wherever reference to the various standards appears in this manual, it shall be taken as a reference to the latest version of the standards.

(1) IRS SPECIFICATIONS

For IRS specifications, refer to Table 12.33

TABLE 12.33

IRS SPECIFICATIONS

SN	IRS	Title	Ref in para of this Manual
1	IRS-WBC	Indian railway standard code of practice for metal arc welding in structural steel bridges carrying rail, rail-cum-road or pedestrian traffic (Welded Bridge Code)	1202, 1214
2	IRS B-1	Indian railway standard specification for fabrication and erection of steel girder bridges and locomotive turn-tables	1201, 1205, 1206, 1207, 1208, 1209, 1210, 1212, 1213, 1214, 1215, 1216, 1217, 1219, 1221,
3	R-19	Wheels and axles for carriages and wagons	
4	M-3	Class I, II, III & IV steel forgings, blooms for forgings and Billets for re- rolling.	
5	M-28	Classification, testing and approval of metal-arc welding electrodes for use on Indian Railways.	1206
6	M-39	Classification, testing and approval of submerged- arc welding wire flux combination	1206(3), 1214(10)
7	M-41	Corrosion resistance steel	
8	M-42	High strength low alloy structural steel with enhanced corrosion resistance	
9	M-43	High strength low alloy structural steel rivet bars with enhanced corrosion resistance.	
10	M-46	Indian Railways Standard Specification for Classification, Testing and Acceptance Criteria of Filler Wires For MIG/MAG Welding (With and Without Gas Shielding)	1206(3)
11	P-31	Zinc chromate read-oxide primer	

(2) Indian Standard (IS) Specifications

For IS Specifications, refer to Table 12.34.

TABLE 12.34

INDIAN STANDARD (IS) SPECIFICATIONS

SN	IS Code	Title	Ref in para of this Manual
1	IS: 51	Zinc chrome for paints.	1206(2), 1219
2	IS:104	Ready mixed paint, brushing, zinc chrome, priming.	1206(2), 1219
3	IS:1148	Hot rolled steel rivet bars (up to 40mm dia.) for structural purposes.	
4	IS:1149	High tensile steel rivet bars for structural purpose.	
5	IS:1367	Technical supply conditions for threaded fasteners	
6	IS:817	Training of Welders	1214(5)
7	IS:1852	Rolling and cutting tolerances for hot rolled steel products.	1205(2)(d)
8	IS:5905	Sprayed Aluminum and zinc coatings on iron and steel.	1219(5)
9	IS:2074	Ready mixed paint, air drying, red oxide-zinc chrome, priming	1206, 1216, 1219
10	IS:2590	Primary aluminum ingots for remelting for general engineering purposes	1206(1)
11	IS:5666	Etch primer.	1206(2), 1219
12	IS:1875	Carbon steel billets, blooms, slabs and bars for forging.	
13	IS:2062	Hot Rolled Low, Medium & High Tensile Structural Steel.	1205(2),
14	IS:2004	Carbon steel forging for general engineering purposes.	
15	IS:2339	Aluminium paint for general purposes, in dual container	1206(2), 1219
16	IS:6586	Recommended practice for metal spraying for protection of iron steel	1206(1)
17	IS:7307 (Part- I)	Approval test for welding procedures	1214(4)(d)
18	IS: 1608	Metallic Materials Tensile Testing at Ambient Temperature	1205(2)(f)
19	IS: 1599	Method for Bend test	1205(2)(f)
20	ISO: 13918	Welding — Studs and ceramic ferrules for arc stud welding	1205(3)

(3) REFERRED BOOKS AND BS REPORTS

For Referred books and BS reports, refer to Table 12.35.

TABLE 12.35

REFERRED BOOKS AND BS REPORTS

SN	BS Report	Title	Ref in para of this Manual
1	BS:124	Fabrication, Assembly, Erection and Launching of Steel Girders for Construction of Bogibeel Bridge over River Brahmaputra N. F. Railway	1203, 1205(2), 1210, 1211, 1214(6),
2	BS:110(R)	Guidelines on Fabrication of Steel Girders for Construction/Field Engineers	1203(2)
3	BS:125	Method Statement for Fabrication of 45.7 M Through Type Open Web Girder For 25t Loading Drawing No. RDSO B-17181 Series	1203(2)
4	BS:130	Guidelines For Fabrication Inspection of RDSO Standard Spans- Composite I-Section Steel Girders for Road Over Bridges (ROBs)	1203(2)
5	BS:115 (R1)	Guidelines for Composite Construction Including Stud Shear Connectors	1205(3), 1214(14)
6	BS:111 Revision 7	Guidelines for use of High Strength Friction Grip (HSFG) bolting assemblies on bridges on Indian Railways	1215, 1221

(4) REFERENCE DOCUMENTS

For Reference Documents, refer to Table 12.36

TABLE 12.36

REFERENCE DOCUMENTS

SN	Para No	Ref. document details	
1	1201(2)	12.01	Railway Board letter No. 2014/CE-III/BR/Bridge Workshops Policy Dt.24.02.2014
2	1201(3)	12.02	BS-S-7.5.3.1-4 'Schedule of Technical Requirements for fabrication of steel girder' Dt.12-07-2022.
3	1201(4), 1202(4), 1204(1)(a)	12.03	Railway Board Instruction No. 24/2019 vide RB No. 2016/54/CE-III/BR/RDSO Misc. Dt.15.07.2019
4	1201(5)	12.04	Railway Board letter no. 2016/54/CE-III/BR/RDSO/Misc. dated 09.05.2019
5	1202(4), 1204(1)(a)	12.05	Railway Board letter No. 2017/16/CE-III/BR/Girder inspection Dt.26.05.2017
6	1202(4)	12.06	RDSO letter no. CBS/INSP/WBG Dt.13-08-2018
7	1202(4)	12.07	Railway Board letter 2017/16/CE-III/BR/Girder Inspection Dt.17-11-2022
8	1204(1) (b) & (c) 1205(2)(e)	12.08	RDSO letter no. CBS/Bridge Insp/Genl Matters Dt.01.03.2023
9	1214(4)(d)	12.09	RDSO letter no. CBS/Bridge Insp/Genl Matters Dt.8.06.2023
10	1214(5)(a)	12.10	Railway Board letter 2017/16/CE-III/BR/Girder Inspection Dt. 25.05.2017
11	1214(5)(c) (ii)	12.11	RDSO letter no. CBS/Bridge Insp/Genl Matters Dt.19.06.2023
12	1218	12.12	RDSO letter no. CBS/INSP/WBG Dt.10.04.2015

***

CHAPTER 13
TUNNELS

With the Indian Railway network getting expanded to all parts of the country, tunnels are being constructed in Jammu & Kashmir, Himachal Pradesh, Uttarakhand and the Northeastern States; mostly in the Himalayas which is one of the youngest geologies of the world. The Himalayas contain complex geological discontinuities and other challenges like joints, faults, folds, shear zones, water charged areas, high tectonic stresses, vulnerable slopes etc. This presents a great challenge to the engineers constructing tunnels. Therefore, proper understanding and appreciation of relevant aspects related to planning, design and construction of tunnels is necessary.

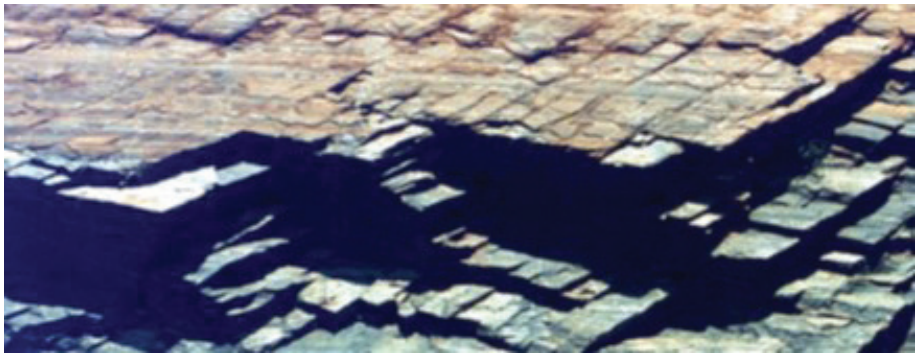
1301 DIFFERENCE BETWEEN ROCK MATERIAL AND ROCK MASS

(1) Rocks

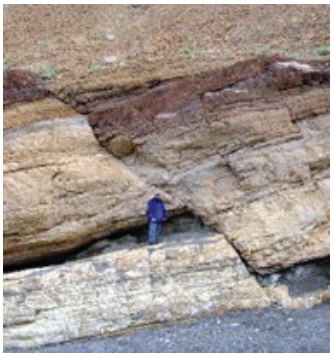
A rock is solid aggregate of one or more minerals that have been cohesively brought together by a rock forming process. Various properties of minerals combined with their arrangement in the rock influence the properties of rocks.

(2) Rock Discontinuities

The rocks are not found in the form of monolithic continua but they consist of intact rock material along with various discontinuities, which are planes/sources of weaknesses. Some of the common discontinuities are Rock Joints, Faults, Folds, Bedding Planes etc. **(Fig. 13.01)**



Rock Joints



Faults

Folds

Bedding Planes

Fig. 13.01: Rock Discontinuities

(3) Rock Material and Rock Mass

For tunnels and slopes, the rocks encountered, termed as rock mass, will contain the "rock material" in the form of intact rock blocks of various sizes and "rock discontinuities". The "rock material" is a stiff and brittle material, very strong in compression but weak in tension. But behaviour of "rock mass" is controlled by the discontinuities which reduce the rock mass strength, reduce rock mass quality and increase deformation under load.

(4) Groundwater

Groundwater is an important factor in any underground excavation because:

(i) Water pressure contributes to the stresses on the tunnel supports.

(ii) Presence of water alters the properties of rock mass.

(iii) Presence of water increases the complexity in construction and maintenance of tunnels.

Therefore, the actual behavior of rock mass will be governed by the combination of rock material, rock discontinuities and ground water.

1302 GEOTECHNICAL INVESTIGATIONS FOR TUNNELS

Planning, design and construction of a tunnel requires various geotechnical investigations to obtain a broad spectrum of pertinent topographic, geologic, geo-hydrological and structural information. Exploration programs for tunneling must be planned by construction engineers in close cooperation with engineering geologists, geotechnical engineers & designers.

(1) Phases of Geotechnical Investigation Program

The geotechnical investigation is generally carried out in following phases:

(A) Preliminary Geotechnical Investigations for Feasibility Studies

In this phase, the emphasis is on defining the regional geology and the basic issues of design and construction. Investigations at this stage are largely confined to:

(i) Collection, organization & study of available data like Topographical maps of Survey of India, Geological maps & reports of GSI/other agencies, Geotechnical investigation reports from other agencies working in that area, Case histories of other underground works in the region, details of land ownership (Government, Private, Forest), access routes, Hydrological information & environmental sensitivity from State Govt./Local bodies, Satellite images, Seismic Records, Records of landslides documented by other agencies etc.

(ii) Preliminary Survey: This study should start with a reconnaissance over the tunnel alignment, to look for potential portal and shaft locations. Features identified on maps and aerial photographs should be verified. Exposed rock outcrops provide information about rock mass fracturing, bedding, location of rock type boundaries, faults and other geologic features. The reconnaissance may cover the immediate project vicinity, as well as a larger regional area, so that regional geologic, hydrologic and seismic influences can be accounted for.

A preliminary horizontal and vertical control survey may be required to obtain general site data for route selection and for design. This survey can be expanded from existing records, alignment posts and benchmarks that are based on the same horizontal and vertical datum that will be used for final design of the structures.

Additional alignment posts and benchmarks can be established, as needed, to support field investigations and mapping.

(iii) Investigations to compare alternative alignments and arrive at a conceptual preliminary design: Carrying out following investigations at this stage would help in comparing alternative alignments and arriving at a conceptual preliminary design:

(a) Preliminary Geological field mapping with particular attention to features that could signify difficulties like slides (particularly in portal areas), major faults, thrusts etc.

(b) Selected exploratory borings in critical locations

(c) Geophysical explorations by using the techniques like Seismic Refraction Survey and Electrical Resistivity Survey etc., Aerial Photography and Hydrological Survey to define the groundwater regime, aquifers and sources of water etc.

(B) Preconstruction Planning and Engineering Phase

More detailed geotechnical investigation is carried out in this phase to refine the tunnel alignment and profile, and to provide the detailed information needed for design of tunnel & selection of appropriate tunneling methodology. Investigations carried out during this phase are:

(i) Topographical Surveys to support surface geology mapping and the layout of exploratory borings, by using the survey techniques like Conventional Survey, Global Positioning System (GPS), Electronic Distance Measuring (EDM) with Total Station, Remote Sensing, Laser Scanning etc.

(ii) Subsurface Investigation which includes requisite Exploratory Boring, In-situ Testing, Geophysical Investigation and Laboratory Testing.

(iii) Detailed Geological Mapping which includes mapping & plotting of joints, faults, and bedding planes. The geologist must then project the geological conditions to the elevation of the proposed tunnel so that tunneling conditions can be assessed.

(iv) Groundwater Investigation

(v) Structure & Utility pre-construction survey, depending on the proposed tunneling method and site conditions. Cut-and-cover tunnel and shallow soft ground tunnel constructions, particularly in urban areas, extensively impacts overlying and adjacent utilities.

(C) Geotechnical Investigation during Construction Phase

The construction phase investigations serve several important functions like:

(i) Verifying initial ground support selection and improvement in their design.

(ii) Documenting existing ground conditions for reference, in case of contractual claims.

(iii) Assessing ground and groundwater conditions ahead of the advancing face, to forewarn about adverse tunneling conditions like water inflow, poor ground etc.

(iv) Verification of conditions assumed for final tunnel lining design.

(v) Mapping for record, to aid in future operations, inspections and maintenance work.

A typical construction phase investigation programme may include combination of subsurface investigation (borings & geophysical), additional groundwater

observation wells and/or piezometers, additional laboratory testing of soil/rock samples, geologic mapping of exposed tunnel face, geotechnical instrumentation, probing in advance from the face of the tunnel, pilot tunnels (typically about 2m x 2 m in size) etc.

Tunnel Seismic Prediction (TSP) is one such modern techniques, which has been used in many tunnels world over including tunnels in Himalayas region, to map the ground and groundwater conditions ahead of the tunnel face.

(2) Scale of Geotechnical Investigations

Because of the complexities of geology and the variety of functional demands, no two tunnels are alike. It is therefore difficult to lay down hard and fast rules about the required scale of explorations or the most appropriate types of exploration. Nonetheless, following can help in the planning of explorations:

(A) Plan explorations to define the best, worst, and average conditions for the construction of the underground works; locate and define conditions that can pose hazards or great difficulty during construction.

(B) Anticipate methods of construction and obtain data required for the selected construction method.

(C) Anticipate potential failure modes for the completed structures and required types of analysis, and obtain the necessary data to analyze them.

(D) Drill at least one bore at each shaft location and at each portal location.

(E) Special problems may require additional explorations.

1303 ROCK MASS CLASSIFICATION SYSTEMS

Rock mass classification systems have been quite popular for the design of tunnels. They have improvised with time, to take into account various developments in geological investigations as well as tunnel support systems (like rock bolts, shotcrete, steel fiber reinforced shotcrete etc.). They have been widely used due to following reasons:

(i) They provide a common platform to geologists, designers, contractors and engineers, in understanding and expressing quality of rock for the intended purpose.

(ii) Rather than expressing the rock quality in subjective terms, they express rock quality in terms of a numerical value, thereby enabling better understanding of rock quality without any element of subjectivity.

Some of the commonly used Rock Mass Classification systems are as under:

(1) Rock Quality Designation (RQD)

The RQD is expressed as:

RQD (%) = Σx_i / L x 100

Where:

x_i = Lengths of individual pieces of core $\geq$10 cm (obtained using NX-Size Core 54.7mm Dia., with double tube core barrel using a diamond bit).

L = Total length of the drill run

RQD represents degree of fracturing of rock mass. It partially reflects the in-situ rock

mass quality. It is a directionally dependent parameter and is used as a component in most of the other "Rock Mass Classification Systems".

(2) Rock Mass Rating (RMR)

The geo-mechanics classification or Rock mass rating (RMR) was developed by Bieniawski in year 1973, with significant evolutions later, with the last being in the year 2014. The most used version is of year 1989. To apply this system, the site should be divided into a number of geological structural units having their boundaries usually coinciding with a major structural feature such as a fault or a change in rock type. Each unit should then be classified separately. Following six parameters are considered for each of the geological structural unit:

(i) Strength of Intact Rock Material

(ii) Rock Quality Designation (RQD)

(iii) Spacing of discontinuities

(iv) Condition of discontinuities

(v) Groundwater conditions

(vi) Orientation of discontinuities

For each geological structural unit, ratings are assigned for first five parameters. After summing up the ratings for these five parameters, a correction is applied for the sixth parameter (i.e. orientation of discontinuity vis-à-vis direction of excavation). The resultant rating, so obtained, is RMR. While assigning the ratings, the typical rather than the worst conditions are evaluated, since this classification being based on case histories, has a built-in safety factor.

(3) Rock Mass Quality (Q)

Barton, Lien and Lunde (1974) of the Norwegian Geotechnical Institute (NGI), proposed this system. The numerical value of Q varies on a logarithmic scale from 0.001 to a maximum of 1000, but its value typically varies from 0.01 to 100. The Rock Mass Quality (Q) is defined as:

$$Q = \left(\frac{RQD}{J_n}\right) \times \left(\frac{J_r}{J_a}\right) \times \left(\frac{J_w}{SRF}\right)$$

Where:

RQD = Rock Quality Designation ≥ 10

$= 115 - 3.3\ J_V$

J_n = Joint Set Number

J_r = Joint Roughness Number for critically oriented joint set

J_a = Joint Alteration Number for critically oriented joint set

J_w = Joint Water Reduction Factor

SRF = Stress Reduction Factor to consider in-situ stresses

J_v = Joint Volume Count

Numerical ratings are assigned to above six parameters, based on rock conditions. The ratings do not include joint orientation to make the classification more general and orientation of joints/discontinuities is considered by taking lowest value of second quotient for computing Q for most unfavourable joint.

The parameter J_n, represents number of joint sets. The parameters J_r and J_a represent roughness and degree of alteration of joint walls or filling materials. The parameter J_w is a measure of water pressure, which has an adverse effect on the shear strength of joints. The parameter SRF is a measure of (i) loosening pressure in the case of an excavation through shear zones and clay bearing rock masses, (ii) rock stress σ_c/σ_1 in a competent rock mass, where σ_c is uniaxial compressive strength of rock material and σ_1 is major principal stress before excavation, and (iii) squeezing or swelling pressures in incompetent rock masses.

RMR and Q system or their variants are the most widely used rock mass classification systems. Both incorporate geological, geometric and design/engineering parameters to obtain a "value" of rock mass quality. But they are empirical and require subjective assessment.

(4) Geological Strength Index (GSI)

Hoek and brown (1980) proposed a method for estimating the strength of jointed rock masses, based upon assessment of interlocking of rock blocks and condition of the surfaces between these blocks. This method was modified over the years and it was eventually extended for heterogeneous rock masses (Marinos and Hoek, 2000) in the form of evaluating a parameter, Geological Strength Index (GSI).

The basic input required are uniaxial compressive strength (σ_{ci}) and a material constant (mi) that is related to the frictional properties of the rock. Ideally, these basic properties should be determined by laboratory testing as described by Hoek and Brown (1997) but, in many cases, the information is required before laboratory tests have been completed. To meet this need, guiding tables have been developed to estimate values for these parameters.

(5) Index of Ground Structure (I) System of Tunnelling (ITM)

I-system has been developed, by H. Bineshian, based on more than 12 years of experience gained in tunnelling on USBRL project. The salient features of this system are:

(i) It is tunnel design method as well as construction philosophy.

(ii) Defines both engineering classification as well as ground characterization.

(iii) It is applicable for both rock and soil.

(iv) It provides predictions for special ground behaviours also like Squeezing, Swelling, Heaving, Visco-Elastic Plastic (VP), Fully Plastic, Gravity driven (GD), Burst prone (BP) conditions.

The I-System is designed to have five indices, which define the mechanical behaviour of ground in relation to the structure based on geo-hydrological, geo-mechanical, geometrical, geophysical, geo-structural and geotechnical parameters/properties and two influencing parameters that have impact on the structure including Dynamic Forces (DFi) and Excavation Technique (ETi).

This system classifies the ground structure in 10 classes, from I-1 to I-10, with I–1 being the best and I-10 being the worst. For each class of ground, recommendations are made for Support System, Excavation Technique, Instrumentation Technique, Prevention Technique, Forecasting Technique and Design etc.

1304 TUNNEL SYSTEM AND CROSS SECTION OF TUNNELS

Besides the main tunnel(s), the tunnel system comprises of cross passages, adits & shafts as escape

routes and other ancillary structures such as ventilation shafts or caverns/niches for technical equipment. The choice of the tunnel system is based mainly on operational, organizational and safety considerations. The ground conditions and the topography may also have an influence on the selection of the tunnel system.

(1) Cross Section of Tunnels

The cross section of the tunnels depends on geology, space requirement for construction equipment to be used, ventilation & other operational safety systems requirements, OHE installations, evacuation pathways, cables carriers, drainage arrangements, maintenance requirements etc.

(A) Railway Board's letter No. 2014/W-I/NF/LMG-SCL/Tunnel-10 dated 01.05.2015 read with Railway Board's letter No. 2010/W-2/NR/J&K//05 dated 01.09.2010 specify that:

(i) For tunnels upto a length of 3 kms, Railway to follow its present practice i.e. to provide normal single track tunnel cross section.

(ii) For tunnels more than 3 kms in length, a wider cross-section be preferred for self-rescue, safe exit/escape.

(iii) Adits being provided should be used for escape.

(iv) Failing (ii) and (iii) above, in view of geological considerations, then only parallel safety tunnel interconnected at suitable interval with the main tunnel be considered keeping cost, operation and maintenance involved in mind.

(v) Cross section of the main and adit tunnel needs to be properly designed. While designing the cross section of the main tunnel it must be ensured to have a passage for movement and use of machinery and equipment to re-rail the derailed rolling stock within the tunnel on rails, and also the cross-section of adit should be so designed that it ensures faster construction.

(B) UIC standard (UIC Codex 779-9, September 2002, Safety in Railway Tunnels) recommends provision of Walkway of minimum 70 cm width (120 cm Optimal) in tunnels and provision of walkway on both sides of tunnel in case of double track tunnels.

(C) Railway Board's letter No. 2023/W-I/Genl/Misc (E-3434089) dated 22.11.2023 specify that:

(i) Escape tunnel will be of same size as of main tunnel.

(ii) If substantial section is in tunnel/bridges & viaducts, doubling to be done concurrently with bi-directional signaling.

(D) The cross section of tunnels should be in conformity with provisions of Para-13, Chapter-I, Scheduel-I of Indian Railway Schedule of Dimensions (IRSOD)-2022. These dimensions are elaborated in Diagram no. 1A and Digram No. 1A(Modified) of IRSOD-2022, which are reproduced as **Ref. 13.02** and **Ref. 13.03** respectively.

Tunnels outside station yards should be treated as heavy overhead strcutures and dimension as mentioned in Note (c) at Para-10 of Chapter-I, Scheduel-I of Indian Railway Schedule of Dimensions (IRSOD)-2022shall be applicable and OHE arrangments shall be as per RDSO drawing.

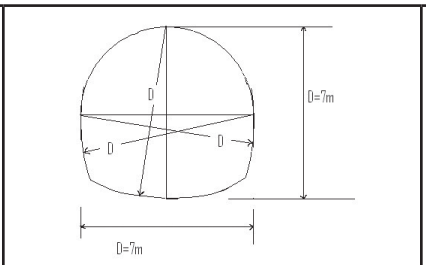
(2) Shape of Railway Tunnels

Following shapes are commonly used in Railway tunnels:

(A) D Shaped

This shape **(Fig. 13.02)** was commonly used in Railway tunnels constructed up to 15-20 years back. But from structural/load distribution point of view, this shape in not efficient, especially when side pressure/horizontal loads are considered. Therefore, this shape is suitable for "Hard Rock" only. Now-a-days this shape is very rarely used.

Fig. 13.02: D Shape



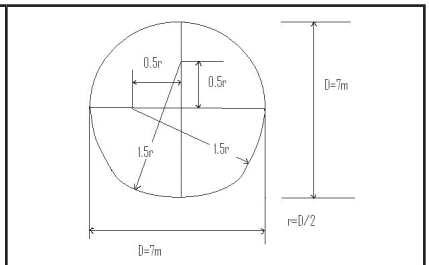


Fig. 13.03: Horse Shoe Shapes

(B) Horse Shoe Shaped

The horse-shoe shapes consist of series of arcs, with no sharp corner **(Fig. 13.03)**. This cross-section offers a good resistance to external ground pressure and is suitable for soft rocks. This shape is most commonly used now-a-days in tunnels constructed with "drill and blast technique".

(C) Circular or Elliptical Shaped

These shapes **(Fig. 13.04 and Fig. 13.05)** are the best theoretical sections for resisting internal or external forces and are best suited for tunnels in "soft grounds". Weak rock zones, squeezing or swelling rock and soft ground (soils) require a circular cross section or at least a horseshoe shaped cross section. The tunnels constructed by Tunnel Boring Machines (TBM) are only circular in shape.

Fig. 13.04: Elliptical Shape

Fig. 13.05: Circular Shape

(3) Parallel Service & Safety Tunnel

UIC standard (UIC Codex 779-9, September 2002, Safety in Railway Tunnels) recommends that a decision on providing parallel service & safety tunnel should be a result of an evaluation

of the system and it is not recommended as a general solution. It also recommends cross section of 3.5m x 3.5m as a guideline, with independent ventilation system to keep it free of smoke, to be accessible by road vehicles with facility to reverse & pass and to be connected to main tunnel by cross passages spaced at about 500m.

(4) Escape Distance

UIC standard (UIC Codex 779-9, September 2002, Safety in Railway Tunnels) recommends maximum distance for cross over passages between two paralle tubes as 500m; but the optimal distance is to be decided based on the result of an evaluation of all relevant parameters influencing safety (e.g. daily traffic, traffic mix, rescue concept, tunnel length etc.).

(5) Lateral Exits/Access

In case lateral exits/access are provided, UIC standard (UIC Codex 779-9, September 2002, Safety in Railway Tunnels) recommends it to be of 2.25m x 2.25m cross section as a guideline, with maximum length of about 150m as a guideline and making it accessible with road vehicles for longer lengths. It also recommends that their design or installation shall prevent smoke from spreading into the safe place, they should be equipped with lighting & communication means and their design or installation shall prevent unauthorized access from outside.

(6) Cross Passages

UIC standard (UIC Codex 779-9, September 2002, Safety in Railway Tunnels) recommends a distance of about 500m between the cross passages, in cross passages between double-bore single-track tunnels or between a double-track tunnel and a safety tunnel. UIC standard also recommends them to be of 2.25m x 2.25m cross section as a guideline, their design or installation shall prevent smoke from spreading into the safe place, they should be equipped with lighting & communication means and their design or installation shall prevent unauthorized access to the neighboring tube if train operation has not yet been stopped.

(7) Access to Tunnel Entrance and Tunnel Exits

UIC standard (UIC Codex 779-9, September 2002, Safety in Railway Tunnels) recommends provision of access road of minimum 3m width, to portals and emergency exits for rescue services.

(8) Ballastless Track (BLT) in Tunnels

As per Railway Board letter no. 2019/W-1/Genl. Policy Pt. 1 Dated 09.03.2022, without exception the track inside tunnel should be “Ballastless Track” (BLT) on safety, maintenance and life cycle cost considerations. RDSO’s letter no. EBS/CB-1/BLT/Committee dated 17.10.2023 **(Ref 13.01)** may be referred for details about the Technical Eligibility Criteria and Special Conditions of Contract for design and construction of ballastless track for Tunnels/ Viaducts/ Station yards/ formation in cutting/filling on Indian Railways”.

1305 TUNNEL PORTALS

Tunnel portals are the structures provided at the end of a tunnel to provide access to the tunnel, protect the entrance of the tunnel from rock or other objects falling on it, support against lateral earth pressure, prevent surface water from entering the tunnel and provide a means to drain the water running down from above the portal.

Generally, the main factors that influence tunnel portal design and execution techniques are:

(a) Site morphology

(b) Geological and geotechnical conditions of the rock or soil mass

(c) Stability of slopes above the portal and on approach

(d) Surface water drainage

(e) Direction of excavation

(f) Seismic conditions

It is desirable that the location selected for the portal be in good rock with earth cover of the same order as tunnel width and height. However, environmental constraints or other relevant considerations sometimes dictate that the portal be located where there is low cover, weathered rock, or even soil. If the tunnel begins at a soil slope, the slope should be cut back to ensure the requisite earth cover above the portal roof (Fig. 13.06). The slope above the portal should be stable. Otherwise the same should be reinforced properly with suitable means like rock anchors or breast walls of concrete.

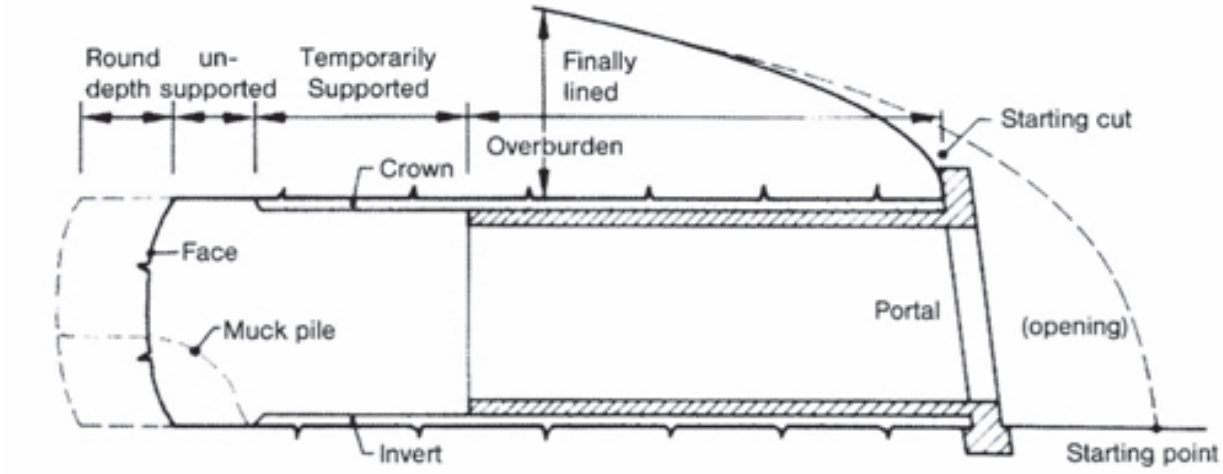


Fig. 13.06: Tunnel portal in longitudinal section

The portal should extend from the tunnel entrance far enough to prevent falling or rolling material from landing on the tunnel entry or approach. To facilitate this, a facade (also known as a False Portal) may be required to be constructed up to the requisite distance from the face of the tunnel. Normally, a suitable thickness of earth pad (a layer of earth) is provided on the roof of false portals, with parapets on both sides. Any boulder or rolling material is retained on this earth pad, with very little impact on the roof, and this debris is cleared from there as part of maintenance operations.

The philosophy of design used for portals is similar to that used for any slope stability analysis. Active support and effective drainage are key elements to ensure the stability of the portal slopes. It must be kept in mind that the portal area serves as the focal center for the tunnelling operations. Since everything goes through it, it must be designed and equipped to facilitate movement workers, materials, equipment etc. through it. The portal location, design and construction should take into account all these factors.

1306 TUNNEL SUPPORTS

Due to creation of the cavity in rock mass for tunneling, the equilibrium of ground stresses is disturbed, creating a zone of higher stresses around the excavation boundary. This causes convergence of the cavity and some extent of rock mass behind the excavation boundary gets adversely affected (i.e. getting into plastic and elastoplastic zone). The magnitude of convergence and the extent of plastic/elastoplastic zone depends on the strength of rock mass, shape/size of tunnel, method of tunnel excavation and the in-situ stresses in the ground.

In case convergence is within permissible limits and the extent of plastic/elastoplastic zone is less, the cavity will become self-stabilizing and no support may be required. However, if the convergence is progressing towards unacceptable limits or the extent of plastic/elastoplastic zone is not stabilizing, tunnel support is required to be installed from within the cavity, to stabilize the cavity. Thus, the purpose of "tunnel supports" is to:

(i) Preserve the integrity of rock mass.

(ii) Provide safe and secure work area.

(iii) Maintain an opening in the rock mass.

(1) Type of Tunnel Supports

Following type of tunnel supports are commonly used:

(A) Steel ribs/Steel sets: They are made using rolled steel sections (e.g. ISMB, ISHB etc.) which are bent to the shape of the tunnel cross section. They are normally used with lagging (made of precast concrete, steel plates etc.) and backfill (of lean concrete or mortar). Till few years back, steel ribs were most commonly used tunnel supports. But due to their poor flexibility and uncertainties in interaction with rock mass, now they are used very rarely as supports, except at the locations warranting very rigid supports (e.g. very poor ground, near portals and intersections etc.).

(B) Lattice Girders: They are trusses fabricated at site, to the shape of cross section of the tunnel, by welding the reinforcement bars. They are relatively light weight (hence economical), flexible and easy to handle. They are normally installed with shotcrete. Use of such supports is very common now-a-days and their flexibility is an added advantage.

(C) Rock Bolts: Rock bolts serve many purposes in the tunnels. First purpose of rock bolts is to support individual rock block, which has become loose due to creation of cavity. The rock bolt anchors/stitches such loose block to the competent rock mass away from the excavation boundary, thereby, providing stability to such potentially unstable block. Rock bolts when used all around cavity, also help in controlling development of plastic zone around the periphery of the excavation, by building a structurally active arch/ring of the reinforced zone around the periphery of the excavation. Some of the common types of rock bolts are Mechanical/Expanding/End Anchor Bolts, Grouted/Friction bolts, Friction Tube/Swellex bolts, Self-Drilling Anchors (SDA), Glass Fiber Reinforced Bolts etc.

(D) Concrete Lining: The concrete lining can be pre-cast or cast in-situ. The lining can be in single layer or double layer. In case of tunneling by Tunnel Boring Machine (TBM), normally pre-cast lining segments are used. In other cases, normally one/multiple layer of shotcrete or cast in-situ concrete lining is used. The in-situ concrete lining is done using a lining shutter of the shape of the tunnel profile.

(E) Shotcrete: Shotcrete (sprayed concrete) sprayed in one layer or multiple layers, is also

used a lining system. Shotcrete provides immediate support after excavation by filling small openings, cracks and fissures. Due to its' flexibility, faster placement time and continuous contact with excavated surface, it is very effective as a support system in mobilizing rock support interaction. In most of the tunneling projects, a layer of shotcrete is sprayed immediately after excavation. Shotcrete can be unreinforced or reinforced by putting a welded wire mesh in the shotcrete layer. Shotcrete reinforced with randomly oriented steel fibers, known as Steel Fiber Reinforced Shotcrete (SFRS), can also be used. Use of structural plastic/polymer fibers has also started recently in lieu of steel fibers.

(2) Initial and Final Support System

Tunnel support systems mainly include initial ground support as well as final/permanent support system. Initial or Primary support is installed immediately after excavation, to make the tunnel opening safe until permanent support is installed. The initial support may also function as the permanent or final support or as a part of the permanent support system.

1307 TUNNEL SUPPORT DESIGN

The design of tunnel mainly involves design of tunnel supports. The most commonly used methods for design of tunnel supports are:

(1) Empirical methods

The Empirical Methods of tunnel support design have evolved based on the extensive experience of various researchers from numerous tunneling projects. There are tables, charts and empirical equations for deciding the tunnels supports based on Terzaghi's Rock Load Factors, Modified Terzaghi's Theory (by Singh et al.), RQD value, RMR value, Q value etc.

(2) Analytical methods

The support pressures, moments, displacements etc. can be estimated by using closed form structural analysis methods. But carrying out such analysis manually is quite time consuming and, therefore, many custom-made software for tunnel analysis/design can be used for this purpose.

(3) Numerical methods

Due to many complexities in tunneling like behaviour of rocks in complex ways (e.g. Elastic, Elastoplastic/Viscoplastic, strain Softening etc.), rock mass being non-homogeneous & anisotropic, complex boundary conditions, difference in behaviour of intact rock vis-à-vis rock mass, effect of excavation sequence etc.; it is not possible to carry out engineering analysis. In such cases, numerical methods are used wherein the undergrounds excavations are analyzed by constructing models catering to relevant loading conditions, boundary conditions and engineering properties of the rock mass. These Numerical methods use the techniques of Finite Difference Method (FDM) or Finite Element Method (FEM) or Boundary Element Method (BEM) or Coupled Finite Element Boundary Element Method (FEBEM) or Distinct Element Method (DEM).

1308 TUNNEL EXCAVATION METHODS

Selection of Tunnel Excavation Method depends on various factors like Geological conditions, Cross Sectional area & Shape of tunnel, Length of tunnel, Ground water condition & expected water

inflow, Vibration restrictions, Allowable ground settlements, Availability of resources (machinery/ equipment, funds & time) etc. Commonly used Tunnel excavation methods can be grouped under two categories, as under:

(1) Excavation Methods for Rock Tunnels

Commonly used excavation methods for rock tunnels are:

(i) Drill and Blast Method (Full Face or Partial Face excavation)

(ii) Road Header Method (Full Face or Partial Face excavation)

(iii) Mechanized Tunnelling, using Tunnel Boring Machine (TBM)

(2) Excavation Methods for Soft Ground Tunnels

Two principal methods for tunneling in soft ground are:

(i) Multiple Drift Method

(ii) Excavation by Tunnel Shields, which includes use of TBM also

1309 TUNNELLING METHODS / PHILOSOPHIES

Tunneling Method or Philosophy does not mean the tunnel excavation method only, but it covers all activities relevant to tunnel construction in totality i.e. data collection (geotechnical investigation, surveying etc.), design of support systems, excavation methods of tunnel, instrumentation & monitoring etc. Various Tunneling Philosophies (generally called as Tunneling Methods) are as under:

(1) Conventional Tunnelling

The definition of "Conventional Tunneling" is rather arbitrary, and subject to variations, depending on the context. The term conventional tunneling is generally used for any method other than Mechanized or Observational methods of Tunneling. Design of support system in conventional tunneling can be done using any approach i.e. Empirical, Analytical or Numerical and using any type of support as per the design. The excavation can be done by Drill & Blast Method or By Road header. The supports can be initial/ primary supports with or without secondary/final supports. The basic principle used in this method is that the load coming on the supports is estimated and the supports are designed to resist this load.

(2) Observational Method of Tunnelling

If some amount of convergence is permitted (within the permissible limit from serviceability point of view and the extent of plastic zone remaining within the critical limit) before installing the support, the required stiffness of the support system will reduce. This in-turn facilitates lighter (and more flexible) support system design, leading to overall reduction/economy in the support system. But for this, the displacement/convergence of tunnel and some other parameters need to be monitored to ensure that support is provided at the right time and it is of right stiffness. This approach is called "Observational Method of Tunnelling". In this approach:

(i) Rock support is estimated based on preliminary assessment (using empirical/ analytical/ numerical approach or some software).

(ii) Ground displacement is monitored with time and the support is installed at the specified displacement.

(iii) If the support is insufficient, displacement continues. In such case, additional support is applied to ensure that displacement is stabilized.

(iv) The tunnel displacements and support pressures are monitored to develop a suitable support system to stabilize the tunnel.

(3) New Austrian Tunnelling Method (NATM)

It is one of the most popular observational method of tunneling. Austrian National Committee defines NATM as "a concept which makes the ground (rock or soil) surrounding the void a supporting construction element through the activation of a ground supporting arch". Another useful definition given by H. Lauffer is "NATM is a tunneling method in which excavation and support procedures, as well as measures to improve the ground - which should be distorted as low as possible - depend on observations of deformation and are continuously adjusted to the encountered conditions".

There are seven features on which NATM is based:

(i) Mobilization of the strength of rock mass – The method relies on the inherent strength of the surrounding rock mass being conserved as the main component of tunnel support.

(ii) Shotcrete protection – Loosening and excessive rock deformation must be minimized. This is achieved by applying a thin layer of shotcrete immediately after face advance. Shotcrete and rock bolts applied close to the excavation face help to maintain the integrity of the rock mass.

(iii) Measurements – Every deformation of the excavation must be measured. NATM requires installation of sophisticated measurement instrumentation. It is embedded in lining, ground, and boreholes. This ensures that support is not installed too early or too late.

(iv) Flexible support – The primary lining is thin and reflects recent strata conditions. Active rather than passive support is used and the tunnel is strengthened not by a thicker concrete lining but by a flexible combination of rock bolts, wire mesh and steel ribs. The lining should not be too stiff or too weak.

(v) Closing of invert – Quickly closing the invert and creating a load-bearing ring is important. It is crucial in soft ground tunnels where no section of the tunnel should be left open even temporarily.

(vi) Contractual arrangements – Since the NATM is based on monitoring measurements, changes in support and construction method are possible. This is possible only if the contractual system enables those changes.

(vii) Rock mass classification determines support measures – There are several main rock classes for tunnels and corresponding support systems for each. These serve as the guidelines for tunnel reinforcement.

(4) Norwegian Method of Tunneling (NMT)

This is also an observational method, quite similar to NATM. The main difference between NATM and NMT are as following:

(i) NATM is most suitable for soft ground which can be machine or hand excavated, where jointing and over break are not dominant, where a smooth profile can often be formed and where a complete load bearing ring can be (and often should be) established. NMT is most suitable for harder ground, where jointing and over break are dominant, and

where drill and blasting or hard rock TBMs are the most usual methods of excavation.

(ii) In NMT, bolting is the dominant form of rock support since it mobilizes the strength of surrounding rock mass in the best possible way. Rigid steel sets or lattice girders are inappropriate in Norway's harder rocks due to the potential over break. Bolting and SFRS (Steel Fiber reinforced shotcrete) are the two most versatile tunnel support methods. A thick load bearing ring (RRS – reinforced rib of shotcrete) can be formed as needed, and matches an uneven profile better than lattice girders or steel sets.

(iii) In NMT, Q-system is used for regulating the description of rock mass conditions and support recommendations. Instrumentation and monitoring is done only in critical cases.

(iv) The shotcrete used in NMT is only SFRS. Concrete lining is used only in extreme conditions such as when tunneling through fault zones, swelling clay and very weak rock that may squeeze.

(5) ADECO-RS Method of Tunneling

ADECO-RS is abbreviation of Italian word which in English reads as "Analysis of Controlled Deformation in Rocks and Soils". The major differences between NATM (and derived methods) and ADECO-RS approach are as following:

(i) In ADECO-RS method, it is always full face excavation whereas in NATM it is not so necessarily.

(ii) In NATM, only "excavation" behind the excavation face is reckoned for design and monitored later on. But in ADECO-RS method, "extrusion" of core face as well as "pre-convergence" of rock mass ahead of excavation face are considered.

(iii) In NATM, the "intervention" in the form of supports is provided only in the cavity behind the excavation face. But in ADECO-RS method, pre-confinement and reinforcement of advance core is also done, if needed.

1310 SAFETY ASPECTS DURING TUNNEL CONSTRUCTION

For details of the safety aspects to be observed during construction of tunnels, RDSO Guidelines No. RDSO/2011/GE:G-016, June'2012, titled as "Guidelines for Safety in Tunnels during Construction" may be referred.

1311 INSTRUMENTATION AND MONITORING OF TUNNELS

(1) Need for Geotechnical Instrumentation

There is a limit to geotechnical data acquisition and no amount of expenditure can enable 100% data acquisition. This gap in geotechnical investigation brings in the need for instrumentation and monitoring. In addition, the instrumentation and monitoring become essential, if "observation approach" of tunneling is followed. It serves following purposes also:

(A) Verification of design and deciding about final support system

(B) Monitoring effect of construction and construction control

(C) Monitoring safety and stability of the excavation

(D) Complying with Regulatory/Environmental clearances

(E) Monitoring in-service performance of the tunnel

(F) Contractual documentation requirements

The Instrumentation and Monitoring Programme for any tunnel is decided taking into account following inputs:

(i) Project conditions

(ii) Mechanisms that are likely to control behavior of the excavation

(iii) Purpose of Instrumentation

(iv) Parameters to be monitored

(2) Parameters to be monitored

Following are the typically monitored parameters:

(A) Convergence or Crown settlement or Floor heave – Using Tape Extensometer or Bi-reflex 3-D Optical Targets or Mini Prism Targets

(B) Load in rock bolts/anchors – Using Centre Hole Load Cells or Measuring Anchors

(C) Stress in shotcrete / concrete – Using Pressure Cells or Shotcrete Strain Meter

(D) Groundwater pressure – Using Piezometers

(E) Water pressure acting on lining – Using Pressure Cells

(F) Surface settlement – Using Borehole Extensometer

(G) Vertical deformation of the ground at depth – Using Multiple Point Borehole Extensometer

(H) Horizontal deformation of the ground at depth – Using Inclinometer

(I) Vertical and horizontal deformation of buildings and other structures – Using Tilt Meter or Engineering Seismographs

(3) Other aspects to be decided

Following aspects are required to be decided, for instrumentation and monitoring plan at each of the tunnel site:

(A) Spacing of the standard monitoring sections

(B) Parameters to be monitored at each of the monitoring section and the frequency of monitoring

(C) Analysis of the parameters monitored and their presentation

(D) **Threshold limits for control limits of various parameters:** Normally following three control limits are defined:

(i) Alert level: On exceedance of which, certain routines will be started to impose an increased attention and surveillance to these specific areas. It indicates that specific area is approaching a level where additional actions and/or contingency measures may be necessary.

(ii) Alarm level: On exceedance of which the element of work may be approaching a critical state. The Geotechnical Engineer shall decide for the specific case and the overall support and rock mass performance.

(iii) Action Level: On exceedance of which the element of work will be considered to be outside the expected range of assessed behaviour. The overall performance shall be re-checked with a related risk assessment. Design review shall be done

together with assessment of need for additional support. Additional support and/ or contingency measures, to guarantee safety of the works, shall be implemented. For ease of identification of an unacceptable safety risk, the works shall be stopped and remedial measures shall be implemented immediately.

1312 DRAINAGE AND WATERPROOFING IN TUNNELS

(1) Stages of providing Drainage

The stages of providing drainage in tunnels are as following:

(A) Pre-drainage: Water should be prevented from entering the tunnel before starting the tunnel construction work. Following are the methods/systems employed for this purpose:

- **(i) Diverting water channels:** Based on detailed survey of the area around the tunnel.
- **(ii) Ground Water Pumping:** By collecting water in ponding/collection areas near the tunnel and then pumping it away.
- **(iii) Grouting:** Creating a grout ring ahead of tunnel advance, using appropriate type of grouting (cement/chemical/resin based). This reduces water permeability, increases stability of the ground and helps in resisting hydrostatic pressure.
- **(iv) Ground Freezing:** The pore water is converted to ice by circulation of a chilled liquid (brine or liquid nitrogen) through a network of small diameter pipes placed in drilled holes. Ice creates a frozen mass of soil and/or rock particles, with improved compressive strength and impermeability. This can temporarily seal and consolidate the ground which is water-bearing but not suitable for grouting. The availability of technology and experience for this technique is rather limited in India.

(B) Drainage during construction: This includes:

- **(i) Construction of Cutoff Walls:** Impervious retaining walls, such as steel interlocking sheeting or concrete slurry wall, upto deeper less pervious layers, to reduce ground water inflow during construction.
- **(ii) Use of Plastic Gutters, Channels and Pipes:** To collect localized water ingress and drain it out, during tunnel construction.
- **(iii) Drainage or Dimpled Mats:** When large quantity of groundwater is expected to appear from large areas. They are often laid on the shotcrete support layer followed by in-situ/shotcrete inner lining.
- **(iv) Dewatering Pumps:** When tunnel is progressing downhill or when the available longitudinal slope is inadequate for draining out the water. Sumps at appropriate locations need to be constructed for this purpose.
- **(v) Drainage Boreholes before tunnel advance:** Such boreholes (Horizontal Drains) should be done when heavy water inflow and/or sudden (but not predictable) water inflows can be expected. Slotted hard PVC pipes or perforated plastic drainage pipes with glass wool filters are inserted into the drainage holes (typically 35 to 100mm diameter) if flow of water can lead to erosion of surrounding strata. The pipes are normally extended with a flexible plastic hose at the exposed end of the hole to drain the water into the side drainage channels or into a temporary drainage pipe

hung from the wall.

(vi) Drainage boreholes after Tunnel Advance: They can prevent build-up of pressure on the support. Drainage boreholes are particularly useful for draining out localized water. The most favourable combination of spacing, length and diameter of the holes should be determined experimentally.

(C) Permanent drainage system: In operational phase of tunnel, a permanent drainage system is required. This can be achieved either by gravity flow system or a pumped system. Gravity flow system will suffice for tunnels with continuous grades. If a low point occurs within the tunnel, it may be necessary to have a pumped system to drain out the collected water.

(2) Waterproofing Systems: Available systems fall under following categories:

(A) Rigid Systems: These include water-resistant plaster, sealing mortar and resin concrete. One major disadvantage of this system is its dependency on quality of application. However, experience in use of synthetically modified concretes or mortars as sealing materials for tunnels is rather limited.

(B) Flexible Systems: The systems currently in use include:

(i) Use of Geo-synthetics: In this system, the tunnels are waterproofed by a geo-composite sandwich **(Fig. 13.06)** consisting of laying:

- A non-woven geotextile layer on the initial shotcrete layer.
- A waterproof geomembrane.
- Cast-in-situ / shotcrete lining (inner/final lining) of concrete.

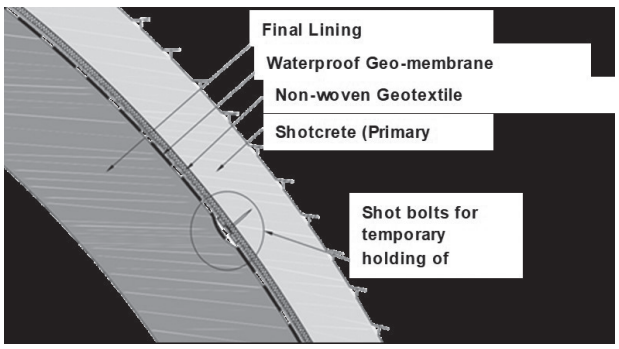


Fig. 13.06: Geo-synthetic Waterproofing Lining

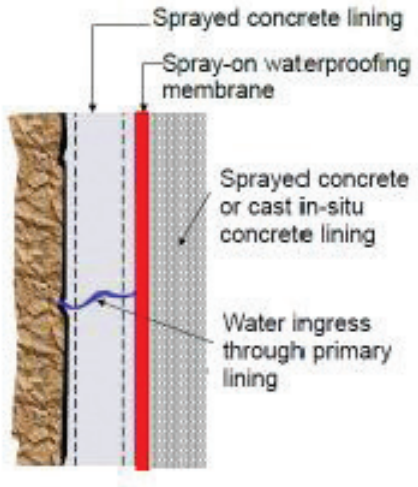


Fig. 13.07: Sprayed Waterproofing Lining

(ii) Sprayed Waterproofing Lining : It consists of a double-bonded spray applied waterproofing membrane embedded between two concrete linings **(Fig. 13.07)**. This bonding property makes the interface between membrane and concrete impermeable. The main advantages of this system are absence of seams, easy installation and easy to repair any defective patch. One major limitation is that the application area should not have any local bumps larger than the layer thickness. The

conditions in a tunnel (dampness etc.) may also cause problems for the application.

1313 TUNNELLING IN WEAK / SOFT GROUNDS

Tunnelling in weak/soft ground presents different challenges because such grounds have very less (or almost zero) standup time and before creation of cavity as well as after creation of cavity, they require extensive stabilization measures to stabilize the ground again. The techniques employed for tunneling in such grounds are as under:

(1) Multiple Drifts

Before the advancements in tunneling technology, the soft ground tunneling was mostly done by "multiple drift" methods, wherein the tunnel face was excavated in multiple phases.

Even now also, a form of this technique called as "Sequential Excavation Method (SEM)" is used for tunneling in soft grounds, wherein the full cross section of the tunnel is opened in different stages **(Fig. 13.08)**.

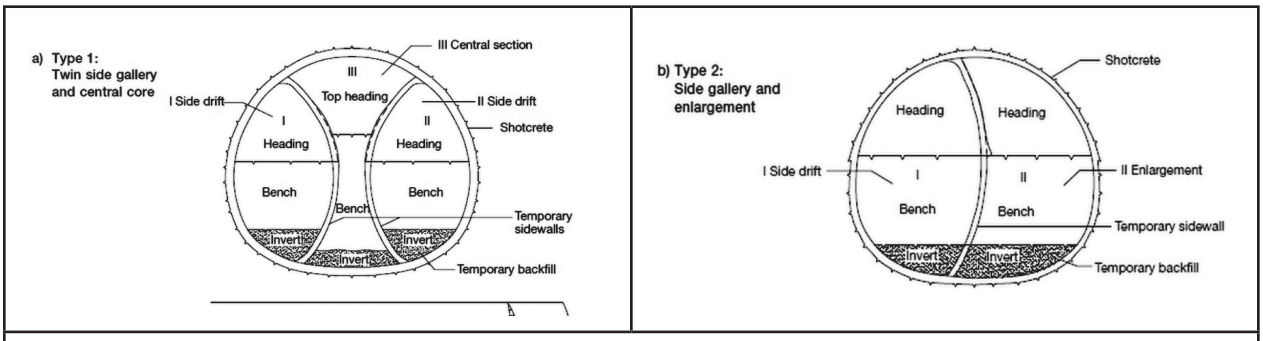


Fig. 13.08: Sequential Excavation Method

(2) Ground Improvement

This involves modification of mechanical and hydrological properties of the ground, to enable tunneling, by using one or combination of following techniques:

(A) Drainage: Before excavation, during excavation and after excavation of tunnel.

(B) Grouting: A ring of grout it created ahead of the tunnel face to be excavated, by carrying out the grouting from one or more locations shown in **Fig. 13.09**.

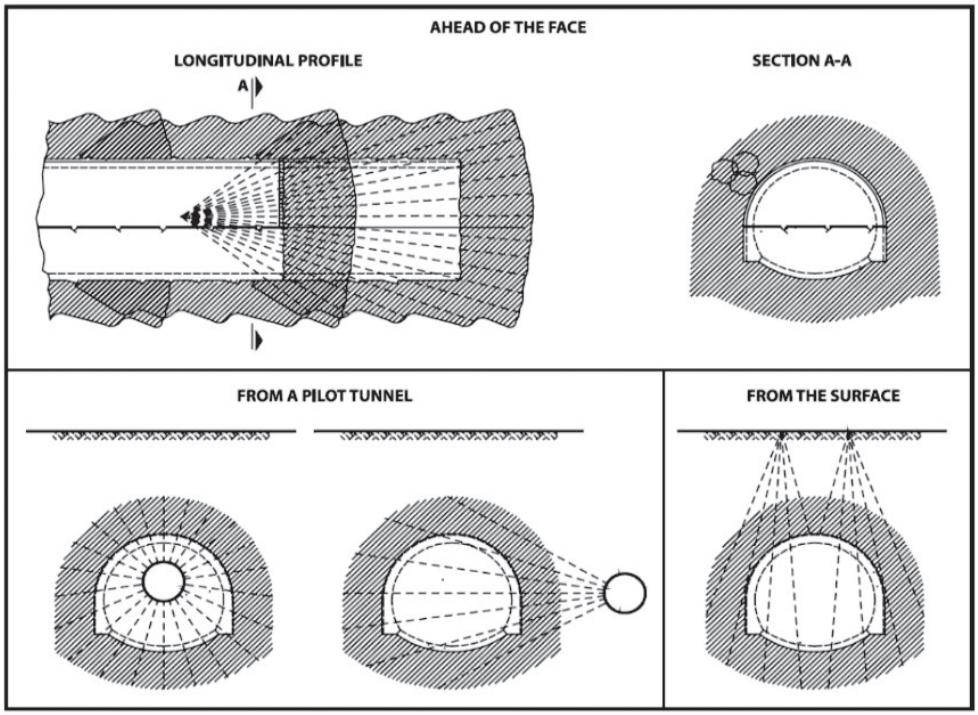


Fig. 13.09: Locations for Grouting

This strengthens loose or weak soil & prevents cave-ins, decreases permeability of the ground & in-turn groundwater flow, reduces subsidence effect of dewatering and stabilises sandy soils which have tendency to run in dry state. The material of the grout (Cement, Micro-cement, Chemical, Epoxy etc.) and grouting technique (Permeation grouting or Compaction/Displacement grouting or Jet Grouting) is decided based on the type of ground (particle size and gradation) and the specific purpose for which grouting is being done.

(C) Ground Freezing: The pore water is converted to ice which creates a frozen mass of soil and/or rock particles, with improved compressive strength and impermeability. The availability of technology and experience for this technique is rather limited in India.

(3) Face Consolidation

In this, face bolts are used for face reinforcement ahead of excavation. Though steel bolts can be used for this, but "fiber glass reinforcement elements" bolts are used more commonly as it is easy to break/snap these elements hanging from the face after excavation.

(4) Advance supporting/ Pre-supporting

On excavation, the weak/soft ground tends to sink into the opening. This can be prevented by any "cavity pre-confinement action" (any action that favours the formation of an arch effect in the ground ahead the tunnel face). Such intervention, in advance of tunnel face excavation, are called as Advance Supports or Pre-supports. Some of the commonly used Advance Support or Pre-support are as under:

(A) Mechnical pre-cutting: In this method, a peripheral cut (like slit) is made around the periphery of the area to be excavated, by using a slit cutting machine. This slit is then filled with concrete, thereby creating an annular ring around the ground to be excavated.

(B) Spiles: In this technique, steel bars are inserted, on the excavation boundary in roof area, ahead of excavation, by jacking, ramming or inserting in drill holes. These bars rest on the first steel rib or lattice girder support in front **(Fig. 13.10)**. Their length is about 3 times the round/step length and are spaced around 30 cm.

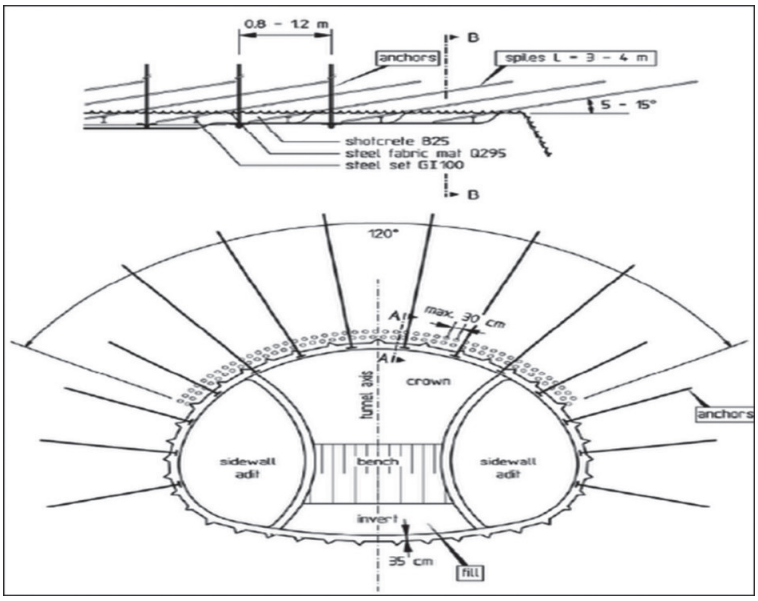


Fig. 13.10: Spiles

(C) Umbrella Arch or Forepoling: It is an economical method to increase the excavation front sustainability. In this method, first bore holes are drilled in a semi-circular pattern around the crown of proposed tunnel profile. Then steel pipes are placed into each of these holes and they are filled by grout, forming a strong umbrella arch tube above the tunnel crown. Pipes are installed in two consecutive steps, with overlapping length, and are provided at a small outwards angle from longitudinal axis of the tunnel **(Fig. 13.11).** Length of pipes is from 15 to 30m and they are spaced at about 30 to 50cm.

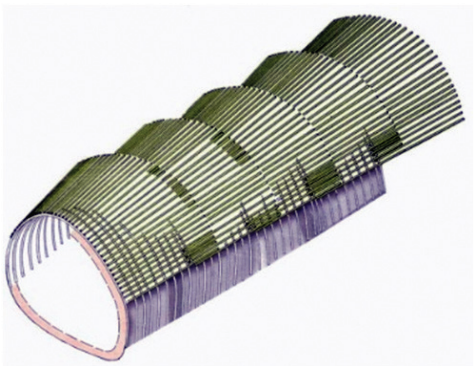


Fig. 13.11: Umbrella Arch Roofing

(5) Yielding Supports

For tunnelling in Squeezing and Swelling ground, various types of yielding supports are used, which have the capability to shorten their length with reduction in size of the cavity. Some of these are:

(A) Toussaint-Heintzmann (TH) Profile Steel Ribs: In this, two or three sliding elements are added in each of the steel rib to allow sliding to a pre-determined distance.

(B) Steel cylinders inserted in slots of shotcrete lining: Steel cylinders are inserted into gaps in shotcrete lining, which get loaded axially due to reduction in size of the cavity. After a given load, these cylinders start shortening and at the same time allow the lining resistance to develop.

(C) Highly compressible concrete elements inserted into shotcrete lining: They are made of cement, sand, hollow glass particles, steel fibers and additives; with steel reinforcement. They get compressed up to 40-50% and do not exhibit sudden brittle failure. On reaching the full deformation capacity, their strength increases.

(6) Concept of Stress Release Holes (SRH): For Squeezing, Swelling and Heaving (SSH) grounds, this concept was introduced by Dr. H. Bineshian in year 2015 and has been successfully applied in 11 tunnels in USBRL Project. In this system, 100+ mm dia. Holes are drilled at a spacing of 2m x 2m in square pattern and perpendicular to periphery of tunnel. The holes are drilled in one to three stages, depending on the severity of convergence. Maximum length of the holes is equal to dia. of tunnel, to ensure that it crosses the plastic zone. These holes assist in releasing the non-uniform shear stresses that produce non-uniform deformation and control accumulation of stresses at surrounding ground. Other conventional measures may also have to be combined, depending on the severity of convergence. Convergence is monitored and final lining is placed only after termination of the convergence and after passage of minimum period of monitoring (which varies from 6 to 12 month depending on the SSH class).

1314 VENTILATION OF TUNNELS

[Ref. Para 1007B of Indian Railway Bridge Manual, 1998]

Ventilation of tunnel is one of the important aspects related to passenger & crew comfort during passage of train and for workmen working inside the tunnel, from their health point of view. Adequate ventilation needs to be provided inside tunnel, so that concentration of hazardous gases and rise in temperature of air inside tunnel remain within permissible limits.

(1) Effect of movement of train inside tunnel

Passage of a train in a tunnel creates following environmental hazards:

(A) Air Quality Deterioration: Emission from diesel locomotive contains potentially hazardous gases such as NO, NO_2, CO, CO_2, SO_2 and hydrocarbons. These pollutant gases may prove to be hazardous, if their concentration exceeds permissible value.

(B) Thermal Environment Hazards: As the locomotive traverses through tunnel, the tunnel gets heated up due to heat emitted from exhaust gases and other part of locomotive. The thermal environment is to be controlled within a safe range for efficient functioning of locomotive and comfort of passengers, crew and workman.

(C) Pressure Transient Hazards: When a train passes through a tunnel, aerodynamic effects come into play. Due to this, the drag and propulsion power increases and the pressure environment around the train gets changed, which may cause severe discomfort to passengers.

(2) Permissible values of Pollutants

These values shall be different for workers who are supposed to work for 8 hours inside tunnel and for passengers and crew who are supposed to pass the tunnel within few minutes. These values are given in **Table 13.03** below. Maximum temperature of air inside tunnel needs to be limited to 50°C considering passengers and workmen comfort

Table 13.03: Threshold levels for Pollutants inside Tunnels

Pollutant Gas	8 Hours Exposure Value	15 Minutes Exposure Values (*)
CO	50 ppm	400 ppm
NO	25 ppm	35 ppm
NO_2	5 ppm	5 ppm
CO_2	5000 ppm	18000 ppm
SO_2	5 ppm	5 ppm

(*) These values are from the consideration of passengers comfort and shall depend upon the length of the tunnel and speed of the train.

(3) Types of Ventilation Systems: The ventilation in a tunnel can be achieved by:

(A) Natural Ventilation

When a train traverses inside tunnel at a relatively high speed and ratio of train frontal area to tunnel cross section is of the order of 0.5 to 0.6, it induces considerable air flow inside tunnel. This type of ventilation is called as natural ventilation. The amount of induced air flow will depend upon orientation of tunnel and atmospheric pressure difference between inside and outside the tunnel. If length of tunnel is small, the induced air flow may be sufficient to keep the pollutants concentration and rise in temperature inside tunnel, within permissible limits. In such case there may not be any necessity for provision of artificial ventilation.

(B) Artificial Ventilation

In long tunnels induced air flow due to train movement is not sufficient to keep concentration of pollutant gases under permissible limit. In such cases artificial ventilation may have to be provided by means of provision of ventilation shafts with or without provision of electric fans, with suction and delivery arrangement. Where provision of shaft is not feasible, longitudinal ventilation with the help of an axial blower fan at the portal supplemented by auxiliary fan of smaller capacity, spaced at suitable intervals along the length of tunnel may be considered.

(4) Design of Ventilation System of tunnels

(A) The essential requirement of a ventilation system of tunnel are as under:

(i) It should ensure sufficient air flow relative to moving train, to keep the concentration of pollutant gases within permissible limits.

(ii) It should ensure sufficient air flow to prevent locomotives from over-heating and to keep thermal effects within desirable limits.

(iii) It should ensure that pressure transient are within acceptable limits.

(B) The amount of air flow and type of ventilation arrangements required depend upon the level of concentration of pollutants and maximum temperature likely to be attained

inside tunnel due to movement of trains; which depend upon the following factors like type of locos, gradient inside tunnel, length of train, speed of the train, time interval between two trains, ambient temperature, length of tunnel, cross section of tunnel, direction of prevailing winds etc.

(C) As large number of factors are involved, it may be difficult to estimate pollutants concentration & maximum temperature likely to be attained analytically. Thus, mathematical modeling and simulation studies are necessary for design of ventilation system. As factors governing designs of ventilation system vary considerably from site to site, therefore design for ventilation of each tunnel has to be developed separately.

(D) Normally on single line sections, tunnels having length upto 2 kms, may not require provision of artificial ventilation but it should be ensured that levels of concentration of pollutants during passage of trains are not likely to exceed threshold levels. Tunnels having length more than 2 kms may require provisions of artificial ventilation, by means of shaft with or without provision of fans, depending upon results of simulation studies.

1315 OTHER SAFETY FEATURES FOR TRAIN OPERATION IN TUNNELS

For provision of other safety features in tunnels, for safety during operations (like scale of ventilation systems, lighting systems, power supply arrangements, communication systems, public address system, siren for emergency, tunnel marking symbols, SCADA system, CCTV, other sensors inside tunnels, fire safety measures etc.), the instruction/guidelines issued by directorates of the concerned departments in RDSO / Railway Board may be followed.

Reference Documents

SN	Para No.	Ref. document details	
1	1304(8)	13.01	RDSO letter no. EBS/CB-1/BLT/Committee dated 17.10.2023 on "Technical Eligibility Criteria and Special conditions of Contract for BLT.
2	1304(1)(D)	13.02	Diagram No. 1A of Indian Railway Schedule of Dimensions (IRSOD)-2022, Standard Dimensions for Tunnels & Through Girder Bridges (Schedule-I, Chapter-I)
3	1304(1)(D)	13.03	Diagram No. 1A (Modified) of Indian Railway Schedule of Dimensions (IRSOD)-2022, Standard Dimensions for Tunnels & Through Girder Bridges to suit 25 k.V.A.C. Traction (Schedule-I, Chapter-I)

***

CHAPTER 14
BUILDINGS AND PASSENGER AMENITIES

PART A
BUILDINGS

1401 ARCHITECTURE

Architecture broadly pertains to planning and designing form and space ambience to reflect functional, technical, social, environmental & aesthetic considerations. It requires the creative manipulation and coordination of materials and technology and of light and shadow.

(1) General Design requirements of Buildings : A building shall be functionally as well as aesthetically pleasing. It shall be suitable for occupants and easy to maintain.

(a) Form, Space and Ambience: The building design shall provide sufficient circulation elements to allow for the free and safe flow of users without disrupting the movement of others flow. The structure should fulfill the desired requirements in a scientific and efficient manner, conforming to the existing norms.

(b) Aesthetics: The quality of building materials and finishes shall be used to formulate identity using form, color, and lighting as tools to create pleasing aesthetic solutions. Planning the building aesthetically good in all respects, including front and side, looking with the latest available maintenance - free material.

(c) Colour Scheme: There should be consistent use of similar colors for like - type spaces (i.e. waiting areas, entrance areas, etc.). Colors for architectural finishes shall be consistent and/or complimentary with those used in existing buildings and previously approved by Indian Railways. The best colour scheme of the building as demanded /matching with the adjacent structures in the area.

(d) Orientation: The Orientation of buildings is a very important factor that is directly connected to the standards of thermal comfort and ventilation within buildings. It is guided by natural elements like sunlight and its intensity, the direction of the wind, seasons of the year, and temperature variations. Orientation is determined by climatic factors such as wind and solar radiation. Orientation principles depend on climatic conditions. The climatic zones of India, as mentioned in the National Building Code (NBC) 2016 (Vol.2 Part 8 Section 1) can be used to determine the orientation of buildings.

(e) Earthquake resistant design: Hospitals, control office buildings, water tanks, and electrical substations should be specifically designed for earthquake forces.

(f) Landscaping: Landscape architecture has more or less a supplementary function; it essentially deals with the surroundings of a building, except in cases of afforestation and the creation of gardens and parks. It is not merely the plantation of trees and shrubs but involves creating an entire environment that comprises living objects and non-living materials.

(2) To achieve various requirements:

(a) Functional: The building shall be designed to provide full weather protection to every user of the building. The building should fulfill the functional requirements of the intended users.

(b) Technical: A building should be planned in such a manner so as to achieve the best possible method of construction with economy.

(c) Social: While planning the building, the social local sentiments, if any, needs to be taken care of.

(d) Environmental: The building should comply with all applicable environmental laws. The aspects of environmental acceptability, sustainability, water and energy efficiency should be considered. Materials used should be eco-friendly. Green/landscaped areas should be increased and coordinated with pedestrian and vehicular traffic.

The Energy Conservation Building Code (ECBC) 2017 (updated) shall be considered in the design of the building for covering items (a), (b) & (d) above.

(e) Heritage Consideration: The Archaeological Survey of India (ASI), under the provisions of the Ancient Monuments and Archaeological Sites and Remains Act, (AMASR Act) 1958, protects monuments, sites, and remains of national importance. It needs to be checked whether the affected monuments and structures are protected by AMASR Act, 1958 and if they are protected, then subsequent action should be taken in conjunction with the provisions of this act.

Besides the above-mentioned, legal aspect, it will be desirable that the appearance of the proposed building does not diminish the heritage value of the place. The building should incorporate and reflect the local heritage in its aesthetics.

1402 DEVELOPMENT CONTROL NORMS

These are regulations defined by Building Bye-Laws, which provide control norms for buildings, excluding the internal arrangements (NBC-2016 Vol.1 Part 3 has information on the norms).

(1) Set Backs or open areas: This is the clear distance between the building line and the nearest boundary line. It varies as per the type of structure, areas, size of the building, height of the building. These setbacks are to be provided as per local bye-laws; if such norms are not available, then NBC provisions shall be followed.

e.g. Front Open Spaces - for residential buildings

Width of street (in m)	Front Open Space (in m)
Up to 7.5 (*)	1.5 (*)
7.5 to 18	3.0
18 to 30	4.5
Above 30	6.0

*for buildings up to a maximum height of 7 meter. (As per NBC 2016 Part 3 clause 8.2.1.1)

(2) Ground Coverage: It is the ratio % of the area covered at the pinth level to the total plot area. In cases of high-rise buildings, the ground coverage can be kept lower; in other cases the maximum ground coverage should be utilized. For any area, the percentage of ground

coverage is defined by local bye-laws.

(3) Floor Area Ratio (FAR)

FAR = Total covered area of all floors / plot area

Depending upon the prescribed FAR of a prescribed zone for the given building, the flexibility of ground coverage and height of the building can be decided.

(4) Height of Building: In the case of flat roofs, this is the vertical distance between the average level of ground around and contiguous to the building or as decided by the authority to the terrace of the last livable floor of the building adjacent to the external wall. For other types of roofs, may refer NBC-2016 Vol.1 Part 4 Cl.2.6. Buildings with a height 15m (As per NBC 2016 Vol. 1 PART 4 FIRE AND LIFE SAFETY clause 2.38) are considered high-rise buildings. For high-rise buildings clearances/NOCs are required to be obtained from authorities such as the Fire Services Department, the Airport Authority of India, etc. wherever required.

(5) Parking Norms (off-street parking, i.e. on site) : Parking space shall be provided as per the applicable local norms. As per NBC-2016 Vol.1 Part 3 cl. 10. , for a car, the minimum parking space to be 3m x 6m when individual parking space is required and 2.75m x 5m when common parking space is required. Space for scooter, two-wheeler and bicycle to be not less than 1.25 m^2 and 1.00 m^2 respectively.

Detailed norms for off-street parking (within the plot of property) are given in Annexure A of Part 3 cl. 10 of NBC-2016.

(6) Access-Entry/Exit: The access to the structure should be clear, smooth, easy, identifiable, speedy, and well defined. For adequate parking space, road width, road surface, signage, etc. should be properly planned. The building should provide ease of access for all users by minimizing physical and psychological impediments to their use of the building. The positioning and character of the building access points will have a critical influence on satisfying this requirement.

Facilities for disables shall comply with the provisions of the “The rights of Persons with Disabilities (RPwD) Act, 2016. The same is elaborated in Part B of this chapter “Passenger Amenities”.

(7) Services and Utilities: Depending upon the type of building, the requirement of various services such as: electricity, gas, water, sewage, telephone, internet, etc. is required to assess and to be incorporated at planning stage itself.

(8) Plinth Level: Plinth level should be adequately higher than road level. It should be at least 45cm above the adjacent road /ground level. While deciding the plinth level, the level of nearest main road, adjacent buildings, and general topography of the area should also be considered.

(9) Drainage: It should be planned in such a way that effective and efficient disposal of all wastes is ensured from the building.

There should be no backflow of waste water from external sewers or other sources. Easy access to all services for proper maintenance should be provided.

(10) Facade: The facade of the building needs to be developed in conformity with the importance of the building and area, heritage value, historical considerations, adjacent structures, aesthetics, etc. Considerations should be given to both traditional and contemporary material

to achieve these goals.

(11) Ventilation: Employ design strategies to provide fresh air intakes that enhance the health and productivity of the railway buildings. The aspects of natural ventilation should be provided. If required, air filtration can also be used.

Dimensions for the residential buildings shall be as given in Indian Railways Works Manual (IRWM). Wherever, certain provisions are not given same shall be adopted as per National Building code of India (may refer to NBC-2016 Vol.2 Part 8 Section 1).

1403 RELEVANT INSTRUCTIONS / CIRCULARS ON THE CONSTRUCTION OF BUILDINGS ON RAILWAY LAND

(1) IRWM Para 201 says:

Section 11 of Indian Railway Act No. 24 of 1989 provides for the right to erect buildings on their own land by railways without having to obtain the sanction of the Municipal or Cantonment authorities in whose area the site is situated. In urban areas, the Urban Development Authority must be consulted, and rules framed by them must be followed. Municipal or Local authorities may, however, be consulted, where appropriate, regarding water connections, sewer lines & sewerage disposals, or similar matters.

In areas where bye-laws have been notified by the local authorities, it would be in the common interest to adopt such bye-laws as being good recommended practice.

In areas where bye-laws have not been notified, it will be desirable to adopt the provisions of the National Building Code of India – 2016, Part 3 of Vol. I).

(2) Other Relevant Central Govt. references / orders :

- The concerned executing authority of Railway shall follow the relevant central Government references/orders as well as local body rules if applicable to Ministry of Railways.
- On 03.10.2018, in reference to Railway Board's cabinet note on 'Redevelopment of Railway Stations' dated 23.05.2028, Union Cabinet approved that – "Railway/ RLDA/ IRSDC shall consult urban local bodies/ other statutory authorities while approving its plans in terms of the power conferred on them by section 11 of the Railway Act' 1989, so that the development in Railway land is harmonious with surrounding development, generally following the National Transit Oriented Development (TOD) Policy. No change in land use is required Pan India by Railways for developing Railway land for commercial use". [Railway Board lt. no. 2019/LML-II/2/11(133) dt. 30.01.2020, including dt.13.11.2019, 01.05.2017 and 17.10.2018 **(Ref. 14.01)**]. Thus, there is no need to obtain the approval from the local authority. However, they shall be consulted while developing Railway land.
- Ministry of Environment, Forest and Climate change vide Lt. no. F.No.IA3-12/3/2023-IA. III (E-220190) dt. 06.10.2023 **(Ref. 14.02)** has given clarification that Railway projects covered under the Railways Act 1989, shall not attract Costal Regulation Zone (CRZ) clearance. Also, Environment Clearance is subject to the preparation of a comprehensive Environmental Management Plan (EMP) fulfilling the standard environmental safeguards as prescribed in Ministry of Environment, Forest and climate change lt. no. F. No. 19-172/2018-IA III dt. 28.05.2020 **(Ref. 14.03)**.

1404 CONCEPTUALIZATION & PLANNING OF THE PROJECT

- Preparation and finalization of the scheme in consultation with user departments.
- To obtain complete brief regarding the details of requirements & site conditions through discussions with user departments.
- Site survey and preparation of master plan of the area indicating the locations of existing structures, roads, land marks, facilities, utilities, and relevant features like drains, access roads, parking, and any other facilities
- Ascertaining the applicable Bye laws, preparation of site plan, preliminary floor plans/ configurations, and elevations with various alternations, and getting conceptual approval of the same from user departments. Preliminary cost estimate for the approved concept plan based on prevailing market rates and approved specifications.
- Planning, designing and preparation of detailed architectural plans, interior design and external/ internal services/utilities pertaining to construction of proposed buildings.
- Preparation of 3-D drawings and model of suitable scale.
- Preparation of all necessary drawings for obtaining the local authorities/bodies approval.
- Final approval of conceptual and architectural drawings

1405 OTHER IMPORTANT ASPECTS

(1) Green Buildings: A green building is one that uses less water, optimizes energy efficiency, conserves natural resources, generates less waste, and provides healthier spaces as compared to conventional buildings.

(a) Objectives

- Conserve nature and natural resources: Building construction involves damage to ecology through land use disturbance energy- intensive materials and processes.
- Increase energy efficiency: Buildings consume about 50% of total energy. Energy consumption is growing at a rate higher than population growth.
- Improve indoor air quality: Construction materials such as paints and varnishes emit polluting gases like nitrous oxide and carbon dioxide.

(b) Economy: Over a 40-year life cycle of building, the energy costs exceed construction costs. Initially, a green building may cost 10%-40% more, but energy costs would go down by 30%-65%. The break-even point is achieved depending on the energy consumption.

(c) Indian Railway's Energy Efficiency Policy

While constructing new buildings, following guidelines shall be followed for making buildings energy efficient:

- All new station buildings shall be green building certified.
- All new and upcoming buildings (other than residential) shall be in accordance with the constructed by following Energy Conservation Building Code (ECBC). This code is issued by the Bureau of Energy Efficiency (BEE) of the Ministry of Power, GOI.
- All new residential buildings, built on a plot of more than or equal to 500 sq. m (Attention is required in reference of clause 2.1 and 5.3 of Indian Railways Energy Efficiency Action Plan & Policy (IREAP) dated 30.12.2022) shall be constructed by following Eco-Niwas

Samhita. This code is issued by the Bureau of Energy Efficiency (BEE) of the Ministry of Power, GOI.

Also, while constructing new buildings, Indian Railways' policy on energy efficiency measures in non-traction issued vide letter no. 2022/EEM/150/09 dt 30.12.2022 shall be adopted **(Ref. 14.04)**.

(2) Water management

(a) Rain water harvesting (RWH)

Provision of rainwater harvesting is mandatory in the construction of all built-up assets as per Railway Board letter no. 2013/LMB/9/1 dt. 09.09.2013 **(Ref. 14.05)**.

As per the Indian Railways water policy – 2017, RWH systems shall be provided in all existing establishments (Offices, Service Buildings, Hospitals, Station Buildings, Railway Quarters , Workshop, Sheds, Yard remodeling, as well as in Doublings, New Lines, Gauge Conversions and Siding.) with a roof top area more than 200 sq m, subject to techno-economic feasibility.

There are two main techniques for RWH -

(i) Storage of rainwater on surfaces for future use

(ii) Artificial recharge to ground (various methods are given in Chapter 2 of IRWM)

RWH may also be done by reviving old water bodies on railway land and creating new water bodies wherever feasible.

(b) Waste water management: As per the Indian Railways water policy – 2017 **(Ref. 14.06)**, STP/ETP/WRP have to be provided at Railway Stations, Colonies, Workshops, Sheds, Hospitals etc. Waste water from residential/service buildings, platforms, etc. is to be treated for re-use as non-potable water. Technology like a water recycling plant (WRP), an Effluent treatment plant (ETP) and a sewage treatment plant (STP) shall be chosen to get maximum benefit with minimum cost. The selection of method shall be strictly on the basis of capital cost, O&M cost, sustainability.

(c) Use of water efficient fittings: Bathroom sinks and toilets, including flushing tanks, shall be equipped with low water consumption kits/fittings. Waterless urinals may also be provided. However, the maintainability of these items/kits shall be kept in view while choosing the design/make of the fittings and fixtures.

(3) Green Building Rating: Green building rating systems basically quantify the site sustainability, water efficiency, energy efficiency, indoor environment quality, material and resources, innovations, etc. There are number of green building rating systems available worldwide, following are some rating systems used in India:

- GRIHA (Green rating for Integrated Habitat Assessment), developed in India.
- IGBC (Indian Green Building Council), developed in India.
- LEED (Leadership in Energy and Environmental Design), developed in USA

Every rating system are having their own marking systems for various green building aspects like sustainability, energy efficiency, water efficiency etc. Also, there are different rating and certifications for different type of buildings e.g. New buildings, existing buildings, offices, retail spaces, institutional buildings, hotels, hospital buildings, healthcare facilities, residences, and multi-family high-rise buildings. All details of such rating system are available on the websites

of above rating system agencies.

1406 CLEARANCES/NOCs FROM LOCAL AUTHORITIES/BODIES

- Clearances from respective departments of local bodies and central Government departments shall be obtained, wherever mandatory or as per local rule.
- Respective Departments for clearances are Local body, fire department, airport authority of India, forest department, ministry of environment, etc.

Local Connections Approvals:

- Lift Authorities
- Electricity Authorities
- Water Supply and Sewerage Authorities
- Telecommunication

1407 AMENITIES TO BE PROVIDED IN BUILDINGS

(1) Residential buildings: All the amenities in residential buildings shall be provided as per the Indian Railways Works Manual or as per the latest Railway Board guidelines. At present, the guidelines issued vide Rly. Board letter no. 2013/LMB/10/15 dt. 11.12.2013 **(Ref. 14.07)** are followed.

(2) Other than residential Buildings: The selection of materials and finishes for the exterior of the building, floors, ceilings, and walls should contribute to the aesthetics, comfort, and safety of the building. It should be durable, maintainable, vandal-resistant, environmentally friendly, fire- resistant, cost-effective, and visually pleasing. The finish material patterns, textures, and colors, together with the building geometry, help to define the architectural quality and identity of a building.

(a) External Finishing

Claddings: Permanent Finishing materials like stones, glass, and metallic cladding can be provided on the elevations of the buildings. However, cleaning arrangements and maintenance requirements should also be planned accordingly.

Vast use of ACP having polyethylene (PE) as a major component, on the exterior of public buildings should be avoided.

Depending on the importance of the structure, texture painting is also a preferred economical way of external finishing.

(b) Internal Finishings

Material finishes of elements, such as flooring, walls, structures, furniture, sanitary fittings, etc. within the public areas of the building where surfaces either come in direct physical contact with the public or are visible to them, should be highly durable, require low maintenance, require less frequent cleaning, and be less likely to catch dust or cobwebs.

In common areas such as corridors, stairs, etc, hard flooring should be provided so that it is maintenance-free and easy to clean. Granite and Kota stone can be preferred options.

In public toilets, Udaipur green marble/granite and in residential toilets ceramic tile

flooring can be provided. Glazed tiles can be provided on walls.

In pantry areas, Kota or granite flooring can be provided as it is weather resistant and easy to clean.

(c) Sanitary Fittings

- Preference for wall-mounted WCs as compared to floor-mounted WCs, as the former ensures more cleanliness and efficiently uses space availability.
- Dual flush cistern for water closet to efficiently use the water and minimize the wastage of water
- Sensor taps for the wash basin in public toilets.
- Auto-sensor for urinal flushing.

1408 FIRE PROTECTION

NBC-2016 Vol. 1 Part 4 Fire and Life Safety is a good reference document.

(1) Fire Resistance and Smoke Generation: The material used should reduce the hazard of fire. It should have minimum burning rates, smoke generation, and toxicity characteristics for building finishes and consistent with requirements of fire/life safety requirements. As per NBC-2016 Vol. 1, Part 4, Fire and Life Safety, Cl. 3.4.11 surface interior finishes shall not generate toxic smoke.

(2) Attachment: Eliminate hazards from dislodgment due to temperature change, vibration, wind, seismic forces, aging, or other causes by using proper attachments and adequate bond strength.

(3) Slip-resistant walking surfaces: Increase pedestrian safety in compliance with accessibility requirements by using floor materials with slip-resistant qualities. Entrances, stairways, platform edge strips, and areas around equipment shall have high slip-resistant properties. ASTM C1028 defines the standard/specification of the materials to be used.

(4) Some of the fire protection systems adopted in high rise buildings are as under:

- Sprinkler systems
- Underground and overhead fire reservoirs
- Fire hydrant systems.
- Fire pumps and ancillaries.
- Fire extinguishers.
- Smoke detectors
- Heat Detectors
- Indication Panels
- Autodial facility
- Access Control

Minimum Requirements for Fire Fighting Installations are given in Table 7 of Part 4 of NBC 2016, Vol. 1.

PART B
PASSENGER AMENITIES

1409 GENERAL

As stations and their environs are the first point of contact between Railways and their customers, special importance is required to be given to the facilities provided to passengers in regard to their adequacy, quality, and maintenance. While planning for provision/ augmentation of amenities at stations, due consideration needs to be given to the importance of the station from the point of view of passenger traffic.

Railway Board, vide letter no. 2018/LM(PA)/03/06 dt. 09.04.2018 **(Ref. 14.08)** has issued Comprehensive instructions for the provision of Passenger amenities and user facilities at stations. Further modifications in the above instructions were made vide Railway Board letter no. 2018/LM(PA)/03/06 dt. 14.02.2022 **(Ref. 14.09)**. The above instructions are to be followed while providing passenger amenities at stations. Updated instructions are to be read with the above guidelines.

The comprehensive instructions for the provisions of passenger amenities and user facilities are broad guidelines. However, GMs/DRMs may make need-based modifications in the design, duly recording the justification there of for the quantum of facilities envisaged in these comprehensive instructions, including stations where the running of double-stack containers is involved.

1410 CATEGORIZATION OF STATIONS

(1) For the purpose of categorization of stations, the basic parameter is the passenger earnings of each station, from both reserved and unreserved passengers and outward passengers handled at the station. (Clause 2.3 of Passenger amenties letter dated 09.04.2018.) The earnings are to be calculated on the basis of the number of passengers boarding at a particular station (both reserved and unreserved), irrespective of the location from where the ticket has been issued. The data of passenger earnings should be collected from PRS, UTS, SPTM and JTBS etc.

(2) Stations have been categorized into three categories, i.e., Suburban stations, Non-Suburban stations and Halt stations based on passenger earnings and/or outward passengers handled at the station. Suburban stations have also been segregated into three categories, i.e. SG-1, SG-2, & SG-3. Non-Suburban stations have been segregated in six categories i.e. NSG-1, NSG-2, NSG-3, NSG-4, NSG-5 & NSG-6. Similarly, Halt stations have been segregated in three categories i.e. HG-1, HG-2, & HG-3 **(Table -14.01).**

(3) The categorization of stations shall be reviewed every 5 years.

Table 14.01

Categorization of stations for provision of passenger amenities

Category of stations	Criteria of Proposed Earnings	Criteria of Proposed outward Passengers handled@
NSG 1	> 500 Crore	> 20 Million
NSG2	> 100 Crore ≤ 500 Crore	>10 Million ≤ 20 Million
NSG3	> 20 Crore ≤ 100 Crore	> 05 Million ≤ 10 Million

NSG4	> 10 Crore ≤ 20 Crore	> 02 Million ≤ 05 Million
NSG5	> 01 Crore ≤ 10 Crore	> 01 Million ≤ 02 Million
NSG6	≤ 01 Crore	≤ 01 Million
SG 1	> 25 Crore	> 30 Million
SG 2	> 10 Crore ≤ 25 Crore	> 10 Million ≤ 30 Million
SG 3	≤ 10 Crore	≤ 10 Million
HG 1	> 50 lakh	> 03 lakh
HG2	>05 lakh ≤ 50 lakh	>01 lakh ≤ 03 lakh
HG3	≤ 05lakh	≤ 01 lakh

Note: NSG (Non-Suburban Grade), SG (Suburban Grade), HG (Halt Grade)

@ Passengers handled are taken on the basis of actual outward passengers handled at the station.

The categorization proposed is on the basis of data for originating passengers and earnings provided by Zonal Railways.

GMs shall have powers to categorize a station as NSG4 category if it is a place of tourist importance and/or is an important junction station.

1411 MINIMUM ESSENTIAL AMENITIES (MEA)

When a station is constructed, certain minimum amenities are required to be provided at each category of station (on the basis of projected traffic/earnings). These are called **Minimum Essential Amenities (MEA)**. These MEA for non –suburban, suburban & halt stations are shown in Table – **14.02, 14.03 & 14.04** respectively) whereas norms (quantum) of MEA for non –suburban, Suburban & halt stations are shown in Table – **14.05, 14.06 & 14.07** below.

Table – 14.02

Minimum essential amenities at non-suburban stations

SN	Amenities	STATION CATEGORY					
		NSG1	NSG2	NSG3	NSG4	NSG5	NSG6
1	Drinking water piped / Hand Pump	Yes	Yes	Yes	Yes	Yes	Yes
2	Waiting hall	Yes	Yes	Yes	Yes	Yes	Yes
3	Seating arrangement	Yes	Yes	Yes	Yes	Yes	Yes
4	Platform shelter	Yes	Yes	Yes	Yes	Yes	Yes
5	Urinals	Yes$	Yes$	Yes$	Yes	Yes	Yes
6	Latrines	Yes$	Yes$	Yes$	Yes	Yes	Yes
7	Platforms- High level- @	Yes	Yes	Yes	Yes	Yes	Yes
8	Lighting #	Yes	Yes	Yes	Yes	Yes	Yes
9	Fans	Yes	Yes	Yes	Yes	Yes	Yes
10	Foot over bridge @	Yes*	Yes*	Yes*	Yes	Yes	Yes
11	Time Table Display	Yes	Yes	Yes	Yes	Yes	Yes
12	Clock	Yes	Yes	Yes	Yes	Yes	Yes

13	Water cooler	Yes	Yes	Yes	Yes	Yes	-
14	Public Address system / Computer based announcement	Yes	Yes	Yes	Yes	Yes	Yes
15	Par king-cum- circulating area, with lights	Yes	Yes	Yes	Yes	Yes	
16	Electronic Train indicator board **	Yes	Yes	Yes	-	-	-
17	Signage(standardized)	Yes	Yes	Yes	Yes	-	-
18	Dustbins***	Yes	Yes	Yes	Yes	Yes	Yes

* With cover

As per Annexure 2 of Railway Board's letter No. 2004 / Elec (G)/109/1 dt 18 .05.2007

** At station entrance/ concourse on foot over bridges (at landing locations) and on platforms located appropriately to guide passengers at every stage. Priority to be accorded as per category of station is subject to station earnings and passenger footfall.

*** Adequate number of uniformly designed standard dustbins should be provided at all categories of stations at NSG1, NSG2, NSG3, NSG4 & NSG5 categories of stations, dustbins should be provided at a regular spacing of 50 m on each platform. At NSG6 category station, an adequate number of dustbins, as required, should be provided. It must be ensured that provision of dustbins does not impede the free flow of passengers.

@ These items are considered as basic requirements, and hence they shall form a part of essential amenities for all categories of stations.

$ Toilets/ Urinals at NSG/1-3 category stations shall have auto-flush after every use.

Table 14.03

Minimum essential amenities at suburban stations

SN	Amenities	STATION CATEGORY		
		SG 1	SG2	SG3
1	Drinking water Piped/Hand Pump	Yes	Yes	Yes
2	Seating arrangement	Yes	Yes	Yes
3	Platform shelter	Yes	Yes	Yes
4	Urinals	Yes	Yes	Yes
5	Latrines	Yes	Yes	Yes
6	Platforms - High level	Yes	Yes	Yes
7	Lighting#	Yes	Yes	Yes
8	Fans	Yes	Yes	Yes
9	Foot over bridge	Yes	Yes	Yes
10	Time Table Display	Yes	Yes	Yes
11	Clock	Yes	Yes	Yes
12	Water cooler	Yes	Yes	-
13	Dustbins***	Yes	Yes	Yes
14	Public address system/ Computer-based announcement	Yes	Yes	Yes
15	Electronic Train indicator board.	Yes	Yes	Yes

#As per Annexure 2 of Railway Board's letter No.2004/Elec (G) /109 /1 dt 18.05.2007

*** Adequate number of uniformly designed standard dustbins should be provided at all categories of stations at SG1, SG2 category of stations, dustbins should be provided at regular spacing of 50 mt on each platform. At SG3 category station, adequate number of dustbins, as required, should be provided. It must be ensured that provision of dustbins does not impede the free flow of passengers.

Table 14.04

Minimum essential amenities at halt stations

SN	Amenities	STATION CATEGORY		
		HG1	HG2	HG3
1	Drinking water Piped 1 / Hand Pump 2	Yes 1	Yes 2	Yes 2
2	Waiting hall	Yes	Yes	-
3	Platform Shelter	Yes*	-	-
	Shady trees	Yes*	Yes	Yes
4	Platforms - High level	Yes	Yes	Yes
5	Lighting#	Yes	Yes ^	Yes ^
6	Foot over bridge$	Yes	Yes	Yes
7	Time Table Display	Yes	-	-
8	Clock	Yes	-	-
9	Dustbins***	Yes	Yes	Yes
10	Fans	Yes	-	-

*Bus type modular shelters

$ In double line section with two PFs provided with high level platforms.

^ At stations where the trains are scheduled to halt after sunset

As per Annexure 2 of Railway Board's letter No .2004/Elect(G)/109/1 dt 18.05.2007

*** Adequate number of uniformly designed standard dustbins should be provided at all categories of stations in the HG1 category of stations, dustbins should be provided at ar regular spacing of 50m on each platform. At HG2 & HG3 category stations, adequate number of dustbins, as required should be provided. It must be ensured that the provision of dustbins does not impede the free flow of passengers.

Table 14.05

Norms of minimum essential amenities at non-suburban stations

SN	Amenity	STATION CATEGORY					
		NSG1	NSG2	NSG3	NSG4	NSG5	NSG6
1	Drinking water /\ (No. of taps/PF) $ /\ /\	20	20	20	20	8	2*
2	Waiting hall @ Sqm	250	250	125	75	30	15
3	Seating arrangement (No. of seats / PF)	150	150	125	100	50	10

4	Platform shelter (on each PF)#	500 sqm	500 sqm	400 sqm	200 sqm	50 sqm+	50 sqm+
5	Urinals##	12	12	10	6	4	1
6	Latrines##	12	12	10	6	4	1
7	Platforms	High Level	High Level	High Level	High Level	High Level	High Level
8	Lighting++ (Lux level)	As per Annexure II of Board's letter No. 2004/ Elec(G)/ 109/ 1dated 18.5.2007					
9	Fans ©	As given below					
10	Foot over bridge®	1 with cover	1 with cover	1 with cover	1	®®	®®*
11	Time table display	As per extant instructions.					
12	Clock	To be decided by zonal railways.					
13	Water cooler £	2 on each PF	2 on each PF	2 on each PF	2 on each PF	1 on main PF	-
14	Public Address system/ Computer based announcement	As per extant instructions					
15	Parking-cum- circulatory area, with lights	As per extant instructions					
16	Electronic Train indicator board.	As per extant instructions					
17	Signage (standardized)	Yes	Yes	Yes	Yes	-	-
18	Dustbins***	Yes	Yes	Yes	Yes	Yes	Yes

Table 14.06

Norms of minimum essential amenities at suburban stations

SN	Amenity	STATION CATEGORY		
		SG1	SG2	SG3
1	Drinking water /\ (No. of taps/PF) $ /\ /\	6	6	6
2	Seating arrangement (No. of seats / PF)	10	10	10
3	Platform shelter (on each PF)#	200 sqm	200 sqm	200 sqm
4	Urinals##	4	4	4
5	Latrines##	2	2	2
6	Platforms	High Level	High Level	High Level
7	Lighting++ (Lux level)	As per Annexure II of Board's letter No. 2004/Elec(G)/109/1 dated 18.5.2007		
8	Fans ©	As given below		

9	Foot over bridge®	3 (20 ft wide)	2 (20 ft wide)	1 (20 ft wide)
10	Time table Display	As per extant instructions.		
11	Clock	To be decided by zonal Railways.		
12	Water cooler £	2 on main PF	2	2
13	Dustbins	1 per 50 sqm area		
14	Public Address System / Computer based Announcement	As per extant instructions		
15	Electronic Train indicator board.	As per extant instructions		

Table 14.07

Norms of minimum essential amenities at halt stations

SN	Amenity	STATION CATEGORY		
		HG1	HG2	HG3
1	Drinking water /\ (No. of taps/PF) $ /\ /\	Appropriate drinking water facility **	Appropriate drinking water facility **	Appropriate drinking water facility**
2	Waiting hall @ Sqm	10 sqm booking office cum Wtg. hall	10 sqm booking office cum Wtg. hall	-
3	Platform shelter (on each PF)#	Bus type modular shelter	Shady trees	Shady trees
4	Platforms ****	High Level	High Level	High Level
5	Lighting++ (Lux level)	As per Annexure II of Board's letter No . 20 0 4 / Elec(G) / 10 9 / 1 dated 18.5.2007		
6	FOB	®®*	®®*	®®*
7	Time table Display	As per extant instructions.		
8	Clock	1	-	-
9	Dustbin***	As per extant instructions.		
10	Fans	1	-	-

Notes for Table 14.5, 14.06 & 14.07:

% At NSG1-5 category of stations, the booking counters to operate round the clock, except at stations where there is no night working.

/\ At stations falling into water scarcity zones or where water source dries up in summer, drinking water facility should be ensured at every platform by means of syntax tanks/CANS/Matkas/Piaos etc. as decided by GM of the Railways. At less important stations, particularly those falling under NSG6 and HG category stations, one water supply source at a location convenient to passengers may be provided. Drinking water facility would include all necessary units whether donated by private parties or provided by the Railways themselves.

$ There should be one drinking water tap suitable for use by disabled persons on alternate water

booths at every platform.

/\ /\ Adequate number of water taps should be suitably located to serve passengers of GS coaches, i.e. at the end of platforms.

*At 'NSG6 category stations, wherever piped water supply is not feasible due to local conditions, separate arrangements for water at each platform shall be made available with the approval of General Manager of the concerned Zonal Railway.

** Drinking water arrangements should be made at halt stations by means of water taps/hand pumps/tube wells/sintex tanks/piaos as decided by the General Manager of the concerned Zonal Railway.

*** Adequate number of uniformly designed standard dustbins should be provided at all categories of stations at NSG/ 1-5, SG/ 1-2 & HG1 category of stations, dustbins should be provided at regular spacing of 50 m on each platform. At NSG6, SG-3 & HG/2-3 category stations, adequate number of dustbins as required should be provided. It must be ensured that provision of dustbins does not impede the free flow of passengers.

@ If the variation is marginally on the lower side (up to -5 sqm), then it can be taken to be adequately provided.

#Shelter should be suitably spaced ensuring natural light and ventilation and covering areas from where passengers aboard the General Coach.

+ Preferably light weight shelters.

1. Number of latrines/urinals includes provision in waiting room/halls. 1/ 3rd of the toilet may be reserved for ladies. In case of 2 toilets existing, one each should be earmarked for ladies & gents.

2. Number of latrines / urinals can be reduced in water scarcity areas by the Railway with the approval of GM.

3. Includes pay and use toilets. The policy for setting up such toilets be referred in terms of Board's letter No. 05/TGIV/ 10/SAN/32/Pay& Use Policy Dt 7.6.06.

® New FOBs should be at least 20 feet wide at NSG 1-3 and SG 1-3 category stations wherever feasible. New FOBs at NSG 1-3 should be compatible for installation of escalators amenable for wheelchair users.

®® Foot over-bridges shall be provided at all stations with more than one platform during doubling/ gauge conversion wherever the same are not available.

®®* A ramped subway shall be considered as the first and the most preferred means of accessibility followed by a second alternative of an FOB with ramp, wherever feasible, at all stations with more than one platform during doubling/gauge conversion wherever the same are not available. First preference shall be given to dog legged ramp (1:12 slope) on FOB. Wherever future augmentation of platforms and number of lines or double decker operations are envisaged, the ramped subway may be explored as first preference.

£ To be provided as per Board's letter No. 69/Elec(g)/730/8 Dt. 30.03.1971.

**** (a) on all New lines, Gauge Conversion & Doubling projects, minimum level of platforms shall be of high level. No low /medium level platform shall henceforth be constructed (in supersession of Board's letter No. 2003/LMB/14/29 Dt. 26.4.2005 and Board's letter No. 2012/LM(PA)/03/07/ Policy dated 06.07.12). (b)Wherever platform height gets reduced on account of track works,

the same should be restored (Board's letter No. 2003/LMB/ 14/29 Dt. 03.02.2005) (c) Platform should be high level of notified minimum height wherever EMU trains are dealt with (clarification to Board's letter No. 2006/LMB/2/ 121 Dt. 11.8.2006).

++Solar energy-based lighting needs to be introduced to provide emergency lighting at NSG 1- 5, SG 1-3 and HG1 category stations, wherever feasible, in non- electric traction areas.

© For covered platforms having width of 6-9mts; one row of fans should be provided @one fan in the center of supporting columns. For covered platforms with more than 9mts width, fans should be provided in 2 rows.

Note: (1) At stations where only one ASM is posted, only one booking window will be provided. In respect of NSG-6 category stations, where the earnings is less than Rs. 50 lakh per annum, the quantum of amenities to be provided could be decided by General Managers based on actual requirements.

(2) Scale of all the amenities prescribed above are the bare minimum to be provided at the appropriate category of stations. Amenities over and above the prescribed minimum scales will continue to be provided as per norms for provision of amenities at "Recommended Level".

1412 RECOMMENDED AMENITIES

(1) The availability of amenities at the station as per the norms of "Minimum Essential Amenities" **(Table – 14.05, 14.06 & 14.07)** may not be commensurate with the actual passenger traffic dealt at the station. Hence, the requirement of actual amenities based on traffic as per the norms given in Comprehensive instruction for provision of Passenger Amenities and user facilities at Stations issued vide letter No. 2018/LM(PA)/03/06 dt. 09.04.2018 **(Ref. 14.08)** should be worked out and any augmentation based on this, will be known as Recommended Amenities.

(2) Powers of GM of the Railway to review -

In case quantum of amenities as worked out on the basis of norms for recommended amenities , as given in Comprehensive instruction for provision of Passenger Amenities and user facilities at Stations issued vide letter No. 2018/LM(PA)/03/06 dt. 09.04.2018 **(Ref. 14.08)** is less than quantum prescribed for minimum essential, the actual quantum of Minimum Essential Amenities, as per **table 14.05, 14.06 & 14.07** to be provided, could be modified, with the approval of GM and Board should be intimated of the same. No further delegation is permitted for such approval.

Provision of recommended level of amenities at stations, which is a parameter of adequacy of the scale of amenities provided as per actual passenger volume, has not received adequate attention. Railways should review the existing facilities vis-a. vis requirements for recommended amenities and a time-bound action plan be made for augmenting shortfalls as a thrust area.

1413 DESIRABLE AMENTITIES

Desirable amenities are those amenities which are considered desirable to improve customer satisfaction and interface process at the station. The quantum of these amenities would depend upon the category of the station. Various desirable level of amenities are given in Comprehensive

instruction for provision of Passenger Amenities and user facilities at Stations issued vide letter No. 2018/LM(PA)/03/06 dt. 09.04.2018 **(Ref. 14.08)**

Pradhan Mantri Bharatiya Janaushadhi Kendras (PMBJKs) at Railway Stations: Indian Railways has conceptualized a policy framework to establish Pradhan Mantri Bharatiya Janaushadhi Kendras (PMBJJKs) in circulating areas and concourses of stations which will be operated by Licensees.

PMBJKs would be deemed "desirable passenger amenity', and accordingly, railways shall provide fabricated outlets in circulating areas and concourses of stations. Under this scheme, 50 stations identified for the pilot project. The details of PMBJK are given in the Railway Board letter no. 2023/NFR/33/JAK E-office no. 3423850 dt. 08.08.2023 **(Ref. 14.27)**.

1414 IMPORTANT ASPECTS

(1) Platform: Island platform should be treated as single platform for provision of Minimum Essential Amenities. Various provisions of IRSOD regarding platform and structures on it are as follows:

(a) Provisions for horizontal distance from centre of track to face of passenger/Goods platform coping (item 3(i) & (ii) of chapter II, IRSOD 2022):

- Maximum: 1680 mm
- Minimum: 1670 mm

(b) Provisions for horizontal distance from centre of track to face of any platform wall (item 3(iii) of chapter II, IRSOD 2022):

- Maximum: 1680 mm
- Minimum: 1675 mm

Note : The coping of passenger platform must be so constructed that when necessary, to allow for introduction of wider stock, it can be easily and expeditiously set back to 1905 mm. from centre of track (see diagram no. 2, chapter II, of IRSOD 2022)

(c) While doing new works and alterations to the existing works, the ends of the platforms should be provided with ramps at a slope not steeper than 1 in 6. In the ramp portion, the horizontal clearance from the end of pltorm towards ramp shall be increased from 1670/1680 mm to 1905 mm. The clearance of 1905 mm shall be achieved at a height of not less than 305mm above rail level.

(d) Height of platform:

Height above rail level for high passenger platforms

- 840 mm maximum
- 760 mm minimum

Maximum Height above rail level for medium level passenger platform

- 455 mm

Maximum height above rail level for goods platforms (except horse and end loading platforms)

- 1065 mm

(e) Provisions for platform width:

i) Minimum horizontal distance of any building/structure on a passenger platform

from centre line of track (item 7(a) of chapter II, IRSOD 2022):

- From platform level to 305mm above platform level - 5180mm increasing uniformly to 5330mm
- From 305mm above platform level to 3430mm above rail level - 5330mm
- From 3430mm above rail level to
  - 4115mm above rail level in case of existing works - 5330mm decreasing uniformly to 3810mm
  - 4610mm above rail level in case of new works or alterations to existing works - 5330mm decreasing uniformly to 3810mm

'Notes' given under these paras in IRSOD shall be read with above provisions.

ii) Minimum horizontal distance of any building or longitudinal boundary fence from the centre line of track of passenger platform which is not an island platform (for new works or alterations to existing works), (item 7(b) of chapter II, IRSOD 2022):

- Minimum 6830mm
- Recommended 12130mm

iii) Minimum horizontal distance from centre line of track to a pillar, column, lamp or similar isolated structure on a passenger platform or any building on a goods platform (item 8 of chapter II, IRSOD 2022):

- From platform level to 305mm above platform level - 4570mm increasing uniformly to 4720mm
- From 305mm above platform level to 3705mm above rail level - 4720mm
- From 3705mm above rail level to
  - 4115mm above rail level in case of existing works - 4720mm decreasing uniformly to 3810mm
  - 4610mm above rail level in case of new works or alterations to existing works - 4720mm decreasing uniformly to 3810mm

iv) Minimum horizontal distance from centre line of track to a pillar, column, lamp or similar isolated structure on goods platforms (item 8(a) of chapter II, IRSOD 2022):

- From platform level to 305mm above platform level – 3960 mm increasing uniformly to 4110 mm
- From 305mm above platform level to
  - 3980mm above rail level in case of existing works - 4110mm
  - 4310mm above rail level in case of new works or alterations to existing works - 4110mm
- From 3980mm above rail level to 4115 mm above rail level in case of existing works – 4110mm decreasing uniformly to 3810mm
- From 43100mm above rail level to 4610 mm above rail level in case of new works - 4110mm decreasing uniformly to 3810mm

Note:

A pillar or column (vide items 8 & 8a of IRSOD 2022, chapter II) which covers more

than 3716 sq.cm in plan, must be classed as "building" and not as "isolated structure"

It shall be noted that the above given are the abstract of provisions of IRSOD related to platforms and structures on it. Various notes are given under each provison in IRSOD, same shall be read with above provisions.

(2) Foot Over Bridges: FOB should be preferably 20 feet wide at NSG 1 to 3 and SG-1 category stations wherever feasible. For other category of stations, Zonal Railways may decide upon the width of FOB based on the feasibility and requirement. Handrails shall be provided as per design.

(3) Toilets: The latest policy guidelines issued for provision of toilet, Pay & Use toilet shall be followed. Toilets/Urinals at NSG/1-3 category stations shall have auto flush after every use.

(a) At Suburban stations:

- Only urinals should be provided at the end of the suburban island platforms as the major requirement of suburban passengers is a urinal. Wash basins should invariably be provided near the urinals.
- The power to dispense with provision of toilets/urinals at the platforms is delegated to the General Managers.
- Toilets should be provided only in concourse/ circulating areas of suburban stations. 'Pay & Use' toilets should be provided in the concourse/ circulating area of all stations. However, at stations where the provision of 'Pay & Use' toilets is not feasible, departmentally operated toilets can be provided with the approval of Divisional Railway Manager.

(b) At Non-suburban stations:

- The power of provision of urinals instead of full toilets at the platforms of NSG/ 1-4 category stations is delegated to the General Managers.
- Only urinals should be provided on island platforms at other than NSG / 1-4 category stations. Wash basins should invariably be provided near the urinals

(4) Signage: All the signage at the station should be standardized in terms of Railway Board's Signage policy for Railway Stations issued vide letter No. 2023/S-II/22/07/02 dt. 15.05.2023 **(Ref. 14.10)**. For location of signage, a plan should be made for each station.

(5) Stalls & Trolleys : The number of trolleys and catering stalls under the platform shelter should be reduced to a minimum and Automatic vending machines should be encouraged to replace existing vending stalls. The norms circulated by Tourism and Catering Directorate in this regard should be adhered to

(6) Circulating Area: In the circulating area, proper traffic movement flow plan should be made. Proper landscaping in the circulating area should also be developed. Wherever circulation areas are redesigned, altered, or whenever stations are congested, possibility of providing FOB landings directly into circulating area should be examined as it decongests main platforms. There should be proper segregation of incoming and outgoing passengers, wherever considered necessary.

(7) Entry & Exit: Proper planning is essential to facilitate easy movement of passengers at stations. In order to decongest the entrance, separate entry/exit gates to be provided at stations, wherever feasible. All unauthorized entry points into the stations irrespective of their class should be closed excepting the specified exit and entry. Second entry with ticketing facility (booking window/ATVM) shall be a desirable amenity at SG1 and SG2 and NSG/1-4 category stations.

(8) Illumination & Energy saving: The illumination at the stations should be improved. The enquiry and Booking Offices should be specially brightened up at all the stations. LED based station name boards on the station building shall be provided at all category stations as per RDSO specifications.

Reflective Station Name Boards (of circular design as provided in suburban stations) shall be provided along the length of the platform with an inter distance of 25 meter at all Stations except Halt stations so that the station name is visible at night to the passengers travelling by trains.

For ensuring energy conservation:

- Platform lighting circuit shall be segregated such that during "No train" period about 30% lights are 'ON' and before train arrival all the lights are switched 'ON'. In this regard, necessary changes in electrical circuits at stations may be planned in a phased manner.
- All the electrical fittings and power supply equipment with at least BEE's (Bureau of Energy Efficiency) 3-star rating shall be used.
- All important stations of historical and archeological value may be suitably illuminated.

(9) Mobile & Laptop Chargers: 5 pin, 5 amp, 230v (Railway approved) sockets for mobile and laptop charging shall be provided in adequate numbers at refreshment rooms and Waiting Rooms.

(10) Air Cooling System: At NSG/ 1-4 category stations where natural ventilation is not adequate, air cooling system should be installed subject to feasibility.

(11) Floorings: Flooring standards for platform, concourse and FOB/waiting room, etc., shall be as per **Annexure -14A** which is placed at the end of this chapter.

(12) Booking counters: Booking counters shall be provided based on the requirement under desirable amenity at SG/ 1-2 and NSG / 1-4 category stations.

(13) Dustbins: Adequate number of uniformly designed standard dustbins should be provided at all categories of stations. At NSG / 1-5, SG/ 1-2 & HG1 category of stations, dustbins should be provided at regular spacing of 50 m on each platform. At NSG6, SG-3 & HG/2-3 category stations, adequate number of dustbins as required should be provided. It must be ensured that provision of dustbins does not impede the free flow of passengers.

1415 FACILITIES FOR PERSONS WITH DISABILITIES (DIVYANGJAN)

As per "Rights of Persons with Disabilities (RPwD) Act, 2016, central Govt. department (Railway) shall make facilities accessible to persons with disability. In this reference, Ministry of Railway in consultation with the Chief Commissioner of Persons with Disabilities (CCPD), has approved the revised "guidelines on accessibility of Indian Railway stations and facilities at stations for differently abled persons (Divyangjans) and passengers with reduced mobility". This guideline

has been issued by Railway Board vide letter no. 2019/Stn. Dev.-I/03/06/Policy/PwDs dated 25.11.2022 **(Ref. 14.11)**.

The items concerning Engineering Department and relevant provisions for Railway are as under:

(1) Station Accessibility:

(a) Accessible Route

i) Entry and Exit of the Railway Station should be accessible.

ii) Railway stations should be planned and designed keeping in view accessibility to Divyangjans and senior citizens.

(b) Entrance Ramps

i) Entrances to the station building should have a ramp for Divyangjans

ii) Double height handrails with rounded grips may be provided on ramps at entrance of the station

iii) Braille signages to be provided at ramps for NSG1 category stations

iv) The Ramps should have Tactile guiding blocks (Line/dot-type) which indicates a correct path/route to follow for a person with visual impairment.

(c) Parking

i) A minimum of two car parking for Divyangjans lots shall be earmarked as accessible car parks with direct access route to station building on NSG -1 to 4 stations as per feasibility.

ii) For other category stations, parking lots for vehicles to be provided as per availability of space, feasibility and requirement.

iii) Parking lot should be as close to the Help-Booth/entry of station as possible. It should ideally be a step free or with ramped access

iv) Floor and vertical signage with blue and white pictogram of accessibility shall be provided for the parking

(d) Ticket Counter

i) Provision of low height ticket and enquiry counters duly marked as being Divyang friendly with accessibility signage should be available at NSG-1 to 3 category stations and SG-1 category stations. For other category stations, Zonal Railway may decide provision of a low height ticket counter based on the feasibility and requirement

ii) Priority shall be given to Divyangjans in queues at the ticket booking office. The queue segregating handrails may be provided.

(e) Help Booths

i) Facilities of wheelchairs, other assistive devices like crutches, etc. shall also be extended from the help booth. The location should be prominent and clearly marked through informational signage and directional signages at main entry of Railway Station itself to keep PwDs locate it with ease.

ii) Accessible Help Booth(s) manned by ''Divyangjan Sahayaks'' shall be provided at all NSG-1 to 3 and SG-1 category stations. An identified office shall be allocated as Help Booth at NSG-4 & NSG-5 and SG-2 category stations.

iii) Location of Help Booth shall be near the entry/exit of the railway station and

prominently identifiable by signage for ease in assistance to persons with disabilities and others. If there are separate accessible ticket counters for Divyangjan, those can serve as a Help Booth as per standards.

iv) Where separate Help Booth cannot be provided due to any constraints, Signage to be provided or Enquiry Booth may be redesignated with a separate accessible counter for Divyangjan to function as Help Booth keeping the practical feasibility of workload of the nominated official.

v) To the extent possible, manning of the help-booths to be done by any NGO working in the field of disability, free of cost. The said manpower be given basic trainings on railway systems like ticketing rules, Divyangjan facilities etc. by Railways and who in turn will guide and provide assistance to Divyangjans. If no NGO is forthcoming for providing free manpower to be deployed in the Help Booths, then possibility to be explored for outsourcing of manpower for manning of Help Booths. The provision of assistance at Help Booths in such cases to be chargeable basis.

(2) PLATFORM ACCESSIBILITY

(a) Platform Zoning & Design

i) Platform design is critical to accessibility and safety of all passengers. It is therefore recommended to create and develop an unobstructed zone as part of every platform.

ii) All the new platforms being raised to High level or during resurfacing of platform, the guiding tactile path will be ensured. The platform edges may be painted with colour strip in high contrast to the floor colour so as to ensure safety for persons with low vision and others while boarding the train or otherwise. Colouring should be such to avoid illusion to driver and also shall not result in false signal sighting.

iii) Platforms should be well illuminated with at least 100 lux levels in case of covered area and at least 30 lux in case of open area for better visibility, high contrast and legibility. (NSG1-4 & SG1 -2 category stations).

iv) All structural elements like columns or coach position indicator poles, etc. shall be painted in contrasting colour scheme from the bottom to 900 mm above to allow adequate visual contrast for persons with low vision/colour blindness.

v) Platform numbers and other signage for platform amenities shall be designed and placed/hung prominently in a uniform manner.

vi) Protruding objects, if any on the platform shall ensure a minimum head clearance of 2000 mm from finished floor level which will ensure an uninterrupted path especially with people with low vision/Blindness.

(b) Toilet

i) At least one toilets may have universal accessibility features and the facility may be used by all types of passengers

ii) Signage at accessible toilet entrance should be clearly visible and should comply with the International Symbol of Accessibility.

iii) Wherever, space is constrained, a unisex toilet cubicle with accessibility features to be provided

(c) Drinking Water Booth

i) Drinking water points accessible for Persons with Disabilities (PwDs) should be provided on each platforms of NSG- I to 4 and SG-I to 2 stations. For other category of stations, Zonal Railways may decide upon the provision of drinking water tap based on the feasibility and requirement.

ii) Any operable part of electrical/electronic controls such as vending machines, electrical switches, wall socket, intercom buttons etc. should be designed and operable.

iii) Faucets and other controls designated for use by Persons with Disabilities may be provided.

iv) Clearly visible signage shall be provided

v) Design & Specification of height, width, Clear floor and knee space etc. may be provided.

(d) Foot Over Bridge

i) FOBs with both stairs and Ramp facility should be provided to make them accessible for senior citizens and persons with physical disabilities (PwDs) as well as ease of self-carrying trolley bag

ii) FOB should be preferably 20 feet wide at NSG 1 to 3 and SG-1 category stations wherever feasible. For other category of stations, Zonal Railways may decide upon the width of FOB based on the feasibility and requirement. Handrails shall be provided as per design.

iii) Tactile guiding and warning blocks may be provided which shall lead to the edge of staircases, lifts or escalators. (NSG 1 to 2 category stations).

iv) Stations where there is more than one platform without any FOB/ Subway connecting them, a pathway for passengers may be provided connecting the ends of the platforms. The pathway should have a minimum width of 2 meter and notices / signages should be prominently displayed near such crossings. (As per para 417 of IRWM).

v) Foot over bridges shall clearly indicate through signage the direction towards the various platforms and also towards the exit side of the station with proper pictograms and adequate colour contrast.

(e) Subway

i) The height of subway should be at least 2.75m and minimum width of subway to be 4m (desirable 7.5m).

ii) Provision of adequate lighting and drainage system and also ensures security and safety for Subway. Power supply to subway should be made available from the feeder cable of traction line (OHE) or other means of uninterrupted power source of electric supply.

iii) Tactile path (guiding and warning) from the platform may seamlessly lead to Subways (NSG1 to 2 & SG1 category stations).

(f) Lifts

i) Access through Lift shall be provided at platforms where FOB ramp is not available

/ feasible.

ii) The minimum size of the lift shall be 1500 mm x 1500mm which allows easy maneuverability of Wheel Chair users with a clear door opening of minimum 900mm to be provided. The gap between the lift door and building floor shall not be more than 12 mm

iii) The call button located outside of the lift may have a clear floor space of minimum 900 mm x 1200 mm with no obstruction so as to enable a Wheel Chair user to easily reach the call button and it shall be installed at a height between 800 mm and 1000 mm. It shall have buttons with Braille / raised letters.

iv) The control panel inside the lift shall be placed at a height between 800mm to 1000mm, for Wheel Chair users. It shall have buttons with Braille / raised letters. Grab bars shall be placed at a height of 900mm from the floor level and be fixed on both sides and rear of the lift. An emergency switch (in Red colour) be placed for emergency support services for all lift users including persons with disabilities.

v) The lift should also have a voice announcement system. At least 50 decibels shall be maintained for the same.

vi) The provision of a mirror on the wall of the lift car opposite the lift door is a positive aid to navigation for Wheel Chair users. It allows the Wheel Chair user to see if anyone is behind them and also to see the floor indicator panel. The mirror shall not extend below 900 mm from the lift floor to avoid confusing people with visual impairments.

(g) Lighting

i) Lighting is an integral part of station architecture and as such should respond to the given architectural conditions and be coordinated with other elements of the stations.

ii) In addition to providing illumination and a sense of security, the lighting system in railway stations should be durable, energy efficient and easily maintained.

ii) The lighting in office rooms, passages, stairs, open areas etc. shall be provided as per established norms and appropriately positioned.

1416 TACTILE PAVERS: GUIDING & WARNING BLOCKS

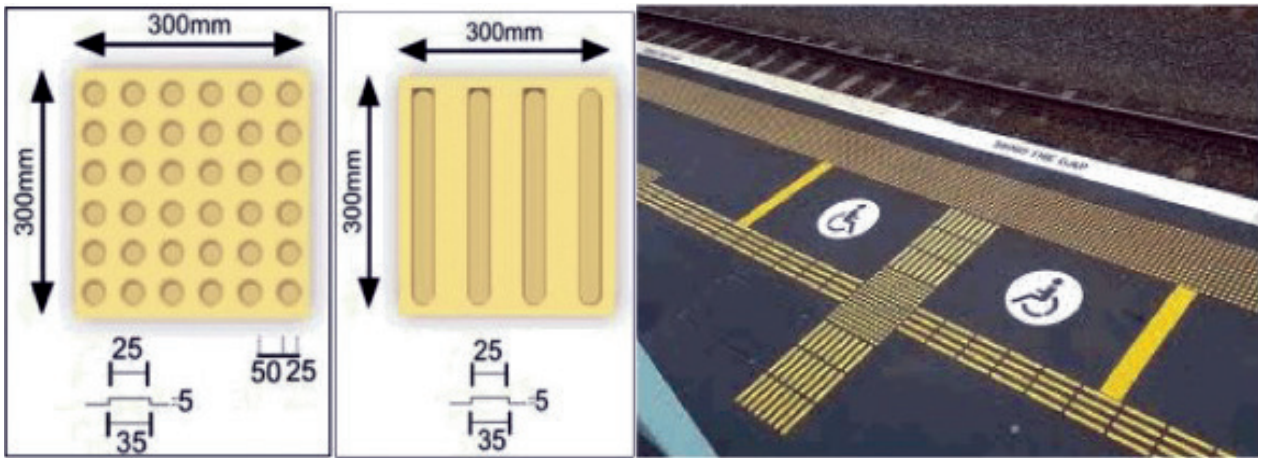
(1) Tactile guiding blocks (Line-type) indicate a correct path/route to follow for a person with visual impairment. One/two rows of tactile guidance tiles along the entire length of the proposed accessible route shall be provided. Care must be taken to ensure that there are no obstacles, such as trees, poles or uneven surfaces, along the route traversed by the guidance blocks. Also, there should be clear headroom of at least 2.1m height above the tactile guidance blocks, free of protruding objects such as overhanging tree branches and signage, along the entire length of the walk.

(2) Tactile warning blocks (Dot-type) indicate an approaching potential hazard or a change in direction of the walkway, and serve as a warning of the approaching danger to persons with visual impairments, preparing them to tread cautiously and expect obstacles along the travel path, traffic intersections, doorways, etc. They are used to screen off obstacles, drop-offs or

other hazards, to discourage movement in an incorrect direction, and to warn of a corner or junction.

(3) Two rows of tactile warning tiles should be installed across the entire width of the designated accessible pathway, before intersections, building entrances, obstacles such as trees, and each time the walkway changes direction. Warning blocks should also be placed 300mm at the beginning and end of the ramps & stairs, at landings and entrance to any door to be used by Divyang Jan.

(4) Warning and Guiding block for reference are shown as under



Warning Blocks **Guiding Blocks**

1417 FUNCTIONAL REQUIREMENTS AND TECHINICAL SPECIFICATIONS FOR MATERIALS, WORKMANSHIP AND FINISHES ETC.

(1) General safety requirements : Safety requirement of Railway systems shall include the following from travelling public requirements:

a) Stations should provide for free and safe movement of people;

b) Platforms should allow for the safe occupancy by people and boarding or alighting trains;

c) Trains should have a safe means of access, egress and of people;

(2) Standards and Codes of Practice

a) The design of the Systems/ facilities/infrastructure and Maintenance shall, in general, comply with the laid down standard and specifications.

b) Standards indicated in the Specifications are provided solely for the guidance. Other National or International Standards may be followed.

c) In general standard laid down in IR code & manuals, by RDSO/ National Building code, IS code etc. shall be followed.

(3) Materials and Workmanship

a) Materials and components to be used in the execution of the Works shall be new, free from imperfection and proven to be reliable in service and that all materials and components incorporated in the Works are new and suitable for their intended purpose, environment and function.

b) All material used shall be of current production and well-proven application for the design and intended use.

c) Workmanship and general finishes shall be of best quality and in accordance with best practice.

d) There is a need to specify basic requirements and criteria for the finish of public areas within the System. While convenience, comfort, and attractiveness will be considered in the selection and application of the finishes, it shall be assured that the goals of safety, durability, and economy are achieved.

(4) Basic Goals

(a) Safety

Fire Resistance and Smoke Generation: Reduce hazard from fire by using materials with minimum burning rates, smoke generation, and toxicity characteristics for station finishes, consistent with requirements of Fire/Life Safety requirements.

Slip-resistant walking surfaces: Increase pedestrian safety, in compliance with accessibility requirements by using floor materials with slip-resistant qualities. Entrances, stairways, platform edge strips, and areas around equipment should have high slip-resistant properties.

The following static coefficients of friction shall be provided as a minimum:

Coefficient of Friction

- Public horizontal surfaces : 0.6
- Non-public horizontal surfaces, exterior: 0.6
- Non-public horizontal surfaces, interior: 0.5
- Platform edge strips Textured Visually-contrasting material: 0.8
- Stairs, ramps, sloping sidewalks area around equipment: 0.6

(b) Durability: Provide for long and economical service by using materials with wear, strength, and weathering qualities consistent with their initial and replacement costs, and their location in the station. The materials must maintain their good appearance throughout their useful life.

(c) Ease of Maintenance

i Cleaning – easily cleanable with reduced costs

ii Repair or Replacement

Reduce maintenance costs by using materials which, if damaged, are easily repaired or replaced without undue interference with the operation of the System.

(d) Resistance to Vandalism: Provide materials and details that do not encourage vandalism, that are difficult to deface, damage or remove. All surfaces exposed to the public are to be finished in such a manner that the results of casual vandalism can be readily removed with normal maintenance techniques.

(e) Aesthetic Qualities: Create feelings of warmth, attractiveness, quality, and to instill civic pride in the facility.

(5) General Criteria: Certain general criteria for finish materials are indicated to achieve the goals outlined above as well as those, which would result in a high level of illumination, good

cleanliness levels, and the appearance of high cleanliness.

(i) Cost: Materials shall be selected for long life, low maintenance, replacement considerations and overall aesthetic and functional qualities.

(ii) Availability: Materials should be selected which are readily available. Domestic products shall be selected unless the product is not available within the country.

(iii) Non-proprietary Materials: Proprietary items should only be used where it is established that no other materials would meet the particular design requirements.

(iv) Installation Standards: Materials shall be detailed and specified to be installed in accordance with industry standards and manufacturer's advice.

Important Note:

For major station upgradation or works under Amrit Bharat Station Scheme if any superior provision regarding various passenger amenities are available then same shall be adopted.

1418 AMRIT BHARAT STATION SCHEME

Ministry of Railways has recently launched a Scheme of 'Amrit Bharat Station' for development of Stations on Indian Railways. This scheme envisages development of stations on a continuous basis with a long term approach.

The scheme involves preparation of Master Plans and their implementation in phases to improve the amenities at the stations like improvement of station access, circulating areas, waiting halls, toilets, lift/escalators as necessary, cleanliness, free WiFi, kiosks for local products through schemes like 'One Station One Product", better passenger information systems, executive lounges, nominated spaces for business meetings, landscaping etc. keeping in view the necessity at each such station.

The scheme also envisages improvement of building, integrating the station with both sides of the city, multimodal integration, amenities for Divyangjans, sustainable and environment friendly solutions, provision of ballast less tracks, 'Roof Plazas' as per necessity phasing and feasibility and creation of city centers at the station in the long term.

Station building construction works being taken up under New Line/Doubling/Gauge Conversion/ Traffic Facility projects should be compliant to the Amrit Bharat Station Scheme.

Details of various items of the scheme may be referred to in reference document list attached **(Ref. 14.12 to Ref. 14.26)**.

Details of Flooring / Walling / Ceiling for Various Areas in Station Premises

S. No	Place	Type of flooring & Basis of station category						
		NSG 1 & NSG 2	NSG 3	NSG 4	SG 1,SG 2 & SG 3	NSG 5	NSG 6	HG 1, HG 2 & HG 3
1.	Platform (Covered Area)	1. ¶Polished Granite flooring. 2. Polished Kota stone or similar stone flooring with or without stone inlays 3. *Fiber reinforced vacuum dewatered concrete flooring.	1. ¶Polished Granite flooring. 2. Polished Kota stone or similar stone flooring with or without stone inlays 3. *Fiber reinforced vacuum dewatered concrete flooring.	1. ¶Polished Granite flooring. 2. Polished Kota stone or similar stone flooring with or without stone inlays 3. *Fiber reinforced vacuum dewatered concrete flooring.	1. ¶Polished Granite flooring. 2. *Fiber reinforced vacuum dewatered concrete flooring. 3. Polished Kota stone or similar stone flooring with or without stone inlays. 4. **Mastic flooring	1. *Fiber reinforced vacuum dewatered concrete flooring 2. ¶Polished Kota stone or similar stone flooring with or without stone inlays 3. **Mastic flooring. 4. Factory made Interlocking pre-cast Cement Concrete hydraulically pressed Paver Blocks using plastic moulds.	1. Rough Dressed Stones Slab flooring. 2. Brick on edge. 3. Factory made Interlocking pre-cast Cement Concrete hydraulically pressed Paver Blocks using plastic moulds	1. Factory made Interlocking pre-cast Cement Concrete Paver hydraulically pressed. 2. Paver Blocks using plastic moulds 3. Moorum surface flooring 4. Quarry dust flooring.
		Dado up to 1500mm height or up to sill level of window whichever is lower with polished granite of matching colour with flooring.						

S. No	Place	Type of flooring & Basis of station category						
		NSG 1 & NSG 2	NSG 3	NSG 4	SG 1,SG 2 & SG 3	NSG 5	NSG 6	HG 1, HG 2 & HG 3
2.	Platform (Uncovered Area)	1. Polished Kota stone or similar stone flooring with or without stone inlays 2. *Fiber reinforced vacuum dewatered concrete flooring.	1. Polished Kota stone or similar stone flooring with or without stone inlays 2. *Fiber reinforced vacuum dewatered concrete flooring.	1. Polished Kota stone or similar stone flooring with or without stone inlays 2. *Fiber reinforced vacuum dewatered concrete flooring.	1. Polished Kota stone or similar stone flooring with or without stone inlays 2. *Fiber reinforced vacuum dewatered concrete flooring.	1. *Fiber reinforced vacuum dewatered concrete flooring 2. Factory made Interlocking pre-cast Cement Concrete hydraulically pressed Paver Blocks using plastic moulds 3. Bituminous flooring.	1. Factory made Interlocking pre-cast Cement Concrete hydraulically pressed Paver Blocks using plastic moulds 2. Rough Dressed Stones Slab. 3. Brick on edge. 4. Moorum surface flooring	1. Factory made Interlocking pre-cast Cement Concrete hydraulically pressed Paver Blocks using plastic moulds 2. Brick on Edge. 3. Moorum surface flooring.

S. No	Place	Type of flooring & Basis of station category						
		NSG 1 & NSG 2	NSG 3	NSG 4	SG 1,SG 2 & SG 3	NSG 5	NSG 6	HG 1, HG 2 & HG 3
3.	# No Trolley Zone on Edges of the Platforms	1. Precast concrete studded tiles manufactured by vibro compaction process and using jointless FRP Moulds 2. Heavy duty (high strength, high abrasion resistance) precast chequered tile 3. Factory made Interlocking pre-cast Cement Concrete hydraulically pressed Paver Blocks using plastic moulds 4. Flamed Granite	1. Precast concrete studded tiles manufactured by vibro compaction process and using jointless FRP Moulds. 2. Heavy duty (high strength, high abrasion resistance) precast chequered tiles. 3. Factory made Interlocking pre-cast Cement Concrete hydraulically pressed Paver Blocks using plastic moulds 4. Flamed Granite	1. Precast concrete studded tiles manufactured by vibro compaction process and using jointless FRP Moulds 2. Heavy duty (high strength, high abrasion resistance) precast chequered tiles. 3. Factory made Interlocking pre-cast Cement Concrete hydraulically pressed Paver Blocks using plastic moulds. 4. Flamed Granite	1. Precast concrete studded tiles manufactured by vibro compaction process and using jointless FRP Moulds 2. Heavy duty (high strength, high abrasion resistance) precast chequered tiles. 3. Factory made Interlocking pre-cast Cement Concrete hydraulically pressed Paver Blocks using plastic 4. Flamed Granite	1. Precast concrete studded tiles manufactured by vibro compaction process and using jointless FRP Moulds 2. Heavy duty (high strength, high abrasion resistance) precast chequered tiles. 3. Factory made Interlocking pre-cast Cement Concrete hydraulically pressed Paver Blocks using plastic moulds 4. Flamed Granite	1. # CC 2. Coping Slabs 3. Chequered CC Tiles 4. Factory made Interlocking pre-cast Cement Concrete hydraulically pressed Paver Blocks using plastic moulds	1. #CC Coping Slabs 2. Chequered CC Tiles 3. Factory made Interlocking pre-cast Cement Concrete hydraulically pressed Paver Blocks using plastic moulds

S. No	Place	Type of flooring & Basis of station category						
		NSG 1 & NSG 2	NSG 3	NSG 4	SG 1,SG 2 & SG 3	NSG 5	NSG 6	HG 1, HG 2 & HG 3
4.	Concourse/ booking Area	1. Polished Granite Flooring 2. Polished Kota stone or similar stone flooring with or without stone inlays	1. Polished Granite Flooring 2. Polished Kota stone or similar stone flooring with or without stone inlays	1. Polished Kota stone or similar stone flooring with or without stone inlays.	1. Polished Granite Flooring 2. Polished Kota stone or similar stone flooring with or without stone inlays	1. Polished Kota stone or similar stone flooring with or without stone inlays	1. Cement Concrete flooring	-
		Dado up to 1500 mm height or up to window sill level whichever is lower with polished granite of matching colour with flooring.						
5.	Portico	1. Factory made Interlocking pre-cast Cement Concrete hydraulically pressed Paver Blocks using plastic moulds 2. *Fiber Reinforced Vacuum Dewatered Concrete Flooring	1. Factory made Interlocking pre-cast Cement Concrete hydraulically pressed Paver Blocks using plastic moulds 2. *Fiber Reinforced Vacuum Dewatered Concrete Flooring	1. Factory made Interlocking pre-cast Cement Concrete hydraulically pressed Paver Blocks using plastic moulds 2. *Fiber Reinforced Vacuum Dewatered Concrete Flooring. 3. Mastic	1. Factory made Interlocking pre-cast Cement Concrete hydraulically pressed Paver Blocks using plastic moulds 2. *Fiber Reinforced Vacuum Dewatered Concrete Flooring	1. Factory made Interlocking pre-cast Cement Concrete hydraulically pressed Paver Blocks using plastic moulds 2. Bituminous flooring 3. *Vacuum Dewatered Concrete flooring	-	-

S. No	Place	Type of flooring & Basis of station category						
		NSG 1 & NSG 2	NSG 3	NSG 4	SG 1,SG 2 & SG 3	NSG 5	NSG 6	HG 1, HG 2 & HG 3
6.	Circulating Area	1. *Fibre Reinforced Vacuum Dewatered concrete flooring 2. Mastic flooring.	1. *Fibre Reinforced Vacuum Dewatered Concrete Flooring. 2. Mastic flooring.	1. *Fibre Reinforced Vacuum Dewatered Concrete Flooring. 2. Mastic flooring.	1. *Fibre Reinforced Vacuum Dewatered Concrete Flooring. 2. Mastic flooring.	1. *Vacuum Dewatered Concrete Flooring. 2. Bituminous flooring	1. Bituminous flooring 2. Levelled surface with good quality soil/moorum	1. Levelled surface with good quality soil/ moorum
7.	Parking Area	1. *Fibre Reinforced Vacuum Dewatered Concrete flooring. 2. Factory made Interlocking pre-cast Cement Concrete hydraulically pressed Paver Blocks using plastic moulds 3. Mastic	1. *Fibre Reinforced Vacuum Dewatered Concrete flooring 2. Factory made Interlocking pre-cast Cement Concrete hydraulically pressed Paver Blocks using plastic moulds 3. Mastic flooring.	1. *Fibre Reinforced Vacuum Dewatered Concrete flooring 2. Factory made Interlocking pre-cast Cement Concrete hydraulically pressed Paver Blocks using plastic moulds 3. Mastic flooring.	1. *Fibre Reinforced Vacuum Dewatered Concrete flooring 2. Factory made Interlocking pre-cast Cement Concrete hydraulically pressed Paver Blocks using plastic moulds	1. *Vacuum Dewatered Concrete flooring 2. Bituminous flooring.	1. Bituminous flooring. 2. Levelled surface with good quality soil/moorum	1. Levelled surface with good quality soil/ moorum

S. No	Place	Type of flooring & Basis of station category						
		NSG 1 & NSG 2	NSG 3	NSG 4	SG 1,SG 2 & SG 3	NSG 5	NSG 6	HG 1, HG 2 & HG 3
8.	Stairs	1. Flamed Granite Flooring 2. Heavy duty (high strength and high abrasion resistance) Chequered Tiles	1. Flamed Granite Flooring. 2. Heavy duty (high strength and high abrasion resistance) Chequered Tiles	1. Flamed Granite Flooring 2. Heavy duty (high strength and high abrasion resistance) Chequered Tiles	1. Flamed Granite Flooring. 2. Heavy duty (high strength and high abrasion resistance) Chequered Tiles	1. Heavy duty (high strength and high abrasion resistance) Chequered Tiles	1. Heavy duty (high strength and high abrasion resistance) Chequered Tiles	-
9	FOB - Pathway	1. Flamed Granite Flooring. 2. Heavy duty (high strength and high abrasion resistance) Chequered Tiles.	1. Flamed Granite Flooring 2. Heavy duty (high strength and high abrasion resistance) Chequered Tiles.	1. Flamed Granite Flooring 2. Heavy duty (high strength and high abrasion resistance) Chequered Tiles.	1. Flamed Granite Flooring 2. Heavy duty (high strength and high abrasion resistance) Chequered Tiles.	1. RCC slabs 2. Heavy duty (high strength and high abrasion resistance) Chequered Tiles.	RCC slabs	

S. No	Place	Type of flooring & Basis of station category						
		NSG 1 & NSG 2	NSG 3	NSG 4	SG 1,SG 2 & SG 3	NSG 5	NSG 6	HG 1, HG 2 & HG 3
10.	Waiting Hall	1. Polished Vitrified Tiles as per IS : 15622 2. Granite tiles flooring.	1. Polished Vitrified Tiles as per IS : 15622 2. Granite Tiles flooring. 3. Ceramic tiles as per IS:15622.	1. Polished vitrified tiles as per IS:15622. 2. Ceramic Tiles as per IS: 15622. 3. Polished Kota stone or similar stone flooring with or without stone inlays	1. Polished Vitrified Tiles as per IS : 15622 2. Ceramic Tiles as per IS:15622. 3. Polished Kota stone or similar stone flooring with or without stone inlays	1. Terrazzo Tiles in white cement 2. Ceramic Tiles as per IS:15622. 3. Polished Kota stone or similar stone flooring with or without stone inlays	1. CC Floor 2. Rough Dressed Stones Slab. 3. Polished Kota stone or similar stone flooring with or without stone inlays	1. CC Floor 2. Rough Dressed Stone Slab 3. Polished Kota stone or similar stone flooring with or without stone inlays
11	Refreshment Room	1. Polished Vitrified Tiles as per IS : 15622 2. Granite tiles flooring.	1. Polished Vitrified Tiles as per IS : 15622 2. Granite tiles flooring.	1. Polished Vitrified Tiles as per IS : 15622 2. Granite tiles flooring.	1. Polished Vitrified Tiles as per IS : 15622 2. Granite tiles flooring.	1. Ceramic floor tiles as per IS:15622 2. Polished Kota stone or similar stone flooring with or without stone inlays	-	-
12.	SS Office	1. Polished Vitrified Tiles as per IS : 15622	1. Polished Vitrified Tiles as per IS : 15622	1. Polished Vitrified Tiles as per IS : 15622	1. Polished Vitrified Tiles as per IS : 15622	1. Ceramic Tiles as per IS:15622. 2. Polished Kota stone or similar stone flooring with or without stone inlays.	1. CC Floor	-

Annexure 14A

S. No	Place	Type of flooring & Basis of station category						
		NSG 1 & NSG 2	NSG 3	NSG 4	SG 1,SG 2 & SG 3	NSG 5	NSG 6	HG 1, HG 2 & HG 3
13.	Waiting Room and Retiring Room	1. Polished Vitrified Tiles as per IS : 15622	1. Polished Vitrified Tiles as per IS : 15622	1. Polished Vitrified tile flooring 2. Ceramic floor Tiles as per IS:15622.	-	1. Terrazzo tiles flooring 2. Ceramic floor tiles as per IS:15622	-	-
14.	Cloak room	1. CC floor with hardened topping on concrete surface	1. CC floor with hardened topping on concrete surface	1. CC floor with hardened topping on concrete surface	1. CC floor with hardened topping on concrete surface	-	-	-
		Fiber reinforced vacuum dewatered concrete shall be provided wherever feasible.						
15.	Parcel Area	1. *Fiber reinforced vacuum dewatered concrete flooring 2. CC floor with hardened topping on concrete surface 3. Mastic flooring	1. *Fiber reinforced vacuum dewatered concrete flooring 2. CC floor with hardened topping on concrete surface 3. Mastic flooring	1. Fiber reinforced vacuum dewatered concrete flooring 3. CC floor with hardened topping on concrete surface 4. Mastic flooring	1. *Fiber reinforced vacuum dewatered concrete flooring 2. CC floor with hardened topping on concrete surface 3. Mastic flooring	1. *Fiber reinforced concrete flooring 2. CC floor with hardened topping on concrete surface 3. Mastic flooring	-	-

S. No	Place	Type of flooring & Basis of station category						
		NSG 1 & NSG 2	NSG 3	NSG 4	SG 1,SG 2 & SG 3	NSG 5	NSG 6	HG 1, HG 2 & HG 3
16.	Toilet	1. Anti-skid ceramic tiles in floor (Group B-II of IS-15622 and ceramic tiles on walls (Group B-III of IS-15622)	1. Anti-skid ceramic tiles in floor (Group B-II of IS-15622 and ceramic tiles on walls (Group B-III of IS- 15622)	1. Anti-skid ceramic tiles in floor (Group B-II of IS-15622 and ceramic tiles on walls (Group B-III of IS-15622)	1. Anti-skid ceramic tiles in floor (Group B-II of IS-15622 and ceramic tiles on walls (Group B-III of IS-15622	1. Anti-skid ceramic tiles in floor (Group B-II of IS-15622 and ceramic tiles on walls (Group B-III of IS-15622)	1. Anti-skid ceramic tiles in floor (Group B-II of IS-15622 and ceramic tiles on walls (Group B-III of IS-15622)	1. Anti-skid ceramic tiles in floor (Group B-II of IS-15622 and ceramic tiles on walls (Group B-III of IS-15622)
		Ceramic wall tiles up to 2100mm height of matching colour with flooring.						
17.	Wall & Ceiling Finish	Smooth finish with POP/ putty and painting with Emulsion in Concourse, Waiting hall, waiting rooms, Refreshment room, Retiring rooms & SS room. Oil bound distemper at other locations.	Smooth finish with POP/ putty and painting with Emulsion in Concourse, Waiting hall, waiting rooms, Refreshment room, Retiring rooms & SS room. Oil bound distemper at other locations.	Smooth finish with POP/ putty and painting with Emulsion in Concourse, Waiting hall, waiting rooms, Refreshment room, Retiring rooms & SS room. Oil bound distemper at other locations.	Smooth finish with POP/ putty and painting with Emulsion in Concourse, Waiting hall, waiting rooms, Refreshment room, Retiring rooms & SS room. Oil bound distemper at other locations.	Painting with oil bound distemper in Concourse, waiting hall, Refreshment room, Retiring rooms & SS room and other locations.	Painting with oil bound distemper in Concourse, Waiting hall & SS room.	Oil bound distemper in Waiting hall.

Notes for Annexure -14A content:

¶ Only on main platform.

* To be provided for all new work. For existing work, it can be provided wherever traffic diversion /protection of surface during setting period is possible.

** Mastic flooring is not to be used for home platform.

The top surface of coping stone should be indented by XPM or some other method.

Reference Documents

SN	Clause	Ref. document details	
1	1403(2)	14.01	Development of railway Land by Zonal Railways/RLDA/IRSDC under section11 of the Railway Act 1989 – Including Railways/RLDA/IRSDC as deemed special planning Authority for development on railway land in local By-laws/Development Control Norms under Railway Act 1989 issued vide letter no. 2019/LML-II/2/11(133) dt. 30.01.2020 (including letter dt.13.11.2019, 01.05.2017 & 17.10.2018)
2	1403(2)	14.02	Clarification on exemption of Railway Projects from the requirement of Environmental Clearance (EC) and Costal Regulation Zone (CRZ) Clearance as per section 11 of Railways Act 1989 – regarding. Issued on 06.10.2023
3	1403(2)	14.03	Commercial development of Railway land in and around Railway Stations – prior environmental clearance under the provisions of EIA Notification, 2006-reg issued vide letter no. F. No. 19-172/2018-IAIII dt. 28.05.2020
4	1405(1)(c)	14.04	Adoption of Energy Efficiency Measures in Non-Traction over Indian Railways issued vide Railway Board letter no. 2022/EEM/150/09 dt. 30.12.2022
5	1405(2)(a)	14.05	Rain Water harvesting - Railway Board's letter no. 2013/LMB/9/1 dt. 09.09.2013
6	1405(2)(b)	14.06	Indian Railway's Water policy -2017
7	1407(1)	14.07	Amenities to be provided in residential building. Rly. Board letter no. 2013/LMB/10/15 dt. 11.12.2013
8	1409	14.08	Comprehensive instruction for provision of Passenger Amenities and user facilities at Stations issued vide letter No. 2018/LM(PA)/03/06 dt. 09.04.2018
9	1409, 1412(2), 1413	14.09	Comprehensive instruction for provision of Passenger Amenities and user facilities at Stations issued vide letter No. 2018/LM(PA)/03/06 dt. 14.02.2022
10	1414(4)	14.10	Signage policy for Railway Stations issued vide letter No. 2023/S-II/22/07/02 dt. 15.05.2023
11	1415	14.11	Guidelines on accessibility of Indian Railway stations and facilities at stations for differently abled persons (Divyangjan) and passengers with reduced mobility issued vide Railway Board letter no. 2019/Stn. Dev-13/06/Policy/PwDs dt. 25.11.2022
12	1418	14.12	Comprehensive instruction for umbrella work of Major Upgradation of Railway Stations on Indian Railways issued vide Lr. No. 2021/Stn. Dev.-I/08/18 dt. 04.05.2022
13	1418	14.13	Format of DPR for Station Development /re-development/major Upgradation projects issued vide Lr. no. 2021/SD-II/22/07/11 dt. 19.08.2022

14	1418	14.14	Provision of ballastless track at major/important stations and stations identified under Major Upgradation/Redevelopment issued vide Lr. no. 2021/CE-II/TSC/10th Extraordinary dt. 29.09.2022
15	1418	14.15	Execution of Station Development works issued vide Lr. no. 2021/ Stn. Dev.-I/08/18 dt. 03.10.2022
16	1418	14.16	Upgradation of Railway Stations on Indian Railways – Design, inspection and audit of the projects reg: issued vide Lr. no. 2021/ Stn. Dev.-I/08/18 dt. 19.10.2022
17	1418	14.17	Amrit Bharat Station Scheme for Indian Railways issued vide Lr. no. 2022/GS/Stn. Dev.-I/08/70 dt. 23.12.2022
18	1418	14.18	Amrit Bharat Station Scheme for Indian Railways issued vide Lr. no. 2022/GS/Stn. Dev.-I/08/70 dt. 31.01.2023
19	1418	14.19	Amrit Bharat Station Scheme for Indian Railways issued vide Lr. no. 2022/GS/Stn. Dev.-I/08/70 dt. 17.02.2023
20	1418	14.20	Amrit Bharat Station Scheme for Indian Railways: Provision of Central Foot Over Bridges (FOBs) issued vide Lr. no. 2022/GS/Stn. Dev.-I/08/70 dt. 19.04.2023
21	1418	14.21	Presentation for Master Plans of Station development works issued vide Lr. no. 2022/GS/Stn. Dev.-I/08/70 dt. 29.04.2023
22	1418	14.22	Commercial development of Station Estate-reg. issued vide Lr. no. 2023/LML-II/2/8 dt. 15.05.2023
23	1418	14.23	Signage Guidelines for Railway Stations issued vide Lr. no. 2023/SD-II/22/07/02 dt. 15.05.2023
24	1418	14.24	General Guidelines for OHE design in concourse area for station development projects issued vide Lr. no. RDSO/759/2022 dt. 12.06.2023
25	1418	14.25	Execution of Amrit Bharat Station Development Scheme works: Role of Chief Engineer/Station issued vide Lr. no. 2022/GS/Stn. Dev.-I/08/70 dt. 19.07.2023
26	1418	14.26	Preparation of Master Plans of Station Development Works issued vide Lr. no. 2022/GS/Stn. Dev.-I/08/70 dt. 25.08.2023
27	1418	14.27	Pradhan Mantri Bharatiya Janaaushadhi Kendras (PMBJKs) at Railway Stations – policy regarding issued vide letter no.2023/NFR/33/JAK E-office no. 3423850 dt. 08.08.2023

***

CHAPTER 15
TRACK LAYING AND ALLIED WORKS

PART A
TRACK LAYING PLANNING & EXECUTION

1501 SANCTIONED PROVISIONS AND INITIAL PLANNING

At the very outset, following aspects/issues need to be checked, examined & taken care of:

(1) Detailed Estimate:

Before taking up the physical execution of the work, it should be ensured that the Detailed Estimate (DE) is sanctioned. Field units should ensure that:

a) Sanctioned copy of the DE is available with them.

b) It should be checked whether the provision of items available in the DE is as per the latest Railway Board guidelines. In any case, the planning of work should be done as per the latest Railway Board guidelines, and changes to items in the estimate, if required, should be done through Revised Estimate (RE).

(2) Planning of P. Way material and preparation of indents for P. Way material

Demand for P. Way material should be raised after thorough planning of the project. While doing material planning, the following aspects should be taken care of:

a) Heavy P. Way material, viz., rails, are procured at the Railway Board level. Hence, material should be demanded after detailed scrutiny so that the material asked is neither excessive nor falls short at the execution stage.

b) Quantity of material should be worked out on the basis of approved ESPs/proposed ESPs, or conceptual ESPs signed by the Division and HQ. Indent should be prepared accordingly.

c) Indents should be prepared, keeping in mind the latest Railway Board guidelines about the track structure or any other relevant instructions. If the items required do not match with the items available in DE, the same should be proposed in RE. However, indents are to be made as per prevalent available guidelines only.

d) In Indents, description of items should be proper, as standard drawing numbers of RDSO or other competent authority, allocation code, consignee code, and address should be clearly mentioned.

e) Sometimes it happens that the indents of some of the critical matching fittings are inadvertently not prepared along with major items, and the same are not available at the execution stage. Hence, while preparing indents, it should be ensured that indents of all matching fittings are prepared simultaneously with major items by referring to concerned available approved drawings so that none of the matching fittings are left out.

f) Indents should be got vetted at the earliest from associate finance. The procurement procedure for P. Way material starts only after vetting of indents from associate finance.

g) In EPC contract, where P. Way work is included, the material procurement except rail is to be done by the EPC contractor. For material and fittings to be used, the latest drawing and instructions should be followed and clearly specified in the tender document.

(3) Approval of ESPs/Plans:

As soon as the Detailed Estimate is sanctioned, the following ESPs/Plans should be initiated for approval of the competent authority:

a) Yard ESPs

b) LWR Plans

c) Track Diagram

d) Other Plans as required for the execution of the P. Way works

(4) Tender Planning:

Tender schedule should be prepared, taking the following aspects into consideration:

a) Tender schedule should be prepared as per the standard tender schedule issued by HQ and the latest guidelines available.

b) Quantity should be worked out on the basis of approved or proposed ESPs/Plans & any other available instructions.

c) Estimated cost for the purpose of the tender schedule should normally be based on the basis of 3 latest available LARs in the area, following the latest prevalent guidelines and instructions on the matter.

Requirement for the submission of Method Statement should be included in special conditions related to site data and specifications. (See Annexure 15A, placed at the end of the chapter). The same should be approved by the competent authority.

(5) Use of mechanized equipment/ machinery for P. Way Works:

Many small mechanized equipment/ machines, without complicated or sophisticated parts or circuitry, are available in the market or can be easily manufactured or assembled. The use of such mechanized means for various construction activities may be suitably incorporated into the contract conditions for better progress and quality of work. Some of such equipments / machinery are described below:

a) Hydra and backhoe loader can be effectively utilized for shifting/carrying P-way materials, including rails. Special slings are attached to Hydra for lifting rails/sleepers, like UTV machine.

b) Backhoe can be used for ballast regulation. During ballast regulation, the front wheel of the Backhoe is in lifted condition.

c) Modified tractor or truck with rail wheels can be used for the unloading of ballast directly into the track, similar to the BOBYN.

d) Two Hydras working in tandem can be efficiently utilized for dismantling and laying of points and crossings. However, the use of T-28 machines for laying of turnout will result in better quality, and T-28 machines can be utilized depending upon the availability of machines in coordination with the open line.

e) Utilizing available light multi-purpose machines like JCB-70 and Hydra of 8T capacity for the laying and alignment of the track.

f) Use of T-28 for shifting existing SEJ on running lines can be done to save SEJ and block time and effort.

g) T-28 machines can be very effectively used for carrying out major Cut and Connection during very less block time.

(6) Cut and Connection Works (cut-n-connection):

a) Cut and connection works should be meticulously planned, as such work involves long traffic blocks and a large amount of labour and machinery input.

b) For cut-n-connection, additional ballast for new or revised alignment should be arranged well in advance. It is always desirable to carry out extra earth work for 50 m on either side of the cut-n-connection. This not only helps in keeping material but also supports the bank, as at some of the cut-n-connection locations, the bank will not be fully compacted. For long high banks and restricted locations, it is a must.

c) Keep 3/5 rail panels welded in-situ ready on cess to reduce welding on linked track.

d) Slewing of track should be done in stages, as slewing of the track to new alignment in one stroke will make a series of small goose necks, sleepers will go out of square due to sharp curvature, breaking of ERCs (most dangerous) and breaking of PSC sleepers at inserts, etc.

1502 UNLOADING AND STACKING OF P.WAY MATERIAL

Proper assessment of the requirement of material in a yard or section/location should be done prior to leading the material to the site so as to avoid re-handling of the material. Unloading and stacking of P. Way material should be done carefully. For proper handling of rail, instructions issued by RDSO vide CT 35 report of February 2023 are to be followed. It should be ensured that handling is done safely, without any infringement to the existing track or structure, and without any damage to the material being handled.

Track should be initially linked with service rail and subsequently renewed with 20 RP [Railway Board letter No. 2019/W-1/Genl./P. Way/2019-20 dated 12.06.19 **(Ref. 15.01)**]. A quick checklist regarding handling and stacking of P-way material is appended below:

(1) Unloading and Stacking of Rails

Rails of higher UTS (90 and above, including R260 and R350HT Grade rails), being brittle in nature, are susceptible to sudden fracture from locations of even minor dents. The dent or deformation on the edge of the rail foot is formed mainly due to the rubbing of rails during unloading and handling of rails at site. R350HT grade rails have a higher UTS and a higher hardness value as compared to 90UTS rails.

The following precautions must be taken while unloading, stacking, and handling new rails: (**Ref:** Para 711(6) of IRPWM) and RDSO guidelines for handling and stacking of rails in February 2023 (CT-35)

SN	Item to be checked
1	**Inspection of unloaded rails before laying:**
	All efforts should be made during the handling of rails so as to not create any dents and kinks in the rails. The damage to rails, including the formation of dents or deformation at the rail foot, can be detected by inspecting the rails before they are laid on track. Rails are to be thoroughly inspected at the level of SSE/P.Way for the presence of damages to rails during transportation, unloading, and handling, if any, before laying in the track. In case any damage, including dent or deformation, is noticed, such rails should not be used in track unless the damaged portion of the rails is removed.
2	**Stacking of rails and welded panels - for flash butt welding plants and other bulk storage-**
	The rails shall be stacked on level and well-drained ground. While stacking in the depot, a slope of 1:400 may be given in the concrete bed across the length of rails for drainage of water.
	Mild steel flats of 100 x 25 mm size should be used between two successive layers of rails and kept at a distance not more than 4.0 m center to center. Number of layers in a stack should not be more than 10.
3	**Handling of Rails- when rails are stacked in layers:**
	The rail should be lifted, preferably with magnetic chucks. In the event that magnetic lifting devices for rails cannot be provided, all handling of rails shall be done with synchronized electric hoists and spreader beams.
	Single-point slinging increases the risk of excessive bending and surface damage to the rails; hence, it should not be done.
	The overhang portion of rail beyond the outer lifting point should not be greater than one-half the distance between two adjacent lifting points. The distance between two adjacent points should not be more than 6.50 m in any case.
4	**Unloading of single rails and 3 rail panels - Loose rails being unloaded by road cranes:**
	Rails shall be unloaded fairly opposite to the position where they are to be laid. Care shall be taken to avoid unloading materials in excess of the actual requirement so as to avoid double handling.
5	**Handling of Long Welded Rail Panels -Unloading of long rail panels from EURs:**
	In order to mitigate the issue of damage such as dent or deformation as a consequence of impact and sudden jerk during unloading, the use of improved end unloading system for long rail panel provisions as specified in 'Technical Specification of Improved End Unloading System for Long Rail Panels' (RDSO's Specification no. TM/HM/29/EUR/450 of 2018) shall be followed.
	For the mechanized system of unloading and loading for long rail panels in the field, the provisions of 'Technical Specification of Improved In Field Unloading and Loading System for Long Rail Panels for BG' (RDSO's Specification no. TM/HM/29/449 of 2019) shall be followed.

	Since there is no provision for holes in newly supplied rails, , clamps or magnetic chucks should be used for lifting and unloading rails in these rail unloading arrangements. When all clamps are fully unlocked, rails should be lifted with extreme care to prevent accidental lifting of the nearby rails by the edges of the feet.
	Unloaded rail panels are to be shifted beyond the toe of the ballast of the existing track. Unloaded rail panels are to be supported @ 4m interval with head upwards.
	20 rail panels are to be unloaded on the side of the new formation, in case of doubling/ multiple line works, at locations where service rails cannot be used. (Required to avoid crossing rails over an existing track from safety consideration)

(2) Unloading & Stacking of Sleepers

SN	Item to be checked
1	It is to be ensured that PSC sleepers are unloaded by road cranes.
2	It is to be ensured that stacking of PSC sleepers is done at level & firm ground.
3	Leading & stacking of sleepers is to be done as per actual requirement at site to avoid shifting of sleepers at a later stage.

1503 FORMATION AND FIXING OF REFERENCE PEGS

Cross section, L-section, and width of formation should be checked with approved drawings as well as with the latest instructions. The extra width of formation at proposed curve locations should also be checked. Reference pegs should be fixed at proper locations in such a manner that they do not get disturbed during the spreading of ballast and the laying or linking of tracks. Reference pegs should have proper marking of ballast bed level, rail levels after each packing, and final rail level. The following points should be ensured during the survey and track-laying operation:

a) Proper survey of all yards using Total Station should be conducted to calculate crossover lengths.

b) In station yards, L-sections should be meticulously finalized, keeping in mind aspects of drainage, level crossings, no change in grade in the turnout zone, and junction points of the new line with existing running lines.

c) Wherever an existing loop line is proposed to be upgraded as the main line in a doubling project, track works like slewing, lifting, TSR, TRR, deep/shallow screening, etc. should be planned well in advance. Such loop lines should preferably be disconnected or isolated with addition/alteration in S&T gears/installations at least 20 days before commissioning. This will help in maintaining good quality work and running during speed trials without any speed restrictions.

d) List of OHE, S&T, and track infringements affecting the works of other departments should be prepared in advance by a foot-to-foot survey of the yard. S&T location boxes and OHE installations infringing the proposed main line or loop line required to be opened for traffic at the time of commissioning should be shifted well in advance to avoid the accumulation of P.Way works in the limited NI period.

e) As far as possible, efforts should be made to keep the rail level of the new track and the old track to which it is connected at the same level to avoid twist in connection and crossover.

Quick checklist regarding formation & fixing of reference pegs is appended below:

(1) Formation:

SN	Item to be checked
1	The formation width of 7.85m for the main line and 6.85m for the loop lines is available before starting track linking work. (Ref: Para 212(1)(i) of IRPWM, 2020)
2	Extra widening on the outside of the curve and other locations, depending upon local conditions, is provided. (Ref: Para 212(1)(iI)(a) of IRPWM, 2020)
3	The formation level is sufficient to maintain the same rail level at level crossings in the case of double line/multiple lines.
4	The formation level is sufficient to maintain the same rail level in new yards.
5	It is ensured that the finished formation levels are as per the approved L-section.
6	Drains have been planned in all cuttings or not.

(2) Fixing of reference pegs:

SN	Item to be checked
1	Reference pegs have been provided by grouting at every 25m interval in the case of straight track and at every 10m interval in the case of curved track.
2	Marking of ballast bed level, rail level after 1st manual packing, 2nd manual packing, 1st machine tamping, 2nd machine tamping, and final rail level (as per approved L-sections) on reference pegs has been done.
3	Reference pegs mentioned in item no. 2 are fixed at a distance of 3.75m from the center of the new formation on the cess side and 2.75m on the existing track side in cases of doubling or multiple lines.
4	Reference pegs have been provided by grouting at TTP, CTP, Centre of curve, and obligatory points.

1504 BALLAST WORKS, LAYING OF SLEEPERS AND LINKING OF NORMAL TRACK

Ballast spreading should not be started unless permission from the competent authority has been received as per the latest instructions. It should also be ensured that before the start of ballast spreading, at least a minimum quantity of ballast, as required for the initial ballast bed, is available at the site. After preparation of the ballast bed, sleepers should be laid with proper spacing as per the proposed sleeper density. The center line and squaring of the sleeper should be checked according to the proposed alignment. The latest instructions on track laying and linking should be adhered to.

A quick checklist regarding ballast works, laying of sleepers, and linking of the normal track is appended below:

(1) Ballast bed:

SN	Item to be checked
1	Reference pegs are not disturbed during the leading and spreading of ballast.
2	Initially, a minimum quantity of ballast just required for a ballast bed of 150 mm, and manual lifting and packing (@1.00 cum per track meter) is being put on the formation. (Balance quantity to be led through hoppers)
3	A uniform layer of ballast bed (150 mm in the case of a 350 mm cushion and 100 mm in the case of a 250 mm cushion) has been provided before placing sleepers for linking.
4	Rolling of the ballast bed has been done by roller of 5 to 8 tonne weight.
5	Minimum ballast cushion of 350 mm in the main line and 250 mm in the loop line has been provided in the track. (Ref. 202(2)(a) of IRPWM, 2020)
6	Shoulder ballast of 500 mm on the outside of turn-in curves of turnout has been provided. (Ref: 408(4)(iii) of IRPWM, 2020)
7	Dressing of ballast after the completion of machine tamping has been done.

(2) Laying of sleepers and linking of normal track:

SN	Item to be checked
1	Center-marked sleepers by permanent marker are being provided at every 15-meter interval correctly and matching the proposed centre line of the track in reference to fixed pegs.
2	String/rope is being used for the correct laying of sleepers in between 2 center-marked sleepers.
3	Marking of sleeper spacing is done on the rail head in one go only by using 30 m of tape to avoid the accumulation of errors.
4	Squaring of sleepers is done by marking the sleeper spacing on the other rail head with the help of a P.Way square.
5	Continuous marking of sleeper spacing is transferred from rail head to rail flange using a template with the help of a permanent fine marker. (Template needs to be developed in the shape of mould shoe, required to avoid error, as with the marking on the railhead only and the center of the insert decided by eye approximation only)
6	Sleeper density of 1660 nos./km (60 cm c/c sleeper spacing) on Main line, 1540 nos./km (65 cm c/c sleeper spacing) on the loop line, and siding has been provided. For sidings with a speed greater than 50 kmph, it is 1660 nos./km. *(**Ref:** Para 209(2)(a) of IRPWM, 2020)*
7	Correct sleeper spacing (sleeper to sleeper variation with respect to theoretical spacing within ± 20 mm) and squaring are being done. *(**Ref:** Para 520(3)(b) of IRPWM, 2020)*
8	Sleeper to sleeper variation of gauge is maintained within 2 mm. *(**Ref:** Para 520(3)(b) of IRPWM, 2020)*
9	No hammering is done on the sleeper to make the sleeper square.
10	Pandrol clip and steel liners are used in the track and are properly painted with anti-corrosive paint. **(IS 9862:2017)** *(**Ref:** Para 613(b)(iii) of IRPWM, 2020)*

11	Greasing is done in the eye of the MCI insert before the insertion of the Pandrol clip. *(**Ref:** Para 628(2) of IRPWM, 2020)*
12	Grease is applied to the leg of Pandrol, below the liner, and over the rail flange. *(**Ref:** Para 628(2) of IRPWM, 2020)*
13	Grease used for lubrication is of the specification **IS: 408-2020**. *(third revision of code to that provided under **Ref:** Para 628(2) of IRPWM, 2020)*
14	Greasing is not done during extreme summer and during heavy rainfall. *(**Ref:** Para 322(2)(b) of IRPWM, 2020)*
15	Liners collar is seated properly in between rail flange and SGCI insert.
16	End of the central leg of the ERC is matched with the eye of the insert during driving (to avoid over-driven or under-driven conditions).
17	Rail panels are longitudinally slewed on rail rollers for pairing rail panels.
18	No rail panels are longitudinally slewed by hitting with rail at rail ends for pairing rail panels.
19	Specified gap is kept at the joint during pairing and butting (to avoid the number of A.T. welds).
20	Rails are painted with anti-corrosive black bituminous paint in corrosion-prone areas.
21	Sleepers are correctly fitted at their position during the fixing of Pandrol clip.
22	Holes in the rail have been chamfered. *(**Ref:** Para 620 (7) of IRPWM, 2020)*
23	Rail joints are square at the beginning and end of curves up to a radius flatter than 400 meters. *(**Ref:** Para 422 of IRPWM, 2020)*
24	Rail joints (fish plate and weld joints) are not supported on sleepers.
25	Hole is not done in track where welding is to be done (use rail clamp in case of temporary work like machine, DMT working).
26	A 1 meter-long fish plate with six bolts is used on fish-plated joints where as spacing is normal on concrete sleepers. *(**Ref:** Para 326(5)(e) of IRPWM, 2020)*
27	Trolley refuse has been provided at appropriate locations as per the provisions in IRPWM. *(**Ref:** Para 646 of IRPWM, 2020)*
28	Distance pieces have been provided at 30 m interval on the platform line. *(**Ref:** Para 649 of IRPWM, 2020)*
29	Rail posts painted in red and white at the starting and end of the curve are provided on the inside of the curve. (Ref: Para 407(2) of IRPWM, 2020)
30	Station number on the gauge face of the outer rail @ 10 m has been written in white paint, extending three stations beyond the tangent point at both the entry and exit of the curve. *(**Ref:** Para 419 (2) of IRPWM, 2020)*
31	Super-elevation or cant has been indicated by painting its value on the inside face of the web of the inner rail of the curve and at every station, beginning with zero at the commencement of the transition curve. (The value of cant should be indicated on the circular curve at its beginning and at its end. In the case of a long circular curve, the cant value should be indicated at intermediate stations at a distance not exceeding 250 m). *(Ref: Para 407 (3) of IRPWM, 2020)*

32	Each approach of a curve has been provided with a curve board at the tangent point fixed on the outside of the curve. This board should indicate the radius of the curve, the length of the curve, the length of the transition in meters, and the maximum cant provided on the circular portion of the curve in millimeters. *(**Ref:** Para 407 (1) of IRPWM, 2020)*
33	The station has been marked in Turn-in Curve at every 3 m. *(**Ref:** Para 419 (2) of IRPWM, 2020)*
34	Curve speed potential has been checked to meet its sectional speed requirement, and wherever the same is not achieved, speed restrictions have been imposed.
35	Automatic gauge face lubricator has been installed in sharp curves. *(**Ref:** Para 424 (2) of IRPWM, 2020)*
36	Holes provided at the end of 20 RP have been eliminated during the welding of the rail as a good practice.

1505 MANUAL PACKING & TAMPING BY MACHINES

Before taking up manual packing and tamping of track by machine, it should be ensured that sufficient quantity of ballast is available in the track. Each lift during packing should be checked with markings on reference pegs. Alignment is also to be ensured to avoid a false curve or kink in track. Before starting tamping by track machine, fixtures, viz., joggled fish plates, check rails, etc., should be removed. The setting of the tamping machine with respect to squeezing pressure, squeezing time, condition of the tamping tools, etc. should be checked and adjusted as per the latest instructions. Track parameters before and after tamping should be recorded.

A quick checklist of manual packing and tamping by machine is appended below:

SN	Item to be checked
1	Sufficient ballast, a minimum of 250mm for the main line and 150mm for loop lines in track, is available before the commencement of machine packing. *(**Ref:** Para 224(2)(b) of IRTMM, 2019)*
2	Reference posts for rail level and alignment have been correctly marked before the commencement of packing.
3	During 1st and 2nd rounds of manual packing, the track is lifted by 75 mm (in the case of 350 mm cushion) and 50 mm (in the case of 250 mm cushion) only.
4	During the 1st and 2nd rounds of manual packing, designed alignment and levels in straights and designed super elevation in curve stretches have been achieved.
5	For machine tamping, fixtures like check rails, guard rails, and joggled fish plates, S&T roddings/fixtures have been removed from track. In the case of an electrified section, earth bonds are also removed from the track before tamping. *(**Ref:** IRTMM 2019 Para 224(3))*
6	L-Xing is opened for each machine tamping.
7	SE and Versines, the curve alignment location (ST: Straight to Transition, TC: Transition to Curve, CT: Curve to Transition, TC: Transition to Curve) has been correctly marked on sleepers and rails before tamping. *(**Ref:** IRTMM 2019 Para 224(3))*
8	Track machine is calibrated before the start of work.

9	Track machine is working in design mode, and design data and track parameters are available for feeding before the machine working. (For getting the absolute design track geometry by machine tamping, the procedure to be followed is described in **Annexure 15B**, placed at the end of the chapter).
10	Sufficient ballast is heaped up in the tamping zone, and ballast is clear from the rail head so as not to obstruct rollers. *(**Ref:** IRTMM 2019 Para 224(3))*
11	Squeezing pressure is in the range of 110–120 kg/sq. cm (in the case of DUOMATIC) and 125–135 kg/sq. cm (in the case of UNIMAT) for PSC track/turnout. *(**Ref:** IRTMM 2019 Para. 206(1))*
12	Squeezing time is in the range of 0.8–1.2 seconds per insertion. *(**Ref:** IRTMM 2019 Para. 206(5))*
13	Machine tools are complete, and wear is not more than 20%. (Size of tools for different types of tamping machines should be as per Annexure 2.1 of IRTMM 2019). *(**Ref:** IRTMM 2019 Para 206(6))*
14	Sleepers are properly spaced, squared, and correctly gauged before machine tamping. *(**Ref:** IRTMM 2019 Para 224(3))*
15	Deficient fittings and fastenings, if any, are recouped before machine tamping. *(**Ref:** IRTMM 2019 Para 224(3))*
16	Single insertion is done for lift up to 30mm and double insertion for lift greater than 30mm. *(**Ref:** IRTMM 2019 Para 220(2))*
17	DGS is deployed behind the TTM machine.
18	DGS is working in the modes specified in para 227. (Ref: IRTMM 2019 Para 227(2))
19	Proper record of track parameters before and after tamping is being maintained. *(**Ref:** IRTMM 2019 Para 229)*
20	Boxing and profiling of ballast is done immediately post tamping.
21	Missing/broken fittings and fastenings, if any, are recouped after machine tamping. *(**Ref:** IRTMM 2019 Para 229(5))*
22	After machine tamping, fixtures like check rails, guard rails, joggled fish plates, and S&T roddings and fixtures have been refixed in track. In the case of an electrified section, earth bonds are also re-fixed in track after tamping. *(**Ref:** IRTMM 2019 Para 229(5))*

1506 LAYING OF POINTS AND CROSSINGS IN YARDS

Laying of points and crossing should be done as per the latest RDSO standard drawings (Ref: Para 427 of IRPWM). Marking for sleepers should be done accurately with the cumulative method to ensure good running on turnouts. In case of turnouts laid on curves, the sleeper spacing and precurving of Tounge and stock rails should be as pe RDSO letter no. CT/PTX/TWS/ Design dated 06-07-2023 **(Ref. 15.02)**. SRJ to SRJ distance and ANC to ANC distance should be marked as per layout calculations. Layout calculations should be done with the actual center-to-center distance available at turnout locations.

As per Railway Board guidelines, in all new construction projects, thick web switches are to be

laid in place of OR switches. The IRPWM 2020 provision in Chapter 4 should be strictly adhered to while laying Points and Crossing.

A quick checklist regarding the laying of points and crossings is appended below:

SN	Item to be checked
1	There is no change in gradient up to 30 m from the SRJ and crossing of the turnout. *(**Ref:** ACS 17 of IRSOD (B.G.) 2004Chapter II Note (e)(2) below Para 2)*
2	Both turnouts of a crossover are on the same plane. *(**Ref:** Para 413 of IRPWM 2020)*
3	Layout calculation is available, and the same has been verified for its feasibility at site.
4	Points and crossings are not laid in a curve with a lead radius on either the main line or on Turnout side becoming sharper than 350 m without the approval of competent authority. *(**Ref:** Para 408 (2)(e) of IRPWM-2020)*
5	Correct length of crossover has been calculated as per the available track center at the site.
6	Correct Layout has been marked on site, and the concerned reference pegs have been fixed.
7	Marking of the calculated TNC to TNC/SRJ to SRJ distance done at site.
8	During the spreading of the sleeper, the RE marked on the sleeper is kept on the right hand of the turnout.
9	Correct sleeper spacing is done at site as per the latest standard drawing, issued by RDSO.
10	Fixing of rubber pad on the sleeper is done using suitable adhesive to avoid lateral shifting of the rubber pad while working.
11	Lead rail joints are centrally placed between the sleepers.
12	Unavoidable joints are gapless.
13	All the screws required to be fixed in the dowels are greased.
14	'J' Type clip along with GFN liner (cut) is provided at glued joints and fish-plated joints.
15	Dowels fixed in the PRC sleepers are cleaned with the help of a soft brush so that all dirt/ muck is removed from them, making the fixing of the screw easy.
16	CMS crossing joints are made gapless.
17	Complete standard fittings are provided in turnout as per the standard RDSO drawing. Single-coil washers and spherical washers are used for the proper tightening of fittings.
18	It is ensured that proper housing of tongue Rail is available.
19	It is ensured that tongue rails are properly rested/seated at the slide chair for free movement. *(**Ref:** IRPWM, 2020 429 (2)(g))*
20	A proper gap (1.5 to 5 mm) is kept between the top of the stretcher bar and the bottom of the stock rail. *(**Ref:** Para 429(2)(j) of IRPWM, 2020)*
21	Proper marking of points is done on turnout for inspection purposes, as per the proforma mentioned in IRPWM.
22	Proper throw of switch is available (Min. 115 mm in case of new works for the OR Switch and 160 mm for the Thick Web Switch). *(**Ref:** IRSOD (B.G.)2004 Chapter II Para 16(ii))*

23	Check rail clearance is available within 41 mm to 45 mm. ***(Ref:** IRSOD (B.G.)2004 Chapter II Para 13 note(a)and para 14 note)*
24	Correct gauge is maintained at the ATS and ANC of turn out. ***(Ref:** Para 429 (4)(a) of IRPWM 2020)*
25	Track parameter are within the permissible limit: (i) Gauge: sleeper-to-sleeper variation of 2 mm (Ref: IRPWM 2020 para 520 (3)) (ii) Cross Level :±3 mm ***(Ref:** IRPWM 2020 para 520 (3))* (iii) Alignment: ±2 mm measured on a 10 m chord in the case of straight track ***(Ref:** IRPWM 2020 para 520 (3))* (iv) The variation in versine on two successive stations in lead curve and turn-in curve portion is not more than 3 mm from its designed value. ***(Ref:** Para 429(4)(a) of IRPWM, 2020)*
26	All S&T fixtures, roddings, stretcher bars are removed from the track during machine tamping of points & crossings.
27	Sufficient ballast cushion is available (300/350 mm).
28	At least one rail on either side of the points and crossing has same section as that of points and crossing assembly. ***(Ref:** Para 717(3)(c) of IRPWM, 2020)*
29	All avoidable joints have been welded including SRJ and Lead joints. ***(Ref:** IRPWM 2020 717 (3)(e))*
30	Fitness of the point has been jointly checked by Engineering and S&T staff.
31	Curvature of Tongue Rail and Stock rail has been checked before laying as per the relevant RDSO drawing. Also, proper pre-curved switch has been ordered when laying T/o in curves. ***(Ref:** RDSO letter No. CT/PTX/TWS/Design, dated: 06.07.23)*
32	Sand hump has been provided as per the standard drawing. (**Ref:** Para 633 of IRPWM 2020)
33	Fouling marks have been provided at appropriate location. (**Ref:** Para 650 of IRPWM 2020)

1507 LONG WELDED RAILS (LWR)

LWR should be laid as per approved plans conforming to IRPWM as well as the latest RDSO guidelines. Destressing should also be done after the laying of rails, as per IRPWM. Improved SEJ (RDSO drawing T-6902/T-6922) is to be used in place of ordinary SEJ.

Quick checklist regarding the laying of LWR is appended below:

SN	Item to be checked
1	LWR plan has been approved by the Chief Track Engineer. ***(Ref:** Para 326(4) of IRPWM, 2020)*
2	LWR is laid at a gradient not steeper than 1 in 100. ***(Ref:** Para 326(3) of IRPWM, 2020)*

3	LWR/CWR is continued through the curves, which are not sharper than 440 meters in radius. *(**Ref:** Para 326(2)(a) of IRPWM, 2020)*
4	LWR/CWR, if continued through reverse curves, has been provided with adequate ballast on the shoulder. *(**Ref:** Para 326(2)(b) of IRPWM, 2020)*
5	A vertical curve is provided at the junction of the grades when the algebraic difference between the grades is equal to or more than 4 mm per meter, or 0.4 percent, as laid down in Para 417 of IRPWM, 2020. (In the case of the BG track, the minimum radius of the vertical curve shall be on A route =4000 m, B route = 3000 m, and C and D route = 2500 m.) *(**Ref:** Para 417 of IRPWM, 2020)*
7	Minimum sleeper density of 1540 km is provided in the LWR track. *(**Ref:** Para 326 (2)(a)(i) of IRPWM, 2020)*
8	Combination SEJ has been provided in LWR in case of any change of rail section, or alternatively, two 3 rail panels (39 m), one of each rail section is provided with a combination fish-plated joint between the two panels. *(**Ref:** Para 346(3)(b) of IRPWM, 2020)*
9	Whether a new SEJ has been inserted at a new location before withdrawing the old SEJ in case of a shift in the SEJ due to a change in the yard diagram or other locations.
10	Rail used in LWR/CWR is without a fish bolt hole, as far as possible. In the case of a hole, whether it is chamfered. Note: Under any circumstances, no bolt hole should be made by gas cutting equipment. *(**Ref:** Para 610 (3) of IRPWM, 2020)*
11	While making LWR/CWR by using SH rail, the battered rail end and bolt hole have been cropped. *(**Ref:** Para 323 (3) of IRPWM, 2020)*
12	Where LWR/CWR is followed by fish-plated/SWR, the same structure as that of LWR/CWR is continued for three rails beyond SEJ. (Ref: Para 326 (6) of IRPWM, 2020)
13	Level crossings situated in LWR/CWR territory are not falling within the breathing lengths. *(**Ref:** Para 326 (7) of IRPWM, 2020)*
14	Where concrete sleeper turnouts are laid, instead of three normal rail lengths, one 3-rail panel is provided between SEJ and SRJ, as well as between the heel of the crossing and SEJ. *(**Ref:** Para 326 (8)(a) of IRPWM, 2020)*
15	All insulations for track circuiting in LWR/CWR is done by providing glued joints of the G3(L) type. *(**Ref:** Para 327 of IRPWM, 2020)*
16	SEJ with straight tongue and stock is not located on curves sharper than 0.5 degree (3500 m radius) as far as possible and also on transitions of curves. *(**Ref:** Para 328 (1) of IRPWM, 2020)*
17	Improved SEJ is provided on curves up to approved 2^0 and beyond 2 degrees and up to 40 with *(**Ref:** Para 328 (2) of IRPWM, 2020)*

18	LWR/CWR is continued over bridges without bearings like slabs, box culverts, and arches. *(**Ref:** Para 329 of IRPWM, 2020)*
19	LWR is not continued over bridges, with an overall length of 11 m in the case of rail-free fastenings on bridges while 23 m with rail-free fastenings on bridges with partly box-anchored sleepers. (For temperature zone IV, 60 kg rail and PRC sleepers) *(**Ref:** Para 331, Table 1, of IRPWM, 2020)* (LWR/CWR is not continued over bridges with overall lengths greater than those specified in IRPWM.)
20	Minimum length of 30 meters of well-anchored track on either side isolates bridges on which LWR/CWR is not permitted or provided. *(**Ref:** Para 331(6) of IRPWM, 2020)*
21	Correct laying of SEJ and the proper initial gap in SEJ are done as per the standard R.D.S.O. drawing. *(**Ref:** Para 338 of IRPWM, 2020)*
22	LWR reference post is fixed correctly at SEJ and at the center. *(**Ref:** Para 343 of IRPWM, 2020)*
23	On the top of the LWR reference post, an arrow mark by chisel perpendicular to the track is made.
24	Destressing of LWR is done before opening to traffic.
25	Destressing of LWR is done when the range of rail temperature is tm to tm+5°c (for zones I, II, and III) and tm+5°C to tm+10°C (Zone IV). *(**Ref:** Para 335 of IRPWM, 2020)*
26	Destressing of LWR is done by using a rail tensor when the prevailing rail temperature is lower than the stress-free temperature. *(**Ref:** Para 339 of IRPWM, 2020)*
27	During destressing, rails are lifted and placed on rollers on every 15th sleeper, and in cases of curved tracks, side rollers are used. (Ref: Para 340(6) of IRPWM, 2020)
28	During destressing, AT weldings are not supported on sleepers.
29	Just after destressing and welding, a paint mark is done on the rail opposite the reference post for checking the creep movement.
30	Proper record of destressing is being maintained.
31	LWR board is fixed and written with all the requisite information.
32	Shoulder ballast widths of 350 mm in straight track and 500 mm on the outer side of the curve in the case of LWR track have been provided. *(**Ref:** Annexure 2/2 (A) of IRPWM, 2020)*
33	In LWR/CWR continued on curves sharper than 440m radius,, shoulder ballast of 600mm over a length of 100 meter on either side of the tangent point is provided. *(**Ref:** Para 326(2)(b) of IRPWM, 2020)*
34	All welds done in LWR/CWR track are tested by the USFD team, and DFW is removed from the track.
35	In LWR/CWR continued on reverse curves, a shoulder ballast of 600mm over a length of 100 meter on either side of the common point is provided. *(**Ref:** Para 326(2)(b) of IRPWM, 2020)*
36	Ballast profile at all tress-passing locations is protected by a ballast retainer or PRC sleeper.

37	LWR register is maintained with all information, and at least one entry of inspection is done in the LWR register.
38	RSI analysis has been done before deciding to continue LWR over bridges with bearings.
39	Ballast retaining wall of appropriate length has been provided on the bridge approach to the major bridge (Ref: Para 630 (3) of IRPWM 2020).
40	For important and major bridge approaches, for a length of about 100 m, width of cess of 90 cm clear of the full ballast section to maintain the ballast profile is provided. *(**Ref:** Para 630 (2) of IRPWM 2020)*
41	For carrying LWR through points and crossing, the instructions given in the CT-48 report have been followed. *(**Ref:** Para 428 of IRPWM 2020)*

1508 LEVEL CROSSINGS

All the works at Level Crossing should be planned and executed on the basis of the class of level crossing and the class of road keeping in view of the latest provisions in IRPWM, Railway Board guidelines, approved ESPs, etc. Different parameters for the road as well as the track should be ensured as per the latest instructions. Safety items, viz., lifting barriers, safety chains, speed breakers, road sign boards, etc., are the most important items at level crossings. The road surface is also important for road users. Smooth road surface should be provided for smooth entry and exit of heavy road vehicles through level crossings. Machine-made check rails instead of gas-cut check rails should be used at level crossings in construction projects. As far as possible, rubberized road surfaces should be provided (Ref: Railway Board letter No. 2008/CE-1/LX/50 dated 05.04.21), as it eliminates check rails and reduces maintenance effort in general.

Quick checklist regarding level crossing works is appended below:

SN	**Item to be checked**
1	Level Crossing upgradation plan (if it is qualifying) has been approved.
2	Gate posts have been provided at the correct distance (between 3 m to 3.3 m from the center line of the track in B.G.) (Ref: Annexure 9/1, items 7.1 and 7.2 of IRPWM, 2020).
3	Minimum width of Road/ gates has been provided as per the class of Road. ***(Ref:** Annexure 9/1, Item 14 of IRPWM, 2020)*
4	**Check rails**
(i)	Check rail has been provided (Minimum 2 m more than width of gate). *(**Ref:** IRPWM, 2020 Annexure-9/1 item 2)*
(ii)	Check Rail clearance is available between 51mm to 57 mm.
(iii)	Check rails are flared at the ends? No gas cut allowed.
(iv)	Whether Chamfering of holes is done? *(**Ref:** Para 620 (7) of IRPWM, 2020)*
5	**Gate lodges** If the provision of a new gate lodge is made:
(ii)	Minimum distance of Gate Lodge from centre line of nearest track is 6 m? *(**Ref:** IRPWM Annexure-9/1 item 8(a))*

(iii)	Minimum distance of Gate Lodge from centre line edge of road metaling is 6 m? *(**Ref:** IRPWM Annexure-9/1 item 8(b))*
(iv)	If the line of approach road is on a curve at or near a level crossing, the gate lodge is built on the outside of the curve *(**Ref:** IRPWM Annexure-9/1, item 8 and 911 (2) of IRPWM, 2020)*
(v)	In case of straight track, the gate lodges have been provided alternatively on either side of track or governed otherwise.
6	**Fencing** of 15 m minimum from each gate post parallel to track has been provided. *(**Ref:** Annexure 9/1 item 11 of IRPWM, 2020)*
7	Width of metaling: Should be as in IRPWM *(**Ref:** Annexure 9/1 item 12 of IRPWM, 2020)*
(i)	Between gates – Width of metaling is same as that of width of gates.
(ii)	Outside gates: Minimum width as per class of Road has been provided.
8	Level length and gradients Should be as in IRPWM *(**Ref:** Annexure 9/1 item 15 of IRPWM, 2020)*
(a)	Between gates: Whether Road surface is level.
(b)	Outside gates: Road surface Level up to and gradients have been provided as per class of Road.
9	**Speed Breakers**
(i)	Speed breaker is provided at required distance. (20 m from L-Xing gate post) *(**Ref:** Para 916(1) of IRPWM 2020)*
(ii)	Speed breaker design and painting is as per standard. *(**Ref:** Annexure 9/5 Para 916 (1) of IRPWM, 2020)*
10	Road sign boards are provided at correct locations. *(**Ref:** Para 916 (2) of IRPWM, 2020)*
11	Road sign boards are of standard design, painting and fixed at appropriate height. *(**Ref:** Annexure 9/6 Para 916 of IRPWM, 2020)*
12	WL boards have been provided at correct locations. At 600 m from L-Xing.
13	WL boards have been provided as per correct dimensions and at appropriate height.(clear height of W/L board at 2m from Rail level in block sections and 0.3 m from Rail level in yards). *(**Ref:** Annexure 9/4 Para 915 of IRPWM, 2020)*
14	Lifting Barriers (to be provided by S&T Deptt in interlocked gates and by Engg. Deptt in case of non-interlocked gates)
(i)	Lifting barrier is of standard drawing.
(ii)	Lifting barrier is fixed at correct distance from centre line of track.
(iii)	Height of lifting barrier is proper when closed. (between 0.8 m to 1.0 m). *(**Ref:** Para 905 of IRPWM, 2020)*
15	Safety chains have been provided for emergencies (in case of boom breakage). *(**Ref:** IRPWM Para 905 1(a)*

16	Posts for fixing the safety chains provided and safety chains are of sufficient length and fixed at correct height. *(**Ref:** IRPWM Annexure 9/2)*
17	Height Gauge
(i)	In case of electrified territory, height gauge have been provided on both side of L-Xing. *(**Ref:** IRPWM Para 910(5))*
(ii)	Height gauge is located at a minimum distance of 8 m from gate post. *(**Ref:** IRPWM Para 910(5)(c)*
(iii)	Adequate vertical clearance is available under the Height gauge. (4.67 m from Road surface to underside of height gauge)
18	Protection diagram has been provided at L-Xing gate. (In case of doubling, it should be as per double line protection diagram). *(**Ref:** IRPWM Annexure 9/7 Para 910(1)(z)*
19	Correct name, Chainage and class of L-Xing has been exhibited at Gate lodge. (In case of up-gradation, check if it is as per new upgraded class).
20	Track structure in level crossings. *(**Ref:** IRPWM 2020 Para 918)*
(i)	No Rail joints in check rails and running rails within level crossing and 3 m on either side. *(**Ref:** Para 918 (1) of IRPWM, 2020)*
(ii)	Where SWR is continuing through L-Xing, it has been ensured that there is no fish plated joint on L-Xing and within 6 m from end of L-Xing . *(**Ref:** Para 918 (2) of IRPWM, 2020)*
(iii)	In case of LWR, it is ensured that L-Xing do not fall within breathing length of LWR. *(**Ref:** Para 918 (3) of IRPWM, 2020)*
(iv)	Rails are painted properly before laying through L-Xing.
(v)	Gauge is ensured in the range (-)5mm to (+)3 mm. *(**Ref:** Para 520 (3)(a) of IRPWM, 2020)*
(vi)	Cross level is ensured in range + 3 mm. *(**Ref:** Para 520 (3)(b) of IRPWM, 2020)*
(vii)	Rail level and road level meet at level preferably or in unavoidable circumstances proper gradient is available for Road between the tracks in case of doubling.
(viii)	During each machine tamping, the L-Xing is opened for continuing the tamping through L-Xing.
(ix)	Road pavers used as road surface at L-Xing, the fixing of pavers is done preferably after machine tamping.
21	Roads at L-Xing is at right angle to railway line as far as possible. *(**Ref:** Para 906 (1) of IRPWM-2020)*
22	Location of L-Xing is such that visibility for Road and Rail user is adequate. *(**Ref:** Para 911 (1) of IRPWM-2020)*
23	L-Xing is having proper drainage and is normally not lower than surrounding road

1509 TRACK STRUCTURE ON BRIDGES

Before taking up the work on bridges, all relevant and reference drawings and literature should be studied thoroughly. Instructions of LWR manual should be strictly followed in cases where the LWR track is laid on the bridge. The provision of guard rails, walkways, and ballast cushions on the bridges as well as on approaches should be checked with the latest instructions before laying track over the bridge.

Quick checklist regarding track structure on bridges is appended below:

SN	Item to be checked
1	On small bridge openings of less than 6.1m span, rail joints are avoided. *(**Ref:** Para 226 (2) of IRPWM, 2020)*
2	Steel sleepers used on girder bridges are fabricated as per standard RDSO drawing.
3	Steel sleepers used on girder bridges are galvanized.
4	Maximum centre to centre sleeper spacing is not more than 600mm, clear distance between two sleepers is not more than 450 mm and clear distance between joint sleepers is not more than 200mm. *(**Ref:** Para 227 (2) of IRPWM, 2020)*
5	Location of steel sleepers is marked correctly on the girder.
6	Rail joints are so located that after laying sleepers, joints do not become supported joints.
7	After laying steel sleepers, tightening of all fittings including hook bolts is done.
8	Marking of arrow on the top of the bolts at right angle to the rails pointing towards the rail. (**Ref:** Para 631 (3) of IRPWM, 2020)
9	Suitable quantity of steel sleepers along with fittings is kept as emergency reserve.
11	Fish plated joints does not fall within 6 m from bridge abutment in case of SWR. (**Ref:** Para 226 (3)(b) of IRPWM, 2020)
12	Fish plated joints does not fall within 3 m from bridge abutment. (**Ref:** Para 630 (1)(d) of IRPWM, 2020)
13	Guard rails are provided on all major bridges.
15	Design of guard rail is as per standard drawing. (**Ref:** Para 228 (2) of IRPWM, 2020)
16	Ends of guard rail are bent vertically and buried into the ballast and a block of timber is fixed at the end. (**Ref:** Para 228 (3)(a) of IRPWM, 2020)
17	Approach guard rail is provided as per drawing no RDSO/T-4088 to 4097.
18	Lateral clearance between guard rail and running rail is 250+50 mm in case of B.G. Track. (**Ref:** Para 228 (2) of IRPWM, 2020)
19	Guard rail is not lower than the running rail by more than 25 mm. (**Ref:** Para 228 (2) of IRPWM, 2020)
20	Bolts used in guard rails are properly fixed.

21	Track fittings are complete and tight on bridge proper and 100 m on either approach of bridges. (**Ref:** Para 630 (1)(b) of IRPWM, 2020)
22	Provision of walkway by chequered plates with holes is provided on un-ballasted girder bridges. (**Ref:** IRPWM Para 229)
23	Minimum 300 mm ballast cushion is available on ballast bridges.
24	Full ballast section is maintained up to 100 m from abutment in case of LWR on bridges. (**Ref:** Para 630 (1)(e) of IRPWM, 2020)
25	A joggled fish plate with clamp or two far end bolts on good AT weld is provided on bridges having length of water way as 100 m or more and on approaches up to 100 m length. (**Ref:** Para 630 (1)(g) of IRPWM, 2020)
26	In case of LWR on slab /arch /box/ major bridges, without guard rails, full ballast is provided between bridge parapets up to sleeper top level. (**Ref:** Para 228 (1) of IRPWM, 2020)

1510 ALUMINOTHERMIC (AT) WELDING

Various pre-, during, and post-welding operations, acceptance tests required to be carried out, precautions, and defects in A.T. welding are given in the "Manual for Fusion Welding of Rails by the Alumino Thermic Process(Revised 2022)", issued by RDSO. The technical requirements for Thermit portions and the procedure for the approval of the welding supervisors and welders are given in "Indian Railway Standard Specification for Fusion Welding of Rails by Alumino-Thermic Process (IRST-19-2021)", issued by RDSO.

As far as possible, AT welding should be avoided, and mobile flash butt welding should be adopted. However, in exceptional cases, AT welding may be adopted for welding of joints of long rail panels, SEJs, P&C, loops, sidings, dead ends, etc. after obtaining approval from CAO/C. For doing AT welding, guidelines or instructions on the issue should be referred to and followed. The latest instructions available for reduction in AT welding as of the date of publication of this manual are contained in the Railway Board's letter No. Track/21/2005/0110/AT welding dated 16.08.2019 **(Ref. 15.03)** and are as follows:

a) Use of long rail panels (260m) supplied from SAIL or free rails converted into 260m long panels to be used in the main line

b) Welding of 260 m panels by Mobile FB welding plant to convert into LWR

c) Required lengths of rails in point and crossing area to be cut from 260-meter-long rails received from SAIL. Only welding of avoidable joints at locations such as Stock rail joints, welding of the front/back leg of a crossing, etc. should be AT welded.

d) Use of in-situ glued joints in place of pre-fabricated glued joints.

e) Loop line rails should also be welded with Mobile Flash Butt welding.

Welding should be done keeping in view the tolerances and instructions mentioned therein. Proper alignment (horizontal and vertical) and gaps between rails are to be maintained before AT welding is started. Preheating of rail ends and reaction time of portion are the critical activities that have a major effect on the quality of AT weld. The parameters of the finished AT

weld should be within the defined range. The test check on measurements and quality of AT should be conducted for contractors' bills as prescribed by the Railway. USFD testing should be done at the earliest.

Quick checklist regarding AT welding is appended below:

SN	Item to be checked
1	Approval of CAO/C has been taken for AT welding in the project before starting AT welding. (**Ref:** Railway Board Letter No. Track/21/2009/0110/7 dated05/05/2015)
2	AT Welding is done by R.D.S.O. approved agency.
3	AT Welding is done by welder who has valid competency certificate issued from TPP/LKO or R.D.S.O.
4	Portion used for AT welding is inspected and passed by R.D.S.O. team.
5	Technique used for AT Welding is approved by R.D.S.O/Rly Board. The welding parameters to be adopted for welding like pre-heating time, preheating technique, mould waiting time, tapping height etc. should be in accordance with the Annexure-I issued by RDSO (along with approval letter) for the welding technique and for the welding portion being used for welding.
6	End bends of rail used for AT Welding are within +0.5 mm,-0mm in vertical and ±0.50 mm in lateral direction when checked with 01 m straight edge (**Ref:** Para 303 of IRPWM, 2020)
7	End cropping of second-hand rail is done before welding.
8	Fish bolt holes in new rails are removed before welding where possible. (**Ref:** Para 303 of IRPWM, 2020)
9	When the welding work is done in situ, the rail fastening for at least five sleepers on either side of proposed weld location is opened.
10	Rail ends shall be cut by sawing or using abrasive disc cuter and not by flame cutting. (**Ref:** Manual for Fusion welding of rails by Alumino Thermic Process Reprint 2022 Para 3.3(vi))
11	In case of repair of fractured rail/defective weld with wide gap (75mm gap) weld, the rail is cut from center of rail fracture/defective weld 37-38mm each side for making suitable gap of 75mm, provided bolt holes do not fall within 40mm from cut faces. (**Ref:** Manual for Fusion welding of rails by Alumino Thermic Process Reprint 2022 Para 3.3(x))
12	Rail end face and adjacent sides at foot (top and bottom), web and head up to 50 mm is thoroughly cleaned using kerosene oil and brushing with wire brush to remove all dirt, grease and rust before welding. Any burrs at the rail ends is removed by chiseling or grinding. (**Ref:** Manual for Fusion welding of rails by Alumino Thermic Process Reprint 2022 Para 4.4)
13	No Alumino Thermic welded joint is located closer than 4 m from any other welded or fish plated joint. (**Ref:** Manual for Fusion welding of rails by Alumino Thermic Process Reprint 2022 Para 4.4)
14	Gap between rail ends before welding is within permissible limit i.e. 25±1/50±1/75±1mm. (**Ref:** Manual for Fusion welding of rails by Alumino Thermic Process Reprint 2022 Para 4.5)

15	Lateral alignment of two rail ends, is within +0.5 mm and vertical alignment is 2 to 2.4 mm for 90 UTS rails when checked with a 1.0 m straight edge at rail ends before welding is done. (**Ref:** Manual for Fusion welding of rails by Alumino Thermic Process Reprint 2022 Para 4.7.1.1 & 4.7.1.2)
16	Three-piece mould is used. (**Ref:** Manual for Fusion welding of rails by Alumino Thermic Process Reprint 2022 Para 4.8.1.1)
17	During fixing the moulds, it is ensured that the centre line of the rail gap coincides with the centre line of the mould to avoid cross joint. (**Ref:** Manual for Fusion welding of rails by Alumino Thermic Process Reprint 2022 Para 4.8.3)
18	No welding is carried out if it is raining. In case, the rains start while the joint is under execution, immediate arrangement to adequately cover the site is made. (**Ref:** Manual for Fusion welding of rails by Alumino Thermic Process Reprint 2022 Para 4.10.7)
19	Single Shot Crucible technique is used.
(i)	Cutting of weld is done by weld trimmer. (**Ref:** Manual for Fusion welding of rails by Alumino Thermic Process 2022 Para 4.10.5)
(ii)	Finishing of weld is done by profile grinder. (**Ref:** Manual for Fusion welding of rails by Alumino Thermic Process Reprint 2022 Para 5.4.1)
20	The first train is allowed to pass on the newly welded joint only after 30 minutes have elapsed since pouring of weld metal. (**Ref:** Manual for Fusion welding of rails by Alumino Thermic Process Reprint 2022 Para 5.3)
21	Finished joints are checked for geometry with tolerances: (i) measured on one metre straight edge: +1.0mm, -0.0mm for vertical alignment, +0.5mm for lateral alignment. (ii) measured on 10cm straight edge :+0.4 mm, -0.0mm for finishing of top surface, + 0.3 mm over gauge side of the rail head for head finishing on sides. (**Ref:** Manual for Fusion welding of rails by Alumino Thermic Process Reprint 2022 Para 5.4.2)
22	The details of geometry of each joint is jointly signed by the firm's and Railway's representative and kept as record. (**Ref:** Manual for Fusion welding of rails by Alumino Thermic Process Reprint 2022 Para 5.5)
23	Each joint is distinctively marked indicating month, year of welding, agency and welder/ supervisor identification code number (as appearing on his competency certificate) at non-gauge face side of A.T. weld on head. (**Ref:** Manual for Fusion welding of rails by Alumino Thermic Process Reprint 2022 Para 5.6.1)
24	Thermit Weld Register as per standard Proforma is maintained. (**Ref:** Manual for Fusion welding of rails by Alumino Thermic Process Reprint 2022 Para 5.6.2)

25	Painting of weld collar is done on all welds to protect them against corrosion immediately after the welding. (**Ref:** Manual for Fusion welding of rails by Alumino Thermic Process Reprint 2022 Para 5.7.1)
26	Welded joints are ultrasonically tested as per the provisions of 'Manual for Ultrasonic testing of rails and welds. (**Ref:** Manual for Fusion welding of rails by Alumino Thermic Process Reprint 2022 Para 6.3)
27	Defective welds found in ultrasonic testing are removed and necessary safety precautions taken. (**Ref:** Manual for Fusion welding of rails by Alumino Thermic Process Reprint 2022 Para 6.3.2)
28	Testing of AT welds (One out of every 100 joints selected at random within one month of welding and tested for Hardness, Transverse Load, Deflection test and Porosity as per Para 4.2 of IRS:T-19-2012) and such tests complies with laid down guidelines. (**Ref:** Manual for Fusion welding of rails by Alumino Thermic Process Reprint 2022)

1511 FLASH BUTT (FB) WELDING

Various pre-, during, and post-welding operations and testing of welds required to be carried out for the Flash Butt Welding of rails are given in the "Manual for Flash Butt Welding of Rails" (Reprint 2022) issued by RDSO. Specifications for stationary flash butt welding of rails are contained in the "Technical specification for stationary Flash Butt Welding plant and connected machines and accessories (NO. IRS-T-49-2019)" issued by RDSO.

RDSO has also issued Specification No. TM/HM/MFBWP/458 of 2019 named "Technical Specifications of Mobile Flash Butt Welding of Machine with Ability of Tension Welding of Rails for BG (1676mm)" **(Ref. 15.04)**, which shall be used for framing conditions for inviting tenders for Mobile Flash Butt Welding of Rails in addition to the detailed instructions contained in the "Manual for Mobile Flash Butt Welding of Rails (Reprint April 2022)".

The procedure for approval of QAP for mobile flash butt welding is given in Annexures X and XI of the 'Manual for Mobile Flash Butt Welding of Rails (Reprint, April 2022)'.

Quick checklist regarding FB welding is appended below:

SN	Item to be checked
1	Rails of the same section and metallurgy (same manufacturer also) are used for welding
2	Rail ends have been checked for Straightness on 1.5m scale and rail end geometry is within the specified tolerance specified (Refer para 3.4 of the "Manual for Flash Butt welding of rails" also called FB Manual)
3	Rail ends are within the permissible tolerance for the type of rail used (new/old) (Refer para 3 of "Manual for Flash Butt welding of rails")
4	End cleaning as well as cleaning of the Electrode contact area is done
5	Alignment of the rail head is proper (2-2.4mm higher at the end) when joint alignment checked with 1m straight edge just before welding.
6	Electrode surface are clean and reconditioned/replaced, if required

7	Stipulated oil and air pressure is available in the welding machine
8	Stripping/trimming of entire cross section is done by Automatic stripper
9	Approved RDSO welding parameters (as contained in approved QAP) have been chosen for the type of rail (90UTS/110UTS/HH rail) used.
9	Post weld controlled cooling is done for Head hardened or 110 UTS rails
10	Welded joint is checked for straightness and finishing on 1m and 10 cm straight edge and the values are within the specified tolerance. (**Refer** Annexure-IV to para 10.1 of the FB Manual).
11	Welded joint is USFD tested using normal, 70^0 and 45^0 probes
12	Numbering of each joint is done as per the numbering format (Refer para 9 of the FB Manual).
13	Testing of Sample Joints (Hardness test, Bend test, Macro examination test and if required Micro examination) is done in the approved testing lab as per the prescribed frequency (**Refer** para 10.2 of the FB Manual).
14	QAP is approved by RDSO for the plant under consideration
15	Welding Supervisor and the welding team is approved by CE (Construction)
16	Periodical Inspection of MFBW Plants by OEM or his authorized representative is done every two years or 20,000 joints (as prescribed by Original Equipment Manufacturer)
17	Audit of the Mobile FBW plant is done every year by CE(Construction)

1512 IN-SITU GLUED INSULATED RAIL JOINTS

G3(L) type of glued joints should be provided in LWR/CWR track as per track circuiting plan. G3(s) type of glued joints to be provided in SWR track. Use of prefabricated glued joints should be minimized and cast-in-situ glued joints should be adopted in general to minimize all in-situ joints. Glued joints should be fabricated as per 'Technical Specification for Re-Furbishing of Existing Glued Insulated Rail Joints and In-situ Fabrication of Glued Insulated Rail Joints (Provisional) January-2020'.

The end post thickness in Glued joint shall be 6mm. [ACS no.1 to manual for Insulated Rail Joints (First Reprint-2022) issued on 01.09.2023 **(Ref. 15.05)**].

Quick checklist regarding in-situ glued joint is appended below:

SN	Item to be checked
1	Materials for glued joints are procured from RDSO approved suppliers. (**Ref:** Para 1.1 of Manual for Glued Insulated Rail Joints, 2022)
2	One rail piece of 6m length has been used for fabricating one glued joints. (**Ref:** Para 2.1.2 of Manual for Glued Insulated Rail Joints, 2022)
3	Proper testing of glued joints has been made by manufacturer & inspecting official. (**Ref:** Para 2.4.2 (A) of Manual for Glued Insulated Rail Joints, 2022)
4	10 sleepers on both side of glued joints has been packed before laying of glued joints. (**Ref:** Para 4.1.2 of Manual for Glued Insulated Rail Joints, 2022)

5	ERC J clip and end cut liners have been provided at the glued joint or not. (**Ref:** Para 5.1.2 of Manual for Glued Insulated Rail Joints, 2022)
6	Speed restriction of 30 KMPH is imposed on running line before starting the work of inserting glued joints.
7	Minimum traffic block of 3 hours sanctioned for glued joints to be fabricated in running track. (**Ref:** Para 5.4 of Technical specification for re-furbishing of Existing Glued Insulated Joints & in-situ Fabrication of Glued Insulated Rail Joints(provisional Jan 2020)
8	Every fabricated/assembled joint is checked for vertical and lateral alignment with 1m straight edge and results are within following tolerances.
	a) Vertical alignment at end of straight edge: (+)1mm and (-0)mm
	b) Lateral alignment measured at centre of 1 m straight edge placed along gauge face (+) (-) 0.5 mm (**Ref:** Para 3.2.1 of Manual for Glued Insulated Rail Joints)
9	Insulation resistance of each joint is tested and the same is not less than 25 mega ohm when checked with meggering voltage of 100 V in dry condition. (**Ref:** Para 3.3 of Manual for Glued Insulated Rail Joints)
10	Pull out test has been done on a lot of every 50 glued joints and samples passed the test for load of 150 tonne and 175 tonne for 52kg and 60 kg rail respectively. (**Ref:** Para 3.4 of Manual for Glued Insulated Rail Joints)
11	Insulation resistance test in wet condition has been conducted. (**Ref:** Para 3.3 of Manual for Glued Insulated Rail Joints)

1513 RAIL PAINTING

Before taking up rail painting, all the relevant paras of IRPWM and latest instructions on the issue should be referred to & followed. Selecting & passing of paint confirming to latest instructions is foremost & important activity. It is to be ensured that preparation of rail surface is being done as per the latest instructions. Time gap between first and second coat of painting should be ensured and thickness of painting should be measured with approved type of elco-meter and should be recorded properly.

Quick checklist regarding Rail Painting is appended below:

SN	Item to be checked
1	Rail painting is done by using Anti corrosive black bituminous paint conforming to IS:9862. (**Ref:** Para 613 (2)(b)(iii) of IRPWM, 2020)
2	Preparation of rail surface is done by using hand operated or power operated tools i.e. scrappers, wire brushes, sand papers, pumice stone etc. (**Ref:** Para 613(2)(b)(ii) of IRPWM, 2020)
3	Surface preparation is not done when ambient temperature is below 10°C or above 50°C. (**Ref:** Para 613(2)(b)(ii) of IRPWM, 2020)
4	Surface preparation is not done in rainy season, during night, in winter before 08 A.M. (**Ref:** Para 613(2)(b)(ii) of IRPWM, 2020)

5	Surface preparation is not done in summer between 11 A.M. to 03 P.M. and in extremely windy/Misty/Dusty Condition. (**Ref:** Para 613(2)(b)(ii) of IRPWM, 2020)
6	Chemical is not used for surface preparation. (**Ref:** Para 613(2)(b)(ii) of IRPWM, 2020)
7	Rail painting is done in two coats of thickness 100 micron in each coat. (**Ref:** Para 613(2)(b)(ii) of IRPWM, 2020)
8	Minimum 8 hrs. elapsing period is given between 1st and 2nd coat of rail painting. (**Ref:** Para 613(2)(b)(ii) of IRPWM, 2020)
9	No thinner/external chemical etc. is mixed with Anti corrosive black bituminous paint in painting.
10	Thickness of painting is checked by approved type Elcometer?
11	If working in severe corrosion prone area, Zinc Aluminium Metallising of Rails (IRS:T-51) has been done or not. (**Ref:** Para 613(2)(b)(i) of IRPWM, 2020)
12	Whether anti-corrosive painting has been done in FB welding plant or not (**Ref:** Para 613(2)(b)(i) of IRPWM, 2020)

1514 P-WAY REGISTERS AND OTHER RECORDS

P.Way registers and other records should be maintained as per IRPWM and other instructions issued from time to time. Records should be maintained as per standard Proforma issued. Same are required for quality checks and as permanent records also for handing over the newly created assets to open line after commissioning. Check List of records/registers to be maintained is as under:

SN	Item to be checked
1	**Following Registers are prepared**
	· LWR/CWR/SWR Register
	· Welding Register (ATW, FBW)
	· Curve Register
	· Points and Crossing Register
	· Section Register
	· Rail/Weld failure Register
	· Level Crossing Register
	· USFD Register
	· Asset Register
	· Deep Cutting Register
	· Tunnel Inspection Register
	· Bridge inspection Register

	· The index plan Register
	· Land Boundary Register
	· Standard Measurement Book for Service buildings/Staff Quarter etc.
	· Infringement Register with details of condonation to the infringements.
	· Bad bank Register
	· Rivet (loose) Inspection Register/Camber Register.
	In addition to above following register shall also be prepared:
	· Ballast Cushion Register T.P. Wise
	· Destressing Register
	· Track Parameters Register
	· Sand Hump Inspection Register
	· Toe load Measurement Register
2	**Following Records (Plans/Drawing) are prepared**
	· The Index plan & "L" Section in tracing paper duly approved.
	· The certified land plans, land acquisition documents and compensation paid, Mutation etc.
	· P. Way Diagram
	· The original Completion drawing of all the bridges including road over bridges, road under bridges, pipe line crossings, buildings, station yard plans, Level crossings etc.
	· Colony layout plans.
	· The water supply arrangement details and plans for water supply distributor system
	· The details of water purification plant
	· List of section having ballast deficiency
	· History of major breaches, Cutting slips etc.
	· List of RATs with details/ History/ plans
	· Special feature like tilting of wells of major bridges, unusual phenomenon encountered while construction of new line etc.
	· CRS's sanctions.
	· Compliances of CRS observation at the time of opening.
	· List of Bridges.
	· List of Buildings.
	· List of Level crossings.
	· List of Bench marks
	· List of Completion drawings.
	· Approved Site Plan
	· Approved GAD.
	· Approved structural drawings.
3	**Following P-way documents are also prepared**

	· Ballast testing reports
	· U.S.F.D. testing report
	· Rail testing Certificate issued by RITES at the time of supply of new rails from BSP.
	· Welding (ATW/FBW) deflection, Metallurgical test report.

PART B
MECHANISATION IN TRACK LINKING IN CONSTRUCTION

1515 INTRODUCTION

Indian Railways is expanding its infrastructure for higher speeds and increased axle loads. For this Indian Railways is going in a big way for multitracking of existing lines, besides construction of new lines and gauge conversion. By mechanized method of construction, progress and quality of work can be improved. Some of the large machines being used for linking track are:

(1) New Track Construction (NTC) machines -To meet the challenges of faster pace of track linking on IR, NTC machines can be gainfully used in construction projects.

(2) Crawler Mounted Portal Cranes (e.g. QUBO TL) -Crawler Mounted Portal Cranes are also being used for laying the new track with long rail panels.

(3) Point and Crossing changing/laying machine (e.g. T-28) - It can be used for yard remodeling works during Pre-NI period when there is space and time constraint. Its use will facilitate faster and quality construction.

(4) Continuous Track Lifter (CTL) - It may be used to do the initial lifts required behind track construction. After unloading the ballast on track, it can provide a 100+ mm lift at 3-5 km/h.

(5) Rail Threader- It can also be used for Rail laying/ TRR works.

Similarly, there are many machines which can help in construction work and can be used for different activities involved during construction. This chapter discusses some of the machines available and being used world over for construction of formation and for laying of tracks.

1516 MACHINES FOR MISCELLANEOUS WORK AND BALLAST SPREADING

These machines are being used by construction organisation. Photographs are given below which themselves explain the working of these machines.

(1) Cranes with attachments for multipurpose Utilisation

Tree cutting attachment

Drilling attachment

Sleeper handling attachment

Lifting attachment

Lifting of slab

Tamping of Track

(2) Ballasting

Ballast distribution hopper

Bulldozer for spreading ballast

Grader for levelling of ballast

Rolling of ballast

1517 MACHINES FOR LAYING OF PLAIN TRACK

(1) New Track Construction (NTC) Machine –

NEW TRACK CONSTRUCTION MACHINE (NTC) by M/s Harsco Pvt Ltd, USA.

SVM-1000, SVM 1000CH from M/s Plasser and Theurer, Austria

Presently all track on DFCCIL in block sections are being laid with the above NTC Machines supplied by M/s Harsco and M/s Plasser and Theurer. In yards also, all lines are being laid with these machines. Connections from one line to another line for machine movement is given by temporary laying false alignment or by cut and connection method. Turnouts in Main lines and other lines are laid later by cutting the track and placing the pre- assembled turnouts.

(a) Advantages of Mechanized laying of Track with NTC machines

(i) Good quality track with desired track parameters like sleepers spacing, squaring and alignment of track.

(ii) Fast construction speed (Track linking of 1.5 km per day is possible).

(iii) Directly 260 m long rail panels laid at site.

(iv) Handling of new wider sleepers weighing about 350 kg will be easy.

(v) No manual packing of track; No sleeper damage.

(vi) Construction of Auxiliary track not required.

(vii) Minimum requirement of skilled and unskilled manpower.

(viii) No damage to prepared formation, sleepers and rails etc. during carting to site.

(ix) Less possibility of infringement of construction machinery with running track.

(b) Pre-requisites for NTC machines

(i) Continuity of offered formation from one end to another.

(ii) Requirement of space for depot working of about 500-600 m length and 50-60 m wide at a suitable place in between the project for stacking welded rail pannels and sleepers.

(iii) Requirement of long stretches for laying the track from economy point of view.

(2) Crawler Mounted Portal Cranes –

In some of the world Railways, crawler mounted portal cranes are also being used for laying the new track with long rail panels. One of the systems being used is QUBO TL (a smaller version of the T-28 machine) designed and developed by M/s COLMAR, Italy. This machine is a compact, small and versatile machine and can move on crawlers and no auxiliary track is required for it. Hence, it can lay the new track in a mechanized manner at a competitive cost and it can also be used for track renewal in open line. This machine has high output of up to 1.0 kms per day for new track construction, based on material availability and site conditions.

Crawler Mounted Portal Cranes seems to be more useful for construction projects of Indian Railways and can be used in small projects also. NTC machine has more scope in large construction projects.

1518 MACHINES FOR LAYING OF POINTS AND CROSSING

(1) T-28 Machine for laying of Points and Crossings

Working of this machine has been described in IRTMM-2019. This is very useful in yard remodeling works during Pre-NI/NI, when there is space and time constraint. In this method, turnout is assembled outside the track at suitable location where there is enough space for linking of whole PSC turnout and during block period, it is laid after dismantling the existing track. Its use will facilitate faster and quality construction as manual insertion is time consuming, more labor oriented and quality of work is also not good. At major junction yards where large no. of turnouts is to be laid in Pre-NI/NI period, this machine can be effectively used.

(2) Other machines used for laying Points and Crossing world over

PEM and LEM by Geismar

TLPS6500, Viacar

Desec Track Layer

Most of these points and crossing laying machines can be used for plain track laying also.

1519 OTHER USEFUL MACHINES FOR TRACK LINKING WORK

(1) Continuous Track Lifter

Continuous Track Lifter (CTL) completes the initial lifts required behind track construction, ballast cleaning, and track renewal operations. After the track is flooded with fresh ballast the CTL can provide a 100+ mm lift at 3-5 km/h. A chain drawn below the sleepers distributes the ballast across the sleeper beds and cribs. This low maintenance machine is typically towed behind the last ballast wagon to complete the initial lift immediately behind the ballast train.

This machine can be very useful for lifting the track after laying with NTC Machine or with Crawler Mounted Portal Crane to give required cushion, otherwise, ballast attrition takes place due to each round of extra machine tamping, for raising the track, for providing required ballast cushion.

(2) Hydraulic Track Lifting and Slewing device –

It is a very useful machine for initial level and Alignment correction of the newly laid track. The track is brought to a position where it can be corrected to correct profile by tamping machines in one to two rounds of tamping.

Hydraulic track lifting and slewing device

(3) Rail Threader

Rail Threader can be used in construction projects for lifting the long rail panels from either side of the track onto the sleepers and positioning them and laying into the track. It can also remove old second-hand rails and renew it with new long rail panels. Rail Threader of different makes like Geismar, Robel etc. are available. It minimizes the operational costs as it is operated by a single worker. The machine can position up to 2 long welded rails simultaneously. It can also slew the alignment of track if track is unballasted. It is self-propelled and can off-track without additional lifting equipment.

It has lifting force of 4.5 T and output is 800 m per hour. Its weight is about 1100 kg. Travels by means of hydraulic engines which allow excellent rail laying output even in steep gradient or cant conditions.

Rail Threader

1520 SMALL TRACK MACHINES USEFUL FOR TRACK LINKING

There are various small track machines which can improve the progress and quality of work. Some of the very useful machines for track linking is shown below. Working of most of these machines are given in Small Track Machine Manual.

(1) Rail drilling machines

Main features of this machine are-

- Core drilling technology
- For all rail web drillings in the signalling and track construction sector
- Manual feed
- Drilling time approx. 60 seconds depending on diameter and rail profile
- Approx. 40 bores per drill bit

Rail Drilling Machine – Core cutting type

- Quick and short drilling time
- Compact + robust
- Safe and easy to use
- Instantly ready to use
- Emission-free and quiet
- No cables

Battery operated drilling machine

(2) Abrasive Rail cutting machine

This machine is used to quickly cut all types of rail, including wear-resistant, head-hardened, and high UTS rails (up to 1175 HT), which saves time while working under Engineering or traffic block. The machine comprises a petrol-driven engine integrated with a cutting unit fitted with an abrasive disc. The approximate time required for various types of rails is given below:

Rail Type	Cutting time in minutes (Recommended)
1175 HT rails	6
60 Kg/m, 90 UTS/110 UTS rails	5

(3) Rail Profile Weld grinder –

It is used for grinding A.T. welded joints after the weld trimming operation is complete to provide the correct profile on the top and both sides of the rail head.

(4) Weld Trimmer and Transporting Device –

A weld trimmer is used for trimming extra weld metal from the rail (top and sides) of an AT welded rail joint after the welding operation. This machine removes the excess weld metal uniformly from the top and sides of the rail head without giving any jerk or shock to the weld while working either by hand pump or motor-driven hydraulic pump fitted with a diesel/ petrol engine.

Transporting device such as the one shown below can be used for quickly transporting welding material along the track during block work.

Weld Trimmer

Transporting Device

(5) Track Parameter measuring trolley

The main features of this machine are-

Track parameter measuring trolley

- Compact device
- Measurement of the rail track geometry (level, track gauge, horizontal and vertical deflection of track.)
- Real time data transmission using satellite navigation system.

1521 ON TRACK MACHINES

Following heavy track machines are required to work at construction site after laying of track. For proper working of these machines, welding manual and IRTMM-2019 may be referred.

1) Flash Butt Welding Plant – A mobile flash butt welding plant can be used to do in-situ welding for the conversion of free rails or 260m rails into longer rail panels to form LWR and also for welding joints in points and crossing area.

Flash Butt Welding Plant (Rail Cum Road Vehicle) **Flash Butt Welding Plant (Rail Borne)**

2) **Tamping and other associated machines-** The tamping machines, like Duomatic, CSM, Tamping Express, etc., are used for the tamping of plain tracks, while points and crossing tamping machines (such as UNIMAT) are used for the tamping of turnouts. They are generally required for bringing the track to the designed track geometry. The items to be checked while working with these machines are given under para 1505. In order to retain the track geometry achieved during tamping operations for a longer duration, Dynamic track stabilizer is used immediately behind the tamping machine. Ballast Regulating machine(BRM) is used for ballast transfer, spreading, and profiling operations. The machine can move ballast towards the center of the track or away from the center of the track, transfer ballast across the track, and transfer ballast from a surplus zone to a deficient zone. This machine can operate in both directions.

Plain Track Tamping Machine

Points and Crossing Tamping Machine e.g. UNIMAT

Dynamic Track Stabiliser

Ballast Regulating Machine (BRM)

The final tamping with Tamping machine should be in 3 Point Design mode to achieve the designed profile. The Dynamic Track Stabiliser (DTS) should be used initially in maximum settlement mode and then with last tamping in controlled settlement mode.

Annexure 15A

Method Statement:

The contractor should identify the various major activities required for successful completion of the work and submit the method statement for each major activity before start of activity for approval of Railway. The method statement shall be submitted activity wise and should broadly contain the following:

1. Purpose
2. Scope
3. List of references used for preparation of method statement and that required during execution of activity.
4. The responsibilities of its staff involved in execution.
5. The detailed methodology of execution for the activity including its sub activities step by step along with sketches/drawings/photographs/other relevant details, as required.
6. List of various equipment/tools/ plants, their capacity and numbers required
7. List of technical persons to be deployed for supervision.
8. List of type of other staff along with their numbers.
9. Tests required/to be carried out, if any, before start of activity, during activities or after completion of activity, if any, duly referring to various IS, IRS, IRC, other codes as applicable along with acceptance criteria for various tests.
10. Quality Assurance Plan with Quality Control measures.
11. Various Performa's required for recording of data/ tests results/observations during the activity for ensuring proper Quality Control.
12. Check list to be observed at various stages of activity as applicable.
13. Safety measures to be adopted at site
14. Any other details as considered necessary for specific activity.

Contractor should submit method statement well in advance of likely start of activity. Contractor shall not have any claim for extension of time of completion due to delay in approval of method statement.

Annexure 15B

Final Track Geometry Attainment

1. Setting up base station either by Taking observations with DGPS (Differential Global Positioning System) for 48 hrs. or
2. Connecting the base station with the CORS (Continuously Operating Reference Station) of the Survey of India Connecting to the nearest Ground Control Point (GCP) of the Survey of India
3. Setting control points –
   - Primary control points – 10-20 km
   - Secondary control points – 1-2 km (By triangulation by Total Station)
   - Tertiary control points – 150 -200m (OHE mast Foundation) (By triangulation by Total Station)

     Taking centre line coordinates of Laid track either by Total Station or Track Geometry measuring Trolleys (Trimble/Amberg etc.)
4. Transferring centre line alignment data to regression software i.e. Bentley Open Rail, Civil 3D, GEDO etc.
5. Designing best fit alignment and vertical profile which solves the needs of high speed and high accuracy
6. Comparing existing centre line coordinates with designed alignment and profile coordinates and get slews (FD) and lift (Y) value for tamping machine.
7. Transferring Slew (FD) & lift (Y) values in ALC of tamping machine
8. Before tamping synchronise tamping machine at known chainage or opposite one of the tertiary control points.
9. Doing 1st round of tamping.
10. Taking centre line alignment /profile data by doing centre line coordinate survey again.
11. Comparing this alignment and profile with design alignment and get slews (FD) and lift (Y) values.
12. Doing second round of tamping after transferring slew (FD) and lift (Y) values to ALC of tamping machine duly synchronizing tamping machine
13. Repeating steps 4-9 in and do 3rd round tamping, if required.
14. Taking centre line coordinates again and compare with design alignment (difference should be within acceptable limit).
15. Taking as built alignment for reference and record.

Reference Document

SN	Para No	Ref. document details	
1	1502	15.01	Railway Board letter No. 2019/W-1/Genl./P. Way/2019-20 dated 12.06.2019
2	1506	15.02	RDSO letter No. CT/PTX/TWS/Design dated 06.07.2023 with subject 'Laying of Thick Web Switches on Curved Track -Instructions regarding Pre-curving.'
3	1510	15.03	Railway Board letter No. Track/21/2005/0110/AT Welding dated 16.08.2019
4	1511	15.04	Specification No. TM/HM/MFBWP/458 of 2019 named as "Technical Specifications of Mobile Flash Butt Welding of machine with ability of Tension welding of Rails for BG (1676mm)
5	1512	15.05	ACS no.1 to Manual for Insulated Rail Joints (First Reprint – 2022) issued on 15.09.2023)

***

CHAPTER 16
SIGNALLING WORKS

1601 UTILITY SHIFTING INVOLVING S&T IN CONSTRUCTION PROJECTS

(1) The track layout plan must be studied in consultation with the Engineering department to understand the route map of the proposed line.

(2) Cable laying Drawings of the existing cables (S&T) of running circuits should be taken from the open line.

(3) Joint Survey (Supervisory or JS officer level) S&T/OL,S&T/C and Engineering/C on foot with a cable route scanner should be carried out to verify the cable route plans physically and find out the patches that are in infringement of the route map.

(4) The Cable route zone identified through a scanner or as per approved plans for existing cable shall be marked (white chalk or lime) on site by the agency, in the presence of open line staff before the start of excavation or digging work.

(5) Alternative places to lay or shift cables/location boxes to be demarcated by the agency under the guidance of S&T/C, S&T/OL and Engineering open line/construction organization.

(6) The Availability of adequate space is crucial and, hence must be clearly identified beforehand.

(7) All cables must be tested in collaboration with the maintenance organization's supervisor.

(8) Before beginning work on an encumbrance-free site, utility shifting must be ensured.

1602 POWER SUPPLY

(Refer to IRSEM Chapter 16: Power Supply Systems for Signalling Installations.)

(1) Power Supply General

Power supply for different types of Signalling installations shall be in accordance with policy approved by the Principal Chief Signal and Telecommunication Engineer of Railway if the standard power supply scheme from the Railway Board or RDSO is unsuitable for a specific application.

(a) At all locations, secondary batteries of appropriate capacity shall be provided for Signalling circuits.

(b) The Normal power supply for Signalling installations shall be 230 V AC (single phase) or 415 V AC (three phase). Any other supply may be used with the specific approval of the Chief Signal and Telecommunication Engineer in charge of the work.

(c) The Power supply system shall be such that fixed stop signals for approaching trains do not become blank when the main power supply source fails.

(d) A Power supply system with secondary batteries of approved type and adequate capacity shall be used for Signalling applications.

(2) Sources of Power Supply

(a) Railway Electrified Area

(i) Electric supply for Signalling and telecommunication installations in RE areas shall normally be provided through Auxiliary Transformers (ATs) of suitable capacity by

tapping 25 KV OHE.

(ii) On double or multi-line sections, the power supply shall be drawn from 25 KV OHE through ATs provided on up and down OHE lines separately. It shall be ensured that supply from at least one AT is available in the event of a power block.

(iii) On single-line section where power supply is drawn from a single AT, a DG set of suitable capacity shall be installed.

(iv) At stations where local power supply is also available, it shall act as a stand-by source of power supply.

(v) In big yards, DG sets of adequate capacity shall be installed in addition to supplies from ATs and local sources.

(vi) The power supply from Auxiliary Transformers (ATs), local sources and DG sets shall be brought and terminated at a power supply control panel in ASM's office or cabin or at the LC gate / IBS/auto huts as required. The power supply control panel shall be provided with the facilities for automatic changeover between source supplies. In addition, manual changeover facilities shall also be provided in the control panel. The power supply control panel, in-coming cable (other than from the DG set), and other associated arrangements shall be provided and maintained by the Electrical department.

(vii) The supply from the power supply control panel as provided by the Electrical Dept. shall be taken to various S&T locations by the S&T Dept. The supply from the power supply control panel shall be extended through separate MCBs to cabins, LC gates, telecom installations etc. For locations that are two kilometers or beyond, a separate set of ATs and power supply control panels shall be provided.

(viii) In the case of IB Signals a separate set of ATs shall be provided, with an automatic change-over switch. Note: Refer to Paragraph No. 20713 of ACTM Volume-II, Chapter-VII.

(ix) DG sets, where installed, shall be provided with a push button start/stop facility. As per site requirements and feasibility, it will also be possible to operate remotely.

(b) Non-Railway Electrified Area

(i) For Colour Light Signalling (CLS) installations, local power supply shall be used as the main source of supply. In addition, two standby diesel generators will be installed. These generators shall be of standard make and have adequate capacity for reliable and trouble-free service.

(ii) The output supply of these generators, along with local supply shall be brought to the ASM office and connected with auto/manual change-over panel compatible to RE.

(iii) Solar Photo Voltaic System/Solar Panels (approved type) may also be used as power supply at wayside stations and LC gates in those areas that have sufficient sun light and are not theft-prone.

(iv) A solar panel consists of a number of modules (typically 12 V each) that are connected in series and parallel configurations to provide a specific voltage and current to charge a battery bank, which in turn supplies the necessary power supply

for Signalling and telecommunication applications.

(v) They may be used to charge a battery bank of integrated power supplies or may be used for signal lighting by using inverters. The number of solar panels to be installed, shall be decided based on the requirements of charging current and voltage.

1603 CABLE LAYING WORK

(1) Cable Laying in New Projects

Railway Board letter No. 2022/GS/IR/Cable Laying Policy dated 29.03.2023 **(Ref. 16.01)**

(a) Cables shall be laid as per the approved plan or GAD in pre-fabricated or precast ducts close to track on both sides at a suitable location. However, in block sections, the duct shall be laid beyond the embankment unless unavoidable.

(b) The path of the duct shall be kept parallel to the track alignment, and any zig-zag path of duct shall be avoided.

(c) Duct and chamber work shall be done under the supervision of Engineering Department.

(d) Laying of cables in all works shall be done by the S&T Department.

(e) In cases where a duct and chamber is constructed in an engineering contract, the duct and chamber constructed shall be handed over to S&T after joint inspection confirming quality and alignment.

(f) Routine maintenance of ducts and chambers shall be done by S&T Department. However, any major repair or replacement activity of duct and chamber shall be done under the supervision of Engineering Department.

(g) The duct and chamber shall be laid after the surface has been properly leveled.

(h) The ducts and chambers shall be as per following norms:

(i) The Inner dimension of duct shall normally be kept at 300 mm x 300 mm. The top of the duct cover shall normally be 300 mm below the surface of soil.

(ii) At suitable intervals, not more than 500 m along the duct and at each location of track crossing, a chamber shall be provided with a lid & locking arrangement.

(iii) The size of the chamber shall preferably be 1200 mm x 1200 mm x 1500 mm (depth). Further, proper arrangements should be made so that there is no water logging in the duct and chamber.

(iv) TheChamber cover shall normally be kept 100 mm below the surface of soil. In theft-prone areas, depth of chamber cover can be increased depending on the local conditions.

(v) If there are more numbers of cables to be laid in large yards, then more than one ducts may be placed side by side based on the requirement of S&T department.

(i) Provision for cable duct shall invariably be made in the GAD for all platforms, stations, culverts and bridges. No drawing for stations or bridges shall be approved without the provision of cable duct.

(j) In places where laying of cable duct is not possible due to site conditions, cable shall preferably be laid by HDD method or other suitable method.

(k) The following may normally be ensured while laying cables:

(i) Cables may be tied together at every 50m or so by suitable tie or GPS tape after laying and before closing the cable duct.

(ii) Entry and exit of cable in the chamber shall be properly sealed to avoid theft and entry of rodents. Sealing through bitumen or suitable compound can be done at the entry & exit of cable chamber to arrest cable theft.

(iii) Partial sand filling of the duct after cable laying may be considered to deter theft.

(iv) RFID markers or GPS tapes shall be provided along with the cables in the duct at regular intervals as per requirement and at every diversion to ensure identification of the cable route.

(v) GIS mapping of the entire duct shall be made available to all concerned stakeholders.

(vi) Cable route markers, wherever provided above the ground, shall be of concrete.

(vii) The Cable at the track crossing and road crossing shall be laid in HDPE pipe or concrete duct of specified or approved cross section and strength.

(viii) In the station section, the location box shall normally be kept on or adjacent to the duct route.

(l) For extending the cable for derivation at location box, signals, LC gates, SSP, SP etc. ducts of 300mm x 100 mm or HDPE pipe of specified diameter shall be used.

(m) HDPE pipe may also be laid in the duct to blow OFC in future, where ever considered necessary.

(n) All entry points of cable in the building must be secured through suitable measures.

(o) Zonal Railway shall finalize drawings for cable duct as per the above guidelines and site requirements. Specifications for pre-fabricated or precast ducts and chambers shall be issued by RDSO in accordance with these guidelines, ensuring adequate strength, no waterlogging, safety of cables from rodents and fire, durability, maintainability etc.

(p) The Digital Integrated Signalling and Telecom Cable route shall be prepared and made available online by Zonal Railways over Railnet.

(q) After the availability of online integrated S&T cable route plans, the same shall be uploaded as a utility layer on the PM Gati Shakti BISAG portal.

(r) Additional steps for the protection of cables in new projects:

Existing cables shall be protected as per the latest directions, policies, and JPO issued by the Railway Board. In addition, the following precautions shall be taken in new projects:

(i) The Executing agency for works shall survey the route along with open line using a cable route tracer (Scanner metal detector) to identify the existing functional cables enroute in the section. Necessary provisions may be made in the contract if needed.

(ii) The Cable route zone identified through a scanner or as per approved plans for existing cable shall be marked (white chalk or lime) on site by the executing agency in the presence of open-line staff before the start of excavation or digging work.

(2) Cable Laying Work- For ongoing works where there is no provision of ducts

(a) Cables should be laid underground, either directly in the trench, in ducts, in cement troughs, or in pipes as per the IRSEM chapter15 para 15.2.3. RB's letter no. 2003/Tele/RCIL/1 Pt IX dt 24.6.13 **(Ref. 16.02)**.

(b) Cables shall be laid generally as per instructions given in IRSEM Chapter 15. However, special precautions to be taken in the station yards etc., where a number of other utilities may exist which may be detailed in a joint circular issued by the Civil Engineering, Signalling and Electrical Departments (where applicable) of the Railway.

(c) The main cable laid parallel to the track shall normally be buried at a depth of 1.0 meters from the top of the cables to ground level, including those laid across the track (1.0 meters below the rail flanges). The depth shall not be less than 0.50 meters for tail cables. In theft-prone areas, the cables may be laid at a depth of 1.2 meters with anchoring at every 10 meters.

(d) Half- cut DWC-HDPE pipe, RCC or any other approved type of ducts or pipes shall be used while laying the cable to protect it.

(e) The ducts being used shall be of such design and length as to prevent or minimise damage to the cable from any other future digging activities in the vicinity. The ducts shall have suitable covers to prevent water collection in the duct.

(f) When cables are to be laid in a rocky area where a depth of 1.0m is not feasible, it is desirable that such cables are protected as shown in Drg.No:15-D2.IRSEM appendix-II

(g) Cables belonging to other departments must not be laid in the same trench along with Signal & Telecommunication cables.

  (i) A distance of approximately 10 cm must be maintained between cables from other department and Signalling cables.

  (ii) The Signalling cables must be separated from LT power cables by a row of bricks or any other approved means, and from HT power cables, a minimum of 3 meters of separation shall be maintained.

(h) Where several cables of different categories have to be laid in the same trench, they shall be placed as far as possible in the following order, starting from the main track side, so that in the event of failures, the maintenance staff may easily recognize the damaged cables.

  (i) Telecommunication cable

  (ii) Signalling cable

  (iii) Power cable

(i) Signalling cables for outdoor circuits should not normally be laid above ground. In exceptional cases where it becomes unavoidable, the following precautions should be taken.

  (i) The cable should be suspended in wooden cleats, from cable hangers or in any other approved manner so that no mechanical damage occurs to the cable even under exposed conditions.

  (ii) The cable supports shall be so spaced as to avoid sagging.

  (iii) In station yards, cable shall be laid in ducts suitably protected.

  (iv) IndoorSignalling cable should normally be laid on ladders, channels or in any other approved manner. The cables should be neatly tied or laced.

  Note: For laying cables in the RE area, refer to Section 3 of IRSEM Chapter 15.

(j) Where it is necessary to take the cable between the tracks, it shall be carried in trunking, Duct, or pipe kept sufficiently below the ballast level.

(k) While laying the cables in accordance with the above instructions, the following instructions should be adhered to:

  (i) Outside the station section, the cables should generally be laid at not less than 5.5 meters from the center of the nearest track.

  (ii) Within the station section, the trenches shall preferably be dug at a distance of not less than 3 meters from the center of the track, the width of the trench being outside the 3 meter distance.

  (iii) At each end of the main cable, an extra loop length of 6 to 8 meters should be kept.

(l) After laying the cables, backfilling of the trenches should be done properly. The soil excavated shall be put back in the trench, rammed and consolidated.

(m) Cable joints of the approved type shall be used.

(n) Cable markers of approved type shall be provided, which should be placed at suitable intervals and at diversion points to mark the route.

(o) Where the cables are entering the Cable room, Relay room, apparatus case etc., the cables shall be firmly held with a suitable clamping arrangement so as to avoid downward displacement. Suitable ducts, ladder supports, cable guides, etc. shall be provided for the cables inside the cable room or Relay room. Sharp cable bends shall be avoided.

1604 AUTOMATIC SIGNALLING WORKS ON INDIAN RAILWAYS

Please refer to Railway Board letter No.2021/SIG/WP/Targets, dated 15.07.2022 **(Ref. 16.03)**. To execute ABS works the following shall be adopted:

(a) A Change in the Engineering Scale Plan (ESP) shall not be allowed for Automatic Signalling works and Signal Interlocking Plan (SIP) for ABS works will be finalised with existing yard layouts.

(b) The Requirement of cables and auto-huts should be optimized. Cable laying, being a critical activity, should be mechanized, and HDD should be used at difficult locations.

(c) Timely completion of civil structures, viz., auto huts, goomties, and relay huts needs to be ensured, if necessary, by adopting the latest construction technologies. Necessary officials like AENs and JE/SSE (Works) shall be deployed for timely construction of goomties.

(d) Provision of AT supply in all auto hut and goomties may be ensured as per requirement of the Project incharge. A necessary official from Electrical/TRD shall be deployed for this purpose.

1605 ELECTRONIC INTERLOCKING (Refer to IRSEM Chapter 21: Relay and Electronic Interlocking)

(1) As per the Railway Board's policy, provision of EI should be made in all works as per the Railway Board's letter No. 2003//Sig/G/5 dated 28.04.2016 **(Ref. 16.04)**. Centralized or Distributed EI shall be provided as per letter No. 2021/Sig/25-Conf/5/SSC dated 26.02.21 based on the number of the routes, physical layout of yard, complexity of the yard involved, the maintainability aspect, etc. **(Ref. 16.05)** Further relay interlocking estimates may be revised for the provision of EI without causing material modification as per Railway Board letter No. 2008/SIG/SGF/4EI/Genl dated 05.07.2011 **(Ref. 16.06)**.

(2) The Railway Board, vide letter No. 2018/Sig/36-SD-1 dated 26.08.2022 **(Ref. 16.07)** has also issued a standard circuit for EI for stations up to 100 routes and has instructed the implementation of the same for future EI up to 100 routes. The standard circuit (i.e., logic and interface) is available at the RailNet website:

http://10.100.2.19/signal/policy/uniform_circuit_diagram.html

(3) All EI shall be provided with a dual VDU.

(4) Inputs required for Electronic Interlocking installation:

(a) Approved Signal Interlocking Plan

(b) Approved Panel Diagram

(c) Approved Route Control Chart/Selection Table

(d) Communication diagram between systems and other consoles

(e) Relay and SM Room Building Layout

(f) Power Supply Scheme for EI Systems and Interlocking equipment.

(g) Cabin-wise Signalling gear segregation in the case of distributed interlocking architecture.

(h) Details of any additional interlocking equipment to be interfaced with the EI system.

(5) There are two RDSO specifications available for Electronic Interlocking

(a) RDSO/SPN/192/2019 Ver 2.0 **(Ref. 16.08)**

(b) RDSO/SPN/203/2011 Ver 1.0 (Only applicable for Big yards) **(Ref. 16.09)**

(6) Following policy circulars, guidelines, and advisory notes issued from Railway Board, RDSO from time to time as stated below may be referred during execution of projects.

SN	Subject	Letter/Circular No.	Date
1.	Centralized and Distributed Architecture of Electronic Interlocking. **(Ref. 16.10)**	RDSO Document No. STS/E/TAN/3008 ver 1.0	31.03.2013
2.	Cyber Security aspects of Electronic Interlocking system. **(Ref. 16.11)**	RDSO Ref no EI/TAN/ SecurityVersion1.0	01.03.2023
3.	Technical Advisory Note (TAN) No. STS/E/ TAN/3012 version 3.0 for Guidelines regarding Technical System Application Approval for Electronic Interlocking Installation **(Ref. 16.12)**	RDSO Ref no STS/E/TAN /3012 Ver 3.0	28.06.2021
4.	Correction in Technical Advisory Note no. 3012 version 3.0 **(Ref. 16.13)**	RDSO-SIG0EI (GEN) /1/ 2020	11.07.2022
5.	Corrigendum of Technical Advisory Note No. 3012 Version 3.0 **(Ref. 16.14)**	RDSO-SIG0EI (GEN) /1/ 2020	03.11.2022
6.	Guidelines for implementation of block working built in to electronic interlocking (with same manufacturer) **(Ref. 16.15)**	RDSO Ref no TN/3013 Version1.0	28.10.2020
7.	Guidelines for implementation of block working built in to electronic interlocking (with same manufacturer) for single line. **(Ref. 16.16)**	RDSO Ref no TN/3014 Version1.0	24.06.2021

8.	Use of Embedded PC and Earthing for Electronic Interlocking (EI) **(Ref. 16.17)**	RDSO Ref no STS/E/ TAN/3007 Ver 1.0	02.11.2012
9.	Revised Checklist for Technical System Application Approval of Electronic Interlocking. **(Ref. 16.18)**	RDSO Ref no STS/L/SSI/ general/160	07.12.2018
10.	Procedure for FAT/SAT of Electronic Interlocking **(Ref. 16.19)**	No. 2017/Sig/3/85th SSC	04.12.2018
11.	EI check list **(Ref. 16.20)**	No. STS/L/SSI	09.05.2012
12.	Modification/Alteration in Electronic Interlocking (Manufactured by M/s Ansaldo make) **(Ref. 16.21)**	RDSO Ref no STS/E/ TAN/3009 Ver 1.0	09.06.2014
13.	Guideline regarding minor modifications/ alterations in the application software of Medha Electronic interlocking (MEI) **(Ref. 16.22)**	RDSO Ref no STS/E/ TAN/3010 Ver 1.0	05.08.2014
14.	Guidelines regarding minor modifications/ alteration in the application logic of VLM6 Electronic Interlocking (EI) of M/s Siemens Rail Automation Pvt. Ltd. **(Ref. 16.23)**	RDSO Ref no STS/E/ TAN/3011 Ver 1.0	14.08.2014
15.	Use of hot stand by architecture for Electronic interlocking **(Ref. 16.24)**	RDSO Ref no STS/E/ TAN/3004 Ver 1.0	13.06.2012
16.	Report for standardization of Typical Circuits for EI- (Report SS 155 2019 VER 2 Dt 29-03-2022) **(Ref. 16.25)**	WCR/N-HQ/110/Rly. Bd'sCorresp./Sig-25 Pt-VIII	29.03.2022

Note:- Above list is not exhaustive and the latest related RDSO circulars, guidelines and advisory notes shall be followed.

(7) Installation of Electronic Interlocking.

(a) Installation of Electronic Interlocking system shall be done as per approved guidelines and technical advisory notes issued from time to time.

(b) Application logic (the site specific logic) shall be verified for safety and functionality by carrying out exhaustive safety and functionality tests by officers authorized by PCSTE.

(c) Only approved application logic with a specified checksum shall be used in the E.I. system, and this data and checksum shall be version controlled and preserved by the Railways.

(d) Electronic Interlocking is required to be provided in dust proof cabinets of approved type having transparent front door.

(e) Interface Relays, where provided, shall be of approved type, and contacts should be paralleled as far as possible for better reliability.

(f) Wherever possible, the spare input/outputs shall also be wired from E.I. cards up to terminals for ease of carrying out future alterations.

(g) The inputs and outputs cables of E.I. shall be twisted to minimize the EMI and EMC effects.

(h) Electronic Interlocking system shall be installed closer to operator room, preferably an

adjacent room. Track crossings should be avoided between the main E.I. system and the operator room.

(i) The Electronic Interlocking room shall be provided with tiles or similar arrangements on the floor and the walls to avoid periodic painting of walls and resultant dust.

(j) FRP, or insulated ladder arrangement shall be used to carry wires from rack to rack or from other equipment.

(k) All entries to Electronic Interlocking room shall be suitably sealed to prevent the entry of rodents, lizards, insects, etc.

(l) Electrostatic floor pads and hand bands shall be provided near electronic equipment to prevent damage to electronic equipment due to electrostatic discharges.

(m) The room where Electronic Interlocking is installed shall be provided with air-conditioning.

(n) The building or room where E.I. is installed shall be protected by external lightning protection arrangement at the top of building. If there is any other metallic earthed structure is available nearby which protects the E.I. building, then separate Class A at the top of E.I. room is not required. The guidelines in the National Building Code of India (2016 or latest) shall be followed for calculations.

(o) Surge and lightning protection devices of appropriate class and rating shall be provided for the regulated power lines before extending them to the Electronic Equipment Room. All equipment in the Electronic Equipment Room shall derive power from these regulated and protected power lines (clean), but not from electrical service lines (dirty) used for room lighting, airconditioning or fans.

(p) Clean and dirty wiring shall be clearly segregated and routed in different enclosures or ladders, and where this is not feasible, a minimum distance of 150mm between clean and dirty wiring shall be maintained.

(q) If clean and dirty wiring need to cross at any place, then the wiring should be arranged at perpendicular to each other.

(r) Indicative-type surge protection devices of appropriate class and rating shall be installed for all copper-based external interface, ports (power, communication, maintenance terminal, control panel interface etc.).

(s) The connectivity between E.I and sub-systems like Control Terminal, Control Panel, and Object Controller shall be planned with OFC cable to avoid damage due to surges and lightning. The OFC shall be provided in a redundant manner to avoid failure due to a cut or damage in one location or path.

(8) Testing of Electronic Interlocking

(a) For Electronic Interlocking, the integrity of the interlocking inside E.I. designed for a specific station can be tested at the factory, which is termed as Factory Acceptance Test (FAT). The interlocking when this is installed at the site and interface wiring is connected, then the test is carried out as laid down for relay interlocking; it is termed as Site Acceptance Test (SAT).

(b) Tests to be performed during FAT: FAT testing is performed with the computer simulation. Only the testing of interlocking on application software with reduced time as per SIP and RCC is performed during this stage. Interface with an I/O card, intercommunication is not

checked as E.I. hardware is not used in FAT. Hence, the following tests are to be usually done during FAT (computer simulation), besides any other tests as required:

(i) Control Table (including negative testing).

(ii) Cross Table (also known as Square Sheet Testing).

(c) Tests to be performed in SAT (for new installations): In SAT, similar testing is being performed at site with E.I. hardware and a simulation panel in the first stage. The correspondence and Interface testing are also performed after the interface with field gears. Any other test may also be conducted as required.

(i) Logic and interlocking testing: control table (including negative testing). Cross Table (square sheet).

(ii) Interface and Equipment Functional Test: Intercommunication test between Sub-racks, Correspondence Test

(d) Tests to be performed in the SAT (for alteration works) :

(i) When the existing ports (I/O and communication) are not disturbed, the following tests, besides FAT and any other tests as required, are to be done:

a. Logic and interlocking testing control table to the extent as decided by the Zonal Railway

b. Interface and Equipment Functional Test:

Correspondence test (new additions) Intercommunication test between sub-racks (if any new additions)

(ii) When the existing ports (I/O and communication) are disturbed, the following tests, besides FAT and any other tests as required, are to be done:

a. I/O port correspondence check between application logic and interface circuits

b. Logic and interlocking testing control table to the extent as decided by the Zonal Railway

Interface and Equipment Functional Test: Correspondence Test (New additions) Intercommunication test between sub-racks (if any new additions)

Note: (i) FAT should preferably be conducted at factory premises. However, FAT can also be done at railway premises at central location but not at the site. For this, the setup should be made by all the Zonal Railways.

(ii) FAT and SAT should be done by separate officials wherever feasible.

(9) Technical System Application Approval (TSAA) for EI Installation

Technical System Application Approval should be obtained for EI works as instructed in Railway Board Letter No. 2012/Sig/ATSS/Pt dated 28.02.2023 **(Ref. 16.26)**. The checklist issued by RDSO via letter No. STS/L/SSI/general/160 dated 07.12.2018 **(Ref. 16.18)** is to be submitted for TSAA approval.

(10) Commissioning of Electronic Interlocking: (Refer to IRSEM Chapter 21, paragraph 21.5.5)

(1) Once the indoor wiring works are completed before conducting the system integrity testing, a simulation test shall be conducted by simulating field gears such as Track circuits, signals & points on a simulation panel and with errors removed. This will ensure the correctness of indoor wiring before connecting to outdoor gears. As per Para 19.8.6

of IRSEM.

(2) Testing of wiring and Commissioning shall be done as per Para 19.8.5 to 19.8.12 of the IRSEM.

(3) A Recommended check list of items for commissioning is given in Annexure 21-A2 of the IRSEM. This list may be suitably modified as needed.

1606 LIGHTNING AND SURGE PROTECTION FOR SIGNALLING EQUIPMENT

(Refer to IRSEM Chapter 21, paragraph 21.7.1.)

Lightning-General: Lightning and surge protection shall be provided to protect electrical & electronic Signalling equipment from lightning & surges.

(1) S&T equipment shall be protected as per National Building Code 2016 (NBC 2016) and IEC 62305. S&T equipment, including those given below, is to be grounded and protected from lightning surges. Code of Practices, Technical Advisory Notes, and Guidelines issued by RDSO on the subject shall be taken into consideration.

(a) Electronic Interlocking Installations including Object Controllers.

(b) BPAC Systems, Axle Counter Systems and Integrated Power Supply Systems.

(2) Equi-potential bonding is to be provided for all the equipment for effective lightning and surge protection in signal equipment rooms.

(3) External Lightning Protection and Class/Type I, II, & III devices are to be provided at:

(a) External Lightning Protection on top of buildings housing S&T equipment.

(b) Class B/Type I devices at the input of power supply equipment.

(c) Class C/Type II devices at output of power supply equipment.

(d) Class D/Type III devices at indoor and field equipment.

1607 DATA LOGGER (Refer to IRSEM Chapter 11, Dataloggers and Predictive Maintenance Systems)

(1) Data loggers are mandatory for all relay interlocking (PI/RRI/EI) installations. It is an asset for status monitoring. A data logger with joint validation shall be commissioned before taking NI. No station shall be considered commissioned without commissioning and proper validation of the datalogger.

(2) The following equipment shall be monitored (not limited to):

(a) Relays: potential free contacts

(b) Power supplies: voltages and Currents

(c) Electronic Interlocking: Signalling element data, diagnostic data of EI

(d) Earth leakage detectors for signal &power cables.

(e) Where potential free contacts are available for any Signalling equipment like SPD, fire detection system, IPS, etc. the same shall be monitored through a data logger.

(f) Diagnostic data from MSDAC, IPS, track side ATP, fire alarm etc.

(g) Door opening or Closing of Relay Rooms.

(3) Synchronization of the EI clock and data logger clock is to be ensured and certified.

(4) All relays and alarms are to be extended to the data logger.

(5) Joint validation of the data logger, with an open line for accurate correspondence of inputs, outputs, alerts, and yard layout display both at the time of initial installation & after every yard or Signalling alteration shall be done.

(6) Networking and remote monitoring of several data loggers from the central location shall be done. All features, like on-line simulation, offline simulation, failure management, exception logics, and Synchronization should be feasible from the central location.

1608 FIRE ALARM AND SMOKE DETECTOR SYSTEM

To protect from fire, the panel interlocking equipment, indication cum operating panel, S&T equipment in panel room, relay room, power supply room, battery room, diagnostic panel room and OFC room. Approved-type automatic fire detection and alarm System should be provided in relay room, and IPS / power room of all Signalling installations, as per Board's guidelines and RDSO specification No.: RDSO/SPN/217/2021 Version No.: 3.0 or latest.

1609 AUTOMATIC FIRE DETECTION AND SUPPRESSION SYSTEM

Automatic fire suppression systems control and extinguish fires automatically without human intervention. For Railway Signalling installations, these shall conform to RDSO draft specification no. RDSO/SPN/218/2016 ver. 1.0 d2 or the latest. Automatic fire suppression systems along with automatic fire detection and alarm systems may be provided at stations with more than 400 routes. As per IRSEM para 21.3.4 and the Railway Board's letter no. 2004/Sig/W/5 dated 27.05.2019 **(Ref. 16.27)**.

1610 GENERAL ARRANGEMENTS

(a) Air conditioning may be provided for every Signalling interlocking (PI/RRI) installation with more than 100 routes. For E.I. installations, air conditioning may be provided irrespective of the number of routes to improve reliability.

(b) For other Signalling installations, with less than 100 routes, airconditioning may be provided for those installations which are

  (i) prone to dust (coal dust, stone dust, iron ore, etc.) or

  (ii) in the vicinity of chemical, fertilizer, or other industrial factories releasing harmful fumes or

  (iii) in areas with extreme temperatures, with the agreement of PCSTE and PCEE.

(c) AC equipment shall be provided and maintained by the Electrical department. Such ACs shall be connected to the local power supply. The switch to operate AC shall be outside the relay room.

(d) 'Automatic Fire Detection and Alarm System' may be provided at all stations, irrespective of the number of routes.

(e) Automatic Fire Suppression System' along with "Automatic Fire Detection and Alarm System" may be provided at stations with more than 400 routes.

  Note: In cases where the provision of an "Automatic fire suppression system" along with "Automatic Fire Detection and Alarm System" is considered desirable by Zonal Railways at

critical stations and important junction stations even below 400 routes, the same may be provided with the approval of competent authority (i.e. PCSTE).

(f) Firefighting equipment shall also be kept in the power supply equipment room.

(g) Suitable standard earthing shall be provided for all control panels, power supplies, switch boards, transformers, inverters, etc.

(h) At all Interlocking Installations, a data logger shall be provided.

(i) Communication between the SM's panel room, relay room, equipment room and locations shall be provided.

(j) Relay room floor plan indicating location of various equipments shall be prepared and approved before the start of work.

1611a PROPOSAL OF WORKS

(i) Standard checklist and performa issued vide Railway Board letter No.2021/SIG/Estimates/DPR dated 22.06.2023 shall be submitted along with proposal for new work **(Ref : 16.32)**

(ii) Test of renumerativeness is not required for S&T projects related with train operations in accordance with Railway Board letter No 2023/ F(X) II/10/2 dated 22.06.2023. **(Ref : 16.33)**

(iii) ABS works shall be proposed in accordance with guidelines issued vide Railway Board letter No No.2023/ABSCOMMITTEE/Railway Board dated 16.11.2023. **(Ref : 16.34)**

1611b PLANNING, PREPARATION AND EXECUTION OF WORKS

(Railway Board letter no. 2012/SIG/SF/2 (Policy) dated 14.09.2018 & 30.12.2016 **(Ref. 16.28)**.
To ensure good quality work and full preparedness, the agency executing the work shall submit the following documents to the PCSTE of the zone for approval before undertaking non-interlocking or commissioning of an interlocked station.

(1) Work is ready for interlocking certification for CSTE's approval. Appendices 1 & 2 as mentioned in the Railway Board's letter No. 2012/Sig/SF/2 (Policy) dated 9.4.2012

(2) Cable Route Plan and Cable Core Chart

(3) Cable Depth Record in A4 size; Cable Meggering Record

(4) Track Circuit Bonding Plan

(5) Signal Sighting Committee Report

(6) Pre-commissioning checklist for EI, IPS, Axle Counters, BPAC, data logger Universal Fail Safe Block Interface, etc.

(7) Earth reading of the various earth provided; earthing arrangement diagram.

(8) Testing record of Selection Table/Table of Control, FAT and SAT.

(9) Reading/parameters of point machine, Signals including distance from Centre Line of Track, Track Circuit reading.

(10) Copy of CRS sanction/authorization letter.

(11) Inspection Certificates of RDSO for El, UFSBI, IPS, axle counters data loggers, relays, battery chargers, cables, ELD's etc.

(12) Works to be done during pre-NI & NI

(1) Planning and preparation of works

Annexure to Railway Board letter no. 2012/SIG/SF/2 (Policy) dated 09.04.2012 **(Ref. 16.28)**

(a) Detailed planning of all the activities should be done keeping in view the basic requirements of NI working and/or traffic blocks. All issues related to each and every portion of the indoor and outdoor Signalling & Telecom works, yard modifications, Electrical & OHE, P. Way and Engineering works should be listed out and tied up for execution in time,

(b) All plans and system design documents Iike Engineering Scale Plan (ESP), Signal Interlocking Plan (SIP), Routes Section Plan (RSP), Selection Table or Route Control Chart (RCC), Track Circuit Bonding Plan, Station Working Rule Diagram (SWRD), Indoor & Outdoor Wiring Diagram and Key Plan (Mini Engg Plan in A4/A3 size) should be carefully prepared and approved along with the tentative wiring diagram. Contact booking, allotment, and contact analysis should be made available to assess the repeater relays, SIP shall be prepared fresh after three alterations.

(c) For better appreciation of SIP, a route table in the following format should be sent to the traffic branch, listing out all routes required for safe train operations as per the proposed SIP:

SN	Signal No	Route upto Signal No	Remarks
			(Regarding Short Shunt, Overlap /Isolation Points locked, Sectional Route Release, Parallel movements and Restrictions, If any).

CRS Observations:

(a) All observations of CRS should be discussed with CTPM and an agreed version of comments duly approved by CSTE & COM should be sent to CRS to avoid dispute at a later date especially with regard to short shunt, overlap release, Isolation, simultaneous movements etc.

(b) In case of existing interlocked installations, completion drawing should be physically verified before starting fresh wiring for incorporating the alterations. Fresh wiring should be done using wires of different colour to distinguish it from existing wiring. Atleast 2 level checking should be done before a wire is tagged and terminated.

(c) Wiring alterations in existing Pl/RRI Installations should generally not be allowed in cases where alteration is involved in existing relay wiring at large. The permission to carry out a sanctioned work by wiring alteration in existing Pl/RRI shall be granted after due deliberation at the level of CSTE only.

(d) The Requirement of NI for alteration work in existing Installations should not be compared with that of new work. Adding one cross-over on the main line may involve large scale changes in the circuit.

(e) The NI period for alteration in the existing Installation should be sought based on the number of jumper wires Involved and the testing of panel as per the selection table,

(f) Calling-on signal below Starter Signals should be allowed to take off with a zero-time

delay. Calling-on below Home Signals should be provided with time delay of 60 Seconds.

(g) The Compatibility of ECR (lamp checking relay) with the LED signal shall be ensured as per latest Instructions.

(h) All Signalling reliability improvement measures issued by Railway Board and RDSO should be compiled while executing new RRl, EI, and PI works to avoid alterations at a later stage.

2.0 Execution of Field Works:

General

(a) As the work progresses, 60 days before the proposed NI, regular weekly reviews at the SAG level should be done for the final planning of all the activities during Pre-NI, NI and Post-NI periods. During these reviews, the progress of these activities should be closely monitored and all hurdles should be resolved in close coordination with concerned departments and agencies.

(b) NI for all RRI works at major stations and Junction stations shall commence only after the approval of CSTE, COM and GM.

(c) Phased commissioning should be adopted to reduce the NI period.

(d) The executing unit should give certificates for compliance of Instructions as per Format enclosed as Appendix-l &ll and should be submitted through Divisional officers before permitting NI by CSTE & COM.

(e) 10 days before NI, all major activities and works that can be completed prior to NI, should be completed in all respects,

(f) Assistance of OEM, RDSO & Zonal design team etc. is to be taken to resolve any design related issues.

Points:

(a) Care should be taken while laying switch rails. LH tongue call should be provided with LH turn-out and similarly for RH side.

(b) All the points to be inserted should be pre-assembled on a staging outside and point machine fixing arrangements and ground connections should be pre-tested and kept ready for final adjustment. Proper housing of tongue rails should be ensured in assembled turnouts by engineering officials at the site.

(c) Single or Double Slip points should be avoided where space is available for a fan shaped turn out.

(d) Interlocking of the Siding point should be done with care, keeping in view restriction imposed if any on CSL (clear standing length).

Schedule of Dimensions (SOD):

(a) All infringements should be checked at the time of installation of the equipment, signal posts with units, point machines and their ground connection, Location boxes etc. and again rechecked before the NI commences.

(b) Point fittings should not infringe SOD;infringing fittings should be corrected.

Relay Wiring & Testing:

(a) For all new works, NI should not be commenced unless the wiring of the Interlocking logic

is complete and at-least one stage of signal lowering is checked from the control panel. In cases of alteration or modification to existing Signalling or Interlocking, testing of new functions and outside gears should be done in advance. In alteration work, verification of existing wiring, contact analysis etc. should be done by deploying additional trained staff.

(b) Old wiring, cabling, fitting of points, track circulating and signals etc., lying unused for more than 3 months, should be rechecked jointly by concerned construction & maintenance supervisors and officers before taking up NI. For old wiring, wiring is re-checked from base point to tag block and tag block to tag block before the Nl Control Panel in checked and verified as per SIP before starting wiring.

(c) A Physical check of the wiring shall be done to check for dry soldering, loose connections, short circuits on terminals or tag blocks, clips, not being plugged, etc. before plugging relays and extending the power supply.

(d) Relays stored for more than 6 months should be separately tested from testing jig for checking their working and contact resistance. Testing Jig should be provided in maintenance panel room.

(e) The Quality of the wiring work should be of a high standard. Temperature controlled soldering iron should be used. Dropping of solder material on the terminal or on wire should be prevented.

Track Circuiting:

(a) The Condition of ballast, track, and sleepers should be thoroughly checked for their suitability for Signalling GFN liners and rubber pads for all PSC sleepers in track circuited zones should be ensured.

(b) Track circuit bonding should be done with double bonds. J clips for glued joint portion should be ensured

Power Supply:

(a) The Power supply arrangement should be properly designed to cater for the additional load on account of modifications to existing Signalling. A dual power supply arrangement should be provided for RRI work at major stations or junction stations. An adequate power supply for outdoor circuits should be made available to ensure proper functioning of the farthest point under load.

Maintenance-Staff Deployment Training, Spares etc.

(a) The maintenance panel should be fully wired and made functional along with RRI for quick rectification of faults. Data logger wiring and validation should be done in advance before Pre-NI.

(b) The Maintenance staff of the station should be fully associated during the course of RRI work. Additional staff as required for maintenance should be sanctioned and deployed.

(c) Spare Modules: 10% of each sub-system / module should be made available before commencing NI. Required T&P items, vehicles and other measuring instruments should be made available by construction before NI. Wherever new concrete sleepers are required to be inserted, they should be electrically re-tested even though they were tested earlier in the sleeper plant.

(d) Training in advanced modern Signalling being installed at the station, should be ensured for all S&T staff posted for maintenance before NI.

(e) NI working should be carefully planned, listing out activities required to be completed during the allowed period, and should be checked for adequacy at the minimum level of the JA Grade officer consulting the Divisional Operating & Signal officers at every stage. In the case of stations having more than 100 routes, the planning and checking of requirements should be done at a higher level.

Telecom facilities & communication arrangements

(a) All Telecom facilities in the new RRI building must be commissioned before Nl.

(b) CUG, or public mobile communication should not be used. Communication amongst staff working on the panel, relay room, equipment room should be through hands- free talk-back system and VHF/Walkie-talkie sets communication with staff deployed at goomties, Relay Huts, temporary shelters and in the field should be only through VHF with standby point to point magneto telephones. Sufficient VHF batteries and battery chargers shall be available.

(c) Telecom Officer of the Railway should be deputed at station, responsible for collection of regular updates from field and relaying them to divisional, Zonal Railway and Railway Board officials. He should also look after the telecom arrangements.

Cable Testing

(a) All cables should be tested jointly with supervisor of maintenance organization.

(3) Pre Nl/ Nl work;

General:

(a) Before permitting NI at major yard / Junction station, a foot-by-foot Inspection of the entire yard at last by JS/SS officers of all concerned departments should be done along with SS of the station.

(b) Security and five fighting arrangements should be ensured during pre-NI/NI.

(c) Transportation, Boarding and lodging facilities should be made available for all staff & officers deployed for NI work. Special Imprest should be sanctioned for the same.

Deployment of Staff and Distribution of Work:

(a) Separate teams round the clock shifts should be formed for Panel, Relay Room, equipment Room, data logger room, relay huts, size locations, and a set of field gear. Activities assigned to each team should be clearly documented and a copy given to all concerned for immediate reference by them.

(b) Distribution of works should be done to different teams by name, giving them documents for various activities or works on S&T equipment expected to be done by them. Officers deputed for Nl work should come with their full support team of supervisors, technicians, and helpers to form effective working team. They should not leave the work site without permission of CSTE/C or Officer In- charge. The team of officers, Supervisors, Technicians & helpers deployed from other divisions and Railways should report at least 3 days before NI and should remain available at least 5 days after NI.

(c) Dy CSTE, in charge of field work, should take control, remaining stationed at the control panel staying in continuous touch with Relay room, Equipment room, each of the site

locations, relay huts etc. through VHF communication, and occasionally inspect the outdoor locations.

(d) The S&T officer in-charge of design, along with his group, should be available on site during the period to assist in testing, and commissioning and issuing of design corrections and modifications, if required.

(e) For RRI work, SAG officers should be available at major or Jn station,

(f) Adequate Engineering, Operating. Electrical and Signalling teams should be Available 3 days before the NI working and for a period of at least 5 days after the NI is completed.

(g) SAG / Officer In-charge should review the NI work every six hours and give directions and send update to Divisional/ Zonal Railway Board officials through nominated telecom officers.

Training of Operating Staff :

(a) Training of ASMs is extremely Important. They should be available during simulation and functional test. Before handing over the panel to traffic, special emphasis should be given for button identification for various Signalled Routes, Crank handle release, LC Gate locking/release, Emergency Operations for route cancellation, emergency sub route release, emergency point operations, Calling-on etc. ASMs posted on a Panel should have Panel Competency Certificate issued by Zonal Training School. ASM should have earlier worked on the Panel and be familiar with buttons, various routes etc.

Testing of Functions:

(a) In Outdoor, special attention is to be paid for greasing and oiling of points where new point machine or new turn out is provided or new cable is provided in existing point machine.

(b) Proper adjustments of various parameters of Point including packing of Points; track, signal, ECR (lamp checking relay) etc. shall be done for their correct functioning.

(c) Old Slot, block, BPAC working etc. shall be kept fully tested for proper change over.

(d) Track bonding to be got checked & verified jointly with Engg & TRD department.

(e) Corresponding test of each function is to be done, before Nl between cable terminations from Relay Room to Location Box and from Panel to function during NI.

(f) Full testing of correspondence of all functions, wire count test, square sheet test for conflicting signals, simulation and functional test (100%) shall be done and records are maintained.

Plan & Documents:

(a) Copy of wiring, circuit diagram should be available at each gears, locations, relay huts and goomties.

(b) Copies of Mini SIP / SWRD should be made available for display at important locations like Relay Room, Panel Room, Equipment Room, Maintenance Panel Room Relay Huts and also handed over to each officer deployed at site.

(c) Supervisors and officials deployed for execution of the work and for train operations should be made to read the documents and instruction to understand the procedure and sequence of NI working and sign the assurance register.

Deployment of Contractor Staff.

(a) Technical representatives of the contractor shall be available and visible during Pre-Nl and NI period for immediately attending to faults or prompt removal of released material etc.

(b) Deployment of Contractor Staff as per requirement should be ensured during work. Technicians and engineer of contractors and/or manufactures should be available 3 days before the start of Nl and should continue for a period of at least 5 days after the NI is completed.

(4) For Train Operations and Control during NI:

(a) No short cut should be adopted to run trains under any circumstances,

(b) All preparatory works and arrangements pertaining to signal, Permanent way, Traction distribution and Electric general and Telecommunication should be pre-tested and kept ready for NI working. PA system should be provided for NI working.

(c) Free Home and Starter Signals should be made available for use of the traffic staff during NI working. For Block working, existing system of block working should be provided for each block section. Point to Point-telecommunication facilities as required for NI shall be provided, tested and kept in working order.

(d) Rehearsal of Special duty traffic staff for setting, camping and padlocking of points for different routes during Nl.

(e) ASM who are trained in use of crank handle for operating the point machines and for prompt delivery of paper authority to the driver in case of signal failure, should be deployed.

(f) At stations, where NI is being undertaken, crossings and precedence of trains should be avoided during duration of NI. No shunting should normally be done. Points should be set in the normal position and clamped and padlocked for straight Up/Down movements.

(g) Train operations during NI working should be effectively controlled by deploying the required number of traffic staff and an officer for monitoring their working. Prompt receipt and dispatch of trains be ensured during NI. An operating officer (DOM/Sr.DOM-G) should be available at site during NI period to monitor and control operations. If required, goods trains or less important passenger trains may be regulated or terminated for major station.

(h) SWR should be issued fresh every five year or after issue of three amendment slips.

(i) The above Instructions shall be legislated in the Temporary Working Order (Instructions/ Rules) Green Notice / Draft Circular Notice / Disconnection Notice.

(5) Post Nl Maintenance & Monitoring:

(a) Nominated Maintenance Teams should be stationed at every 10-12 points, relay huts and other locations having S&T equipment.

(b) Trouble shooting flow chart should be provided in relay room, panel room, maintenance panel room, relay huts etc. for quick diagnostic of failures.

(c) Released materials should be shifted promptly from station after NI working period is completed and the system handed over for operations,

(d) Proper record of various events shall be kept in separate register and this shall continue

till the installation gets fully stabilized.

(e) Field lighting of the yard during night hours shall continue for 3 days after NI is over.

(f) All major station/Junction station, Operating Staff deployed for NI Working should continue even after commissioning of Panel till it get stabilized and certified by Sr.DSTE & Sr.DOM of the Division.

(g) Completion Drawing should be carefully prepared with the required level of checking and finalized. One copy be kept available at station.

1612 JOINT INSPECTION/HANDING OVER OF NEW ASSETS

(1) A Joint inspection by the divisional open line and construction/work executing agency both at SSE(Signal)/In charge and officer level shall be undertaken before taking up non-interlocking of a station in connection with yard remodeling, interlocking changes or commissioning of Signalling works for a new line or gauge converted line. Refer to Annexure 9-A7 of IRSEM.

(2) The non-interlocking of the station or commissioning of any Signalling work shall be undertaken after the items considered essential for the safety of train operation are completed.

(3) Within 15 days of the commissioning of Signalling works, another Joint inspection both at the SSE/in-charge and Officer level by divisional open line and/construction/work executing agency shall be undertaken. The deficiencies noted during these inspections shall be listed as follows:

(i) Category A: Items that shall be complied with before handing over

(ii) Category B: Petty items (like painting, labeling etc.) that may be complied with after handing over as per the MOU to be entered between the open line and the construction organisation/work executing agency.

(4) All the new Signalling equipment and associated gadgets shall be handed over or taken over within 2 months period after the commissioning of the Signalling works. After the expiration of the 2 months period, however, the responsibility of maintenance shall devolve on to the divisional open-line organisation after commissioning.

(5) In order to ensure that handing over or taking over of Signalling assets is accomplished in a smooth manner, a specific handing over or taking over procedure as detailed in Annexure 9-A7 of IRSEM shall be followed.

For Joint Inspection/Handing over of new assets, IRSEM Para 9.1.5 be followed

1613 DO'S AND DON'TS FOR WORK EXECUTION

Following need to be ensured in all projects

(A) General

1. Before inviting any tender for a work, it shall be ensured that the work is sanctioned by the competent authority.
2. The scope of work shall be in accordance with the sanctioned work.
3. At the time of inviting the tenders, it shall be ensured that the site is available. Approved ESP and SIP shall be annexed to the tender document to ensure clarity about the scope of work.

4. Before the process of inviting the tender, it shall be ensured that sufficient funds are available for the execution of work so that work may not be hampered due to paucity of funds. In case of unavailability of sufficient fund for a particular work, demands for funds shall be raised timely through re-appropriation of funds.
5. Drawings shall be approved or available at the time of seeking approval from competent authority to float the tender. Approved SIP shall normally be a part of the tender document. In projects where the Sigdate can be implemented, approved RCC orTOC may also be part of tender document in future projects.
6. Following guidelines may be adhered for alteration works :
   a. Completion drawing shall be available before taking up any alteration work.
   b. Fresh wiring should be done by wires tagged with different color tags for ease of identification of circuits & to distinguish from existing wiring. Terminal/Fuse/Relay contacts positions shall be reconfirmed before a wire is tagged / terminated.
   c. Old wires including those getting released should be rechecked jointly by concerned work executing supervisor and maintenance supervisor from base point to tag block and tag block to tag block in relay room, control panel, location box etc. before starling of the work.
   d. Before start of any alteration work all necessary approved drawing/plan/wiring diagrams etc. shall be available at work site as per IRSEM. For changes in existing wiring in relay room, guidelines issued vide Railway Board's JPO no.2023/TT/IV/9/2 dtd.16.06.2023 shall be followed.
   e. Correspondence test of each function being affected by wiring, has to be done before & after wire/cable terminations between relay room, control panel, location box & up to respective gear. Necessary guidelines issued vide Railway Board's JPO no.2023/TT/IV/9/2 dtd.16.06.2023 shall be followed prior to acceptance of reconnection by SM.
   f. After completing the work all necessary drawing such as wiring diagrams, contact & fuse analysis sheet, terminal details etc. shall be updated for the changes, duly signed by concerned supervisors and officers with their name, designation and date. Completion drawing shall be based on the physically verified diagram and shall be provided at site at the earliest.
   g. The permission to carry out wiring alteration in existing signalling installation shall be granted after due deliberations by competent authority.

(B) Indoor Items

1. All plans and system design documents Iike Engineering Scale Plan (ESP), Signal Interlocking Plan (SIP), Routes Section Plan (RSP), Selection Table or Route Control Chart (RCC), Track Circuit Bonding Plan, Station Working Rule Diagram (SWRD), Indoor & Outdoor Wiring Diagram and Key Plan (Mini Engg Plan in A4/A3 size) should be carefully prepared and approved along with the tentative wiring diagram
2. A duly signed Pre-commissioning checklist issued by RDSO and OEM commissioning certification shall be available for EI, fire alarm system, IPS, data logger,SSDAC/BPAC,earth

leakage detector etc.

3. NI for all RRI works at major stations or Junction stations shall commence only after due approval as per extant guidelines.
4. All major activities and works, that can be completed prior to NI, should be completed In all respects.
5. For all new works, NI should not be commenced unless the wiring of the Interlocking logic is complete and at least one stage of signal lowering is checked from control panel. In case of alteration or modification to existing Signalling or Interlocking, testing of new functions and outside gears should be done in advance. In alteration work, verification of existing wiring, contact analysis etc. should be done by deploying additional trained staff.
6. A corresponding test of each function is to be done before Nl between cable terminations from relay room to location box and from panel to function during NI.
7. Full testing of correspondence of all functions, the wire count test, the square sheet test for conflicting signals, the simulation and the functional test (100%) shall be done and records shall be maintained.
8. Relay Room
   (a) Proper wire for wiring relays (16/0.20) shall be used.
   (b) For metal to carbon relays, the number of contacts in series in a circuit should be limited to 45.
   (c) Approved relay connectors shall be provided.
   (d) Bunching, dressing and lacing of the wiring shall be completed.
   (e) Insulation of the relay rack to be done.
   (f) Parallel loading for contacts of all important relays is to be ensured.
   (g) Relay Room opening and closing shall be proved in the datalogger.
   (h) An approved type of fire detection and alarm system shall be provided.
   (i) The Cable entry hole and all other holes are to be sealed to prevent entry of rodents in to the relay room.
9. Fuses
   (a) Non-deteriorating, HRC fuse of approved type is to be provided.
   (b) Approved type Automatic fuse changeover along with a fuse blown off indication shall be provided.
10. Data Logger
   (a) Configuration, design, and wiring shall be done as per the diagram approved by HQ.
   (b) Contacts of all relays, IPS, ELD, power supplies, Track feed battery charger are to be taken in data logger.
   (c) Monitoring of relay room opening is to be done.
   (d) Validation and networking of the datalogger shall be ensured.
   (e) Uninterrupted power supply for the datalogger shall be ensured.

11. Electronic Interlocking Synchronization with Data Logger:
    (a) Synchronization of the El clock and datalogger clock through CMU in network condition shall be verified and certified by minimum Assistant level officers.
    (b) The analog output of DC-DC converter shall be wired into a data logger for monitoring the healthiness of the converter.

    Wiring Practice:
    (a) The input, output, data and power supply cable shall be routed in different cable troughs separated with a gap as specified in latest RDSO TAN.
    (b) The input and output cables (RDSO-approved) of El shall be twisted to minimize EMI & EMC effect.
    (c) The fuse terminals shall be fixed with proper fuse rating marking.
    (d) Lightening and surge protection devices (indicative type) shall be installed as per the concerned El installation document.
    (e) The Wire ends shall be properly crimped with the correct size of lugs and there are no loose connections at the end terminals.
12. IPS & Power Supply Arrangement
    (a) The IPS for Railway Signalling circuits shall be provided as per the latest RDSO specification.
    (b) A Power budget based on the anticipated load of S&T at the station shall be prepared and IPS of suitable capacity shall be provided. Any deviation from the above shall be approved by PCSTE.
    (c) A Power schematic for the station shall be prepared and approved by the engineer in-charge before the start of work.
    (d) Proper earthing and lightning protection arrangement shall be provided for the IPS power supply system as per RB letter no.2011/Sig/SF/1 Dt.19.08.2011 **(Ref. 16.29)** or latest.
    (e) Input supply arrangements (AT, Local, DG and solar supply) shall be made as per latest guidelines.
    (f) A status monitoring Panel shall be provided and it is visible to ASM from his sitting position.
    (g) Configuration of IPS shall be as per latest guidelines.
    (h) Spare wires are available between the main supply distribution boards to CT rack for internal, external and point supply duly terminated at both the end.
    (i) Spare cables are laid between Changeover panel to IPS SPD box duly, terminating at both ends with a changeover arrangement.
    (j) Provision of separate 24V DC and 110V AC in ring arrangements for LC gates located in the station yard.
    (k) An exhaust fan is to be provided in IPS room.
    (l) The Supply of adequate spare modules of IPS as per the RDSO specification shall be ensured.
    (m) Training to the maintenance staff shall be done along with the installation &

commissioning of the IPS system. The O&M manual for IPS shall also be supplied to staff before the commissioning of station.

13. IPS Battery
    (a) Check the type (LMLA or VRLA),capacity and make of batteries.
    (b) The Physical condition of the battery shall be good.
    (c) Charging (number of cycles, back up time etc.) is to be done in the proper way as per the manual.
    (d) Proper ventilation is to be provided in battery room.
14. Earthing and SPD
    (a) While preparing the GAD of the station building, the location and arrangement of S&T earthing is to be marked on the GAD before approval.
    (b) IPS shall be provided with B&C- class SPD connected to earth with earth resistance less than 1 ohm.
    (c) Preferably indicative type SPD shall be installed.
    (d) The value of earth resistance is less than 1 ohm for electronic equipment with equipotential bonding as per RDSO guidelines.
    (e) Separate earth for block instruments shall be provided.
    (f) The earthing of signals and location boxes shall be done.
    (g) The earthing and soldering of cable armor shall be done.
    (h) Appropriate gauge earth wire (green color) shall be provided between the earth pit to MEEB, MEEB to SEEB and SEEB to equipment as per RDSO guidelines.
    (i) Nuts, bolts, washers used for connection to MEEB, SEEB, equipment shall be of rust-free materials.
    (j) Standard size copper strips shall be provided as MEEB and SEEB/perimetric bus bar as per RDSO guidelines.

(C) Outdoor items

1. All SOD infringements should be checked at the time of installation of the equipment, including signal posts with units, point machines and their ground connection, location boxes etc and again rechecked before the NI commences.
2. Signal

(a) Joint Signal Sighting of new signals shall be done before commissioning of the section or station.

(b) Retro-reflective number plates shall be provided on the signals.

(c) The implantation of signal shall be measured and painted on the signal.

(d) All openings of signal unit shall be provided with suitable gaskets. All cable and wire entrances shall be sealed.

(e) An adequate track center must be kept to ensure that there is no SOD infringement with the signal foundation.

3. Track Circuit
    (a) Improvement in availability of track vacancy detection in station section shall

normally be achieved by DC track circuit in parallel with DAC, Railway Board letter No. 2012/Sig/M/DAC/DD , Dtd.31.12.2013. **(Ref. 16.30)**.

(b) For ABS, IBS, BPAC, DAC with design redundancy shall be provided as per the guidelines in IRSEM.

(c) Double bonding shall be provided for the DC track circuit.

(d) In the RE area, choke shall be provided.

(e) Proper fixing of the TLJB at rail level.

(f) It must be ensured that all type traction bonds i.e. structure, transverse, cross and continuity bonds are provided for Track circuits.

(g) GFN liners and rubber pads shall be provided in track circuited areas.

(h) J-type pandrol clip shall be provided on glued joints.

(i) Batteries for TC shall be provided in separate location boxes.

(j) All battery connection should be done using proper lugs.

(k) Track Feed Charger and Battery shall be wired to ensure both are not disconnected simultaneously

(l) +ve and -ve rail to be wired as per the TC bonding plan.

(m) The series wiring of point zone track circuit is to be ensured.

(n) The provision of dual detection to be checked as per SIP.

4. Cable

(a) Availability of spare conductors in each main cable and tail cable shall be ensured.

(b) Signalling cables shall be laid in ducts as per Railway Board policy issued on 29.03.2023 or latest guidelines..

(c) For track crossings. Signalling cable shall be laid in DWC-HDPE pipe and the crossing must be perpendicular to the track.

(d) Ensure cable is laid on Bridges and Culverts as per approved guidelines.

(e) Provision of line or function wise Signalling cable must be made as per guidelines.

(f) All cable entry points in cabin, relay room, battery room. SM's room, location boxes, location huts, junction boxes, etc. must be closed with suitable masonry works, sand covering and plastering to prevent the entry of rodents.

(g) RCC slab shall be provided on the cable pit of the relay room.

(h) Cable markers shall be provided along the cable route.

(i) Provision of ELD shall be made to monitor the health of cables.

(j) The approved cable route plan shall be updated or modified as per the actual cabling done, indicating the distance of the cable, cable crossing locations with respect to fixed structures.

5. Location Boxes

(a) Earthing, sand filling and plastering of the location box shall be done.

(b) Proper painting shall be done inside and outside the location box.

(c) The description of the terminals shall be written neatly on the hylum board. A drawing of the circuits, if required shall be provided on the inside surface of the

door of the location boxes on a hylum sheet of suitable size.

(d) He soldering of cable armor with catenary shall be done.

(e) The earthwork around the foundation must be done as per requirements to keep it upright.

6. Point

(a) Any new point layout shall conform to the provisions pertaining to engineering as enumerated in (a) As per the NEW IRSEM Para No. 12.3.1, 19.3.1 (b) Annexure 12-A1

(b) Before any newly laid point is connected to a point machine and interlocked, it shall be ensured that the SSE/JE (P-Way) has taken the necessary steps as detailed in Annexure 12-A1 of IRSEM.

(c) Proper lubrication of point shall be done.

(d) Ground connections shall be free from obstructions.

(e) The ward plate as per the nominated CH shall be installed on point machine.

7. Level Crossing gate and Electric lifting barrier

(a) The Working of road signals and hooter shall be ensured.

(b) The height of boom shall be 0.8 m to 1 m from the road surface.

(c) CH for emergency operations shall be provided and its operation shall be incorporated in GWR.

(d) All indications and operations shall be provided as per SWR/GWR.

(e) A reliable power supply shall be available for the operation of the electric lifting barrier.

(f) Positive boom locking shall be effective.

(g) Boom shall be painted alternately with 300 mm bands of black and yellow colour and additionally provided with luminous stripes.

(h) 600mm Red disc shall be provided at the center of boom, with red reflector buttons or luminous stripes facing road traffic. Disc marked with “STOP” sign of 50mm width in white luminous paint/stripes.

(i) Sliding boom shall be provided at all interlocked gates.

8. Block working

(a) The Condition of quad cable (Insulation resistance, dB loss etc) shall be proper.

(b) The Power supply arrangement shall be only through a battery charger suitable for Axle Counter working or through IPS.

(c) Provision of dual detection shall be done for Axle Counters used for IBS and Block.

(d) Availability of media diversity shall be ensured.

(e) For BPAC, OEM certification shall be ensured before commissioning.

9. Testing and Measurements

(a) Cable meggering must be carried out jointly and report kept at station.

(b) Availability of records of various testings like TOC, FAT, SAT, Square sheet etc must be ensured at station.

(D) RDSO/OEM Checklist:

RDSO/OEM Checklist and OEM certificates shall be obtained for all the prescribed equipment before commissioning. The installation shall be examined with respect to checklist by open line officials jointly. OEM certificate shall be handed over to Open Line after the commissioning of the station. The Pre-commissioning checklist shall be jointly filled in and signed by Open Line in addition to Construction officials.

1614 SIGNALLING GEARS DESCRIPTION WRITING

Description Writing in Outdoor Location Boxes and Cable Termination Particulars of CTR in Relay Room / Relay Huts / Goomties plays a very vital role during Maintenance & Testing including Cable Testing and during attending failures. Guidelines issued vide RB letter 2023/Sig/17-Sig Equip/ Maintenance/Part Dated 06.11.2023 shall be followed **(Ref. 16.31)**.

1615 MISCELLANEOUS

Following needs to be ensured

(a) An approved completion drawing shall be issued normally within 01 month of commissioning.

(b) Before commissioning, Training of field staff and officers in advanced modem Signalling being installed at the station shall be ensured.

(c) All operation and maintenance manuals of S&T equipment installed at the station shall be handed over to open line before commissioning.

1616 LATEST VERSION OF ALL GUIDELINES/ SPECIFICATIONS/ DIRECTIONS OF REFERENCE MADE IN THIS CHAPTER MAY BE FOLLOWED

The above guidelines are for execution of S&T works based on existing policy, norms and best practices. In case of any contradiction between these guidelines stated in this chapter and the latest directions issued by the Board, RDSO specification/ SEM provisions, the latter shall prevail.

Reference Documents

SN	Clause	Ref. document details	
1.	1603 (1)	16.01	Railway Board letter No. 2022/GS/IR/Cable laying policy Dt. 29.03.2023: guidelines for S&T cable laying in ducts.
2.	1603(2)(a)	16.02	RB's letter no. 2003/Tele/RCIL/1 Pt IX dt 24.6.13, procedure for undertaking digging work.
3.	1604	16.03	Railway board letter No. 2021/SIG/WP/Targets, dated 15.07.2022: Automatic Signalling Works on Indian Railways.
4.	1605(1)	16.04	Provision of EI should be made in all works, Railway Board's letter No. 2003//Sig/G/5 dated 28.04.2016
5.	1605(1)	16.05	Centralized/Distributed EI, Letter No. 2021/Sig/25-Conf/5/SSC dated 26.02.21
6.	1605(1)	16.06	Estimates may be revised for provision of EI without causing material modification as per Railway board letter No. 2008/SIG/SGF/4EI/Genl dated 05.07.2011
7.	1605(2)	16.07	Implementation of standard circuit for future EI up to 100 routes, Railway board vide letter No. 2018/Sig/36-SD-1 dated 26.08.2022
8.	1605 (5) (a)	16.08	RDSO/SPN/192/2019 Ver 2.0 or latest
9.	1605 (5) (b)	16.09	RDSO/SPN/203/2011 Ver 1.0 or latest (Only applicable for Big yards)
10.	1605 (6)	16.10	Centralized and Distributed Architecture of Electronic Interlocking, RDSO Document No. STS/E/TAN/3008 ver 1.0 Dt.31.03.2013 or latest.
11.	1605 (6)	16.11	Cyber Security aspects of Electronic Interlocking system. RDSO **Ref** no EI/TAN/SecurityVersion1.0 Dt.01.03.2023o or latest.
12.	1605 (6)	16.12	Technical Advisory Note (TAN) No. STS/E/TAN/3012 version 3.0 for Guidelines regarding Technical System Application Approval for Electronic Interlocking Installation RDSO **Ref** no STS/E/TAN/301 Ver 3.0 Dt28.06.2021 or latest.
13.	1605 (6)	16.13	Correction in Technical Advisory Note no. 3012 version 3.0 RDSO-SIG0EI(GEN)/1/2020 Dt 11.07.2022
14.	1605 (6)	16.14	Corrigendum of Technical Advisory Note No. 3012 Version RDSO-SIG0EI (GEN)/1/2020 Dt 03-11-2022
15.	1605 (6)	16.15	Guidelines for implementation of block working built in to electronic interlocking (with same manufacturer) RDSO **Ref** no TN/3013 Version1.0 Dt 28.10.2020 or latest.
16.	1605 (6)	16.16	Guidelines for implementation of block working built in to electronic interlocking (with same manufacturer) for single line. RDSO **Ref** no TN/3014 Version1.0 Dt 24.06.2021or latest.

17.	1605 (6)	16.17	Use of Embedded PC and Earthing for Electronic Interlocking (EI) RDSO **Ref** no STS/E/TAN/3007 Ver 1.0 Dt 02.11.2012 or latest.
18.	1605 (6)	16.18	Revised Checklist for Technical System Application Approval of Electronic Interlocking. RDSO **Ref** no STS/L/SSI/general/160 Dt 07.12.2018 or latest.
19.	1605 (6)	16.19	Procedure for FAT/SAT of Electronic Interlocking No. 2017/Sig/3/85th SSC Dt 04.12.2018
20.	1605 (6)	16.20	EI check list as per No. STS/L/SSI Dt 09.05.2012 or latest.
21.	1605 (6)	16.21	Modification/Alteration in Electronic Interlocking (Manufactured by M/s Ansaldo make) RDSO **Ref** no STS/E/TAN/3009 Ver 1.0 Dt 09.06.2014 or latest.
22.	1605 (6)	16.22	Guideline regarding minor modifications/alterations in the application software of Medha Electronic interlocking (MEI) RDSO **Ref** no STS/E/TAN/3010 Ver 1.0 Dt 05.08.2014 or latest.
23.	1605 (6)	16.23	Guidelines regarding minor modifications/alteration in the application logic of VLM6 Electronic Interlocking (EI) of M/s Siemens Rail Automation Pvt. Ltd. RDSO **Ref** no STS/E/TAN/3011 Ver 1.0 Dt 14.08.2014 or latest.
24.	1605 (6)	16.24	Use of hot stand by architecture for Electronic interlocking RDSO Ref **no** STS/E/TAN/3004 Ver 1.0 Dt 13.06.2012 or latest.
25.	1605 (6)	16.25	Report for standardization of Typical Circuits for EI- (Report SS 155 2019 VER 2 Dt 29-03-2022) WCR/N-HQ/110/Rly. Bd'sCorresp./Sig-25 Pt-VIII Dt 29.03.2022 or latest.
26	1605(9)	16.26	Technical System Application Approval for EI works as instructed vide Railway Board Letter No 2012/Sig/ATSS/Pt dated 28.02.2023 or latest.
27.	1609	16.27	Automatic fire suppression system along with Automatic fire detection & alarm system as per Railway board's letter no. 2004/ Sig/W/5 dated 27.05.2019 or latest.
28.	1611	16.28	Planning, Preparation & Execution of Works, Railway Board letter no. 2012/SIG/SF/2 (Policy) dated 14.09.2018 & 30.12.2016.
29.	1613 (B) 12 (d)	16.29	Earthing & Lightening Protection arrangement shall be provided for the IPS power supply system. RB letter no.2011/Sig/SF/1 Dt.19.08.2011 or latest.
30.	1613 (c) 3(a)	16.30	Safe and Reliable Train Detection- Redundancy in Design Railway Board letter No. 2012/Sig/M/DAC/DD, Dtd.31.12.2013.
31.	1614	16.31	Streamlining Signalling functions Description writing 2023/Sig/17-Sig Equip/Maintenance/Part Dated 06.11.2023.
32.	1611a (i)	16.32	Standard checklist and performa issued vide Railway Board letter No.2021/SIG/Estimates/DPR dated 22.06.2023
33.	1611a(ii)	16.33	Test of renumerativeness for S&T projects-Railway Board letter No 2023/ F(X) II/10/2 dated 22.06.2023.

34	1611a(iii)	16.34	Guidelines for provision of Automatic Signalling and Twin Single line working- Railway Board letter No No.2023/ABSCOMMITTEE/Railway Board dated 16.11.2023. (Ref : 16.34)

***

CHAPTER 17
ELECTRICAL AND TRACTION DISTRIBUTION WORK

1701 DEFINITION

The following terms wherever occurring in the Regulations, shall, unless excluded by or repugnant to the context, have the meaning attributed thereto as under:

"Principal Chief Electrical Engineer "means the officer designated as such by the Zonal Railway or his successors in office or on whom his duties devolve.

"Power line crossing" means an electrical overhead line or underground cable placed across railway track(s) for the transmission and/or distribution of electrical energy. It may also be referred to as a "crossing" in these regulations.

"Electrical Inspector" means the officer appointed by the appropriate government under Section 162 of the Indian Electricity Act, 2003, to exercise the powers and perform the functions under the said Act. On the Zonal Railway, the Principal Chief Electrical Engineer is the Electrical Inspector.

"Owner" means the owner of an electrical crossing. "Railway" means the Zonal Railway administration in whose territorial jurisdiction the electrical crossing is located or proposed to be located and includes the Principal Chief Electrical Engineer, the Divisional Railway Manager (Electrical) of the Zonal Railway Administration.

"Writing" includes all matters written, typewritten or printed either in whole or in part.

1702 SCOPE

The electrical overhead lines and/or underground cables crossing railway tracks operated by the Indian Railways, Railway Companies etc., including assisted and private sidings on which rolling stock of the Indian Railways may work.

(Reference: Appendix-4 of ACTM Volume 2 Part 2 of Nov'22- Regulations for power line crossings of railway tracks), IRSOD schedule I, Chapter1 Para11

(1) If any existing crossing infringes the provisions of the Regulations at the time of its issue, the infringement(s) shall be treated as permissible infringement(s) provided that necessary relaxation has been granted in respect of the clearances under clause 21 thereof

(2) The Regulations do not apply to crossing(s) of railway track(s) laid underground or inside tubes and tunnels.

(3) These do not also apply to Railway Tractions systems (1500VD.C.and 25kV/2x25 kV, 50HzA.C. Single-phase) whose feeders, conductors or wires run along or across the tracks for traction purposes.

(4) On sections proposed to be electrified on or to be converted to suit 25 kV/2x25kV, 50 Hz AC single phase traction system, the crossing existing at the time of electrification or modification proposed shall be critically examined with a view to avoid modifications to the extent possible without jeopardizing safety. If any modifications are considered essential to achieve the minimum clearances, they shall only be modified.

(5) In special cases where the Electrical Inspector has specifically permitted a reduction in

clearance under clause 21 of ACTM Volume 2 Part 2, a clear declaration to this effect shall be recorded in the CERTIFICATE OF COMPLIANCE (in the format Annexure II A 4.04 of ACTM volume 2 Part 2 of Nov'22) to these regulations.

1703 WORKS TO BE EXECUTED BY THE RAILWAY

The disturbance of any rail, road or ground or any attachment to any railway structure as may be necessary for the placing and/or maintenance of the crossing shall be affected by or under the direct supervision of the Railway and any conduit, culvert or similar work passing under Railway premises shall be constructed by the Railway in such manner and of such materials as it may approve of and the entire cost of such works shall be borne by the owner of the crossing.

1704 METHOD OF CROSSING

(1) Overhead Line or Underground Cable

All low, medium and high voltage up to and including 11 kV crossing(s) shall normally be by means of underground cable(s). While for voltages higher than 11 kV, crossings may be by overhead lines or underground cables, the use of underground cable to the extent possible would be advantageous, particularly for 22 kV and 33 kV system.

(2) Overhead Line Crossings

(a) Angle of Crossing

An overhead line crossing shall normally be at right angles to the railway track, in special cases a deviation of up to 30 degrees may be permitted. Deviations larger than 30 degrees shall have to be specifically authorized by the Electrical Inspector of the Railway Structure

(b) Structure

(i) Steel poles/masts fabricated steel structures or reinforced or pre-stressed concrete poles either of the self-supporting type or guyed type conforming in all respects to the Indian electricity Rules 1956 (as amended up to November 1984) and complying with the latest editions of codes of practice, IS 800-1962 for "Code of Practice for use of structural steel in general building construction, IS 875-2015 for "Code of Practice for structural safety of buildings; loading standards" and IS 456-1978 for "Code of Practice for plain and reinforced concrete" shall be used on either side of the track to support the crossing span. These structures shall be of the terminal type. For arriving at the crippling load, the wind loads as detailed in the latest edition of IS 875 (Part 3) 2015 for "Loads and permissible stresses "shall be adopted. The steel structures shall normally be galvanized in accordance with IS 2629-1966 for "recommended practice for hot-dip galvanizing of iron and steel".

(ii) The minimum horizontal distance measured at right-angle to, and from the centre of the nearest track to any part of the structure above ground level, carrying electrical conductor crossing a railway line shall be as per IRSOD Chapter I para no. 11(iv) reproduced below:

i for new structure: (H+6) m

ii for existing rigid well-founded post or structures: 3m, or 1.5m away from the

toe of Embankment/top of cutting, whichever is more.

Where, 'H' is the height of post/structure from nearest ground level

Note:

(i) Rigid well-founded post/structure: Any post/structure which is so constructed or guyed as to remain in a vertical position, or failing this to continue to provide the minimum horizontal clearances of 2.135m from the center of the nearest track, with one or all of the conductors broken or with its conductors attached, when subjected to maximum wind pressure, shall be considered to be a "rigid well-founded post/structure".

(ii) The existing rigid well-founded post/structures, presently at a distance equal to or more than as given above but less than (H+2.135) m, shall be inspected by the railway's nominated electrical official once a year jointly with the owner of the post or structure and certify the safety of the structure, keeping appropriate records of inspections.

If the existing post/structure carrying electrical conductors crossing a railway line, is not rigid and well-founded then the minimum horizontal distance, measured at right angles from the center of nearest track, shall be equal to the height of post or structure above ground level plus 2.135m.

(iii) Crossing span shall be restricted to 300m or to 80% of the normal span for which the structures are designed, whichever is less.

(c) Clearance between the Overhead Line & Railway Track

(i) Overhead Line Crossing Location:

An overhead line crossing over railway track already electrified shall be located in the middle of an overhead equipment span supported by two adjacent traction masts or structures. The distance between any of the crossing conditions and the nearest traction mast or structure under the most adverse conditions shall not be less than 6 m.

Note: No overhead line crossing shall be located over an auto transformer, traction switching station, traction sub-station or a track cabin location in an electrified area. (As per ACS-27 ACTM)

(ii) Vertical Clearance:

The minimum height above rail level of the lowest portion of any conductor of a crossing, including guard wire under the condition of maximum sag in electrified/ non-electrified (proposed to be electrified) shall be as per para 3 of Chapter V(B) & Chapter-I Para11(i) of IRSOD-2022 and reproduced below:

11	Overhead	Minimum Clearance from rail level			Minimum
	Crossing Voltage	Existing Power line crossing for non-electrified territory	New Power line crossing or crossing Planned for alteration		clearance between highest traction conductor and lowest transmission line crossing conductor
			Other than High rise OHE	High Rise OHE	
1	**2**	**3**	**4**		**5**
1	Up to and including 11kV	By underground cable			
2	Above11kV & including 33kV	Normally by underground cable* (parameters required wherever overhead crossing)			
3	Above33kV & upto 66 kV	11160mm	14960mm	16960 mm	2440mm
4	Above66 kV & upto 132 kV	11760mm	15560mm	17560 mm	3050mm
5	Above 132kV & up to 220kV	12660mm	16460mm	18460 mm	4580mm
6	Above220kV & upto 400 kV	14460mm	18260mm	20260 mm	5490mm
7	Above 400kV & up to 500kV	15360mm	19160mm	21160 mm	7940mm
8	Above500kV & upto 800 kV	18060mm	21860mm	23860 mm	7940mm

Reference: * Railway Board letter no. 2021/EEM/180/5 Part (1) dated 18-04-2023 **(Ref. 17.01)**.

NOTE: All clearances mentioned above are under maximum sag conditions. Power line crossings in yards and stations are to be avoided. For any electrification work of an existing line or construction of doubling or gauge conversion along with electrification, existing crossings can continue if dimensions are as per table.

iii) Relaxation by the Electrical Inspector

Power line crossings in station areas and yards are to be avoided. Under un-avoidable circumstances, relaxation by the EIG will be necessary.

For electrification works of existing lines and existing electrified lines, existing power line crossings can continue if dimensions are as per columns (5) and (6) of Para 17.3 of ACTM vol.2, Part-2/Nov'22 of appendix 4. EIG of the concerned Railway to ensure fulfillment of vertical clearances at column 5 & 6 of Para 17.3 with additional safeguards if necessary. Wherever feasible special design of traction overhead equipment, return conductor,

25 kV feeder line be developed keeping in view the need for economy.

All new power line crossings, whether in electrified and non-electrified territories, must satisfy the dimensions as mentioned at column 4, 5 and 6 of Para 17.3 of

ACTM Vol.2, part-2/Nov'22 of Appendix 4.

In the case of non-electrified lines in double-stack container routes, all efforts should be made for the maintenance of dimensions as per column 4. However, EIG may issue relaxation with suitable safeguards on a case by case basis after ensuring vertical clearances as per dimensions in column 5, considering the height of the double stack container as 7100 mm from rail level.

(iv) Earthing

i. Each structure on either side of the crossing span supporting the transmission/ distribution line conductors shall be earthed effectively by two separate and distinct earths and connections. At least one separate earth electrode with resistance below 10Ω in any season shall be provided for each earth connection.

ii. All guard and stay wires shall be properly clamped to the structures connected to the earth so as to maintain proper electrical continuity with the earth.

iii. Where struts are provided, they shall also be effectively connected to the earth separately as well as to the main structure of the earth.

iv. Where the earth resistance of the independent tower or structure is higher than 10 ohms, the owner shall take the necessary steps to improve the earth resistance, either by providing multiple earth electrodes, or by suitably treating the soil surrounding the earth electrode, or by resorting to counterpoise earthing. The method of earthing the transmission/distribution line structures etc., for the crossing span shall be approved by the railway.

v. The earth shall be inspected and tested annually on a hot-dry day and results thereof furnished to the Railway for verification and record. If the earth resistance is found to be high, i.e. above 10 ohms, steps shall be taken to reduce it and advice given to the railway.

vi. The cross section of the earth conductor or connections for the earthing system shall be adequate for the application. They shall not be damaged, overhead, melted while carrying the short-circuit current.

1705 IMPORTANT ASPECTS FOR RAILWAY ELECTRIFICATION

(1) Purpose of Railway Electrification

Railway electrification is carried out to prove better hauling capacity, less line haul cost and an eco-friendly, green, and clean mode of transport as compared to diesel traction.

(2) Railway Electrification Works

(a) Discipline-wise Division of Works

(i) Electrical

i. Provision of 25kv/2x25 kV Overhead equipment's.

ii. Construction of traction substation, transmission lines and bays at Grid substation.

iii. Construction of Power Supply Control Posts, i.e. SP/SSPs including auto transformers for 25kV/ 2x25 kV system.

iv. Remote Control of the Power Supply Equipment with Supervisory Control and Data Acquisition (SCADA) from RCC.

v. Electrification of Electric Locomotive Maintenance facilities.

vi. Ancillary works of modification to the existing power supply arrangements on the route to immunize the system against induced voltages.

vii. Liaison with Electricity Authorities & all other stakeholders to modify their power line crossings to suit 25 kV/2x25 kV AC traction.

viii. Consequential electrical works for the electrification and air conditioning of service buildings and staff quarters.

ix. Electrification of associated siding and loco sheds

x. Modification and undergrounding of overhead power line crossings as applicable.

(ii) Signals and Telecommunications:

i. Provision of colour light signals.

ii. Provision of underground cables for the railway's telecommunication lines and provision of additional traction control circuits.

iii. Liaising with the Department of Telecommunications for modification of their circuits to immunize them against induced voltages due to traction current.

iv. Provision of approved SIP and Track bonding plan.

v. Joint marking of Signal installation.

(iii) Civil Engineering:

i. Yard remodeling, slewing of tracks, sidings, and all track works.

ii. Construction of loco sheds, Tower wagon sheds with linking track, OHE depots, service buildings, and staff quarters.

iii. Modification to over-line structures such as over bridges, flyovers, through girder bridges, as well as to tunnels, platform shelters, and water columns to suit 25 kV/2x25 kV AC clearance for conventional or high rise OHE, wherever applicable..

iv. Provision of approved ESP, L-Section drawing and marking of rail level.

v. Provision of designed soil-bearing pressure at the formation level.

vi. Joint marking of stock rail joint (SRJ) and Track center with respect to fixed reference.

vii. Joint marking of infringement.

viii. Joint marking of rail level.

ix. Replacement of faulty glue joints.

(b) Choice of System of Power Supply

Before designing the power supply arrangements and the type of overhead equipment of a section, a choice is required to be made as to whether conventional 25 kV systems are to be adopted or a 2x25 kV auto transformer system is to be adopted as per existing policy. The type of trains, load and frequency of trains, terrain, headway, etc., determine

the traction power requirement in MVA/RKM

(c) Coordination of Works

Railway electrification, being a multi-disciplinary project work, needs close coordination amongst the electrical, signaling & telecommunications and civil engineering disciplines. It further needs coordination with outside agencies such as Power Supply Authorities, the Department of Telecommunications, revenue officials, and the forest department, as well as with the Open Line organization in whose section the work is to be taken up.

(3) Survey for Electrification

(a) General

To ascertain the following details a route is surveyed either be a 'Reconnaissance Survey' or a detailed Foot by Foot, 'cost-cum-feasibility survey', or LIDAR survey. as the circumstances call for.

(b) Reconnaissance Survey:

This is a rapid survey examining the salient and vital points.

(i) Assessment of existing traffic forecasts of projected traffic for the next five years at least both for goods and passenger.

(ii) Availability of Electric Power.

(iii) Details of the section covering the terrain, the terminal yards, the signal and telecommunication installations.

(iv) Route length

(v) The information collected by this rapid survey yields a fairly accurate idea of the volume of electrification work. The quantities of the component works are estimated and the project cost is worked out based on the latest cost of inputs of fuel electric energy, specific fuel consumption or energy consumption and other operating and maintenance norms derived from statistical data. A rate of return is then worked out.

(c) Foot by Foot Survey

(i) General

This survey forms the basis of Survey Sheets. These sheets are prepared to scale, with the longitudinal scale being 1:1000 in the open route and 1:500 within station limits and in yards. The sub-scale chosen for cross sections is 1:200. On these sheets, the OHE structures and anchor, foundations are marked according to the Principles for OHE Layout Plans and Sectioning Diagrams for 25 KV AC Traction as per ACTM Vol. 2, Part 2 of Nov'22/Appendix-1. These plans, called pre-pegging plans are then verified at site and modified according to site conditions and finalized. The final plan thus issued is called the Pegging Plan, and forms the basis for the estimation of quantities, the cost estimates and the schedule of quantities to tenders for OHE Construction contracts.

(ii) Important features to be noted for the preparation of pegging Plan.

i. Track centres between all tracks.

ii. Track structure i.e. type of sleeper, depth of ballast, and width of cess,

embankment, and level of cutting.

iii. Details of the cross section every 250 m.

iv. Type and condition of soil every 250 m and at geologic discontinuities.

v. Buried water mains, cables, and their runs alongside and across tracks.

vi. Signal cabins and location boxes, signal wires, point rods, cranks and signal cables.

vii. Signals: Main Routing, Shunt; their type and track for which meant.

viii. Buildings, huts, platforms, and other structures such as columns for over bridges, abutments of road over bridges.

ix. Platform shelters, their profiles across tracks, the height and distance of columns, and the edges of shelters from adjacent track.

x. Turnouts, crossovers, and diamond crossings, their deviation numbers viz. 1 in 8.5, 1 in 12 or 1 in 16 chainage of the fouling boards / marks, track centres at the toes of turnouts and at the fouling boards / marks.

xi. Water columns, Fueling points for Diesel locomotives.

xii. Overhead equipment, Metallic circuits (electric, low or high tension, signal, or telecommunications) running parallel to tracks and their distance from adjacent tracks centres.

xiii. Fencing: Metallic or otherwise, running along tracks, chainages of their beginning and end, and their distance to adjacent tracks at regular intervals; their type of construction.

xiv. Overhead wire crossings of tracks Telecommunications (railway or belonging to the Department of Telecommunications) and power line crossings.

xv. Over-line structures such as Road over bridges. Flyovers, foot over bridges and signal gantries: their vertical clearances from each track spanned and the horizontal distances of their support columns or abutments from the adjacent tracks.

xvi. Curves: whether right hand or left hand, as seen in the direction of increasing chainage; the degree of curvature, and the chainage of tangent points. Versine in mm are at curvature with nylon cord for the entire curve. The super-elevation as found at the site should be recorded.

xvii. Level crossings, their chainage, and the location of gate lodges, whether manned or unmanned and location of gate signals, if any.

xviii Locations of gradient posts and signal location marker posts.

xix Culverts and bridges: Chainage of their abutments, piers, trolley and man-refuges whether culverts or long bridges.

xx Tunnels; their chainages and profile, whether lined or unlined, location of trolley and man refuses.

xxi Identification and extent of exposed locations: Areas where full wind effects are likely to be encountered by OHE structures and termed ‘Exposed locations’ should be noted.

xxii Identification of polluted locations: areas, adjacent to factories and power stations having high ambient pollution particles should be identified and recorded.

xxiii Identification of bridge mast locations on piers by maintaining 10m distance from the bridge outer wall face and up to 5 m with condonation from EIG and CBE. Measurement of piers to explore the possibility of a type of bridge mast arrangement.

xxiv Identifications of locations with suitable land as well as nearest EHV supply source point for the traction substation (TSS) and Switching posts (SP/SSP) as proposed

xxv Identification of tree & forest removal for a clear corridor and necessary forest clearance.

(5) Preparation of Pre-Pegging and Pegging Plans

(a) General

The plan actually followed for field work, incorporating further details of the type of structures used, the style of the cantilevers used, the stagger of the OHE conductors, the run of wires, portal spans, as well as the setting distances of the structure legs becomes the 'OHE layout plan'.

(b) Pre-requisites for layout plans:

(i) Actual or Designed soil bearing pressure of the formation level.

(ii) Approved Drawings: the following approved drawings are required.

i Engineering Scale Plan (ESP) and L-Section.

ii SIP and Track bonding plan.

(6) Meteorological conditions

(a) The maximum, the minimum, and the mean ambient temperatures: The mean temperature adopted over the entire Indian subcontinent is 35 Degree centigrade. A range of 15 Degree centigrade to 65 Degree centigrade as the minimum and the maximum is adopted for India except the northern plains having colder winters for which the range adopted is 4 Degree centigrade to 65 Degree centigrade. For regulated OHE a contact wire height at supports of 5.65 m is adopted for the former range of temperatures and of 5.75 m for the latter range of temperatures. The contact wire height of regulated OHE is uniformly kept at 5.80 m at supports. The requirement for high-rise OHE is more. All these requirements are stipulated in IRSOD Chapter V (A) Para 2.

(b) Wind Speed zone; It is to be ascertained from IS 875 as to in which zone area the section to be electrified falls. This dictates the maximum permissible span to be adopted and the relevant employment schedule to be adopted for the design of structures and foundations.

(7) Movement of Over-dimensional Consignments (ODC)

The minimum height of the contact wire under heavy overline structures is normally kept such that class 'C' over dimensional consignments of Height 4.92 m can be moved at unrestricted speed with electric locomotives.

(8) Span Lengths

Span lengths are chosen in multiples of 4.5 m. The shortest span adopted is 22.5 m, and the longest span depends upon the particular specification of the wind speed zone and the type of equipment, with maximum of 72 m or less (varies as per different wind zones). The difference between two consecutive spans should not exceed 18 m to ensure compatible flexibility over the adjacent spans. Non-standard span lengths are permitted only if special conditions do not permit the choice of standard span sizes, such as while locating on bridge structure.

(9) The Setting Distance (Implantation) of Structures: The setting distance to be provided is stipulated in ACTM VOL.II/Part-II/Appendix-I/Para 20.0 of Nov'22.

(a) For individual masts carrying one OHE:

(i) On the tangent track Standard 2.80 m

(ii) Curved track

The minimum setting distance of masts, including portals, head span masts etc. on curves is obtained by adding the curve allowance and 150 mm slewing allowance to the setting distance specified for the tangent track.

(b) For a Portal upright, or a head span leg, or a mast carrying more than one OHE and balanced weight assembly (BWA) locations, the setting distance adopted should not be less than 3.00 m. can be relaxed to 2.80 m with personnel approval of PCEE/open line.

(10) Location of the Obligatory Structure

There are certain features along the track that require an OHE structure for supporting OHE. These are, for example, turnouts and crossovers. These OHE structures are called 'obligatory structures'. For the best result the track separation should be between 500 mm to 700 mm. However, if, due to site conditions, it is not possible to locate the obligatory structure as mentioned, it should be located at the position where track separation is between 150 mm -700mm.

The span under an over line structure should not exceed 54 m to limit the amount of push-up of the Catenary by the upward thrust of the pantograph; also, the structures supporting the OHE should be more or less equidistant from the centre line of the over line structure to ensure maximum clearance between the over line structure and the OHE conductors.

The curvature on the turn out requires staggers that should not exceed 300 mm in all cases towards the main track. Further, there should be a minimum horizontal separation between the two contact wires of 50 mm and a maximum of 200 mm at support to ensure non-interference between two OHEs and smooth changeover of contact wire for the pantograph of the locomotive negotiating the turn out.

Reference: RDSO Maintenance Instruction Note /MI/0028 Rev.-2 (**Ref. 17.02**)

(11) Distance between OHE structures and signal post

Reference: Railway Board letter No. 2021/EEM/148/3/ACTM dated 19.12.22

a) The distance between the signal post and traction mast shall be large as possible. In case the traction mast is located in front of signals post, the distance between the traction mast and signal post should not be less than 30 m. In addition it should be ensured that no mast shall be located beyond a signal post at a distance of less than 10 m. Layout plan

(LOP) showing placement of traction mast & signal shall be approved by PCSTE (or his authorized representative) with the concerned electrical officer. S&T Branch shall give SIP at earliest for preparedness of LOP.

In cases where the minimum distance stipulated in Para (a) above cannot be adhered due to field constraints, PCSTE and| PCEE (jointly) are empowered to give dispensation for further reduction in the distance, keeping in view the visibility of signal and safety aspects.

b) Reduction in distance between 30 m and 10 m with the dispensation of PCSTE and PCEE both jointly, after ensuring visibility of the signal and safety aspects.

(12) The location of Overlaps: Location of uninsulated overlaps inserted ensures the longest tension lengths, the effort being to have the minimum number of overlaps in the section. There is a limit of 750 m between the anti-creep central masts to the corresponding balance weight anchor mast at the overlap for regulated OHE. This limits the tension lengths to a maximum of 1500 m. For unregulated OHE, no anti creeps are required and the maximum tension length of conductors is increased to 2000 m. A half tension length of maximum 750 m OHE with one end as fixed termination may be adopted, omitting the anti-creep.

The centre line of insulated overlaps should be arranged in such a manner that there should be margin of min. 120m behind the stop signal and in a single line section the best practice is to keep it within the home signal and advance starter signal.

13 Location of Section Insulator: The total weight of the section insulator, including the weight of the two insulators on the OHE and the copper runners, is about 55 kg to accommodate the two insulators for both the conductors and to permit the locomotive pantograph to glide over the two runners of the section insulators. There is a requirement of a minimum dropper length of 450 mm and a maximum permissible stagger of 100 mm at the location of the section insulator. Since the maximum encumbrances at the OHE structure are limited to 1.4 m, this imposes a limit on the sag, and therefore, the distance of the section insulator should be located nearest to the OHE support.

Provisions for section insulator assembly shall be made at a distance from supporting mast as given in the table 17.01 below for copper conventional OHE. The pre-sag of the span carrying section insulator shall be zero.

Table 17.01

Section insulator assembly distance from supporting mast

Span	72 mts	67.5 mts	63 mts	58.4 mts	54 mts	49.5 mts	45 mts	40.5 mts
Permissible distance from support	7.7 mts	8.1 mts	9.4 mts	12.3 mts	13.5 mts	15.0 mts	18.2 mts	Any Where

It should be located beyond the point where the centre distance between two tracks is equal to or more than 1.65m. If the section insulator assembly is erected with the free end of the runner away from the centre of the turnout this distance may be reduced to 1.45m.

14 Bonding and Earthing Plans

Plans for suitable earthing and bonding of the metal work adjacent to track, breaking the long fencing in to smaller electrical sections, and providing safe passage of traction currents through rails by providing longitudinal and transverse bonds for the running rails of electrified

tracks are made. All OHE structures are bonded to the non-track circuited rail as per bonding & earthing code structure bonds or if such a rail is not available to an earth wire run on the OHE structures.

Proper arrangement are to be made for bonding and earthing of ROB/FOB girders at the time of erection by making holes of suitable size.

1706 PRINCIPLES FOR LAYOUT PLANS & SECTIONING DIAGRAMS FOR 25KV AC TRACTION

(1) Bond: An electrical connection across a joint in or between adjacent lengths of rail.

(a) Bond, Continuity.

(b) Bond, Cross.

(c) Bond, Impedance

(d) Bond Rail.

(e) Bond, Structure.

(2) Cantilever (Assembly)

It is an insulated swiveling-type structural member, comprising of different sizes of steel tubes, to support and to keep the overhead Catenary system in position so as to facilitate current collection by the pantograph at all speeds without infringing the structural members.

(3) Electrical Clearance

The clearance between 25 kV live parts and earthed parts of fixed structures or moving loads shall be as large as possible. The electrical clearances to be maintained under the worst conditions of temperature, wind, etc. are given below:

Minimum lateral distance between any live part of overhead equipment or pantographs and parts of any fixed structures (earthed or otherwise) or moving loads: for Long duration 250 mm and for Short duration 200 mm.

(4) Working Clearance

The minimum clearance between live conductors, equipment and such earthed structure or live parts of different elementary sections where men are required to work shall be 2 m.

(5) Wind Pressure

i. The wind Load wind pressures for the design of all masts and the determination of spans are based on wind loads as per IS:875(Part-3)-2015 “Design Loads (Other than Earthquake) for Buildings and Structures- Code of Practice” .The standard wind pressures adopted are as follows for all new works in different zones, as indicated in the specification.

Navy Blue	73 kgf/m
Yellow	105 kgf/m2
Blue	136 kgf/m2
Green	155 kgf/m
Red	178 kgf/m2
Hatched Red	216 kgf/m2

ii. The loading calculation for working out the wind loading takes into account 190% of the projected area for the rolled and fabricated sections and 3/4th of the projected area for

conductors and other circular member is taken into account.

Note: The safety of masts and portals is checked for two conditions.

a. At 35 degree Celsius and full wind pressure.

b. At 4 degree Celsius and 20% of the governing wind pressure

(6) Span Restrictions

The following restrictions are applicable:

(a) On main tracks, the lengths of two consecutive spans shall not normally differ by more than 18 m.

(b) The lengths of spans with unequal encumbrances shall be such that the axial distance between the Catenary and the contact wire at the minimum dropper is not less than 150 mm. For example, the length of the span with 1.4 m and 0.9 m encumbrances at the two ends shall not exceed 67.5 m. This restriction is applicable to the two spans on each side of the structure, equipping a turnout for the main OHE.

(c) Spans in the vicinity of over line structures with restricted headroom shall be determined with reference to the electrical clearances available.

(d) The lengths of spans loaded with section insulators may require to be restricted.

(e) Non-standard spans may be adopted in difficult locations, e.g. in rocky cuttings, on through girder bridges, for locations of masts on bridge piers and within station limits.

(f) With cross over equipment with actual crossings of OHEs at facing turnouts, the anchor spans shall be restricted to 54 m.

(g) Where earth wire is provided, the maximum span over level crossings should be 58.5 m

(7) Masts / Portals, Head Spans and Foundations

(a) Types of Masts

OHE conductors are suspended from swiveling cantilever assemblies generally erected on individual masts.

Different nine types of masts are used. These are designated as (150 x 150) BFB, (200 x 150) RSJ, K/B-100, K/B 150, K/B-175, K/B-200, K/B-225, & K/B-250B etc. The first two are rolled sections and remaining seven are fabricated masts.

(b) Two Track Cantilever

In the yards and sidings when the mast cannot be erected near the track to be equipped, it may be erected across one or two tracks using a two-track cantilever. This is generally used for supporting the OHE near turnouts and X-overs. These arrangements should not be used for supporting OHE of two main lines. The OHE can be supported up to a distance of 10.5 m from the upright with this arrangement.

(c) Portals

Three types of portals have been standardized. 'N' type portal is used for clear spans of 10m-20m (for 4 tracks maximum). 'O' type portal is for clear spans of 20m-30 m (for 6 tracks maximum) and 'R' type portal with spans of 30m-40m (for 8 tracks maximum). For more than 8 tracks a special type portal Upright with Boom may be adopted.

(d) Foundations

(i) Volume Charts: Selection of the type and size of foundation is done from the volume

chart (Drg. No. ETI/C/0058 Drawing No. T1/DRG/CIV/FND/RDSO/ 00001/04/0 on the basis of foundation bending moment (FBM) code, type and bearing capacity of soil/shoulder width and the extent of projection above ground level.

(ii) Type of foundations: Various types of foundations for OHE masts and portals are given in Table 17.03 below:

Table 17.03

Type foundation for OHE mast & Portals

	FOR MAST	**Drawing number**
1	(A) Side bearing (Type B) (B) Side gravity (type : BG) (C) Pure gravity (Type: G) (D) Pure gravity for black cotton soil (Type: WBC)	TI/DRG/CIV/FND/ RDSO/00001/04/0 (Sheet-1) "MOD-B"
2	New Pure gravity (Type: NG)	-DO- (SHEET-2)
3	NBC type foundation for dry black cotton soil (16500 & 11000 kgf/m2) 3.0 m depth.	-DO- (SHEET-3)
4	New pure gravity for different soil and site conditions (500 mm exposed) (Type-. NG or SPL)	DO- (SHEET-4)
5	New pure gravity for black cotton soil	
	(for 8000 kgf/m2 soil pressure. 2.5 m depth. (Type : NBC)	DO- (SHEET-5)
6	Foundations in soft rock (bearing capacity 45000 Kgf/m2)	ETI/C/0059 "MOD-C".
7	Foundations in hard rock (bearing capacity 90,000 kgf/m2)	ETI/C/0060 "MOD-D".
8	Bolted Foundation in hard Rock (Bearing Capacity-90000 kgf/m2)	TI/Drg/CIV/ANCHFDN/ 00001/17/0/ MOD-C
	FOR PORTAL	
1	In ordinary soil	ETI/C/0005/68
2	In dry black cotton soil	ETI/C/0063

(iii) Selection of foundations

Side bearing foundations are used for masts where the soil bearing capacity is 11,000 or 21,500 kg/m2 and a 300 mm wide shoulder is available on the banks.

New pure gravity foundations may be used for masts where soil bearing capacity is 5500, 8000, and 11000 kg/m2 or where an adequate shoulder width of 300 mm is not available.

Side gravity foundations may be used for masts where the soil bearing capacity is 8000 and 11000 kg/m2 or adequate shoulder width of 300 mm is not available.

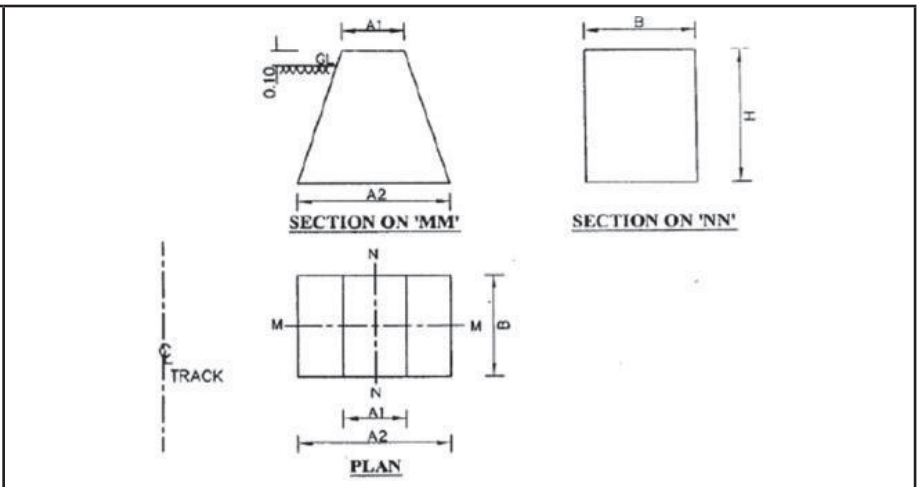
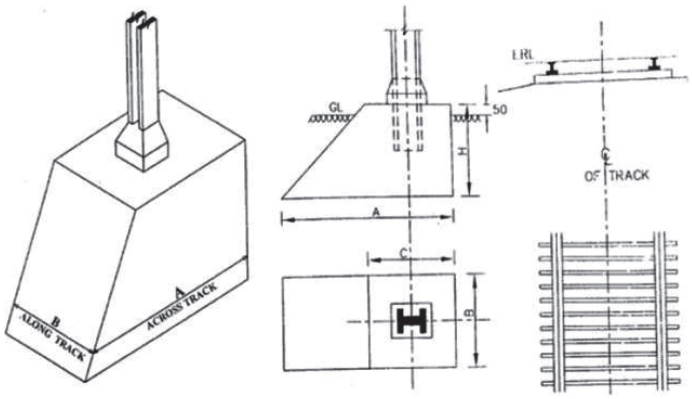
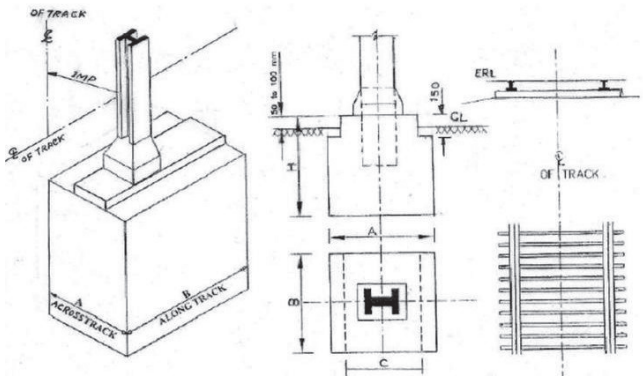
Pure gravity foundations (Type- MG G) are used for independent masts where the soil surrounding the foundations is loose and cannot exert passive pressure on the

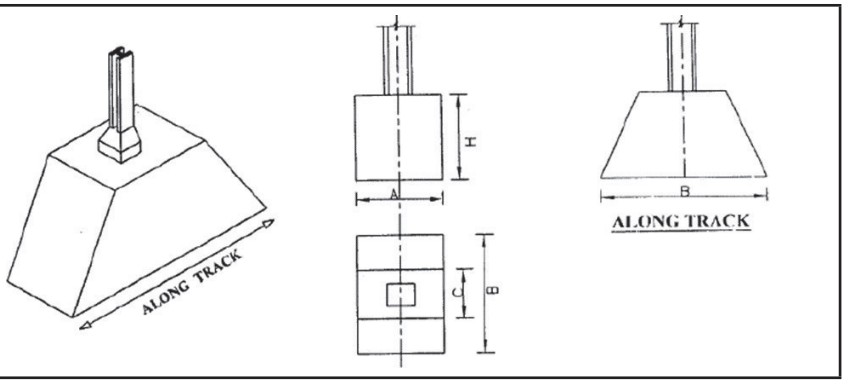
foundations. G-type foundations have been designed for soil bearing capacity of 5500, 8000, and 11000 kg/m2.

Pure gravity foundations (Type P) are used for portals and are designed for soil bearing capacity of 8250 and 11000 kg/m2.

The top of the foundation should be 50-100 mm above the surrounding ground level. The length of mast below rail level should be minimum 1850 mm for regulated OHE.

Fig. 17.01 - Typical Foundations

Pure Gravity Foundation	
Side Gravity Foundatio	
Side Bearing Foundation	

New Pure Gravity Foundation	

(e) Normally, the height of the contact wire (under side surface) above the track plane shall not be less than 5.50 m at any point in the span under the worst temperature conditions. To ensure this, the normal height at the suspension point shall be as follows:

Type of OHE Normal height of contact wire at the support point.

1. Regulated
    a. Normal with 10 cm pre-sag 5.60 m
    b. Normal with 5 cm pre-sag 5.55 m
2. Unregulated
    a. Unregulated OHE is designed at 5.75 m for areas with a temp range of 4 degree Centigrade to 65 degree Centigrade
    b. Unregulated OHE is designed at 5.65 m for areas with a temp range of 15 degree Centigrade to 65 degree Centigrade

For section planned to be electrified to suit high rise OHE, the above provisions shall be follows, as stipulated in IRSOD Para chapter V (B)

(f) Contact Wire Gradient

Any change in the height of the contact wire should be made gradually, and the slope should not normally exceed 3 mm/m on main lines and 10 mm/m on sidings. In no case shall the relative gradient of the contact wire in two adjacent spans be greater than 1.5 mm/m on main lines and 5 mm/m on sidings. The Railway Board vide letter no. 2001/ Elect(G)/170/1 dated 22.11.16 revised the contact wire gradient and relative gradient to 2 mm/m and 1 mm/m respectively for new electrification works.

(g) Stagger

On a tangent track, the contact wire is normally given a stagger of 200 mm at each support, alternately on the side of the centre of the track.

The catenary stagger is zero for masts supporting a single piece of equipment. The catenary is fixed vertically.

Un-insulated overlaps, the stagger of the in-running contact wire does not exceed 200 mm on the tangent track and 300 mm on the curve track at any support, at which only one contact wire is in-running. The two contact wires run parallel to each other between the intermediate supports at a distance of 200 mm from each other.

Insulated Overlap, between the intermediate masts the two contact wires run parallel at a distance of 500 mm from each other.

Neutral sections, the stagger at the section insulator type neutral section should be so adopted that the stagger at the section insulator assembly is within the limit of +/- 100 mm.

Polytetra fluoro ethylene (PTFE) type neutral section shall be erected on a tangent track only or as per the OEM installation manual. The stagger shall be zero at support. PTFE should be erected at a minimum distance of 400 m after and 200 m before the signal to prevent the stalling of trains.

(h) Encumbrances

(i) Normal- Encumbrance should be 1.40 m

(ii) Minimum Encumbrance should be 0.9m

Normally, the axial distance between the catenary and the contact wire at the minimum dropper should not be less than 150 mm.

(i) Locations of Section Insulators

Sectional insulators should be so located that the following conditions are fulfilled:

At the location of section insulator, the axial distance between the catenary and contact wire shall not be less than 450 mm.

The section insulator is to be located beyond the point where the centre distance between the two tracks is equal to or more than 1.65m. If the section insulator assembly is erected with the free end of the runner away from the centre of the turnout this distance may be reduced to 1.45m.

The stagger of the contact wire at the location of the section insulator should normally be zero, but in no case it should exceed 100 mm.

On loops, the section insulator shall, as far as possible, be located close to the first support of the overhead equipment for the loop.

The preferred location of the section insulator on the main running track is 2 to 10 m from the support in the direction of traffic, though its provision on the main line should be avoided.

In double line section, the runners should be in the trailing direction.

(j) Permissible Speeds

On double-line sections, with runners trailing, are fit for speeds up to 120 km/h.

In case the runners of the section insulator are facing or it is not installed within 1/3rd of the span, the speed should be restricted to 80 km/h.

(k) Tension Lengths

(i) Regulated Equipment

With regulated overhead equipment, every tension length is equipped with an automatic tensioning device at each end and an anticreep located approximately midway between the tensioning devices. The distance between the anticreep and the anchor mast / structures on either side should not exceed 750 m.

(ii) Half Tension Lengths

Half tension lengths of regulated overhead equipment, not greater than 750 m between anchorages, may be adopted where necessary. The equipment is fixed at

one end and provided with an automatic tensioning device at the other. The fixed end being determined to suit convenience of erection. The half tension length on either side of the neutral section should not exceed 600 m when the whole or a part of it is located on a curve. The distance of the axis of a 4-span insulated overlap from the anti-creeps or fixed terminations on either side shall not exceed 600 m.

(l) Bridges and Tunnels

Where the catenary is anchored on the face of an over line structure, the anchor shall be at the anticreep point. Termination of overhead equipment or provision of an anticreep should be avoided as far as possible inside the tunnels and on the mast set on bridge piers.

As per BS-121 "Guidelines for Provision of OHE mast for Electrification at new and existing bridge pier/abutment". When bridge/bridge pier to be designed, it must have provision for OHE masts irrespective of whether Electrification is sanctioned or not. The foundation arrangement to be followed should be as per BS-121.Provision of span location for mounting of mast or cantilever shall be made on bridge or tunnels.

(m) Masts near Signals

The visibility of signals should be kept in mind while deciding the setting up masts in their vicinity. The following principles should be observed for deciding the setting of masts near signals:

Colour light signals located outside all tracks

(i) Colour light signals without route indicators:

i Where no approach signal is provided: The minimum setting distance of structure before the signal should be 3.55, 3.40, 3.35, 3.20 & 3.05 m for distance up to 80m, beyond and up to 110m, beyond and up to 190m, beyond and up to 270m, and beyond and up to 400 m respectively.

ii Where approach signal is provided and for signals other than distant signals: The minimum setting of structures before the signal should be 3.55, 3.40, 3.25, 3.10, and 3.05 m for distance up to 50 m, beyond and up to 70 m, beyond and up to 115m, beyond and up to 160 m and beyond and up to 240 m respectively.

(ii) Colour light signals with route indicators:

i. With horizontal route indicator: The minimum setting distance of structure before the signal shall be 4.02, 3.80, 3.55, 3.35, 3.20 and 3.05 m for distance up to 60 m, beyond up to 125 m, beyond and up to 170 m, beyond and up to 215 m, beyond and up to 250 m and beyond and up to 310 m respectively.

ii With other than horizontal route indicator: The minimum setting distance of structures before the signals shall be 3.80, 3.55, 3.35, 3.20 and 3.05 m for distances up to 70m, beyond and up to 130m, beyond and up to 170m, beyond and up to 215m and beyond and up to 280m respectively.

(iii) Setting distance may be reduced for starter signals of loop lines and yard lines. The setting can be reduced in special cases, conforming to Fig.6 to 9 of Revised RDSO Drg. No. ETI/OHE/G/00112.Colour light signals located between tracks.

(i) Signals without route indicators: No overhead equipment structure should, as

far as possible, be located in the same lane as signals for a distance of at least 600m before a signal. Drop arms of portals should also not normally be located in the lane where signals are located, at least for a distance of 600 m before the signal. Where this is not possible for any reason, the signal should be mounted on an offset bracket. In addition, a special study should be made in each such case in respect of three drop arms before the signal to see whether the drop arms can be offset from the centre line of the lane in a direction opposite to the arms. A reduction in the signal height must also be examined.

(ii) Signals with route indicators: No part of a colour light signal without a route indicator should, as far as possible, be higher than 5.2 m above rail level. Great care must be exercised in deciding the location of the colour light signals with route indicators so that the necessary minimum clearances are available between the signals and live out-run wires, or pantograph sway zone.

1707 GUIDELINES FOR ANTI-THEFT CHARGING OF OHE

1. **General :**

(a) Publication and display of notices.

i. At least a month in advance of the energisation of any section or sections the following public notifications should be got published in all the prominent dailies in English, Hindi and local language and issued to all concerned as normally done for 25 kV energisation, (Reference may also be made to Para 21008)

1. General Notification to the Users of Railway lines regarding section/sections to be energised.

2. Notification to the users of level crossings.

ii. Display of general caution notices for public and staff at prominent places at each station, stenciling on the locos warning message to not to climb on the top of locos, caution notices at all loco sheds at which locos working in the energised section are maintained.

iii The loco pilot shall be warned not to climb on the roof of the tender and the engine on the section proposed to be energised.

(b) Certificates to be issued

Besides the certificates regarding completion of works to suit 2.2 kV energisation as mentioned in para 4.2 above, the following safety certificates shall also be obtained.

1. Joint certificate by CEE (P), CSTE (P) and CE (P) regarding safety to traffic as per draft at Annexure A 7.02.

2. Certificate of concerned officers of Division of particular Railway about knowledge of their staff regarding safety

(c) EIG Sanction

An application to EIG seeking his approval of the proposal of energisation of OHE at 2.2 kV as an antitheft measure may be made in advance. While applying for sanction, the upto date status of works to be completed prior to 2.2 kV energisation should be given and the list of certificates for its completion as well as other safety certificates proposed

to be forwarded at the time of seeking EIG's' formal sanction may also be indicated, EIG's' sanction shall be obtained prior to energization.

(2) Checks and Tests Prior to Commissioning

PCEE and Electrical Inspector to the Government for the Railway may nominate at his discretion one of his officers, preferably Sr. DEE (TRD) for joint checks and tests of the section proposed to be energised. For such joint check Dy. CEE(OHE)/RE will associate from RE side. Alternately he may authorize Dy. CEE(OHE)/RE to conduct checks and tests before energisation.

The following checks and tests shall normally be carried out.

(a) Checks

i. Clearance between live and earthed structures is in accordance with the provisions of Schedule of Dimensions.

ii. Earthing and bonding of the OHE have been carried out as per Bonding and Earthing code with exception for station area as specified in para 2.1.2 above.

iii. Height of contact wire at level crossings is proper and height gauges have been provided

iv. Protective screens have been provided in FOB, ROBs and signalling structure

v. Earthing and isolation of overhead equipment adjacent to the section to be energised has been carried out properly.

vi. AC immunised track relays have been provided

vii. Overhead P&T as well as Rly crossings have been cabled and wire removed.

(b) Tests

i. Megger tests for continuity and insulation of the OHE

ii. With the above checks and tests and after it is certified either jointly by Sr. DEE/TRD and Dy. CEE(OHE)/RE or by Dy. CEE(OHE)/RE that the section can be energised at 2.2 kV for test purposes, the following fault tests shall be conducted on the section energised at 2.2 kV. 1.

1. By creating an earth fault at the farthest end of energised OHE through discharge rod
2. By creating an earth fault at the farthest end of energised OHE touching only ballast.
3. By creating an earth fault at the farthest end of energised OHE touching only rail.

In all these cases of earth faults, it should be ensured that fuse provided at the supply point is blown.

(3) Condition before energization of OHE

Immediately after the successful completion of the checks and tests of the OHE, the OHE can be energised provided that:

1. All the certificates mentioned in paras 4.2 and 4.3 above have been obtained.
2. DOTs clearance and EIG's sanction are obtained

(4) Immediately after energisation, a notification to that effect may be issued, as normally done for 25 kV energisation.

1708 HIGH RISE OHE

Indian Railways decided to adopt double-stack containers on flat Wagons. The maximum height of the stock worked out to 6809 mm from rail level. Electrification of route suitable for movement of double-stack container had to be worked out. After lots of studies of expected OHE design and behaviour of the Locomotive Pantograph, IR decided to erect an OHE, where height of Contact wire at mid-span would be 7450 mm. The design for OHE, suitable for running of 7100 mm high consignment has been firmed up after detailed deliberations and site visits. The design also catered for the transition zone i.e. between normal OHE and high rise OHE. Transition zone OHE is essentially required so that the Pantograph may negotiate the feeder routes (with normal OHE) to the proposed high-rise OHE route without contact loss and ensure smooth current collection.

For smooth passage of the pantograph from normal OHE to high rise OHE or vice versa, the RDSO design shall be followed.

For 2x25kV electrification work OHE and PSI guidelines have been issued vide letter no. RDSO-TILKO(OHE)/47/2020 dated 23.10.20 and RDSO-TI0LKO(PSI)/1/2022 dated 25.02.22.

The high-rise OHE has been developed to strengthen the freight transport capacity of Railways with use of double-stack containers. The major advantages of double-stack container operation are Increased Throughput and Reduction in unit cost.

The advent of double-stack container transport has changed the entire intermodal freight industry worldwide. It has resulted in cost-effective, secure and reliable freight shipments and provided domestic intermodal Rail capacity that could not otherwise have been possible. RDSO has issued Design Document (No. TI/DESIGNS/OHE/2014/00001(Rev-1) for Over-Head Equipment for running double-stack containers and Three Tier Car under electrified route (High-Rise OHE) with speed potential of 140 KMPH.

(1) Important Parameters for High-Rise OHE : Tech specification:

OHE parameter	Value
Maximum Height of Double / Triple Stack Container	6809/6827MM
Minimum Height of contact wire from support from Rail level on curves height shall be measured from higher super electrical rail in open.	7220 mm
Maximum span length	Span length may vary from 54 to 67.5 m depending which has to be decided as per wind zone.
Type of foundation	As per foundation chart of RDSO drawing no. TI/ DRG/ CIV/ FDN/ 00001/ 13/0 (Sheet 1 to 5) for High Rise OHE
Maximum stagger at tangent track	(+/-) 150 mm
Maximum stagger at curves	(+/-) 250 mm
Standard Encumbrance	1400 mm

Dropper schedule to be followed	1.400/1.400 m Encumbrance Generally. (Based on Site conditions other prescribed standard Encumbrance may be followed)
Speed	140 kmph
Type of mast (Fabricated)	K/B-100, K/B 150 , K/B-175,K/B ,200 K/B 225 & K/B- 250 B.
Mast length	11.40 m
Minimum implantation	3.00 m
Minimum implantation on Platform	4.75 m
Tension in contact wire	1000 Kgf
Tension in catenary wire	1000 Kgf
Maximum tension length	1.5 km
Catenary wire	65 sq. mm
Contact wire	107 sq.mm
Merging with existing OHE	
For main line OHE (Height of contact wire at support)	5.80 m
For High Rise OHE (Height of contact wire at support)	7.57 m
Difference	1.77 m
ATD details	
Type of Auto Tensioning Device	Three Pulley modified groove auto tensioning device as per RDSO Specification No. no. TI/ SPC/ OHE/ ATD/0060 with A&C Slip No. 1 to 3- for total tension of 2000 Kgf
Stainless Steel Wire Rope	As per RDSO Specification No. TI/SPC/ OHE/WR/1060 with A&C Slip No. 1 & 2 (Length: 10 m)
X-Y Adjustment Chart	As per RDSO drawing no. TI/DRG/OHE/ ATD/RDSO/0000 3/99/0-Three Pulley ATD
Minimum vertical clearances under over line structures	
Heavy overhead structure such as Road Over Bridge	7870 mm (For new ROB)
Light overhead structure such as Foot Over Bridge	8250 mm (For new ROB)
Heavy overhead structure at Turn Outs Crossover is located under 40 m from nearest track	8250 mm

Reference Documents

SN	Para	Ref. document details	
1	1704(2) (C) (ii)	17.01	Railway Board letter no. 2021/EEM/180/5 Part (1) dated 18-04-2023
2	17.05(10)	17.02	RDSO Maintenance Instruction Note /MI/0028 Rev.-2

***

CHAPTER 18
Pre-NI AND NI WORKS AND COMMISSIONING FOR RAILWAY PROJECTS

1801 PLANNING FOR Pre-NI & NI WORKS

(1) GENERAL:

Construction organization is primarily involved in Pre-NI/NI working (Before or Pre-Non interlocked working / Non interlocked working) in connection with yard remodelling, new yard layouts in multi tracking/traffic facility works involving longer loops, additional loops, etc. Safer & faster execution of Pre-NI/NI works is the desire & requirement of one & all involved with train operations directly or indirectly. Hence, all relevant information, experiences for Pre-NI/NI working have been put at one place for ready reference. The chapter primarily covers the engineering works during Pre-NI/NI leaving aside the S&T and operating parts that can be referred separately from Operating manual, G&SR and instructions issued time to time from Zonal HQ/Railway Board for safe train operations during Pre-NI/NI.

(2) INTRODUCTION:

NI means temporary disconnection of points/signals/Axle counters & other signaling gadgets for any designated works. NI working not only slows down train operations; it is also less safe system vis-a-vis interlocked working. Detailed instructions are available in 'Operating manual' and G&SR for train operations during NI work. Generally, NI working is required for:

Overhauling of cabins/lever frames;

Yard remodelling;

Introduction/Replacement of Panel/RRI/EI working.

1802 NI WORKING IN ANY PROJECT

Planning of Pre-NI/NI starts with the conceptualization of yard plan. If we keep in mind the execution of Pre-NI/NI while processing the yard plan (ESP) for approval, half of the journey is completed successfully. NI working can be divided into three stages-

(1) CATEGORY 'A' WORKS:

Before Pre-NI works which can be done independently without affecting existing operations/ signalling system. These are the works which are not infringing in anyway with the existing signalling system. Generally, these works are carried within 2-3 months' time before Pre-NI/ NI. Following works can be there in this category:

(a) Leading of P. Way materials to exact/nearest locations.

(b) Assembly of switch portion of turnouts on staging.

(c) TRR/TSR in the yard.

(d) Deep screening of track at proposed turnout locations.

(e) Insertion of PSC sleepers in the lead and crossing portion of turnouts.

(f) Existing Steel Turn outturnouts, if any, to be replaced by Fan Shaped turnouts with S&T assistance.

(g) Linking of track to the extent possible.

(h) Insertion of Glued Joints, Rail weldings etc. as per available scope

(i) Provision of GFN liners in proposed track circuiting area (Generally it gets overlooked)

(2) CATEGORY 'B' WORKS:

Pre-NI Works are done in running lines and partially infringe with the signalling or existing operations. Theoretically speaking, there is no such thing like Pre-NI, as most of the alterations on running lines literally affect the train operations in some way, but to reduce the NI period which is relatively more restrictive in nature & potentially unsafe due to 'no signalled movement', few alterations can be done on running lines just before NI (say 4-7 days before NI). Therefore, meticulous planning is required to identify the works that can be executed in Pre-NI, as still there is a potential safety hazard. Following works can be there in this category:

(a) Processing for CRS minor sanction of yard works as required

(b) Assessment of all required materials and put arrangements in place to ensure all their timely supply

(c) TSR with GFN liners in track circuiting area.

(d) Insertion of new turnouts on running lines.

(e) Insertion of GJs and AT welding, etc.

(f) Partial commissioning of NI – Works of insertion/dismantling on blocked/ suspended/ surrendered lines i.e., depending upon the amount of works involved, few lines can be got blocked successively just before NI and all works on those lines can be got completed so as to commission these lines with NI This helps to reduce NI period greatly e.g., earlier in Amroha yard on MB-GZB section & in Raiwala yard on HW-DDN section, new loop line no.1 was coming at the same location of existing high level platform. So, it was judiciously decided to take NI & commission the yard without commissioning new loop line no.1 but completing the panel work by inserting the end turnouts with GJs, etc.

(3) CATEGORY 'C' WORKS:

NI works are those works wherein complete yard interlocking is removed and dismantling of existing signalling/turnouts, etc. is done. Testing of all S&T gears, signals and commissioning of new interlocking (PI/EI/RRI) is carried out.

1803 PRECAUTIONS FOR SAFE AND SMOOTH NI WORKING

(1) GENERAL ATTENTION PRIOR TO PRE-NI WORKS:

(a) Planning, and execution of Preliminary activities:

(i) Plan and Process for Green Notice/Temporary Working Rules/Padlocks required during Pre-NI/NI works.

(ii) 1st round of identification of interdepartmental (joint) activities such as -–

- Requirement of GFN liners/TSR etc. in track circuited area.
- Shifting/removal of location box, OHE mast Signaling foundation & signal etc.
- Joint testing/marking of GJs.
- Joint testing of all 'switches assembled outside'.

- Fixing of motor point on existing Turnouts – change of sleeper spacing.
- Overhauling of Level crossing in the yard, if any (Notice for road closure)

(iii) Plan for fixing of Gumties (water proof tent, portable toilet, table, chairs, potable water, men with crow bar, telephone, lighting etc.) at each station clearly mentioning location and dates on which Gumties will be required.

(iv) Plan for logistic arrangements for all staffs and officers; Vehicle/ Transport; Fooding; Water etc.

(v) Assess requirement of P.Way labour, machineries, supervisors for the entire Before Pre-NI, Pre-NI and NI period. The NI works should be taken up only after mobilization of adequate resources.

(vi) Plan for deployment of staff such as SSE/JE, Artisans, Track maintainers -

- Dedicated SSE/JE (Works) to be planned for Dismantling of any cabin/ structure/ taking out signal foundation, location box & simultaneous filling the generated cavity with already filled up sand bags.
- SSE/JE(P.way/Works) and labour from outside to be kept bare minimum; once deployed, their stay, food, water (tanker) arrangements to be taken care of.

(vii) Plan Walkie-Talkie sets for communication between Engg. S&T and Optg. Officials so as to optimally utilize Pre-NI/NI period despite availability of mobile phones.

(viii) Finalise day to day Pre-NI/NI programme clearly bringing out the traffic/power blocks with repercussion on train operations.

(ix.) As multiple departments work jointly in field at overlapping locations, the responsibility of departments regarding protection of track and safety should be segregated to the extent possible.

(b) Execution:

(i) Arrange sufficient number of rail cutting machines (Abrasive disc cutter, hack saw with adequate number of discs, blades & repair tool box), Rail drilling machines (with adequate drilling bits) hydra, JCBs including sufficient quantity of fuel.

(ii) Arrange adequate number of Gas cutters to meet any urgency

(iii) Arrange additional ballast required for turnouts in running lines and crossovers, cut and connection locations, etc.

(iv) Arrange adequate number of Blacksmiths (besides P.Way track labour) to avoid backlog of previous day interfacial work with S&T. All good retired Black-smiths contact numbers can be taken to mobilize them for NI work besides taking concentrated assistance from Open Line on programmed basis.

(v) Hiring of Carpenter for various identified misc. works e.g., distance blocks etc. directly from market & paid through special imprest.

(vi) Readiness of Welding teams duly assigning work before hand to optimally utilise them in traffic block.

(vii) Arrange to erect Engineering indicators and depute flagman for track protection as per requirement

(viii) Leading of all P.Way materials to nearest location, (special attention to rail pieces/ fish plates-bolts/joggles plates).

(ix) Testing of all GJs, Joint marking of location of all GJs and SRJs.

(x) Arrange Rail panels cut to suitable sizes for cut and connections and lead portion of turnouts at suitable location near the site of laying.

(xi) Fabricate Point/switch assemblies along with point machines at suitable location near the site of laying (on staging if required) and test jointly with S&T.

(xii) Erection and Use of 'Calling-on Signal' in yard remodelling works to reduce NI duration and requirement of blocks, if feasible.

(xiii) Arrange departmental artisans and departmental small track machines as standby.

(2) GENERAL ATTENTION FOR Pre-NI/NI WORKS:

(a) Identification of 'Interfacial activities' jointly & its review time to time.

(b) ADRM and concerned Open Line team of Divisional Officers and Supervisors should be nominated to ensure proper coordination and timely completion of NI.

(c) Erection of sturdy water proof Gumties well before the requirement

(d) Adhere to 'Day to Day programme' & clear everyday works so as to leave no back log. Leave 'no back log' of blacksmith work: make proper teams i.e., for attention of previous day work & for the days work separately.

(e) Make full Use of machineries e.g., hydra/JCB etc. for turnout insertion which is relatively better than T-28 machine in most of the locations due to all round/easier accessibility by hydra/JCB.

(f) Form teams & assign duties to various teams by meticulously dividing the entire yard work in different zones.

(g) Meticulous planning of all on track vehicles/ machines, duly indicating their marshalling and direction of movements.

(h) Organise 'daily evening inter departmental meeting' with officials of involved department (i.e., Engineering, S&T, Electrical, Operating) to review and to assign next day work (but of short duration about 15-20 minutes).

(i) Enquire/Discuss the probable timings of traffic blocks so as to arrange logistics i.e., lunch, rest, etc. of labour accordingly.

(j) A few motorcycles/ pick up vans to be kept at site, if feasible, to transport small machines, consumables and staff from one point to another in the long yard else lot of precious time gets wasted on these petty issues.

(k) 01/02 Push Trolley for faster movement from one end to other in long yard.

(l) List of names and mobile numbers of all officials (Dy. CE/XEN/AEN/ SSE/JE/blacksmiths etc.) to be prepared & circulated. WhatsApp Group (Name as NI- 'A' station) connecting all officials of NI Deptt. for sharing relevant information quickly in one go.

(m) Small folder containing 'Day to day NI programme'; Contact numbers; A-4/A-3 yard plan be given to all officers.

(3) PLANNING OF CONSTRUCTION WORKS UNDER ROLLING BLOCK PLANS

Concpt of Rolling Block Plan: A concept of Rolling Blocks has been introduced in Railways to streamline the maintenance and asset creation activities. The term Rolling Block implies that a programme for maintenance activities of all stake holders and construction blocks, including Non Interlocking works, etc. is framed for a period, at present for 12 weeks, and is approved at the divisional level. These blocks are then given in next week, taking into consideration the operational exigencies. The planning is extended every week for one week, duly reviewing the blocks granted in the previous week. The planning for the next week is then detailed properly. Railway Board had advised for implementation of Rolling Block Plans, and accordingly divisions are preparing rolling block plans for execution of various planned works in terms of JPO dated 29.08.2023 issued by the Railway Board vide letter no. 202/track-III/TK/2(**Ref. 18.01**). Accordingly, all activities of construction organization requiring blocks shall be planned as part of Rolling Block plans being prepared by divisions. The following guidelines may be kept in consideration while framing rolling block plans:

a) Rolling Block programme shall eventually be prepared for 26 weeks and submitted to concerned Division and approved by DRM. It shall be reviewed weekly and another one-week planning will be added every week.

b) Rolling Block Plan shall fulfill the requirement of traffic/power blocks for all activities of the construction organization, including NI working, movement of track machines, inspection vehicles and RMCs, etc. Mega blocks may be planned once in a week or as per the requirements of major infrastructure works or NI works.

c) The weekly block planning will be finalized by concerned branch officers and approved by DRM. Grant of blocks & output of blocks shall be reviewed by DRMs regularly and the review of grant and utilisation of blocks in the previous week shall be part of Rolling Block Programme.

d) This programme is for planned works. Activities requiring urgent blocks will continue to be governed as per the existing practices/provisions.

e) Appropriate and adequate resources should be mobilised to optimise the productivity during these blocks. Proper planning and resource mobilisation should be ensured to complete the planned work within the planned block time with the required quality.

f) Eventually, planning for blocks for mega works and NI works necessitating cancellation/ rescheduling/diversion of trains, should be made adequately in advance, and such works should be eventually slotted for exact dates in the 26-weeks horizon so that trains can be cancelled/rescheduled/diverted before the commencement of Advance Reservation Period (ARP), so that passengers are not inconvenienced. However, to start with, cancellation/ rescheduling/ diversion are to be made 4 weeks in advance as far as possible and the period should be gradually increased to ARP.

g) For increasing the maintenance corridors, intra-zonal trains can be rescheduled with the approval of GM under information to Railway Board.

h) For increasing the maintenance corridors, trains involving only 2 zones can be rescheduled by the zones concerned with mutual consultation and approval of GMs under information to the Railway Board. If agreement is not reached between the two zones, the matter may be referred to the Railway Board.

Based on the above methodology, construction organisation shall plan their requirement of blocks for effective utilization of avialble time for construction works.

1804 SPEED RESTRICTION DURING NI WORKING

Railway Board vide letter no. 2020/safety (A&R)/19/07 dated 18.03.2020, circulated Gazette notification regarding amendment to GR 4.10 **(Ref. 18.02)** permitting 30 KMPH speed of trains during NI period subject to few stipulations as follows –

(1) Clamp padlocking of points by using suitable clamps.

(2) No separate temporary panel is needed and only free home signal shall be given.

(3) Integrity of point shall be checked by Operating Staff and normal detection of facing points shall be proved in the concerned signal by suitable circuit wiring.

(3) Physical verification of track shall be done by ASM.

(4) Necessary safety direction should be incorporated in temporary working instructions for non-interlocking at 30 Kmph under approved special instruction with suitable infrastructural support as deemed necessary.

Field Officials should ensure compliance to these instructions before carrying out NI works with 30 kmph speed of train.

1805 CRS INSPECTION FOR OPENING OF SECTIONS

The commissioning of a project/section is of paramount importance and a mile stone. The present part describes the preparations required before, during, and after the inspection. A planned preparation helps in conducting the smooth inspection and commissioning of assets. After commissioning of the section and completion of balance works, the assets should expeditiously be handed over to Open Line.

The Commission of Railway Safety (CRS), working under the administrative control of the Ministry of Civil Aviation of the Government of India, deals with matters pertaining to safety of rail travel and train operation and is charged with certain statutory functions as laid down in The Railways Act (1989), which are of an inspectorial, investigatory, & advisory nature. The Commission functions according to certain rules.

1806 STATUTORY PROVISIONS FOR OPENING

In terms of Section 22 of The Railways Act, 1989 and Rules made under Sections 198 of the Act, the CRS has to carry out his statutory inspection of the new railway line (including Multi tracking works/ gauge conversion), its appurtenances, various sub-grade and accommodation works, etc., and submit his report to the Central Government stating whether the railway can be opened without any danger to the public using it. In case the railway cannot be opened without any danger to the public using it, he shall state the grounds thereof as also the requirements, which, in his opinion are to be complied with before the sanction is given by the Central Government.

The Railways Opening for Public Carriage of Passengers Amendment Rules, 2001 amended till 27.04.2023 provides for the detailed procedure to be followed. In this amended provision dated 27.04.2023 -

(1) Commission of few civil engineering works like Construction, rebuilding, modification, strengthening of foot-over-bridges, road over-bridges; Construction, rebuilding, regirdering, strengthening of minor bridges; Regirdering strengthening of all existing bridges, other than minor bridges; Elimination of manned level crossing; Upgradation of non-interlocked level crossing & diversion of Roads at level crossings; Upgradation of interlocked level crossing, including interlocking outside station limits; and Work related to Dedicated Freight Corridor. has been entrusted to Principal Chief Engineer and

(2) Commissioning of Electrification works has been entrusted to Principal Chief Electrical Engineer of zonal railway.

Further reference has also been given in Para 1210 of chapter XII of Indian Railway P. Way Manual 2020.

-Besides this, all codes/ manuals/ guidelines/ CE circulars issued by RDSO/ Railway Board/ respective Zonal Railways are also applicable and need to be followed.

This topic covers various aspects of CRS Inspection, starting from statutory provisions to preparations and submission of documents to CRS, planning for inspection, preparation for inspection, points to be observed during inspection and post inspection activities. Similar action should be taken for commissioning of few civil engineering works by Principal Chief Engineer, and electrification works (i.e., introduction of electric traction on lines already opened or being opened for passenger traffic) by Principal Chief Electrical Engineer requested through an application enclosing all applicable requisite documents in terms of Rule 5A of "The Railways Opening for Public Carriage of Passengers) Amendment Rules, 2001 amended till 27.04.2023"

1807 PLANNING FOR CRS INSPECTION

Planning for CRS inspection should start well in advance of proposed date of opening. It starts from compilation of drawings and records related to the work, followed by preparation of documents to be submitted.

(1) DETAILS REQUIRED IN CRS DOCUMENT-

The General Manager of a Zonal Railway shall furnish all the relevant documents to the Commissioner while making reference for inspection under rule 3 of "The Railways Opening for Public Carriage of Passengers) Amendment Rules, 2001 amended till 27.04.2023", from the list of following documents:

(2) TABULATED DETAILS –

These consist of important characteristics of the railway or a portion of railway to be opened for public carriage of passengers and in particular include –

i. Curve abstract
ii. Gradient abstract
iii. Bridge abstract
iv. Important bridges - particulars of waterway and construction
v. Ballast and permanent way
vi. Station and station sites

vii. Station accommodation

viii. Station machinery

ix. Level crossing abstract

The standard forms of these details have been given as Form (I) to (IX) in "The Railways Opening for Public Carriage of Passengers) Amendment Rules, 2001 amended till 27.04.2023",

(a) Index Plan and Section – These sheets shall be prepared as laid down in Para 443 to 451 of Engineering Code. Besides that, following drawings are also required to be submitted.

(i) Completion drawings of bridges, with drawings showing each type of girders used and giving the loading standard for which, each is designed, and (if called for by the Commissioner), details of the calculations of their strength;

(ii) Completion drawing of tunnels, if any;

(iii) Diagrammatic plans of station yard showing the gradients, the layout of track particulars of turnout, block working, and of any signals and interlocking installed.

(b) List of Questions and Answers – For all relevant questions enlisted in Form XV

(c) Certificate of works as per Form XVI of "The Railways Opening for Public Carriage of Passengers) Amendment Rules, 2001 amended till 27.04.2023", containing the comments on the following matters, namely:

(i) Maximum and Minimum dimensions

(ii) Strength of bridges

(iii) Number of engines on one span

(iv) Brake and communications

(v) Accommodation in coach to cater, for different categories of passengers

(vi) System of working

(vii) Types of rolling stock proposed along with list of restrictions

(d) List of infringements of maximum and minimum dimensions – It shall be prepared in Form XVII of "The Railways Opening for Public Carriage of Passengers Amendment Rules, 2001 amended till 27.04.2023" and shall show the gauge of the railway and items infringing and shall contain full explanation for infringement and the reference to the authority under which the infringement is permitted or allowed.

(e) Working orders – The working orders to be enforced at each station on the railway to be opened shall be prepared in accordance with the rules provided in Chapter V of The General Rules and shall specify any special conditions that are required to be met with.

Note:

(i) The documents referred to shall indicate the distances from the same fixed point, in kilometers up to two decimal digits and the referred fixed point shall be clearly defined in a Note and on the Plan and Section sheets of the work documents.

(ii) The datum adopted shall be Mean Sea Level as fixed by the Survey of India and all heights shall be mentioned with reference to the datum in meters and decimals up to two digits.

(iii) Track Certificate where applicable should be enclosed with application, on Form (Annexure 12/2 to IRPWM) signed by Deputy Chief Engineer (Track) to the effect that the track is suitable for the maximum axle loads stated therein. The certificate shall be countersigned by the Chief Track Engineer/Principal Chief Engineer.

(iv) For a major bridge, or when or when special spans (designed and constructed by Zonal Railways based on site requirement) are used, a certificate on Form (Annexure 12/3 to IRPWM) issued by Deputy Chief Engineer (Bridge) to the effect that the bridge or bridges are designed to carry the axle loads proposed to be run, should accompany the application. The bridge certificate shall be countersigned by the Chief Bridge Engineer/ Principal Chief Engineer.

(v) All the documents prepared/ collected should be compiled in form of booklet along with safety certificate and forwarding letter from General Manager of the railway.

(vi) The safety certificate is to be signed by all concerned PHOD and General Manager of the railway.

(vii) The document along with drawings should be submitted to Commissioner of Railway Safety by the concerned Chief Engineer when the section is nearly ready for inspection.

(3) COMPILATION OF DRAWINGS FOR CRS INSPECTION

A list of all working drawings and completion plans shall be prepared and drawings be arranged in set accordingly compiled which may include the following:

(a) Index Plan and L-section.

(b) LWR Plans

(c) GAD and completion plan of all bridges

(d) ESPs of Yards, Halt stations

(e) SIPs.

(f) Level crossings plans/ ESP

(g) Buildings.

(h) Land plans.

(i) FOB & PF shelter.

(j) Miscellaneous plans

(k) Completion plan of all works in connection with the railway to be opened

(4) Compilation of Documents for CRS Inspection

(a) All construction time records related to quality shall be compiled which may include the following:

Earthwork -	Soil quality and Compaction record
Blanketing -	Material quality and Compaction record
RCC -	Material quality and Cube strength record
PSC -	Material quality and Stressing record
Steel -	Material quality and Fabrication record
Major/Important Bridges -	Technical inspection, Load test, Camber record
Track -	L-section proposed vis-à-vis actual, Track parameters, Layout

calculations vis-à-vis actual layout parameters, Ballast cushion, LWR distressing, Welding, USFD testing of rail & welds.

(b) Other records related to inspection, infringement, Manpower, etc., shall be compiled which may include the following:

Inspections -	Inspection registers for Curve, LWR, Point and crossing, Level crossing, Sand hump, Bridges (Important, major and Minor separately in their specified format), Channel sleepers, Steel structure etc.
	First inspection done of all these assets and details recorded in respective registers.
	Joint inspection by officers at appropriate level from Engineering, Electrical and S&T department, and compliance status of their observations.
Infringement w.r.t. Indian Railway Schedule of Dimensions (IRSOD) -	Implantation to various structures w.r.t. center line of track (Masts, overhead lines, buildings, FOB, platforms etc.), Infringement details w.r.t. SOD and its condonation
Man power -	Requirement and matching creation of posts, Posting orders for newly created Engineering, Electrical and S&T assets

(5) Finalization of Date of Inspection:

First the internal probable date(s) of Inspection should be fixed by Chief Engineer after consulting all concerned officers. Thereafter, the Chief Engineer should approach the CRS for fixing for the suitable inspection date.

(6) Planning for Inspection:

After the date for CRS inspection is fixed, detailed planning shall be done, giving due consideration to the following points:

(a) Preparedness of section

(b) The end from which section is proposed to be inspected

(c) Direction of speed trial

(d) Road facilities for approaching road/vehicle/stations

(e) Stay facilities

1808 PREPARATION FOR CRS INSPECTION

Preparation for inspection requires extensive work. Some work may be completed before dates of inspection are fixed, where as some other can be planned only after the dates are fixed. Collection of documents, etc. should be completed before inspection dates are fixed to avoid last minute rush. Detailed check lists may be prepared as a reference for compilation of documents related to different works. Summary of care while preparing for CRS inspection as well as during CRS inspection (PCEE inspection for RE works) may be referred from document in annexure (**Ref. 18.03** and **Ref. 18.04**).

(1) DOCUMENTS DURING INSPECTION:

A number of documents are required to be carried during the inspection, which includes drawings, construction records, inspection registers, and codes manuals, detailed as under-

(a) Drawings:

All drawings of works executed should be collected and arranged in folders with index for quick retrieval during the inspection.

(b) Construction records:

All records of construction works related to quality and quantity should be collected and arranged in folders with index for quick retrieval during the inspection.

(c) Inspection Register:

All inspection registers should be prepared and carried during the inspection:.

(d) Code and Manuals:

All relevant codes and manuals duly updated with latest correction slips be collected for carrying during the inspection Following is the suggested list.

(i) Engineering Code
(ii) P.Way Manual
(iii) Bridge Manual
(iv) Work Manual
(v) Track Manual
(vi) USFD Manuals and welding manuals
(vii) Concrete Bridge Code
(viii) Steel Structure code
(ix) Pile/well Code
(x) Fabrication Standard – IRS-B1
(xi) RDSO Guidelines on earthwork.
(xii) Ballast specification
(xiii) CE/Circulars
(xiv) GCC
(xv) LHS/RUB/Level crossing guidelines
(xvi) Working Time table
(xvii) SWR of all stations
(xviii) Working time table

(2) Inspection/Measuring Equipment:

The calibrated instruments/ kits shall be kept with inspection trolley for inspection/testing of the works. Following shall form part of it:

(a) Gauge cum level
(b) Curve measuring kit
(c) Turnout measuring kit
(d) Level crossing measuring kit

(e) LWR/SEJ measuring kit
(f) Bridge inspection kit
(g) Level equipment with staff
(h) Theodolite/ Total station
(i) Measuring tape, Laser distance meter
(j) Steel Scale
(k) Soil density measuring kit (sand replacement & core cutter)
(l) USFD equipment with SE/P.Way/USFD
(i) Elcometer for measuring paint thickness
(j) Meggar for measuring insulation resistance of Glued Joints

(3) Oscillation Monitoring System (OMS):

OMS recording is required during trial run. Prior intimation should be given to concerned official for arranging OMS during trial run. Arrangement for carrying the equipment and personnel from their HQ to site should be made, if required.

(4) Inspection Trolleys

About 40 officers and staff use to accompany CRS during the inspection. Minimum 6 Motor trolleys should be arranged to accommodate the inspection team. It is desirable to keep 1-2 standby trolleys also. Detailed seating plan should be prepared and finalized in consultation with CRS. The seating arrangement should be fixed on each trolley for easy management during the inspection. Generally, the following arrangement works well:

(a) CRS, CE/C, DyCE/C
(b) Measuring kit + Refreshment + ABE + SE/W &P. Way + Supporting staff
(c) CAO/C, DRM, Sr.DEN
(d) Dy. CRS, XEN/C, ADEN: SE/PWay/C, SE/PWay/OL, SE/W/C, T/Man with measuring kit
(e) CSTE/C, CEE/C, CE/THOD: Dy. CSTE, Dy. CEE, Div. officers
(f) Other divisional officers as required
(g) 2 Numbers spare

(5) Other Arrangement During Inspection:

(a) Inspection steps and standing platforms should be provided on all important and major bridges.
(b) Besides that, Inspection steps should be prepared on at least all offered minor bridges for easy approach.
(c) For offered bridges, open foundation of wing wall/ abutment should be opened in small length for ready inspection.
(d) Ballast cushion should be opened at every km and on bridges to save time during inspection.
(e) Route markers for stations should be provided for road vehicles.
(f) If night stay is involved, place for stay shall be decided and booked in advance.

(6) Identification of Specific Duties of Officials:

All the inspection related work be divided on functional basis, and competent officers/staff should be deputed on the same for smooth inspection.

(7) Identification of Assets to be Offered For Inspection:

Civil engineering assets to be offered for inspection should be judiciously selected and also informed to the concerned officers of open line. Usually, following norm is followed in selection of number of assets to be offered for inspection.

(a) All Important bridges

(b) 20% of major and 10% of minor bridge (Minimum 2 of each type per block section)

(c) 10% Level crossings (Minimum 2 per block section)

(d) Blanketing and earth work (including bank profile) on approaches of all offered assets.

(e) Highest embankment, Deepest cutting and a Tunnel

(f) 2 turnouts per station

(g) 1 LWRs per block section

(h) 1 sand hump per station (if provided)

(i) 1 curve per block section including sharpest curve

(j) Ballast cushion on approaches of all offered assets

(k) Sleeper spacing and squaring on approaches of all offered assets

(l) Welds on approaches of all offered assets

(8) Minute to Minute Programme:

A detailed minute to minute program should be prepared for the inspection, giving due breaks for tea and lunch time. While preparing the program, inspection time for offered assets be duly accounted for. Normally, 30 minute per important and major bridge and 15 minutes per minor bridge/ turnout/ curve/ LWR is considered reasonable. If too many assets are offered, allowance should be made for assets skipped from inspection while planning lunch and tea break. It is advisable that CE/C discuss the program with CRS to incorporate his views. Once finalized, the program should be circulated to all concerned for information and necessary action.

(9) Resolving/Preparing for Foreseeable Issues:

There may be local issues which are best known to SE/AEN or Dy.CE, e.g., demand for some facility by local public, issues related to land payment, any likely agitation. These should be deliberated, and any likely issue should be brought in to the knowledge of higher-ups. The issue may be resolved, preferably before inspection or at least planning be made for their solution. If required, assistance of district administration may also be sought. A pre-planned strategy to handle such issues may avoid embracing situation during the inspection.

(10) Liasoning With Open Line/Bridge Line

Due intimation should be given to the open line officials, including DRM, Sr.DEN, Sr.DOM, Sr.DSTE, Sr.DEE, SE/PWay/USFD, SE/OMS with their allied staffs, for accompanying the inspection. Intimation should also be given to Dy. CE/Br. Line for deputing his staff to accompany during the CRS Inspection.

(11) Local Liaisoning

An intimation should be given to the concerned District Magistrate/ Superintendent of Police for maintaining Law & Order and security along the track, Level crossings, during inspection and Speed trial run. Public advertisement regarding CRS inspection date should be given for awareness of local public through newspapers.

(12) Miscellaneous

Working lunch arrangements should be planned for the inspection. In case of long section, this may be planned at any station enroute to save time. In case of short section opening where time is not the constraint, working lunch may be planned in resting facility.

1809 PROCEDURE FOR CRS INSPECTION

(1) MARSHALLING OF TROLLEYS:

A due care shall be given for marshalling of trolleys as given in para 18083(4) above. The trolleys should be tested on previous day and any deficiencies noted should be rectified. Brakes of motor trollies should be tested for their effective application. All trolleys be kept ready at least 1 hour in advance of inspection, duly fueled, along with properly dressed trolley men having competency certificate. Fast moving trolleys should be placed in front. Slow moving may preferably be kept as spare in rear. Sufficient distance shall be kept in adjacent trollies to avoid collisions.

(2) START OF INSPECTION:

A handout may be given to senior officers before inspection as ready reckoner. Other officers may be given a copy of minute-to-minute program.

(3) INSPECTION OF ASSETS:

Inspection will usually be done as per minute-to-minute programme drawn earlier, unless some major anomaly or feature is noted during inspection. Offered assets should be pre-inspected by open line officials with inspection results duly filled in respective proforma. CRS may like to only get results test checked or may order for complete inspection. In any case, pre-inspection is required, and it helps.

(4) REPLY TO QUERIES DURING INSPECTION:

The reply of queries raised by CRS will generally be given by Chief Engineer/Construction or Dy.CE/C (or their counterparts for S&T and Electrical related issues). AEN/XEN should be ready with supporting records related to queries and should produce the same expeditiously whenever asked for. However, questions may be asked from other officers/ staff also and in that case, the person being asked is supposed to reply. In case of his failure to reply satisfactorily, others may reply with due permission of CRS.

(5) MISCELLANEOUS

Other arrangements like Umbrella, Raincoat, Torch, Cap, Road Vehicle,First aid Box etc. may be planned as per requirement

1810 ACTIONS POST INSPECTION

(1) ISSUES RELATED TO IMMEDIATE COMPLIANCE

CRS may ask for immediate compliance of some items either before opening or in very short time after opening. Such work should be planned on priority and carried out expeditiously.

(2) ISSUE OF AUTHORIZATION:

Authorization is issued after the inspection. In case of Multi-tracking works, where trains are already plying, authorization is issued on the same day after speed trial. In case of New lines, as trains operation on the line are not affected, authorization is issued after some time. For commencement of operations subsequent to CRS authorization, the fit certificate for all the infrastructure like track, signal and OHE is must and should be issued by concerned supervisor at the earliest.

(3) COMPLIANCE OF CONDITIONS IN AUTHORIZATION:

As soon as authorization is issued from CRS based on his inspection, the inspection note/ condition should be studied and complied at the earliest within stipulated period given in authorization. The compliance of the same must be submitted to CRS soon after the compliance.

1811 HANDING OVER AND TAKING OVER OF NEWLY COMMISSIONED ASSETS

All newly created assets should be transferred expeditiously to open line as per concurrent guidelines of Railway Board and Zonal Railways. A sample procedure Order order for Handing/ taking Over of New Assets of Northern Railway (PCE/NR's Circular No. 268 R dated 10.04.2015) is provided as **Ref. 18.05**.

Reference Documents

SN	Para No.	Ref. document details	
1	1803(3)	18.01	Rolling Block Plan – JPO issued vide Rly. Bd. Ltr. no. 2020/track-III/ TK/2 dt. 29.08.2023
2	1804	18.02	Railway Board letter regarding 30 Kmph speed of trains during NI working
3	1808	18.03	Checklist for CRS Inspection
4	1808	18.04	Checklist for PCEE Inspection
5	1811	18.05	Procedure Order for Handing/Taking over of New Assets

***

SUMMARY OF REFERENCE DOCUMENTS

CHAPTER 1 – ALIGNMENT AND SURVEY

SN	Para No	Ref. document details	
1	101(1), 103	1.01	Setting up of Gati Shakti Units in Divisions Railway Board's Lr. No. 2021/W-I/Gen/Gati Shakti dt. 27.07.2022
2	101(2), 102(3)(a), 104	1.02	Fast-tracking the sanction & execution of Projects - Rly Bd's Lr. No. 2021/W-I/Genl./Gati Shakti dt. 28.10.2022
3	102(3)(C)(vi), 104(3)(q)(i)	1.03	Financial Appraisal framework for evaluation of Railway Project - Railway Board's latest Circular No.2023/ Gatishakti/TF/02 dt. 14.09.2023
4	102(3)(C)(vi), 104(3)(q)(ii)	1.04	Economic appraisal framework for evaluation of Railway Projects - Railway Board's latest Circular No.2022/ Gatishakti/EU/49 dt. 19.08.2022
5	104	1.05	Proposals for sanction of Final Location Survey (FLS) 2021/W-I/ Genl./Gatishakti Pt. 3 dt. 31.07.2023
6	104(3)(r)	1.06	Proforma for preparation and submission for DPR for NL/MT/GC - Railway Board's Lr. No. 2022/W-I/Gen/DPR Proforma dt. 02.09.2022
7	104(3)(r)(iii)	1.07	Development of a short video by project Proponent on the Proposed Project 2021/W-I/Genl./Gatishakti (E-3378115) dt. 24.08.2023
8	…….	1.08	CAO Conference on the subject "Efficient Project Management" on 22.04.2023 2023/Gatishakti/ Genl./ CAO/Conf. dt. 29.05.2023
9	……	1.09	Fast-tracking the execution of Projects No.2023/W-I/Genl./CAO/C/ Conference.Pt.7 dt. 16.03.2023

CHAPTER 2 – PROJECT PLANNING

SN	Para No	Ref. document details	
1	201(1)	2.01	Degree of curvature for new projects of New Line, Gauge conversion and Doubling and Level Crossing in New Line. [Railway Board's Lr. Nos. 2013/W-I/Genl./0/30 Pt-II dt. 04.05.2018 & 28.05.2018]
2	201(1)	2.02	Speed Policy framework for Indian Railways. [Railway Board's Lr. No. 2017/Mobility/2/3 dt. 08/12.06.2018 and 2015/W-1/Genl./ Corr.GM/pt. dt. 06.12.2018]
3	201(2)	2.03	Construction of formation for Doubling on DFC feeder routes. [Railway Board's Lr. No. 2013/W-1/Genl./0/30 Pt-II dt. 18.12.2019]
4	201(4)	2.04	Construction of bridges during doubling. [Railway Board's Lr. No. 2017/29/CE-III/BR/Br.588/ECoR dt. 03.08.2017]
5	201(5)	2.05	Planning of OHE Layout While Executing Electrification work on single line sections. [Railway Board's Lr. No. 2017 /W-I/Genl./NL- RE dt. 27.01.2017]

SN	Para No	Ref. document details	
6	201(6)	2.06	Level Crossings on New Line/Gauge Conversion/ Doubling/ Multi Tracking projects. 2021/W-I/Genl./Gatishakti (e-3378115) dt. 18.08.2023
7	201(8)	2.07	Policy guidelines-Execution and Alignment of 3rd line projects. [Railway Board's Lr. nos. 2013/PL/19/1 (Policy) dt. 05.07.2018, Lr. No. 2018/W-I/Genl./Policy dt. 04.09.2018 and Lr. No. 2023/W-I/Genl/ CAO/C/ Conference. Pt.7 dt. 16.03.2023]
8	201(8)(a)	2.08	Comprehensive instructions for provision of passenger Amenities and user facilities at station. [Railway Board's Lr. No. 2018/ LM(PA)/03/06 dt. 09.04.2018]
9	201(8)(a)	2.09	Platform length at Railway stations for new line, gauge conversion and doubling projects. [Railway Board's Lr. No. 2013/W-I/ Genl./0/30/Pt-II dt. 25.02.2020]
10	201(8)(a)	2.10	Provision of Fixed structures in New Line/Gauge conversion projects and setting of Gate lodges, station buildings etc. alongside the existing track. [Railway Board's Lr. No. 2013NV-I/Genl./0/30 Pt. II dt. 12.05.2017]
11	201(11)	2.11	Up-gradation of electric traction system [Railway Board Lr. No. 2022/RE/161/4 dt. 27.05.2022]
12	202(10)	2.12	Standard yard layouts [Railway Board Lr. No.2015 /Sig/ WG/ Standard layout dt. 12.07.2017
13	202(3)(A)	2.13	Provision of different type of services/consultancies for project implementation in Indian Railways. [Railway Board's Lr. No. 2023/CE-I/CT/1/Policy dt. 15.03.2023]
14	201(6)	2.14	Policy for Road Crossing Works (ROB /RUB /LHS /FOBs / Subway) to eliminate level crossing and Trespassing areas under PH-30 issued vide Rly. Bd. Lr. No. 2017/CE-IV/LX-Misc./ 244 (LCs) Pt. dt. 02-03-2023

CHAPTER 3 – LAND ACQUISITION AND FOREST CLEARANCE

SN	Para No	Ref. document details	
1	303(1)(b)	3.01	Railway Board's Lr. no 2010/LML/12/8 dt. 19.12.2014 authorising General Managers of Railways to notify any project as "Special Railway Project."
2	303(1)(c)	3.02	Railway Board's Lr. No. 2018/W-1/Genl/Land Acquisition dt. 25.11.2022 to declare projects as "Special Rly Project".
3	303(1)(c)	3.03	Railway Board's Lr. No. 2010/LML/12/8 dt. 21.02.2020 to declare projects as "Special Rly Project"
4	303(3)(a)	3.04	Railway Board's Lr. no 2015/W-2/SCR/NL/22 dt. 20.10.2016 listing cases where land acquisition can be done under Direct Purchase Policy

SN	Para No	Ref. document details	
5	307(8)	3.05	As per Railway Board's Lr. No. 2018/W-I/Genl./Land Acquisition/ Pt I dt. 06.09.2018 regarding land acquisition for tunnels.
6	310(2), 310(3)(a), 310(6)(a)	3.06	Rly Board's Lr. No. 2008/LML/12/2 dt. 13.02.2008 authorising CAO/C and GM to notify Competent Authority for land acquisition under Rly Act.
7	310(1)	3.07	Sample Gazette Notification to notify Special Railway Project u/s 2(37A) of Railway Act
8	310(2)	3.08	Sample Gazette Notification to notify "Competent Authority for Land Acquisition" u/s 2(7A) of Railway Act
9	310(3)(a)	3.09	Sample Gazette Notification to declare intention to acquire land u/s 20A(1)
10	310(6)(a)	3.10	Sample Gazette Notification for declaration of land acquisition u/s 20E(1)
11	310(9)(a)	3.11	Land Acquisition (Special Railways Projects) Rules, 2016
12	310(9)(a)	3.12	Rly Bd. Lr. No. 2018/W-I/Genl./Land Acquisition dt. 05.02.2020 reg. opening of joint account for payment under Rly Act
13	310 (9) (a)	3.13	Railway Board's Lr. No 2023/ACII/9/2/e 342205 dt. 27.02.2023 reg. opening of joint account for payment under Rly Act
14	311 (17) (d)	3.14	Railway Board's instructions vide Lr. no 2021/W-1/377/SR/7 dt. 06.02.2023, reg. expeditious payment of compensation amount.
15	311(14) (c)	3.15	Railway Board's Lr. No. E(NG)II/2010/RC-5/1 dt. 11.11.2019 reg. Lump sum payment of Rs. 5 lakh and no employment to the affected families
16	314(1)	3.16	Railway Board vide Lr. no 2019/W-1/Genl/Land-LC (E-3280805) dt. 08.06.2023, reg. mutation and completing land records.
17	314(5)	3.17	Railway Board's Lr. No. 2014/LML-11/13/7 dt. 09.07.2014 reg. handing over of land records to open line
18	314(5)(f)	3.18	Sample Copy of Land Taking/handing over note with Railway and Revenue officials
19	318(2)(e)	3.19	MoEF's Lr. dt. 10.03.2022 reg. non applicability of Forest Conservation Act, 1980 and Wild life Protection Act, 1972 for Rly land in forest area.
20	318(2)(e)	3.20	MoEF's Lr. dt. 22.02.2023 reg. non applicability of Forest Conservation Act, 1980 and Wild life Protection Act, 1972 for Rly land in forest area.
21	318(4)	3.21	Ministry of Environment, Forest and Climate Change's Lr. no F.No. IA3-12/3/2023-IA.III (E-220190), dt. 06.10.2023, reg CRZ clearance.
22	317(1)	3.22	Ministry of Defence's Lr. No. 11015/2/2012/D (Lands) dt. 11.3.2015 regarding transfer of defence land.
23	317(1)(vi)	3.23	Ministry of Defence's Lr. No. 11015/2/2012/D (Lands) dt. 02.02.2016 regarding transfer of defence land.

CHAPTER 4 – DRAWING APPROVALS

SN	Para No	Ref. document details	
1	403	4.01	Approval of Engineering Drgs. – Rly. Bd. Lr. No. 2017/CE-1/CT/13/ Procedure simplification dt. 20.10.2017
2	403	4.02	Advance correction slip No. 36 of IRBM dt. 27.03.2018
3	403	4.03	Advance correction slip No. 38 of IRBM dt. 14.01.2020
4	404 408	4.04	Standard procedure order for ESP, SIP & GAD approval in zonal Rly. 2017/CE-UTC/13/Procedure simplification dt. 22.04.2022
5	405	4.05	Approval of bridge designs and drawings for works being executed by RVNL – Rly Bd. Lr. No. 2021/CE-III/BR/1/Bridge Policy dt. 28.10.2021
6	406	4.06	Rly Bd Lr. No. 2018/Sig/36-SD/1 dt. 26.11.2019, for standard scheme for preparation of SIP.
7	406	4.07	Rly Bd Lr. No. 2020/Sig/Drawings dt. 02.03.2022 regarding guidelines for use of standard layouts of double line sections.
8	406(2)	4.08	IRSEM Drg. No. 8- D2 (Sheets 1 of 4, 2 of 4, 3 of 4, 4 of 4) of control table for double line station for guidance.
9	406(3)	4.09	IRSEM Drg. No. 17- D2 for track circuit bonding diagram for a 4-road station (double line) for guidance.
10	406(4)	4.10	SWRD related details in Operating Manual Chapter station working rules (SWRs) and temporary working order.
11	406(5)	4.11	Interface Circuit and logic Circuit Diagram related details in CHAPTER 4 of Electronic Interlocking notes of IRISET S-18 regarding installation of electronic interlocking system.
12	406(6)	4.12	IRSEM Drg. No. 21- D5 (Sheet 1 of 2 and 2 of 2) for CONTACT ANALYSIS FORMAT for guidance.
13	406(7)	4.13	IRSEM Drg. No. 8- D3 VDU layout plan for electronic interlocking (EI) for guidance.
14	406(8)	4.14	IRSEM Annexure: 9-A7 Joint Inspection/Handing Over of New Assets.
15	406(9)	4.15	IRSEM Drg. No. 15-D9 (Sheet 1 of 3, 2 of 3 and 3 of 3) i.e. CABLE CORE PLAN for guidance.
16	406(10)	4.16	IRSEM Drg. No. 19-D8 and 19-D9 for location wiring FORMAT for guidance.
17	406(11)	4.17	Relay room floor plan for guidance.
18	406(12)	4.18	Policy guidelines for signalling works by W. Rly, No. SG 216/0 Dt:-10/11/2022.
19	406(12)(f)	4.19	IRSEM drawings i.e. 21-D1: S&T Building Plan for End Goomties (EI), 21-D2: ASM Room Layout Plan, 21-D3: SM`s Table with Dual VDUs etc. for guidance.
20	406(12)(f)	4.20	Typical Drawing for S&T Service Building (up to 100 routes with single IPS) with Centralized Interlocking System issued vide Railway Board 85th SSC dt. 08.01.2019.

CHAPTER 5 – TENDER, CONTRACT & CONTRACT MANAGEMENT

SN	Para No	Ref. document details	
1	507(8)	5.01	Railway Board Lr. No. 97/CE. I/CT/42 dt. 04/07/97
2	504(3)(d)(iv)	5.02	CVC Lr. No. 8(1)(h)/98(1) dt. 18/11/98
3	505(3)	5.03	Railway Board Lr. No. 2004/V-1/CVC/1/18 dt. 02/01/06
4	506(17)(a)	5.04	Railway Board Lr. No. 2010/CE-I/CT/11 dt. 11/06/10
5	503(6)	5.05	Railway Board Lr. No. 2012/CE-I/CT/O/5 dt. 09/04/12
6	503(2)(c)(ii)	5.06	Railway Board Lr. no 94/CE-I/CT/4 pt.17 dt. 13/08/12
7	503(1)(g)	5.07	Railway Board Lr. No. 2013/CE-I/CT/O/12/ZT dt. 07/06/13
8	504(4)	5.08	Railway Board Lr. No. 98/W-I/Genl./O/30/Pt-I dt. 03/07/13
9	504(4)	5.09	Railway Board Lr. No. 2012/CE-I/CT/O/10 dt. 26/08/13
10	502(1)(c)	5.10	Railway Board Lr. No. 2010-BC-AP-3.34/08.09 dt. 05/11/13
11	506(9)(b)	5.11	Railway Board Lr. No. 2013/CE-1/CT/O/29/VAR dt. 05/03/14
12	503(8)	5.12	Railway Board Lr. No. 2014/CE-I/WP/5 dt. 05/02/16
13	509(3)(l)	5.13	Railway Board Lr. No. 2016/CE(I)/CT/ARB/3 (NITI Aayog)/Pt. dt. 08/03/17
14	502(1)(a), 504(2), 506(13)	5.14	Railway Board Lr. No. 2017/Trans/01/Policy dt. 08/02/18
15	502(1)(a), 503(6), 503(11), 506(17)(b)	5.15	Relevant abstract of Model SOP 2018
16	504(3)(b)(iii)	5.16	Railway Board Lr. No. 2017/Trans/01/Policy/Pt-S dt. 28/03/18
17	503(11)	5.17	Railway Board Lr. No.2018/Trans. Cell/S&T/NIT Period dt. 26/07/18
18	503(3)(f)	5.18	Railway Board Lr. No.2018/Trans. Cell/ S&T/ Contractual Staff dt. 20/11/18
19	502(3)(d), 503(2)(c)(ii)	5.19	Railway Board Lr. No. 2015/W-l/Genl./CORR.GM/Pt.III dt. 30/11/18
20	502(1)(c), 502(1)(e), 504 (4)	5.20	Railway Board Lr. No.2018/CE-I/CT/36-EPC Contract Policy dt. 30/12/19
21	509(3)(k)	5.21	Railway Board Lr. No. 2016/CE(I)/CT/ARB/3 (NITI Aayog)/Pt. dt. 05/05/20
22	504(3)(a)(iii)	5.22	Railway Board Lr. No. 2017/CE-I/CT/9 dt. 10/09/20
23	503(8)	5.23	Railway Board Lr. No. 2018/Trans Cell/ S&T/Model SOP dt. 21/09/20
24	506(13)	5.24	Railway Board Lr. No. 2018/CE_I/CT/36-EPC Contracts policy/ Pt-1 dt. 09/10/20
25	506	5.25	Railway Board Lr. No. 2018/CE-I/CT/30 dt. 24/06/22
26	502(1)(a)	5.26	Railway Board Lr. No. 2022/F(X)II/PW/3 dt. 20/07/22

SN	Para No	Ref. document details	
27	506	5.27	Railway Board Lr. No. 2018/CE-I/CT/30 dt. 01/08/22
28	506	5.28	Railway Board Lr. No. 2018/CE-I/CT/30 dt. 22/11/22
29	503(3)(f)	5.29	Railway Board Lr. No. 2023/CE-I/CT/1/Policy dt. 15/03/23
30	503(11)	5.30	Abstract of General Terms & Conditions on GeM dt. 02/05/23
31	503(2)(c)	5.31	Railway Board Lr. No. 2023/GatiShakti/Genl./CAO-Conf. dt. 29/05/23
32	511	5.32	Summary of internet link for standard documents for procurements

CHAPTER 9 – PLANNING OF BRIDGES

SN	Para No	Ref. document details	
1	904(3)(a)	9.01	Railway Board's Lr. No.2021/W I/ Genl. / Gati Shakti dt. 28.10.2022
2	908(4)	9.02	RDSO Lr. No RBF/GIS dt. 11.03.2022
3	913(7)(a) 914(4)(b)	9.03	Railway Board's Lr. No.2014/CE-III/BR/ Bridge Policy dt. 21.04.2015
4	913(8) 914(7)(a)	9.04	Railway Board's Lr. No.2017/29/CEIII/BR/ Br. 588/ECoR dt. 03.08.2017
5	915(7)(a)	9.05	RDSO Lr. No. CBS/DWF dt. 15.07.2019
6	916(1)(a)	9.06	Railway Board Lr. No.2015/CE-III/BR/Structure Code dt. 19.01.2022
7	916(1)(d)	9.07	Railway Board's Lr. No. 2005/CE-I/BR-11/8 dt. 28.05.2009
8	916(2)	9.08	Railway Board No. 2013/CE-III/BR/RDSO/Misc. dt. 11.08.2014
9	919(2)	9.09	RDSO Lr. No. CBS/DPA dt-09.07.2020
10	920	9.10	Railway Board's Lr. No. 2014/CEIII/BR/Bridge Policy dt. 09.10.2014
11	922(7)	9.11	Railway Board's Lr. No.2013/CE-III/BR/RDSO/Misc. dt. 04.06.2014
12	922(7), 922(8)(a)	9.12	Railway Board's Lr. No 2014/CE- III/BR/Bridge Policy dt. 09.03.2017
13	922(7)	9.13	Railway Board's Lr. No 2014/CE- III/BR/Bridge Policy dt. 11.11.2019
14	922(7)	9.14	Railway Board's Lr. No 2014/CE- III/BR/Bridge Policy dt. 12.02.2020
15	922(7), 922(8)(b)	9.15	Railway Board's Lr. No. 2014/CE-III/BR/Bridge Policy dt. 20.4.23
16	923	9.16	Railway Board's Lr. No. 2021/2/CE-III/BR/1/Bridge Policy dt. 28.10.2021
17	923	9.17	Railway Board's Lr. No. 2021/2/CE-III/BR/1/Bridge Policy dt. 17.05.2021
18	923	9.18	Railway Board's Lr. No. 2021/2/CE-III/BR/1/Bridge Policy dt. 19.07.2021.

CHAPTER 10 – EXECUTION OF BRIDGE WORKS

SN	Para No	Ref. document details	
1	1036(3)	10.01	Rly Bd's Lr. No.2014/CE-III/BR/Bridge Policy dt. 15.11.2016
2	1059(4)	10.02	RDSO Lr. No CBS/DWF dt. 15.07.2019
3	1092 (3)(c)	10.03	Railway Board's Lr. No. 2015/CE-IV/RUB/206 dt. 15.02.2016
4	1095 (3)(c)	10.04	RBs Lr. No. 2015/CE-IV/RUB/206 dt. 11.08.2016
5	1092(1)(d)	10.05	RDSO Lr. No. CBS/PBEJ/Reg. dt. 28.02.2023

CHAPTER 11 – GRADE SEPARATOR

SN	Para No	Ref. document details	
1	1102(1) (vi)	11.01	Railway Board's Lr. No. 2017/CE-IV/RUB/88 dt. 22.04.2020.
2	1102(1) (vi)	11.02	Railway Board's Lr. No. 2017/CE-IV/RUB/88 dt. 27.01.2022.
3	1102(1) (vi)	11.03	Railway Board's Lr. No. 2017/CE-IV/RUB/88 dt. 18.02.2021
4	1104(1)	11.04	Railway Board's Lr. No. 2015/CE-IV/ROB/76 dt. 01-03-2016 and No. 2015/CE-IV/ROB-RUB/Misc. dt. 15-02-23
5	1104(1)	11.05	Railway Board's Lr. No 2015/CE/IV/ROB-RUB/ Misc. /49 dt. 29.10.2019
6	1104(1)(d)	11.06	Railway Board's Lr. No. 2015/CE-IV/ROB/78 Pt. dt. 15.01.2020
7	1104(1)(e)	11.07	Railway Board's Lr. No. 2017/CE-IV/ROB/164 (policy) dt. 16- 02-2021
8	1105	11.08	Railway Board's Lr. No. 2017/CE-IV/88 dt. 23-02-2023
9	1106(2) (xviii)	11.09	Railway Board's Lr. No. 2015/CE-IV/RUB/206 dt. 15.02.2016
10	1106(2) (xviii)	11.10	Railway Board's Lr. No. 2015/CE-IV/RUB/206 dt. 11.08.2016
11	1104	11.11	BS 112- RDSO guidelines for planning of ROB
12	1104	11.12	BS132- Compendium for Road Over Bridges on Indian Railways
13	1106(3) (a)(iii)	11.13	Railway Board's Lr. No. 2017/CE-III/BR/Safety dt. 27-09-2022

CHAPTER 12 – STEEL GIRDER FABRICATION

SN	Para No	Ref. document details	
1	1201(2)	12.01	Railway Board Lr. No. 2014/CE-III/BR/Bridge Workshops Policy dt. 24.02.2014
2	1201(3)	12.02	BS-S-7.5.3.1-4 'Schedule of Technical Requirements for fabrication of steel girder' dt. 12-07-2022.
3	1201(4), 1202(4), 1204(1)(a)	12.03	Railway Board Instruction No. 24/2019 vide RB No. 2016/54/CE- III/BR/RDSO Misc. dt. 15.07.2019
4	1201(5)	12.04	Railway Board Lr. no 2016/54/CE-III/ BR/ RDSO /Misc. dt. 09.05.2019
5	1202(4), 1204(1)(a)	12.05	Railway Board Lr. No. 2017/16/CE-III/BR/Girder inspection dt. 26.05.2017
6	1202(4)	12.06	RDSO Lr. No. CBS/INSP/WBG dt. 13-08-2018
7	1202(4)	12.07	Railway Board Lr. 2017/1 6/CE-III/BR/Girder Inspection dt. 17- 11-2022
8	1204(1) (b)&(c) 1205(2)(e)	12.08	RDSO Lr. No. CBS/Bridge Insp/Genl Matters dt. 01.03.2023
9	1214(4)(d)	12.09	RDSO Lr. No. CBS/Bridge Insp/Genl Matters dt. 8.06.2023
10	1214(5)(a)	12.10	Rly Bd Lr. 2017/16/CE-III/BR/Girder Inspection dt. 25.05.2017
11	1214(5) (c(ii)	12.11	RDSO Lr. No. CBS/Bridge Insp/Genl Matters dt. 19.06.2023
12	1218	12.12	RDSO Lr. No. CBS/INSP/WBG dt. 10.04.2015

CHAPTER 13 – TUNNELS

SN	Para No	Ref. document details	
1	1304 (8)	13.01	RDSO Lr. No. EBS/CB-1/BLT/Committee dt. 17.10.2023 on "Technical Eligibility Criteria and Special conditions of Contract for BLT.
2	1304(1) (D)	13.02	Diagram No. 1A of Indian Railway Schedule of Dimensions (IRSOD)-2022, Standard Dimensions for Tunnels & Through Girder Bridges (Schedule-I, Chapter-I)
3	1304(1) (D)	13.03	Diagram No. 1A (Modified) of Indian Railway Schedule of Dimensions (IRSOD)-2022, Standard Dimensions for Tunnels & Through Girder Bridges to suit 25 K.V. A.C. Traction (Schedule-I, Chapter-I)

CHAPTER 14 – BUILDINGS AND PASSENGER AMENITIES

SN	Para No	Ref. document details	
1	1403(2)	14.01	Development of Railway Land by Zonal Railways/RLDA/IRSDC under section11 of the Railway Act 1989 – Including Railways/RLDA/IRSDC as deemed special planning Authority for development on Railway land in local By-laws/Development Control Norms under Railway Act 1989 issued vide Lr. No. 2019/LML-II/2/11(133) dt. 30.01.2020 (including Lr. dt. 13.11.2019, 01.05.2017 & 17.10.2018)
2	1403(2)	14.02	Clarification on exemption of Railway Projects from the requirement of Environmental Clearance (EC) and Costal Regulation Zone (CRZ) Clearance as per section 11 of Railways Act 1989 – regarding. Issued on 06.10.2023
3	1403(2)	14.03	Commercial development of Railway land in and around Railway Stations – prior environmental clearance under the provisions of EIA Notification, 2006-reg issued vide Lr. No. F. No. 19-172/2018-IAIII dt. 28.05.2020
4	1405(1)(c)	14.04	Adoption of Energy Efficiency Measures in Non-Traction over Indian Railways issued vide Railway Board Lr. No. 2022/EEM/150/09 dt. 30.12.2022
5	1405(2)(a)	14.05	Rain Water harvesting - Railway Board's Lr. No. 2013 /LMB /9 /1 dt. 09.09.2013
6	1405(2)(b)	14.06	Indian Railway's Water policy -2017
7	1407(1)	14.07	Amenities to be provided in residential building. Rly. Board Lr. No. 2013/LMB/10/15 dt. 11.12.2013
8	1409	14.08	Comprehensive instruction for provision of Passenger Amenities and user facilities at Stations issued vide Lr. No. 2018/LM (PA)/03/06 dt. 09.04.2018
9	1409	14.09	Comprehensive instruction for provision of Passenger Amenities and user facilities at Stations issued vide Lr. No. 2018/LM (PA)/03/06 dt. 14.02.2022
10	1414(4)	14.10	Signage policy for Railway Stations issued vide Lr. No. 2023/S- II/22/07/02 dt. 15.05.2023
11	1415	14.11	Guidelines on accessibility of Indian Railway stations and facilities at stations for differently abled persons (Divyangjan) and passengers with reduced mobility issued vide Railway Board Lr. No. 2019/Stn. Dev-13/06/Policy/PwDs dt. 25.11.2022
12	1418	14.12	Comprehensive instruction for umbrella work of Major Upgradation of Railway Stations on Indian Railways issued vide Lr. No. 2021/Stn. Dev.-I/08/18 dt. 04.05.2022
13	1418	14.13	Format of DPR for Station Development /re-development/major Upgradation projects issued vide Lr. No. 2021/SD-II/22/07/11 dt. 19.08.2022

SN	Para No	Ref. document details	
14	1418	14.14	Provision of ballastless track at major/important stations and stations identified under Major Upgradation / Redevelopment issued vide Lr. No. 2021/CE-II/TSC/10th Extraordinary dt. 29.09.2022
15	1418	14.15	Execution of Station Development works issued vide Lr. No. 2021/ Stn. Dev.-I/08/18 dt. 03.10.2022
16	1418	14.16	Upgradation of Railway Stations on Indian Railways – Design, inspection and audit of the projects reg: issued vide Lr. No. 2021/ Stn. Dev.-I/08/18 dt. 19.10.2022
17	1418	14.17	Amrit Bharat Station Scheme for Indian Railways issued vide Lr. No. 2022/GS/Stn. Dev.-I/08/70 dt. 23.12.2022
18	1418	14.18	Amrit Bharat Station Scheme for Indian Railways issued vide Lr. No. 2022/GS/Stn. Dev.-I/08/70 dt. 31.01.2023
19	1418	14.19	Amrit Bharat Station Scheme for Indian Railways issued vide Lr. No. 2022/GS/Stn. Dev.-I/08/70 dt. 17.02.2023
20	1418	14.20	Amrit Bharat Station Scheme for Indian Railways: Provision of Central Foot Over Bridges (FOBs) issued vide Lr. No. 2022/GS/Stn. Dev.-I/08/70 dt. 19.04.2023
21	1418	14.21	Presentation for Master Plans of Station development works issued vide Lr. No. 2022/GS/Stn. Dev.-I/08/70 dt. 29.04.2023
22	1418	14.22	Commercial development of Station Estate-reg. issued vide Lr. No. 2023/LML-II/2/8 dt. 15.05.2023
23	1418	14.23	Signage Guidelines for Railway Stations issued vide Lr. No. 2023/SD- II/22/07/02 dt. 15.05.2023
24	1418	14.24	General Guidelines for OHE design in concourse area for station development projects issued vide Lr. No. RDSO/759/2022 dt. 12.06.2023
25	1418	14.25	Execution of Amrit Bharat Station Development Scheme works: Role of Chief Engineer/Station issued vide Lr. No. 2022/GS/Stn. Dev.-I/08/70 dt. 19.07.2023
26	1418	14.26	Preparation of Master Plans of Station Development Works issued vide Lr. No. 2022/GS/Stn. Dev.-I/08/70 dt. 25.08.2023
27	1418	14.27	Pradhan Mantri Bharatiya Janaaushadhi Kendras (PMBJKs) at Railway Stations – policy regarding issued vide Lr. No. 2023/NFR/33/JAK E-office No. 3423850 dt. 08.08.2023

CHAPTER 15 – TRACK LAYING AND ALLIED WORKS

SN	Para No	Ref. document details	
1	1502	15.01	Railway Board Lr. No. 2019/W-1/Genl/P. Way/ 2019-20 dt. 12.06.2019
2	1506	15.02	RDSO Lr. No. CT/PTX/TWS/Design dt. 06.07.2023 with subject 'Laying of Thick Web Switches on Curved Track -Instructions regarding Pre-curving.'
3	1510	15.03	Railway Board Lr. No. Track/21/2005/0110/AT Welding dt. 16.08.2019
4	1511	15.04	Specification No. TM/HM/MFBWP/458 of 2019 named as "Technical Specifications of Mobile Flash Butt Welding of machine with ability of Tension welding of Rails for BG (1676mm)
5	1512	15.05	ACS No.1 to Manual for Insulated Rail Joints (First Reprint – 2022) issued on 15.09.2023)

CHAPTER 16 – SIGNALLING WORK

SN	Para No	Ref. document details	
1	1603 (1)	16.01	Railway Board Lr. No. 2022/GS/IR/Cable laying policy dt. 29.03.2023: guidelines for S&T cable laying in ducts.
2	1603(2)(a)	16.02	RB's Lr. No. 2003/Tele/RCIL/1 Pt IX dt. 24.6.13, procedure for undertaking digging work.
3	1604	16.03	Railway Board Lr. No. 2021/SIG/WP/Targets, dt. 15.07.2022: Automatic Signaling Works on Indian Railways.
4	1605(1)	16.04	Provision of EI should be made in all works, Railway Board's Lr. No. 2003//Sig/G/5 dt. 28.04.2016
5	1605(1)	16.05	Centralized/Distributed EI, Lr. No. 2021/Sig/25-Conf/5/SSC dt. 26.02.21
6	1605(1)	16.06	Estimates may be revised for provision of EI without causing material modification as per Railway Board Lr. No. 2008/SIG/SGF/4EI/Genl dt. 05.07.2011
7	1605(2)	16.07	Implementation of standard circuit for future EI up to 100 routes, Railway Board vide Lr. No. 2018/Sig/36-SD-1 dt. 26.08.2022
8	1605(5)(a)	16.08	RDSO/SPN/192/2019 Ver 2.0 or latest
9	1605(5)(b)	16.09	RDSO/SPN/203/2011 Ver 1.0 or latest (Only applicable for Big yards)
10	1605 (6)	16.10	Centralized and Distributed Architecture of Electronic Interlocking, RDSO Document No. STS/E/TAN/3008 Ver 1.0 dt. 31.03.2013 or latest.
11	1605 (6)	16.11	Cyber Security aspects of Electronic Interlocking system. RDSO Ref no EI/TAN/SecurityVersion1.0 dt. 01.03.2023o or latest.

SN	Para No	Ref. document details	
12	1605 (6)	16.12	Technical Advisory Note (TAN) No. STS/E/TAN/3012 version 3.0 for Guidelines regarding Technical System Application Approval for Electronic Interlocking Installation RDSO Ref no STS/E/TAN/301 Ver3.0 Dt 28.06.2021 or latest.
13	1605 (6)	16.13	Correction in Technical Advisory Note No. 3012 version 3.0 RDSO- SIG0EI(GEN)/1/2020 Dt 11.07.2022
14	1605 (6)	16.14	Corrigendum of Technical Advisory Note No. 3012 Version RDSO- SIG0EI (GEN)/1/2020 Dt 03-11-2022
15	1605 (6)	16.15	Guidelines for implementation of block working built in to electronic interlocking (with same manufacturer) RDSO Ref no TN/3013 Version1.0 Dt 28.10.2020 or latest.
16	1605 (6)	16.16	Guidelines for implementation of block working built in to electronic interlocking (with same manufacturer) for single line. RDSO Ref no TN/3014 Version1.0 Dt 24.06.2021 or latest.
17	1605 (6)	16.17	Use of Embedded PC and Earthing for Electronic Interlocking (EI) RDSO Ref no STS/E/TAN/3007 Ver 1.0 Dt 02.11.2012 or latest.
18	1605 (6)	16.18	Revised Checklist for Technical System Application Approval of Electronic Interlocking. RDSO Ref no STS/L/SSI/general/160 Dt 07.12.2018 or latest.
19	1605 (6)	16.19	Procedure for FAT/SAT of Electronic Interlocking No 2017/Sig/3/85th SSC Dt 04.12.2018
20	1605 (6)	16.20	EI check list as per No. STS/L/SSI Dt 09.05.2012 or latest.
21	1605 (6)	16.21	Modification/Alteration in Electronic Interlocking (Manufactured by M/s Ansaldo make) RDSO Ref no STS/E/TAN/3009 Ver 1.0 Dt 09.06.2014 or latest.
22	1605 (6)	16.22	Guideline regarding minor modifications/alterations in the application software of Medha Electronic interlocking (MEI) RDSO Ref no STS/E/TAN/3010 Ver 1.0 Dt 05.08.2014 or latest.
23	1605 (6)	16.23	Guidelines regarding minor modifications/alteration in the application logic of VLM6 Electronic Interlocking (EI) of M/s Siemens Rail Automation Pvt. Ltd. RDSO Ref no STS/E/TAN/3011 Ver 1.0 Dt 14.08.2014 or latest.
24	1605 (6)	16.24	Use of hot stand by architecture for Electronic interlocking RDSO Ref no STS/E/TAN/3004 Ver 1.0 Dt 13.06.2012 or latest.
25	1605 (6)	16.25	Report for standardization of Typical Circuits for EI- (Report SS 155 2019 VER 2 Dt 29-03-2022) WCR/N HQ/ 110/ Rly. Bd's Corresp./Sig- 25 Pt-VIII Dt 29.03.2022 or latest.
26	1605(9)	16.26	Technical System Application Approval for EI works as instructed vide Railway Board Lr. No 2012/Sig/ATSS/Pt dt. 28.02.2023 or latest.

SN	Para No	Ref. document details	
27	1609	16.27	Automatic fire suppression system along with Automatic fire detection & alarm system as per Railway Board's Lr. No. 2004/ Sig/W/5 dt. 27.05.2019 or latest.
28	1611	16.28	Planning, Preparation & Execution of Works, Railway Board Lr. No. 2012/SIG/SF/2 (Policy) dt. 14.09.2018 & 30.12.2016.
29	1613(B) 12 (d)	16.29	Earthing & Lightening Protection arrangement shall be provided for the IPS power supply system. RB Lr. No.2011/Sig/SF/1 dt. 19.08.2011 or latest.
30	1613(C) 3 (a)	16.30	Safe and Reliable Train Detection- Redundancy in Design Railway Board Lr. No. 2012/Sig/M/DAC/DD, Dt. 31.12.2013.
31	1614	16.31	Streamlining Signalling functions Description Writing 2023/Sig/17-Sig Equip/Maintenance/Part dt. 06-11-2023
32	1611 a(i)	16.32	Standard Checklist and Proforma issued vide Railway Board Lr. No. 2021/SIG/Estimates/DPR dt. 22-06-2023
33	1611 a(ii)	16.33	Test of renumerativeness for S&T projects – Railway Board Lr. No. 2023/F(X) II / 10/2 dt. 22-06-2023
34	1611 a(iii)	16.34	Guidelines for provision of Automatic Signalling and Twin Single line working – Railway Board Lr. No. 2023/ABSCOMMITTEE / Railway Board dt. 16-11-2023

CHAPTER 17 – ELECTRICAL AND TRACTION DISTRIBUTION WORK

SN	Para No	Ref. document details	
1	1704(2) (C) (ii)	17.01	Target for TRD& Electrical Gel. Services [Railway Board Lr. No. 2021/EEM/180/5 Part (1) dt. 18-04-2023]
2	1705(9)	17.02	Special maintenance instructions (SMI) for overhead equipment on turnout/crossovers to avoid panto entanglement - Instruction Note /MI/0028 Rev.-2

CHAPTER 18 – Pre-NI AND NI WORKS AND COMMISSIONING FOR RAILWAY PROJECTS

SN	Para No	Ref. document details	
1	1803(3)	18.01	Rolling Block Plan - JPO issued vide Rly. Bd. Lr. No. 2020/track-lll/TK/2 dt. 29.08.2023
2	1804	18.02	Railway Board Lr. regarding 30 Kmph speed of trains during NI working
3	1808	18.03	Checklist for CRS inspection
4	1808	18.04	Checklist for PCEE inspection
5	1811	18.05	Procedure Order for Handing/Taking over of New Assets

***

Bogibeel Bridge, N F Rly.

Sir M. Visvesvaraya Terminal, Bangalore

Tunnel T-3, Katra – Reasi Block section, USBRL

Kanpur Central (proposed Station Improvement view), N C Rly