Tender Document for Works

(Two-Envelope Tendering Process Without Prequalification)

Procurement of:

Contract Package C-5: Composite Contract package in connection with New BG Double Railway Line of HORC project between stations Prithla and Dhulawat for:

(i) Design and Construction of Civil Works (Earthwork, Bridges, Stations and Retaining Walls) from km -2.296 to km 12.00 & km 18.00 to km 20.942;

(ii) Design & Construction of viaduct from km 20.942 to km 24.844;

(iii) Design & Construction of Ballastless track from km 20.842 to km 24.844; and

(iv) Design, Supply, Installation, Testing & Commissioning of General Electrical Services from km -2.296 to km 12.00 and Km 18.00 to Km 24.844.

Summary

Specific Procurement Notice (SPN)

PART 2 – Employer's Requirements

Summary Table

Section VII: Employer's Requirements

Section VII-1: General

EMPLOYER'S REQUIREMENTS – GENERAL

1 Project Profile and Background.

1.1 General

State of Haryana is strategically located bordering the National capital of Delhi. NCT, Delhi shares three fourth of its border with Haryana alone and remaining with Uttar Pradesh. The development of Haryana region, bordering Delhi is very important for balanced growth of NCR as it acts as buffer zone against rampant migration and other support infrastructure. At present on account of growth of Metro network in Delhi & NCR, there is radial movement of commuters to and from, Delhi being in centre. This "Hub and Spoke" traffic planning has resulted in rapid growth of Noida, Greater Noida, Faridabad and Gurugram. However, for hub and spoke concept to sustain it is necessary to link the ends of spoke by ring connectivity. There will be natural demand for commuter movement within these towns like Gurugram, Faridabad, Ballabhgarh, Palwal, Sohna, Manesar etc. Peripheral roads have been commissioned recently, linking these towns around Delhi but Rail link provides economical, sustainable, eco-friendly and bulk freight transport option. The peripheral Rail link will also help in growth of other cities within the same distance from Delhi like Sonipat, Panipat, and Rohtak. Western DFC originating from Dadri station is passing through Asaoti Station on Delhi- Mathura route, providing connectivity to Haryana Orbital Rail Corridor (HORC). This will also help in easing the pressure on the transport network of Delhi as some of the commuter traffic moving on the radials will get shifted to HORC. Apart from passenger traffic, substantial amount of freight traffic, which is entering the Delhi area of rail network but is not meant to be consumed in Delhi, will also get diverted via this corridor. Apart from this, there are major goods sheds in the heart of Delhi causing endless avoidable traffic jams. The goods sheds in west Delhi are Azadpur, Shakurbasti, Dayabasti, Sabzi Mandi which are located on prime commercial land and are black spots of the urban planning. Previously moving out commercial activity to other states had interstate taxation issues but now with GST in place, there is no reason of not shifting these activities to the peripheral region. In any case, if freight traffic movement through Delhi is restricted, then these goods sheds or alternatives will be serviced via the proposed HORC. Haryana Orbital Rail Corridor (HORC) from Palwal to Sonipat Via Sohna, Manesar, Kharkhoda and Harsana Kalan is to be constructed as an Electrified (1X25kV AC-50Hz) double line track, capable of operating at a maximum train speed of 160 kmph.

1.2 Forest and Environmental Clearance

It is mentioned that for Railway projects no prior environmental clearance is required as per Environment Impact Assessment (EIA) Notification, 2006. Further, the Forest (Conservation) Act, 1980 is not applicable to the Project in terms of Ministry of Environment, Forest and Climate Change (MoEFCC's) OM No.11-37/2016 FC dated 10.03.2022.

2 DEFINITIONS AND INTERPRETATIONS

In addition to the words and expressions defined in the General Conditions of Contract, further following words and expressions shall have the meaning assigned to them except where the context otherwise requires:

- **"As-Built Drawings"** means those drawings produced by the Contractor and endorsed by its true records of construction of the Permanent Works and which have been given a consent from the Engineer.

- **"As-Built Documents"** mean the set of drawings and documents which are a true record of the construction of the Permanent Works prepared by the Contractor.

- **"CAD Standards"** means requirements for CAD, as specified in the Appendix 9 of Employer's Requirements.

- **"Charted Utilities"** mean identified Utilities listed in Employer's Requirements-Tender Drawings and Documents, which may be affected by the execution of the Works under the Contract.

- **"Cold Joint"** means a joint or discontinuity formed when a concrete surface hardens before the next batch is placed against it, characterised by poor bond unless necessary procedures are observed.

- **Combined Services Drawings" (CSD):** means drawings showing the locations, layouts and sizes of all services including those of other contractors co-ordinated so as to eliminate all clashes.

- **"Construction Phase":** has the meaning identified in the Employer's Requirements - General.

- **"Construction Reference Drawings":** means those drawings referred in the Employer's Requirements - Design in respect of which a Notice has been issued.

- **"Construction Reference Drawings Submission":** means the submission of Construction Reference Drawings representing elements of the Permanent Works and for which the Contractor seeks a Notice.

- **"Contract Spares"** means any Spare Parts recommended by the Contractor for the operation and maintenance of the Permanent Works following the Taking Over of the Works.

- **"Consumables"** means those parts that are not repairable and usually have a relatively short life span.

- **"Critical Path Method"** means a schedule network analysis technique used to determine the amount of scheduling flexibility (the amount of float) on various logical network paths in the project schedule network, and to determine the minimum total project duration.

- **"Definitive Design Submission":** means the submission of documents which comprise the whole or parts of the proposed Definitive Design and for which the Contractor seeks a Notice.

- **"Design Criteria":** means the criteria defined in Employer's Requirements- Design and Outline Design Specifications.

- **"Design Manual":** means the manual to be prepared and submitted by The Contractor as part of the Definitive Design and as described in the Employer's Requirements - Design.

- **"DN Line"** means the down line of the HORC double line track route from Sonipat to Palwal.

- "**Final Design":** has the meaning identified in the Employer's Requirements – Design.

- **"Fixed Structure Gauge":** means the profile related to the designed normal co-ordinated axis of the track into which no part of any structures or fixed equipment may penetrate.

- **"Good For Construction Drawings (GFC)":** Construction Reference Drawings or Working Drawings which have received Notice from the Engineer, shall be endorsed as "Good For Construction Drawings" and will be issued to the Site. Execution of work shall be carried out only as per drawings which have been endorsed as GFC.

- **"Interface Management Plan"** means the plan for all interface issues that may arise during the design, construction, testing and commissioning of the Works, in consultation with the Interfacing Contractors/ Interfacing Parties and the Engineer.

- **"Independent Laboratory"** means a laboratory, submitted by the Contractor to the Engineer for approval, that is free from outside control and not subject to direct or indirect influence or authority of the Employer, the Engineer, or the Contractor

- **"Inspection and Test Plan"** means a document that states inspection and testing requirements and actions provisioned for the Works, related process, Plant, or Materials. It is used to control, check, monitor and record; testing procedures that are required for quality assurance and to achieve the agreed quality requirements for the Works.

- **"Installation Tests"** means the tests to be performed to verify the conformity of completion of an installation/assembly to the design documents approved by the Engineer prior to the start of Commissioning, and they must be successfully completed before the Tests on Completion.

- **"Interface Coordinator"** means the person who has the responsibility, and authority with substantial experience to resolve interface matters to the satisfaction of the Engineer and provide the necessary support team for the Interface Management System as specified in Appendix 5

- **"Interfacing Contractor"** means the Contractor engaged by the Employer or other agencies having an interface issue with the Contractor for the Works.

- **"Interfacing Parties"** comprises the interfacing contractors / consultants / service providers, who are engaged in part of the works, relevant authorities and public utility agency.

- **"Interface Table"** means the table that describes the relationships between the Contractor and Interfacing Contractors / Interfacing Parties and their roles and responsibilities is a key document.

- **"Kick-Off Meeting"** means the meeting held by the Engineer to formally notify all parties concerned under the Contract that the project has commenced and to ensure that every party has a common understanding of their role from the Commencement Date up until issuance of the Performance Certificate.

- **"Maintenance Manuals"** means the manuals providing detailed instructions for the maintenance of infrastructure and maintenance facilities.

- **"Method Statement"** means a document that states the way a particular work, task, or process along with various associated aspects such as quality, safety, environment protection, time and resources; are planned to be directly controlled by the Contractor or its Subcontractor.

- **"Monthly Progress Meeting"** means the meeting specified under Appendix 7 of the Employer's Requirements.

- **"Monthly Progress Report"** means the report that the Contractor shall prepare and submit to the Engineer.

- **"Nonconformity Report"** means a report documenting non-fulfilment of a requirement, with objective evidence, the location and time of occurrence or detection, and provision for its proper resolution by the concerned responsible.

- **"Notice":** means a Notice of No Objection.

- **"Notice of Objection"** means a category of Engineer's response, issued by the Engineer to the Contractor.

- **"Not Reviewed"** means a category of Engineer's response, issued by the Engineer to the Contractor.

- **"On-Site Laboratory"** means Contractor's own laboratory submitted by the Contractor to the Engineer for approval as specified in Appendix 12 of the Employer's Requirements.

- **"Operation and Maintenance Manuals (O&M Manuals)"** means the manual that will be indicating the provisions which are required for maintenance of various assets created under the Contract by the Employer under their operation phase.

- **"Priority Section"** means the section from Km 49.7 to Km 55.6 of HORC Main line and connectivity line from Manesar station on HORC and Patli station on Delhi-Rewari section of Indian Railway Network.

- **"Programme Analysis Report"** means the report submitted to the Engineer that shall, in narrative format, describe the basis and assumptions used to develop each programme.

- **"Project"** means the project named as "Haryana Orbital Rail Corridor (HORC)".

- **"Project Management Plan"** refers to the plan that will be established by the Contractor for the management of activities related to design, procurement, manufacture, execution/construction, delivery, installation, testing and commissioning.

- **"Project Management Information System"** means a document, information and communication technology system (platform) that is to be implemented by the Contractor so that the management of information between the Contractor, the Employer and the Engineer is efficient, reliable, and secure.

- **"Preliminary Design":** means the submission of documents which comprise the initial stage of the design phase.

- **"Indian Railway"** means the rail tracks of the Indian Railway or any other organization and any ancillary areas of Indian Railway such as the depots, sidings, stations, terminus, traction power stations, etc.

- **"Request for Inspection"** means the form used to give notice by the Contractor to the Engineer.

- **"Railway Representative"** means a person, or persons, nominated by the Employer / Engineer to liaise with the Contractor and the Engineer on matters affecting the operation of Indian Railway.

- **"Tender drawings and Documents"** means the drawings and documents prepared by the Employer for reference purposes only and included in the Tender Documents.

- **"Right of Way"** means the land area of the Project, either acquired by the Employer or for which the Employer has the permission of the Stakeholder to construct the embankment & bridges, etc. over their area.

- **"Environmental, Social, Health and Safety Management Plan"** means the plan in accordance with the requirements of Appendix 13 of the Employer's Requirements.

- "**Safety**" freedom from unacceptable risk of harm.

- **"Site Office"** means Site Office for Employer's/Engineer's Personnel constructed by the Contractor.

- **"Spare Parts"** means those parts which are generally repairable and have normally a service life of several years.

- **"Specification"** has the meaning identified in the Employer's Requirements - General.

- **"Station Yard"** is defined as the section between points at either end of the station which are located 50 m from the outermost points away from the station.

- **"Tertiary Control Points (TCP)"** means the benchmarks provided by the Employer, used to locate & confirm the Right of Way (ROW) and its co-ordinates including levels for the purpose of execution of works.

- **"Three Months Rolling Programme"** means the programme which the Contractor shall prepare and update monthly as per Appendix 6 of the Employer's Requirements.

- **"Three Weeks Rolling Programme"** means the programme which the Contractor shall prepare and update weekly as per Appendix 6 of the Employer's Requirements.

- **"Time Bar Chart",** known as "Gantt Chart" too is a type of bar chart which illustrates a project schedule. i.e. the start and finish dates of the activities and summary elements of a project

- **"Uncharted Utilities"** mean Utilities other than Charted Utilities which are identified during a survey conducted by the Contractor or encountered during excavation/ other works.

- **"UP Line"** means the up line of the HORC double line track route from Palwal to Sonipat.

- **"Utilities"** means the electricity, lighting, traffic control, telephone and/or communication cables, gas, water, sewage and drainage pipes, including all associated protection, supports, ancillary structures, fittings and equipment.

- **"Working Drawing"** means additional drawings developed by the Contractor as necessary to supplement the Construction Reference Drawings and to specify additional details and procedures for construction of the Works, such as shop drawings, fabrication drawings, erection drawings, Temporary Works drawings, bar bending schedules, bar reference drawings, embankment/cutting cross sections. All such drawings shall comply with the requirements of the Contract.

- **"Works Areas"** means the areas of the Site within the Right of Way and any additional areas which may be obtained by the Contractor and agreed by the Engineer as additional working area.

- **"Works Programme"** means the time-scaled and resource-loaded critical path network, updated from time to time in accordance with the General Conditions of Contract and Employer's Requirements, depicting activities, durations, sequences and interrelationships that represent the Contractor's work plan, work breakdown, schedule structure for constructing and completing the Works, distributed over the Time for Completion of the Contract.

- **Abbreviations**

AC	**:**	**Alternating Current**
ACB	**:**	**Air Circuit Breaker**
AIIB	**:**	**Asian Infrastructure Investment Bank**
ALARP	**:**	**As Low As Reasonably Practicable**
ASLI	**:**	**Automatic Safe Load Indicator**
BG	**:**	**Broad Gauge**
BIS	**:**	**Bureau Of Indian Standards**
BOCW	**:**	**Building Or Other Construction Work**
BS	**:**	**British Standards**
CAD	**:**	**Computer Aided Design**
CCTV	**:**	**Closed Circuit Television**
CP	**:**	**Contract Package**
CPCB	**:**	**Centre Pollution Control Board**
CPM	**:**	**Critical Path Method**
CRS	**:**	**Commissioner Of Railway Safety**
CSD	**:**	**Combined Service Drawings**
CV	**:**	**Curriculum Vitae**

DB	**:**	**Distribution Box**
DCN	**:**	**Design Change Notice**
DFC	**:**	**Dedicated Freight Corridor**
DFCCIL	**:**	**Dedicated Freight Corridor Corporation Of India Limited**
DG	**:**	**Diesel Generator**
DGPS	**:**	**Differential Global Positioning System**
DIN	**:**	**Deutsche Industrial Norms**
DL	**:**	**Double Line**
DNP	**:**	**Defect Notification Period**
DPR	**:**	**Daily Progress Report**
DT	**:**	**Down Time**
E&M	**:**	**Electrical & Mechanical**
EIA	**:**	**Environmental Impact Assessment**
ELCB	**:**	**Earth Leakage Circuit Breaker**
EMC	**:**	**Electro Magnetic Compatibility**
EMI	**:**	**Electro Magnetic Interference**
ESHS	**:**	**Environmental, Social, Health And Safety**
FAT	**:**	**Factory Acceptance Test(S)**
FCN	**:**	**Field Change Notice**
FFL	**:**	**Finished Floor Level**
FL	**:**	**Formation Level**
GAD	**:**	**General Arrangement Drawing**
GCC	**:**	**General Conditions Of Contract**
GE	**:**	**Geotechnical Engineering**
GFL	**:**	**Ground Floor Level**
GIS	**:**	**Geographical Information System**

GL	**:**	**Ground Level**
GNSS	**:**	**Global Navigation Satellite System**
GOI	**:**	**Government Of India**
GPS	**:**	**Global Positioning System**
GRC	**:**	**Grievance Redress Committee**
GRM	**:**	**Grievance Redress Mechanism**
HDPE	**:**	**High Density Polyethylene**
HFL	**:**	**Highest Flood Level**
HORC	**:**	**Haryana Orbital Rail Corridor**
HT	**:**	**High Tension**
HV	**:**	**High Voltage**
HVAC	**:**	**Heating, Ventilation And Air Conditioning**
Hz	**:**	**Hertz**
IC	**:**	**Integrated Circuit**
ID	**:**	**Identification**
IMD	**:**	**Integrated Maintenance Depot**
IMP	**:**	**Interface Management Plan**
INR	**:**	**Indian Rupee**
IP	**:**	**Point Of Intersection**
IPS	**:**	**Integrated Power Supply**
IR	**:**	**Indian Railways**
IRC	**:**	**Indian Road Congress**
IRS	**:**	**Indian Railway Standards**
IS	**:**	**Indian Standards**
ISO	**:**	**International Organization For Standardization**
IT	**:**	**Information Technology**

ITP	**:**	**Inspection And Test Plan**
Km	**:**	**Kilometre**
kV	**:**	**Kilo Volt**
LAN	**:**	**Local Area Network**
LCD	**:**	**Liquid Crystal Display**
LCX	**:**	**Leaky Coaxial Cable**
LED	**:**	**Light Emitting Diode**
LT	**:**	**Low Tension**
LV	**:**	**Low Voltage**
LWL	**:**	**Lowest Water Level**
MC	**:**	**Municipal Corporation**
MCB/LV	**:**	**Miniature Circuit Breaker / Low Voltage**
MCCB	**:**	**Moulded Case Circuit Breaker**
MDR	**:**	**Major District Roads**
MOR	**:**	**Ministry Of Railway**
MPR	**:**	**Monthly Progress Report**
MQR	**:**	**Monthly Quality Report**
MS	**:**	**Method Statement**
MSDS	**:**	**Material Safety Data Sheet**
MSL	**:**	**Mean Sea Level**
NABL	**:**	**National Accreditation Board For Testing And Calibration Laboratories**
NCR	**:**	**Nonconformity Report**
NFPA	**:**	**National Fire Protection Association**
NGO	**:**	**Non-Governmental Organization**
NH	**:**	**National Highway**
NHAI	**:**	**National Highway Authority Of India**

NOC	**:**	**No Objection Certificate**
NONO	**:**	**Notice Of No Objection**
NONOC	**:**	**Notice Of No Objection With Comments**
NOO	**:**	**Notice Of Objection**
NR	**:**	**Not Reviewed**
O&M	**:**	**Operation And Maintenance**
OCS	**:**	**Overhead Catenary System**
ODR	**:**	**Other District Roads**
OEM	**:**	**Original Equipment Manufacturer**
OFC	**:**	**Optical Fibre Cable**
OHE	**:**	**Over Head Electrification**
OHSAS	**:**	**Occupational Health And Safety Assessment Series**
OHTL	**:**	**Over Head Transmission Lines**
PCC	**:**	**Particular Conditions Of Contract**
PDF	**:**	**Portable Document Format**
PHA	**:**	**Preliminary Hazard Analysis**
PMIS	**:**	**Project Management Information System**
PPE	**:**	**Personal Protective Equipment**
PR	**:**	**Public Relation**
PS	**:**	**Particular Specifications**
PVC	**:**	**Polyvinyl Chloride**
PWD	**:**	**Public Works Department**
QA	**:**	**Quality Assurance**
RAMS	**:**	**Reliability, Availability, Maintainability And Safety**
RAP	**:**	**Resettlement Action Plan**
RCC	**:**	**Reinforced Cement Concrete**

RDSO	**:**	**Research Designs And Standards Organization**
RFI	**:**	**Request For Inspection**
RFO	**:**	**Rail Fly Over**
RINL	**:**	**Rashtriya Ispat Nigam Limited**
RL	**:**	**Reduced Level**
ROB	**:**	**Road Over Bridge**
ROW	**:**	**Right Of Way**
RUB	**:**	**Road Under Bridge**
S&T	**:**	**Signalling And Telecommunication**
SAIL	**:**	**Steel Authority Of India Limited**
SAT	**:**	**System Acceptance Test**
SCADA	**:**	**Supervisory Control And Data Acquisition**
SH	**:**	**State Highway**
SI	**:**	**International System Of Units**
SL	**:**	**Single Line**
SM	**:**	**Station Master**
SOD	**:**	**Schedule Of Dimensions**
SP	**:**	**Sectioning Post**
SRR	**:**	**Submission Review Request**
SSP	**:**	**Sub-Sectioning Post**
TSS	**:**	**Traction Substation**
UG	**:**	**Under Ground**
UPS	**:**	**Uninterrupted Power Supply**
USB	**:**	**Universal Serial Bus**
UTM	**:**	**Universal Transverse Mercator**
VN	**:**	**Variation Notice**

WGS84	**:**	**World Geodetic System 84**
WHO	**:**	**World Health Organization**
WQMP	**:**	**Works Quality Management Plan**

3 RELEVANT DOCUMENTS

The Design Criteria shall be read in conjunction with the General Conditions of Contract (GCC), the Particular Conditions of Contract (PCC), the Employer's Requirements, the drawings and any other document forming part of the Contract.

In case of conflict in Design Criteria in various Sub-Sections of Section VII, Employer's Requirement the order of precedence shall be as follows :

CIVIL

- Outline Design Specifications (ODS)-Civil & BLT,
- Outline Construction Specification (OCS)-Civil & BLT,
- Tender drawings,
- Employer's Requirements - Functional,
- Employer's Requirements -Design (Civil & BLT) ,
- Employer's Requirements- Construction (Civil & BLT),
- Employer's Requirements- General,
- Employer's Requirements- Appendices,
- Indian and other International Standards referenced herein,
- Indian and other International Standards.

All relevant RDSO Standards/drawings required by the Contractor for performance of its obligations under the Contract shall be obtained by the Contractor at their own cost from the office of RDSO. RDSO drawings can also be purchased online from RDSO website.

4 PHASES (DESIGN AND CONSTRUCTION)

a) The Contractor shall execute the Works in two phases, the Design Phase and the Construction Phase.

b) The Design Phase shall commence upon the date of Letter of Acceptance (LOA). This phase shall include the preparation and submission of:

   i. the Preliminary Design,

   ii. the Definitive Design;

   iii. The Construction Reference Drawings.

   iv. The Design Phase will be complete upon the issue of a Notice in respect of the comprehensive and complete Construction Reference Drawings Submission for the whole of the Permanent Works.

c) The requirements for the Preliminary Design, Definitive Design and Construction Reference Drawings are stated in Clause 2 of the Employer's Requirements -Design.

d) The Construction Phase for the whole or a part of the Permanent Works shall commence immediately upon the issue of a Notice by the Engineer/Employer in respect of the relevant Construction Reference Drawings Submission. Such Notice may be issued by the Engineer in respect of a Construction Reference Drawing Submission covering a major and distinctive part of the Permanent Works. However, construction shall not be commenced until the appropriate Working Drawings have been endorsed:

(a) by the Contractor as "Good for Construction"; and

(b) by the Engineer that he has no objections to the drawing.

The Construction Phase shall include the completion and submission of the Final Design and the preparation and submission of the As Built Drawings and other records as specified.

e) Notwithstanding Clause *4 (b) (iv)* above, for those elements identified under Clause *2.6* of the Employer's Requirements - Design, the Construction Phase may commence immediately upon the issue of the Notice in respect of the Definitive Design Submission in respect of each such element subject to availability of the site in accordance with agreed programme.

f) The Contractor shall furnish Contractor's Warranty in the format approved by the Employer given in Section X – Contract Forms.

5 SPECIFICATIONS

In accordance with the provisions of these Employer's Requirements (Section VII-1 to Section VII-9), the Contract Specification contained in the Contract shall be developed during the design stage and submitted as part of the Definitive Design Submission. When the Specification has received a Notice of No Objection from the Engineer, it shall become the Particular Specifications and shall take precedence over the other Specifications for construction purposes.

6 SPECIFICATIONS IN METRIC AND IMPERIAL UNITS

a) The Contract shall utilise the SI system of units. Codes and Standards in imperial units shall not be used unless the Engineer has given his consent.

b) Conversion between metric units and imperial units shall be in accordance with the relevant Indian Standards.

7 WORKS PROGRAMME

a) The Key Dates are defined in Appendix 2 to these Employer's Requirements.

b) The Contractor shall prepare and submit its Works Programme and three-month rolling programmes and the detailed requirements contained in Appendix 6 to these Employer's Requirements.

c) In compiling its Works Programme and in all subsequent updating and reporting, the Contractor shall make provision for the time required for co-ordinating and completing the design, testing, commissioning and integrated testing of the Works, including, inter alia, design co-ordination periods during which the Contractor shall co-ordinate its design with those of Interfacing Contractors, the review procedures, determining and complying with the requirements of all Government Departments and all others whose consent, permissions, authority or licence is required prior to the execution of any work.

d) The Works Programme shall take full account of the Design Submission Programme.

8 MONITORING OF PROGRESS

a) Project Monitoring shall be done by Project Monitoring and Information System (PMIS). The contractor has to prepare Primavera P6 schedule as per the Programme Requirements provided in Appendix 6.

b) The Contractor shall submit to the Engineer three copies (along with an additional copy in digital format) of a Monthly Progress Report (MPR), as described in Appendix 7 to these Employer's Requirements, describing the progress and current status of the Works. The MPR shall address the matters set out in the Works Programme.

c) The MPR shall be submitted by the end of each calendar month. It shall account for all works actually performed in the current month.

d) The MPR shall be divided into two sections. The first section shall cover progress and current status relating to design and the second section shall cover progress and current status relating to construction.

e) A monthly meeting to monitor & review the progress of the project shall be convened by the Engineer. Contractor's site Representative & Designer Representative of Contractor and site representative of all Interfacing Contractors shall also attend the meeting. The Employer may also be present in the meeting.

f) The Engineer or Employer may also conduct progress review meetings and Interface meetings on weekly /bi-weekly intervals depending upon the requirements or urgency of works. In these review meetings Engineer may call Contractor's Supplier/Sub-Contractor/Designer etc. as per the requirements.

9 QUALITY ASSURANCE

The Contractor shall establish and maintain a Quality Assurance System in accordance with Appendix 11 to these Employer's Requirements for design and construction procedures and the interfaces between them. This Quality Assurance system shall be applied without prejudice to, or without in any way limiting, any Quality Assurance Systems that the Contractor already maintains.

10 IMPLEMENTATION OF SOFTWARE BASED BILLING & PROJECT MANAGEMENT SYSTEMS

The Contractor shall perform all billing processes through the software-based billing system as and when introduced by HORC free of cost. The Contractor shall also introduce appropriate Project Management Systems during the project execution phase.

11 CO-ORDINATION WITH INTERFACING CONTRACTORS

11.1 General

a) The Contractor is responsible for detailed co-ordination of his design and construction activities with Interfacing Contractors. Such co-ordination responsibilities of the Contractor shall include the following:

i. To provide all information reasonably required by the Interfacing Contractors in a timely and professional manner to allow them to proceed with their design or construction activities, and specifically to meet their contractual obligations.

ii. To ensure that the Contractor's requirements are provided to all other Interfacing Contractors before the cut-off dates to be identified in the Interface Management Plan (IMP).

iii. To obtain from the Interfacing Contractors information reasonably required to enable the Contractor to meet the design submission dates as identified in Appendix 2.

iv. Where the execution of the work of the Interfacing Contractors depends upon the site management or information to be given by the Contractor, the Contractor shall provide to such Interfacing Contractors the services or correct and accurate information required to enable them to meet their own programme or construct their work.

v. To attend regular co-ordination meetings convened by the Engineer with the Interfacing Contractors. The Contractor shall conduct separate meetings with the Interfacing Contractors as necessary to clarify particular aspects of the interfacing requirements of the Works. The party who convenes the meeting shall prepare minutes recording all matters discussed and agreed at the meeting.

vi. To ensure that copies of all correspondence, drawings, meeting minutes, programmes, etc. relating to the Contractor's co-ordination with the Interfacing Contractors are issued to all concerned parties and the Engineer no later than two (2) calendar days from the date of such correspondence and meetings.

b) The Contractor, shall in carrying out his co-ordination responsibilities, raise in good time and provide sufficient information for the Engineer to decide on any disagreement between the Contractor and the Interfacing Contractors as to the extent of services or information required to pass between them. If such disagreement cannot be resolved by the Contractor despite having taken all reasonable efforts, then the decision of the Engineer shall be final and binding on the Contractor.

c) Where an Interfacing Contract is yet to be awarded the Contractor shall proceed with the co-ordination activities with the Engineer until such time when the Interfacing Contractor is available. The Contractor shall provide the Interfacing Contractor with all information necessary to enable the Interfacing Contractor to follow-on and proceed with their co-ordination.

d) The cut-off dates to be identified in the IMP are the latest dates. Any claim of additional costs by the Interfacing Contractors as a result of the Contractor's failure in adhering to these dates shall be borne by the Contractor. The Contractor shall note that the information exchange is an iterative process requiring the exchange and update of information at the earliest opportunity and shall be carried out on a regular and progressive basis so that the process is completed for each design stage by the cut-off dates.

e) The Contractor shall co-ordinate with the Engineer on all matters relating to works that may affect the Operation & Maintenance of the already operational

Section corridor of the of Employer in general. Such work shall be subject to the rules and regulations imposed by the Employer.

11.2 Design Interface

a) The dates shown in Employer's Requirements Appendix 2 are critical to the timely completion of the project. The Contractor shall commence design interface with the Interfacing Contractors as soon as he has been notified by the Engineer that such Interfacing Contract has been awarded. In the case of utility agencies and other statutory boards, interface shall commence as soon as it is practicable. Where no design interface date has been established whether because the Interfacing Contractor(s) have not been identified or for whatever reason, the Contractor shall liaise with such Interfacing Contractor/s as soon as they have been awarded.

b) The Contractor shall immediately upon award of the Contract gather all necessary information and develop his design to a level where meaningful interaction can take place as soon as the Interfacing Contracts are available. The Contractor shall submit together with each of his Design Submissions a joint statement from the Contractor and the relevant Interfacing Contractor confirming that design co-ordination has been completed and that they have jointly reviewed the appropriate document to ensure that a consistent design is being presented.

c) The design interface is an iterative process requiring regular exchange and update of interfacing information. The Contractor shall ensure that the information he requires from the Interfacing Contractors is made known at the outset of each design interface and vice versa so that the information can be provided in time for the Contractor and the Interfacing Contractors to complete their design to meet their various design submission stages.

11.3 Construction Interface

a) Construction interface will be necessary throughout the duration of the Works commencing from the time the Contractor mobilises to the Site to the completion of the Works. Construction interface will overlap design interface, involving cast-in and buried items such as pipes for electrical and mechanical services, supports, brackets, plinths, ducts, service buildings, openings, cableways, trenches etc. that are to be incorporated at the early stage of the construction up to provision of attendance during the testing and commissioning stage.

b) The Contractor shall ensure that there is no interference with the Works of the Interfacing Contractors and shall maintain close co-ordination with them to ensure that his work progresses in a smooth and orderly manner. The Contractor shall carry out and complete the Works, or any part thereof, in such order as may be agreed by the Engineer or in such revised order as may be requested by the Engineer from time to time. The Contractor shall, unless otherwise provided, be liable for and shall indemnify the Employer against all costs, charges, expenses and the like resulting from failure of the Contractor to co-ordinate the Works as specified.

12 SURVEY AND SITE INVESTIGATIONS

a) The datum used for the Contract shall be Mean Sea Level Datum.

b) The Contractor shall carry out all further site investigations (such as detailed utility identification, detailed geo technical investigation) necessary for the design of the Permanent Works and to enable the determination of the methods of construction and the nature, extent and design of the Temporary Works.

c) The Contractor shall carry out geotechnical investigation using conventional method of boreholes and geo-physical methods for the entire alignment.

13 CLIMATIC CONDITIONS

a) The entire section of HORC with connecting IR Station is situated in the state of Haryana. During summer months the temperature can be as high as 45°C with a high level of humidity, nights can be relatively cool with temperatures dipping to 30°C. Torrential rains and high humidity accompany the monsoon in late June to early September. In the winter months temperatures can vary from a high of 21°C during day to a low of 2°C during night.

b) The information given above is only indicative. The contractor shall obtain detailed climatic data in respect of minimum & maximum temperatures, rain, relative humidity, sunshine, and wind velocity/pressure etc. from "India Meteorological Department publications" and the same shall be taken into account by the Contractor when designing any part of the Permanent Works. The Contractor shall ensure that due allowance is made for more severe local conditions when Permanent Works are required to operate, for example, with restricted ventilation that may lead to higher local ambient temperatures, and any other factors that may affect the operating environment in any way.

c) Unless specific figures are provided elsewhere, the Permanent Works will generally be required to function at its rated value with the values of ambient temperature and relative humidity appropriate to the location of the equipment within the classifications shown in Table given below. Certain parts of the Permanent Works may need to be rated for more or less onerous conditions as required by the PS.

d) The Contractor's attention is drawn to the more severe environmental conditions that may exist during the construction/installation period and shall take adequate measures to protect the Permanent works against any deleterious effects of such conditions during the time between installation and final completion of the project. Also, Air throughout the project will contain considerable moisture content, hence the permanent works shall be tropicalized and vermin proof.

14 PROJECT MANAGEMENT INFORMATION SYSTEM (PMIS)

The Contractor shall utilise an available PMIS such that all documents generated by the Contractor can be transmitted to the Engineer by electronic means (and vice versa) and that all documents generated by either party are electronically captured at the point of origin and can be reproduced later, electronically and in hard copy. A similar link shall also be provided between the Engineer office at site and the Employer's Office by the Contractor. In case of non-availability, the Contractor may devise a PMIS of its own.

15 CONTRACTOR'S PROJECT ORGANISATION

a) The Contractor shall have a competent team of Managers, Engineers, Technical staff etc so as to complete the work satisfactory as per various requirements of the Contract.

b) The designations of the various project organisations team members shall be got approved by the Engineer before adoption so as to avoid any duplication of the designations with those of the Employer or the Engineer.

16 CONTRACTOR'S CERTIFICATE

The Contractor shall provide his registration details for GST Registration, EPF registration, ESI registration, Statutory Certificate, Certificate as per ESHS Manual etc. as required for the execution and completion of the Works.

Section VII: Employer's Requirements

Section VII-2:   Functional

EMPLOYER'S REQUIREMENTS – FUNCTIONAL

Objective

The objective of the Contract is the design, construction, testing and commissioning of the permanent works by the Contractor (including without limitation, the design, construction and removal of the Temporary Works) and the rectification of defects appearing in Permanent Works in the manner and to the standards and within the time obligations, liabilities and risks which may be involved, the Contractor shall undertake the execution of the Works.

1. GENERAL

1.1 The Works to be executed under Package C-5 is for design and construction of civil works and General Electrical Services work as per Employer's Requirements on 'Design Build' basis. All information available with the Employer has been furnished in Section VII-Tender Drawings and Documents, Part 2, Employer's Requirements. The Works are to be designed by the Contractor. Any other site data and information required for design of the Works shall be collected (through tests or otherwise), arranged, produced by the Contractor at his own cost. No claim from the Contractor whatsoever shall be entertained on the ground of certain information not being furnished in the Contract. The design and performance of the Permanent Works shall comply with the specific core requirements contained in these Employer's Requirements – Functional.

1.2 The design of the Permanent Works shall be developed in accordance with these Employer's Requirements – Functional and other requirements of the Contract.

1.3 The Permanent Works shall be designed and constructed to the highest standards available using proven up-to-date good engineering practices. The Specifications shall in no case specify standards which, in the Engineer's opinion, are less than or inferior to those described in the Outline Design Specifications (ODS) - Civil & BLT and Outline Construction Specifications (OCS) -Civil & BLT. Construction shall be carried out employing the procedures established by the Contractor as per approved Quality Assurance and Quality Control plan and Environmental, Social, Health and Safety (ESHS) Plan.

1.4 The Contractor shall be responsible for obtaining all necessary approvals from the relevant Public/Government/Local/Statutory or any agencies in the design and construction of the Works at his own cost.

1.5 Employer's Requirements- Functional shall be read in conjunction with Employer's Requirements- Design, Construction, Outline Design Specifications (ODS)- Civil & BLT, Outline Construction Specifications (OCS) -Civil & BLT, General Electrical Services, S&T works and other requirements of the Contract. The price quoted by the Contractor shall be deemed to have included cost of Works as per Part 2-Employer's Requirements (General, Functional, Design- Civil & BLT, Construction - Civil & BLT, Outline Design specifications (ODS) - Civil & BLT, Outline Construction Specifications (OCS) - Civil & BLT, General Electrical Services, Tender Drawings and Documents and Appendices).

1.6 Jurisdictional Sketch of Civil works under C-5 package is given in Section VII-8: Tender Drawings and Documents, Part 2, Employer's Requirements.

2. SCOPE OF WORK

2.1.1 Scope under Lump Sum Price Schedule 'A'

The through Chainages mentioned in the Scope of the Works/Tender drawings can undergo some minor corrections, without any impact on the overall length/Scope of the Works. The Lumpsum Scope of Work in brief is given below but the scope also includes all other requirements stipulated in various parts/sections of the Contract Document including Appendices and Annexures.

2.1.2 Design of the Works

i. Schedule 'A'

a) Design and drawings of all items of the Works under Schedule 'A' shall be carried out by the Contractor and the payment for the same is included in Cost Centre 'CD' of Schedule 'A'.

b) Design and drawings of all the temporary works, temporary road diversion shall also be carried out by the Contractor and the payment for the same is included in Cost Centre 'CD' of Schedule 'A'.

ii. Schedule 'B'

a) Design and drawings of all items of the Works under Schedule 'B' shall be carried out by the Contractor and the payment for the same is included in Cost Centre 'CD' of Schedule 'A'.

b) Design and drawings of all the temporary works, temporary road diversion shall also be carried out by the Contractor and the cost for the same is deemed to be included in the rates quoted for the relevant item of Schedule 'B' unless otherwise specified in the Contract.

Payment matrix for design of bridges, viaduct, temporary diversions, permanent diversions, widening of existing roads and restoration of existing roads is given in **Annexure F-7.**

2.1.3 Design and construction of railway formation

The Contractor shall design and construct railway formation for 32.5 t axle load as per updated RDSO Specifications "Comprehensive Guidelines and Specifications for Railway Formation- Specification No. RDSO/2020/GE: IRS-0004, (Including ACS No-01 dated 16.12.2021)" from Chainage -855.0 m to Chainage 12000 m and from Chainage 18000 m to Chainage 20942.473 m for double tracks of Main line; as per Employer's Requirements and shall include earthwork in cutting/filling, subgrade, prepared subgrade and blanketing including mechanical compaction. The Contractor shall arrange borrow areas for earthwork in embankment at his own cost.

Surplus excavated earth (approximately 2.0 lakh cum) from C-4 Package (herein after called the Employer's earth) available between Chainage 18,000 m to 20,000 m shall be utilised for construction of formation in C-5 Package. The Contractor shall measure quantity of available earth and seek approval of the Engineer before its use in construction of formation. A deduction @ INR 225.0 per cum shall be made from the Cost Centre 'CE-Earthwork and Blanketing' for use of Employer's earth. Royalty & other taxes payable for use of Employer's earth shall be borne by the Contractor. Surplus/unsuitable Employer's earth shall be disposed off by the Contractor at his own cost.

Formation width in station yards (i.e. from platform end to a distance of 200m beyond outermost SRJs on both up and down sides at both ends of station) shall be increased by 1.0m to lay cables and other utilities.

Formation at Chainage 7860 to 8036 (176m), Chainage 8036 to 8298 (262m) & Chainage 9650 to 9890 (240m) passes through pond/waterlogged stretches. In all such stretches, before undertaking earthwork in formation, minimum 500 mm thick layer of coarse sand (Zone I, II & III as per IS:383) shall be provided at bottom of embankment after dewatering by providing suitable arrangement like bunding etc. and removing slush/mud. Depression/ditch shall be filled with earth up to a distance beyond toe equal to H (height of embarkment) or ROW, whichever is less. A toe wall of boulder filled in crates shall be provided at the end of earth filling as shown in Tender drawings.

2.1.4 Design and construction of slope protection work

The slope of embankment/cuttings shall be protected by vegetative cover comprising perennial turf forming grass in accordance with Section VII- 6 Outline Construction Specifications (OCS)-Civil & BLT. On embankments higher than 4 m, vegetative cover shall be provided using coir netting as per IS:15869, IS:15872 and IRC: 56.

After Taking Over the Works, the Contractor shall maintain slopes of embankment/cutting and vegetative cover for a period of one (01) year and shall make good any loss/damage to formation and vegetative cover due to rain cuts, pedestrian movement or any other reason.

2.1.5 Design and construction of drainage system on embankments by providing precast RCC drains on berms, chute drains & sumps

The Contractor shall design and construct precast RCC longitudinal drains on berms of embankments to collect surface runoff from the slope. Precast RCC chute drains shall be provided at approximately every 50 m for collecting water from drains on berms and discharging it safely away from toe of embankments as shown in the Tender drawings. RCC collecting chambers shall be provided at the junction of longitudinal berm drains and chutes.

After Taking Over the Works, the Contractor shall maintain drainage system on embankments including sump, drain on berms, chutes etc. for a period of one (01) year and shall make good any damage to the drainage system due to rain cuts, pedestrian movement or any other reason.

2.1.6 Design and construction of Viaduct with Ballastless track

The Contractor shall design and construct viaduct for double track from Chainage 20942.473 m to Chainage 24843.548 m, with Long Welded Rail (LWR) on Ballastless track (BLT), including protection works on viaduct approaches at A1 as per Employer's Requirements. For providing LWR on viaduct the Contractor shall carry out RSI analysis.

The superstructure of proposed elevated viaduct shall consist of standard RDSO span configuration having span of 24.4m or above with 1.0 m wide pathway over deck slab on outer sides of each track. The substructure of proposed elevated viaduct shall have deep foundation at locations shown in Tender drawings. Open foundation may be permitted, wherever it is shown in Tender Drawings, subject to availability of sufficient bearing capacity as per GT investigations duly approved by the Engineer.

Design and construction of abutment A2 is not in the scope of C-5 Package. However, the Contractor shall make design data available to C-4 contractor for design and construction of abutment A2.

2.1.7 Design and Construction of Ballastless Track on Viaduct

The Contractor shall design and construct ballastless track including supplying & fixing rails and fittings complete in all respect on viaduct (Chainage 20842.0 m to Chainage 24843.548 m) including transition from ballastless track to ballasted track on abutment A1 side approach. The Contractor shall also provide derailment guards as per Employer's Requirements. The Works also includes supply of spare track fittings and maintenance of ballastless track for a period of one year after start of traffic as per Employer's Requirements.

2.1.8 Design and construction of minor bridges

The Contractor shall design and construct minor bridges (RUBs, canal and waterway bridges) including protection works on bridge approaches and height gauges at all RUBs as per Employer's Requirements. List of minor bridges is given in **Annexure-F-1.** Approach road on both sides of RUBs shall be designed and constructed by the Contractor upto ROW of HORC for full clear width of RUB. Design and construction of permanent diversion at RUBs shall be carried out by the Contractor, as shown in the Tender drawings or wherever required. In bridges over canals, RCC lining shall be designed & constructed by the Contractor upto ROW of HORC Payment matrix for various items incidental to bridges is given in **Annexure F-7.** Drainage arrangement shall be designed and constructed at RUBs where road level in the RUB is below natural ground level.

2.1.9 Design and construction of major bridges

The Contractor shall design and construct major bridges (RUBs, canal and waterway bridges) including protection works on bridge approaches and height gauges at all RUBs as per Employer's Requirements. List of major bridges is given in **Annexure- F-2**. Approach road on both sides of RUBs shall be designed and constructed by the Contractor upto ROW of HORC for full clear width of RUB. Design and construction of permanent diversion at RUBs shall be carried out by the Contractor as shown in the Tender drawings or wherever required. In bridges over canals, RCC lining shall be designed & constructed by the Contractor upto ROW of HORC. Payment matrix for various items incidental to bridges is given in **Annexure F-7.** LWR shall be provided on major bridges. The Contractor shall carry out RSI analysis of all the major Bridges to cater to the effect of providing LWRs in design of bridges.

2.1.10 Design and construction of stations

The Contractor shall design and construct three new stations namely Prithla, Silani & IMT Sohna.

i. **Prithla station**

   This is a crossing station with four tracks and two end platforms a double storey station building, RCC portico etc as shown in Tender drawings.

ii. Silani Station

This is a halt station having only two tracks and two end platforms. Ticket Booking Office building, RCC portico etc as shown in Tender drawings.

iii. IMT Sohna

This is a crossing station with four tracks and two end platforms a double storey station building, RCC portico etc as shown in Tender drawings.

The items of works to be carried out at various stations are shown in **Annexure F-3. Two** subway shall be constructed at Prithla, Silani & IMT Sohna stations each as shown in Tender drawings. The list of subways is shown in **Annexure F-5.** The works at stations shall be carried out in accordance with Tender drawings, Outline Design specifications (ODS) – Civil & BLT, Outline Construction Specifications (OCS) - Civil & BLT and other requirements of the Contract.

2.1.11 Design and construction of deep bore well, water storage tank & pipeline

Design and construction of one deep bore well of minimum 15,000 litre/hr yield with pump house and overhead gantry for lowering/taking out pumps, one underground & one overhead water storage tank, providing GI/Mild Steel pipeline from tube well to underground water storage tank and from underground water storage tank to overhead water storage tank with all accessories including distribution network from over head tank at Prithla, Silani-and IMT Sohna stations.

2.1.12 Design and application of water proofing system

Design and application of water proofing system in subway at three stations i.e, Prithla, Silani and IMT Sohna as per the Employer's Requirements.

2.1.13 Design and construction of MS pipe in embankment

Design and construction of Mild Steel pipe of 323.9 mm outer diameter in the embankment at approximately 500m interval (except in station yards) for crossing utilities in future as shown in Tender drawings.

2.1.14 Design of Auto Location Hut (ALH):

Design of 6 Nos. Auto Location Huts along the alignment between km 0 to km 25.0 as per Tender drawings**.** Floor level of the Auto Location Hut shall be at least 300 mm above the formation level. Auto Location Hut shall be supported on columns wherever adequate land is not available. Construction of Auto Location Huts shall be paid under Schedule 'B'.

2.1.15 Design of approach road

Design of concrete approach road at Prithla, Silani and IMT Sohna stations including retaining/RE wall, footpath, ramp drain etc as shown in Tender drawings. Construction of road, retaining/RE wall, footpath, ramp, drain etc shall be paid under schedule 'B'.

2.1.16 Design of prefabricated/precast cable duct

Design of prefabricated/precast cable duct of 300mm x 300mm internal size, with RCC cover, for laying of S&T cables in station yards buried under formation. The top of duct cover shall be minimum 690 mm below the formation level. The duct shall be designed with chamber of size 1200mmX1200mmX1500mm depth with a lid and locking arrangement at suitable interval, not more than 500m along the duct and at each track crossing location. Construction of precast duct and chamber shall be paid under schedule 'B'.

2.1.17 Design of precast/cast in situ RCC longitudinal drain

Design of precast/cast in situ RCC longitudinal drain of required capacity with suitable slope and outfall at places where HORC embankment overlaps with DFC embankment to safely cater the surface runoff from the slopes of HORC embankment and DFC embankment. Construction of precast/cast in situ RCC drain shall be paid under Schedule 'B'.

2.1.18 Design of precast and cast in-situ retaining walls

Design of precast and cast in-situ retaining walls for retaining formation slope along the alignment at locations given in **Annexure F-4**. Construction of these retaining walls shall be paid under Schedule 'B'.

2.1.19 Design of bridges & protection works included in Schedule ' B'

Design of bridges including protection works as mentioned in **Annexure F-6.** In major bridge Nos. 17, 28, 45 & 68 superstructure shall also be designed for LWR including design of BLT. In case, the Employer/Engineer decides to adopt standard RDSO span, the design of superstructure of above bridges shall not be done by the Contractor and shall be deleted from the scope of the work. Construction of these bridges shall be paid under Schedule 'B'.

2.1.20 Design of minor works at stations not included in Schedule 'A'

Design of minor works at stations like circulating area, land scaping etc. shall also be carried out by the Contractor. Construction of above-mentioned items shall be paid under Schedule 'B'.

2.1.21 Design of Staircase in Viaduct

Design of Staircase in viaduct at interval of 500 m in staggered manner on Up and Down tracks to evacuate the passengers in case of emergency. Construction of stair case shall be paid under Schedule 'B'

2.1.22 Traffic management

Traffic management along the work site including construction works required in connection with traffic management like road works, footpaths, drains and other services etc. and repair and maintenance of these construction works during construction period. Any road widening / diversion along with associated drainage system required to facilitate the movement of traffic and their repair & maintenance shall also be carried out by the Contractor. It also includes reinstatement of land/structure/roads/services etc. to original condition wherever road diversion has been made outside original road including reconstruction of structure demolished for traffic management. Materials and other specification related to traffic control devices shall conform to IRC standards.

2.1.23 Barricading

The Contractor shall provide and maintain during progress of works barricading around the work area where vehicular or pedestrian traffic passes with all safety measures as shown in Tender drawings. The excavations near habitations/public movement areas and all works along the roads shall be provided with proper caution signs and marked with red lights, reflectors at night to avoid accidents near public places to ensure safety of public.

2.1.24 Reinstatement/Restoration of roads and services

Reinstatement/Restoration of roads and services with new material of similar specification as per codal requirement after completion of work for the area disturbed by the Contractor during construction activities. However, reinstatement of roads and its drainage system will be as per current standards being used by the roads/service owning agency for similar roads. Proper survey to be done before dismantling of any of the above services along with extensive photographs, videos & sample of these services by the Contractor & get it verified by the representative of Engineer, so as to ascertain the extent of these existing services and its specification.

2.1.25 There is possibility of some of the items not getting mentioned in the above list of works. Tenderers are requested to go through the Tender drawings also in details as the works listed in Clause 2.1 above as well as indicated in the Tender drawings would be considered inclusive in the scope of work under lump sum quoted price except the items mentioned in Sub-Clause 2.2, 2.3 and 2.4 below unless specified otherwise in the Contract. Engineer's decision shall be final in this regard in case of dispute.

2.1.26 The work content against the lump sum component of the work i.e. Schedule 'A' shall also include, but not be limited to, the following:

a) Site clearance and dismantling of obstructions etc., before commencement of work as specified or as directed by the Engineer;

b) True and proper setting out and layout of the Works, benchmarks and provision of all necessary labour, instruments and appliances in connection therewith as specified or as directed by the Engineer;

c) All aspects of quality assurance, including testing of materials as per the approved Inspection and Test Plan and other components of the work, as specified or as directed by the Engineer;

d) Day to day cleaning of worksite throughout the execution period;

e) Maintenance of the completed Works during the period as specified or as directed by the Engineer;

f) Submission of completion (i.e., 'As-Built') drawings 06 (Six) sets in A-1 size and all other related documents as specified including scanned (in .pdf) and AutoCAD copy with soft copies in both formats of all As-built drawings & documents.

g) Preparing Definitive Design, Construction Reference drawings, Good For Construction (GFC) drawings and working drawings for various components of the works and obtaining approval in respect thereof from the Engineer, inclusive of incorporation of all modifications, alterations, changes, etc. that may be required to be carried out as directed by the Engineer;

h) Compliance of requirements of Environmental, Social, Health and Safety (ESHS) Manual as per Appendix 13 of Employer's Requirements, Section VII-9

i) Results of sub-surface investigations conducted at project site are enclosed with the Tender documents. This information about the soil and sub-soil water conditions is being made available to the Contractor in good faith and the Contractor shall have to obtain the details of sub-soil parameters independently. There are certain locations where weak sub-soil exist. Tentative location of weak subsoil stretches for formation has been given in ODS. Contractor shall be required to take necessary action for ground improvement. No claim whatsoever on account of any discrepancy/variation about the soil parameters and sub soil water conditions that may be actually encountered at the time of execution of the work and those given in these Tender Documents shall be admissible to the Contractor under any circumstances.

2.1.27 Other Works under Lump Sum

The Interface Management Document as per Appendix- 5 of Employer's Requirements shall also be complied with**.**

2.1.28 Safety of adjoining structures of DFC

Alignment is passing adjacent to DFC Tracks. The Contractor shall ensure that the design and construction of the Works should be carried out with adequate measures for the safety & protection of DFC or any other nearby structures. Construction activities shall be planned without affecting the operations of the existing system. It shall be ensured that no damage is caused to any element/person/ property of these systems. The Engineer/ Employer shall be indemnified against any damage caused to such structures at no extra cost.

2.1.29 Associated Works

Works to be performed shall also include all general works, preparatory works for the construction and works of any kind necessary for the design and satisfactory construction, completion and maintenance of the works to the intent and meaning of the drawings adopted and Outline Construction Specifications (OCS) - Civil & BLT , to best Engineering standards and orders that may be issued by the Engineer from time to time, compliance with all Conditions of Contract, supply of all materials, apparatus, plants, equipment, tools, fuel, water, strutting, timbering, transport, offices, stores, workshop, staff, labour and the provision of proper and sufficient protective works, diversion, temporary fencing, lighting and watching required for the safety of the public and protection of works on adjoining land; first-aid equipment, sanitary accommodation for the staff and workmen, effecting and maintenance of all insurances, the payment of all wages, salaries, fees, royalties, duties or the other charges arising out of the execution of works and the regular clearance of rubbish, clearing up, leaving the site perfect and tidy on completion.

2.1.30 Land for Contractor's Facilities & Site Office

For batching plants, field quality control laboratories, site offices and other activities (excluding labour camps), land total measuring approx. 20,000 Sq. m will be made available at multiple locations between km 0 to km 12.00 and km 18.00 to km 24.84 by the Employer on 'as is where is basis' free of cost. This land shall be made good for such offsite activities as needed by the Contractor at no extra cost to the Employer. Any land required beyond the above area will have to be arranged by the Contractor at his own cost. The land shall be cleared from debris, all structures made by the Contractor including RCC footings and rafts etc. and reinstated to the line, level and to the same conditions as existed before the work started before handing over back to the Employer within 91 days after Taking over Certificate. The final bill shall be released to the Contractor after all structures from the Contractor facility and site office are removed & clearance of site. The cost of setting up of all the above-mentioned facilities & the office and reinstatement of site is included in lump sum price in Schedule 'A'.

2.2 Scope under BOQ Schedule 'B'

Under this Schedule, the Contractor is required to carry out works which are not covered in Schedule 'A'. Broadly following works shall be carried out under this Schedule 'B':

a) Construction of railway formation from Chainage -2296 m to Chainage -855 m for connecting single track from Prithla Station to New Prithla Station (DFC)

b) Construction of cast in-situ retaining walls along the embankment at locations as given in **Annexure F-4**.

c) Construction of bridges including slope protection on bridge approaches and height gauge of bridges mentioned in **Annexure F-6**.

d) Construction of Ballastless track on major bridge Nos. 17, 28, 45 & 48 including supplying & fixing rails and fittings complete in all respect including transition from ballastless track to ballasted track on approaches & derailment guard.

e) Construction of stairs in viaduct at interval of 500 m in staggered manner.

f) Permanent diversion of canal required for construction of bridge Nos. 30, & 67.

g) Construction of precast S&T cable duct of 300mmX300mm internal dimensions with RCC cover and chamber in station yards. The top of duct cover shall be minimum 690 mm below the formation level. The Chamber shall be 1200 mmx 1200 mm x1500 mm (depth) size, with a lid & locking arrangement, shall be provided at suitable interval not more than 500m along the duct and at each track crossing location. The design of cable ducts is included in Schedule 'A'.

h) Construction of approach road including RE wall/Retaining wall, foot path, ramp, drain etc at Prithla, IMT Sohna and Silani Stations.

i) Construction of circulating area at Prithla, IMT Sohna and Silani Stations.

j) Construction of precast/cast in-situ RCC longitudinal drain of required capacity with outfall arrangement where HORC embankment overlaps with DFC/KMP embankment to safely cater the surface runoff from the slopes of HORC embankment and DFC/KMP embankment.

k) Earth filling in station area near the circulating area to improve drainage etc.

l) Any other item as directed by the Engineer related to the work.

2.3 Scope under Schedule 'C' (General Electrical Services works)

Under this Schedule, the Contractor is required to carry out General Electrical Services works. Detailed Scope of Works is given in Section VII-7A: General Electrical Services, Part 2-Employer's Requirements.

2.4 Scope under Schedule 'D' (Signalling and Telecommunication works)

Under this Schedule, the Contractor is required to carry out Signalling & Telecommunication (S&T) works. Detailed Scope of the Works is given in Section VII-7B: Signalling & Telecommunication (S&T) Works, Part 2- Employer's Requirements.

2.5 REFERENCE TO THE STANDARD CODES OF PRACTICE

2.5.1 All Standards, Outline Construction Specifications (OCS) - Civil & BLT, Technical Specifications and Codes of Practice referred to shall be latest editions including all applicable official amendments and revisions. The Contractor shall make available at site all relevant Indian Standard Codes of practice, IRS, IS, IRC, UIC, as applicable.

2.5.2 Wherever Indian Standards do not cover some particular aspects of design/ construction, relevant International Standards will be referred to. The Contractor shall make available at site such standard codes of practice.

2.5.3 In case of discrepancy among Standard codes of practice and Section VII-6: Outline Construction Specifications (OCS) -Civil & BLT, the order of precedence shall be as given below:

a. Outline Design Specifications (ODS) - Civil & BLT
b. Outline Construction Specifications (OCS) - Civil & BLT.
c. Standard Codes of Practice. In case of discrepancy among Standard Codes of Practice, the order of precedence will be
    i. IRS,
    ii. IS,
    iii. IRC,
    iv. other International codes
d. Indian Railway Unified Standard Specifications,
e. CPWD specifications,
f. NBC 2016,
g. MORTH Specification for Road & Bridges

2.6 DIMENSIONS

As regards errors, omissions and discrepancies in Specifications and Drawings, relevant clause of Particular Specification will apply. The levels, measurements and other information concerning the existing site as shown on the conceptual / layout drawings are believed to be correct, but the Contractor shall verify them for himself and examine the nature of the ground as no claim or allowance whatsoever shall be entertained on account of any errors or omissions in the levels or strata turning out different from what is shown on the drawings.

2.7 INSPECTION

The Employer may appoint an independent agency to ensure the quality checking of design, supply, fabrication, erection and construction of all works under scope of work. Payment to the independent agency shall be made by the Employer separately. The Contractor shall ensure complete co-operation with the agency to perform their work satisfactorily. In addition, the Employer also reserves right to undertake quality check and inspection directly by itself.

2.8 ALIGNMENT OF TRACKS

2.8.1 The alignment shall be as shown in the Tender drawings. The alignment has been developed by the Employer to meet operational and technical criteria. The Contractor is not required to evaluate the alignment for compliance with these criteria but shall review it with respect to his own design and construction proposals and shall satisfy himself that it suites to the available land width and there is no conflict with the clearances at proposed structures.

2.8.2 The Contractor is permitted to propose minor deviations in alignment to suit his construction proposals, but he must demonstrate that any such deviations shall comply with good design practice and the alignment requirement of the Design Criteria. Such deviations shall require prior approval of the Employer subject to following conditions:

i. There is no extra cost to the employer.

ii. Changes proposed are essentially required to suit the contractor's specific design.

iii. There is no change at the contract boundaries or if there is any, the same is agreed by the Contractor of the adjoining section without any extra cost to the employer**.**

2.8.3 The ground levels shown in Conceptual Alignment Plan & L-Section Tender drawings are based on preliminary survey. Detailed survey will have to be carried out by the Contractor for confirming and preparation of final Alignment Plan & L-Section. No cost implication shall be considered for any variation in the ground levels with respect to ground levels shown in conceptual Alignment Plan & L-Section tender drawings.

2.9 DURABILITY AND MAINTENANCE

The Permanent Works shall be designed and constructed such that, if maintained reasonably, they shall endure in a serviceable condition throughout their minimum lives as described in

Section VII-5: Outline Design Specifications (ODS) – Civil & BLT. The Permanent Works shall be designed and constructed so as to minimise the cost of maintenance whilst not compromising the performance characteristics and ride quality of the railway.

2.10 OPERATIONAL REQUIREMENTS

a) The vertical and horizontal alignments for the main and connectivity line shall comply with the conditions laid in para 2.8 above.

b) During construction the Contractor shall be responsible for providing and maintaining adequate flood protection to ensure protection of the works.

2.11 ENVIRONMENTAL CONSIDERATIONS

All provisions and conditions contained in the Environmental, Social, Health and Safety (ESHS) Manual as per Appendix 13 shall be strictly complied with.

2.12 TRAFFIC MANAGEMENT

The Contractor shall carry out the Works so as to minimise disruption to road and pedestrian traffic. The Contractor shall prepare his traffic management plan based on his proposed construction methodology in co-ordination with the Engineer and in conjunction with the concerned road authority as per Appendix 10. He shall comply strictly with the approved plan during construction of his works.

2.13 CRS INSPECTION

The Contractor shall note that the Commissioner for Railway Safety (CRS) will inspect the Works from time to time for the purpose of determining whether the HORC Project complies with the terms of operational and infrastructural safety in accordance with the Laws of India. The Contractor shall note that CRS approval is mandatory for commissioning the system. Notwithstanding other provisions of the Contract, the Contractor shall ensure that the Works comply with the requirements of CRS in terms of construction to the drawings and shall make all necessary arrangements and assist the representatives of the Employer and CRS in carrying out their inspection duties and also comply with their instructions regarding rectifying any defects and making good any deficiencies. Contractor shall prepare and make available all drawings, documents, sketches, photographs etc. as required for submission of application for inspection of CRS as instructed by the Engineer.

2.14 STANDARDS

Equipment, materials and systems shall be designed, manufactured and tested in accordance with the latest issue of National and/or International codes and standards. The Contractor shall submit hard copies in original to the Engineer of all codes and standards used for the work.

Reference to standards or to materials and equipment of a particular manufacturer shall be regarded as followed by the words "or equivalent". The Contractor may propose alternative standard materials, or equipment that shall be equal to or better than those specified. If the Contractor for any reason proposes alternatives to or deviations from the specified standards, or desires to use materials or equipment not covered by the specified standards, the Contractor shall apply for the consent of the Engineer. The Contractor shall state the exact nature of the change, the reason for making the change and relevant specifications of the materials and equipment in the English language. The decision of the Engineer in the matter of quality will be final.

ANNEXURE-F-1

LIST OF MINOR BRIDGES**

S. No.	Br. No.	*Chainage (m)	Type of Crossing	Type of Bridge	SPAN No. x L (in m) x H (in m)	No. of Tracks
1.	6	-574.471	Balancing Culvert	RCC Box	1x2.0x2.0	2
2.	7	-252.537	RUB	RCC Box	1x4.6x5.65	4
3.	9	139.953	RUB	RCC Box	1X4.6X4.15	4
4.	10	371.033	Canal + RUB	RCC Box	1X5.2X5.0+ 1X4.7X5.0	4
5.	11	958.395	RUB	RCC Box	1X4.6X4.15	2
6.	13	2034.964	RUB	RCC Box	1X4.6X4.15	2
7.	14	2493.015	RUB+ Drain	RCC Box	2X5.2X4.15	2
8.	15	3153.203	Balancing Culvert	RCC Box	1X2.0X2.0	2
9.	18	4373.615	RUB	RCC Box	1X9.75X6.7	2
10.	19	4858.791	RUB	RCC Box	1X4.6X4.15	2
11.	20	4891.994	Balancing Culvert	RCC Box	1X2.0X2.0	2
12.	21	5340.100	RUB	RCC Box	1X4.6X4.15	2
13.	22	5807.675	RUB	RCC BOX	1X4.6X4.15	2
14.	23	6409.986	Balancing Culvert	RCC BOX	1X3.0X3.0	2
15.	24	6881.539	RUB	RCC Box	1X4.6X4.15	2
16.	25	7548.546	RUB	RCC BOX	1X4.6X4.5	2

S. No.	Br. No.	*Chainage (m)	Type of Crossing	Type of Bridge	SPAN	No. of Tracks
					No. x L (in m) x H (in m)	
17.	27	7941.374	Balancing Culvert	RCC BOX	1X2.0X2.0	2
18.	29	8141.419	Balancing Culvert	RCC BOX	1X2.0X2.0	2
19.	31	8593.734	Balancing Culvert	RCC BOX	1X4.0X3.0	2
20.	32	8891.591	Balancing Culvert	RCC BOX	1X4.0X3.7	2
21.	33	9293.620	RUB	RCC BOX	1X7.0X4.15	2
22.	35	9591.677	Balancing Culvert	RCC BOX	1X2.0X2.0	2
23.	38	10090.792	Balancing Culvert	RCC BOX	1X3.0X3.0	2
24.	40	10410.702	RUB	RCC BOX	1X8.4X5.15	2
25.	42	10907.894	Balancing Culvert	RCC BOX	1X2.0X2.0	2
26.	43	11203.249	RUB	RCC BOX	1X4.6X5.65	2
27.	44	11403.443	Balancing Culvert	RCC BOX	1X2.0X2.0	2
28.	64	18558.000	RUB	RCC Box	2X6.0X4.0	2
29.	65	18735.000	Balancing Culvert	RCC Box	1X2.0X2.0	4
30.	67	19435.000	Canal	RCC Box	2x7.5x7.5	4

Notes:

1. *Chainages start from Prithla station of HORC.

2. **Payment of bridges in Annexure F-1 will be made in Cost Centre 'CB'-Bridges under lumpsum Schedule 'A'.
3. There can be minor change in span arrangement to suit site conditions. Nothing extra shall be payable to the Contractor on this account.
4. Deep foundation shall be provided at locations shown in tender drawings. Type of foundation at other locations shall be decided as per design requirements.

ANNEXURE-F-2

ANNEXURE-F-2/1

LIST OF MAJOR BRIDGES**

A. MAIN LINE

S. No.	Bridge No.	*Chainage (m)	Type of Crossing	Type of Bridge Super structure	Span Arrangement	No. of Tracks
1.	5	-592.612	ROAD	RCC Box	1x12x6.10	2
2.	12	1696.624	RUB	PSC U SLAB	1x12.2	2
3.	16	3472.548	RUB	RCC Box	1x12.0x6.10	2
4.	26	7753.296	RUB	RCC Box	1x12.0x6.10	2
5.	34	9536.901	IOCL Pipeline	Composite Girder	1X24.4	2
6.	41	10709.675	RUB	RCC BOX	1X12.0X5.65	2
7.	69	20400.000	Sub-station	Composite Girder + PSC U slab	1x12.2+2x18.3+1x12.2	2

Note:

1. *Chainages start from centre line of Prithla station of HORC.
2. **Payment of bridges in Annexure F-2/1 will be made in Cost Centre 'CB'-Bridges under lumpsum Schedule 'A'.
3. There can be minor change in span arrangement to suit site conditions. Nothing extra shall be payable to the Contractor on this account.
4. Deep foundation shall be provided at locations shown in Tender drawings. Type of foundation at other locations shall be decided as per design requirements.

ANNEXURE-F-2/2

Details of Viaduct**

S. No.	Bridge No	*Chainage (m)	Type of Crossing	Type of Bridge Superstructure	Span Arrangement	No. of Tracks
1.	70	20942.473 to 24843.548	Viaduct	Composite Girder	107x24.4+1x30.5+41x24.4+1x29.5+1x12.2 (UP Line) & 107x24.4+1x30.5+41x24.4+1x46.1+1x12.2 (DN Line)	2

Note:

1. *Chainages start from centre line of Prithla station of HORC.
2. **Payment of Viaduct in Annexure F-2/2 will be made in Cost Centre 'CV- Viaduct under lumpsum Schedule 'A'.
3. There can be minor change in span arrangement to suit site conditions. Nothing extra shall be payable to the Contractor on this account.
4. Deep foundation shall be provided at locations shown in Tender drawings. Type of foundation at other locations shall be decided as per design requirements.

ANNEXURE-F-3

List of items of works to be carried out at stations under Schedule 'A'

S. No	Item	Prithla	Silani	IMT Sohna
1	**Station Building**			
	a) Station Building.	1 No.	Ticket Booking Office	1 No.
	b) S & T huts.	-.	-	-
2	**Platforms (HL) -**			
	a) Earthwork in filling above formation level, cast in-situ RCC platform face Wall.	2 Nos. 6m x 600m each	02 No. 6m x 425m each	2 Nos. 6m x 600m each
	b) Surfacing of platform with VDC RCC precast coping, tactile tiles, precast fencing at end platforms.	For entire area of platform.	For entire area of platform.	For entire area of platform.
	c) PF Shelters	2 x 20m on each PF	2 x 20m on each PF	2 x 20m on each PF
	d) Mini PF Shelters	4 Nos. on each PF	4 Nos. on each PF	4 Nos. on each PF
	e) Passenger amenities-			
	i) Toilet blocks.	01 No. on each PF	01 No. on each PF	01 No. on each PF
	ii) Drinking water booths at platforms.	5 Nos. on each PF	5 Nos. on each PF	5 Nos. on each PF

S. No	Item	Prithla	Silani	IMT Sohna
	iii) Seating arrangement (Stainless steel).	48 Nos. seats on each PF	24 Nos. seats on each PF	48 Nos. seats on each PF
3	a) Subway for inter-platform transfer with covered stairs & ramps to platform, flooring, dado, wall cladding, water proofing, drainage, complete in all respects.	2 No.	2 No.	2 No.
	b) Lift Well & space for escalator	-	-	2 No.
4	**Water supply system-**			
	a) Borewell & pump house.	Yes	Yes	Yes
	b) Underground RCC water storage tank. (litres)	50,000	50,000	50,000
	c) Overhead RCC water storage tank. (litres)	20,000	20,000	20,000
	d) Water supply distribution system complete from borewell to service building and platforms.	Yes	Yes	Yes
5	**Drainage & Sewerage system-**			
	i) Platform drainage.	Yes	Yes	Yes
	ii) Station Yard drainage.	Yes	Yes	Yes

S. No	Item	Prithla	Silani	IMT Sohna
	iii) Sewerage system.	1 No. septic tank for 50 users at each PF; 1 No. septic tank for 100 users for station building.	1 No. septic tank for 50 users at each PF.	1 No. septic tank for 50 users at each PF; 1 No. septic tank for 100 users for station building.
6	**Miscellaneous Work –**			
	a) Station name board at station building and at platform ends.	Yes	Yes	Yes
	b) Platform number boards at each platform.	Yes	Yes	Yes
	c) RCC portico at entrance to subway	Yes	Yes	Yes

Annexure-F-4

Approximate Details of Retaining Wall Along Formation under Schedule 'B'

Connectivity Line (LHS) along the formation				
S.No	Chainage (m)		Length (m)	Approx. Height (m) Above ground level
	From	To		
1.	-1900	-1840	60	2.50
2.	-1840	-1720	120	6.00
3.	-1720	-1600	120	1.50
4.	-1600	-1480	120	2.00

ANNEXURE-F-5

LIST OF SUBWAYS** AT STATIONS

S. No.	Bridge No.	*Chainage (m)	Type of Crossing/Station	Type of Bridge	SPAN	No. of Tracks
					No. x L (in m) x H (in m)	
1	8	-145.0	Pedestrian Subway/ Prithla	RCC Box	1x6x3.15	4
2	8A	55.0	Pedestrian Subway/ Prithla	RCC Box	1x6x3.15	4
3	39	10240.0	Pedestrian Subway/ Silani	RCC Box	1x6x3.15	2
4	39A	10440.0	Pedestrian Subway/ Silani	RCC Box	1x6x3.15	2
5	66	18985.0	Pedestrian Subway/ IMT Sohna	RCC Box	1x10x3.15	4
6	66A	19185.0	Pedestrian Subway/ IMT Sohna	RCC Box	1x10x3.15	4

Note:-

1. *Chainages start from Prithla station of HORC
2. * *Payment of above subways will be made in Cost Centre 'CS'-Stations under lumpsum Schedule 'A'.

ANNEXURE-F-6

LIST OF BRIDGES UNDER SCHEDULE 'B'

1) LIST OF MINOR BRIDGES**

S. No.	Br. No.	*Chainage (m)	Type of Crossing	Type of Bridge	SPAN No. x L (in m) x H (in m)	No. of Tracks
1.	36	9882.453	Balancing Culvert	RCC BOX	1X2.0X2.0	2
2.	37	9894.460	RUB	RCC BOX	1X5.7X4.15	2
3.	1	-1950.000	Drain	RCC pipe	1x1.2	1
4.	2	-1832.759	Road + Balancing Culvert	RCC Box	(1x2.50x5.05) + (1x3.6x5.05)	1
5.	3	-1312.056	Road	RCC Box	1x4.6x5.65	1

2) LIST OF MAJOR BRIDGES**

S. No.	Bridge No.	*Chainage (m)	Type of Crossing	Type of Bridge	Span Arrangement	No. of Tracks
1.	4	-795.733	Canal + Road	CG + RCC Box	(1x 8 x 7.5) + (1x24.4) + (1x8x7.5)	2
2.	17	4256.298	RUB	OWG	4X30.5	2
3.	28	8036.354	Canal	OWG+CG	1x18.3+2x30.5 +1x18.3	2
4.	30	8298.110	RUB+ Drain	Composite Girder	1X30.5	2
5.	45	11543.518	NH71B RUB	OWG	2X76.2	2
6.	63	18310.000	Drain	PSC U Slab+ RCC Box	1x5x4.9+1x12. 2+1x5x4.9	2
7.	68	20184.000	RUB + Canal	OWG	2 x 61.0	2
8.	53#	14472.112	Stream	CG	2 x 24.4	2

Note:

1. *Chainages start from centre line of Prithla station of HORC.
2. **Payment for construction of bridges in Annexure F-6 will be made under BOQ Schedule 'B'.
3. #Only fabrication & erection of composite steel superstructure including bearings is in the scope. Construction of substructure is not included in the scope.
4. There can be minor change in span arrangement to suit site conditions. Payment shall be made as per actual quantities executed.
5. Deep foundation shall be provided at locations shown in Tender drawings. Type of foundation at other locations shall be decided as per design requirements.

Annexure F-7

Payment matrix for Design of Bridges, Viaduct, Temporary diversions, Permanent diversions, widening of existing roads and Restoration of existing roads for C5 package.

Sr No	Activity	Minor bridges in Annexure F-1 included in Schedule 'A'	Major bridges in Annexure F-2 included in Schedule 'A'	Subways at stations in Annexure F-5 included in Schedule 'A'	Bridges in Annexure F-6 included in Schedule 'B'
	Number of bridges covered	30	8	06	13
i.	a. Submission of design of permanent works, permanent diversion and regrading of roads and submission of As Built drawings and documents	Included in Cost Centre 'CD' of Price Schedule A	Included in Cost Centre 'CD' of Price Schedule A	Included in Cost Centre 'CD' of Price Schedule A	Included in Cost Centre 'CD' of Price Schedule A
	b. Design of Temporary works and temporary diversion/widening of roads	Included in Cost Centre 'CD' of Price Schedule A	Included in Cost Centre 'CD' of Price Schedule A	NA	Included in quoted rates of relevant items under Schedule-B
ii.	Construction of temporary diversions, if any including additional land (if any required beyond ROW) for constructing the same	Included in quoted lumpsum cost of works under Schedule A	Included in quoted lumpsum cost of works under Schedule A	NA	Included in quoted rates of relevant items under Schedule-B
iii.	Construction of permanent diversions and re-grading, if any required	Included in quoted lumpsum cost of works under Schedule A	Included in quoted lumpsum cost of works under Schedule A.	NA	Will be paid separately under Schedule -B
iv.	Widening of existing roads (within HORC ROW)	Included in quoted lumpsum cost of works under Schedule A	Included in quoted lumpsum cost of works under Schedule A	NA	Included in quoted rates of relevant items under Schedule-B

Sr No	Activity	Minor bridges in Annexure F-1 included in Schedule 'A'	Major bridges in Annexure F-2 included in Schedule 'A'	Subways at stations in Annexure F-5 included in Schedule 'A'	Bridges in Annexure F-6 included in Schedule 'B'
	Number of bridges covered	30	8	06	13
v.	Restoration of existing roads damaged during construction activities	Included in quoted lumpsum cost of works under Schedule A	Included in quoted lumpsum cost of works under Schedule A	NA	Included in the rates quoted under Schedule-B

ANNEXURE F-8

LIST OF TRACK FITTINGS

TABLE OF BILL OF MATERIALS FOR 1 SET OF H- BEAM SLEEPERS 60 Kg RUNNING RAIL WITH 52 Kg GUARD RAIL.

SL NO.	DESCRIPTION OF PARTS	DRAWING NO.	SPECIFICATION	NO/SL.
1	H-BEAM (ISHB 200X200) 2655 mm LENGTH	BASED ON R.D.S.O./B-1636/4/R	BS :45, IS :4759	1
2	M.S BASE PLATE	R.D.S.O./T-8760	IS.2062-2011	2
3	RAIL PAD WITH EMBEDDED STEEL PLATE	R.D.S.O./T-8761	IRS. SPECIFICATION FOR 10mm. THICK G.R. PAD (PROVISIONAL-1989) & STEEL AS PER PROVISIONAL-2019	2
4	SPL.CAST LINER (INNER)FOR 60KG RAIL	R.D.S.O./T-8762	IRS. SPECIFICATION PROVISIONAL -2019	2
5	SPL.CAST LINER (OUTER)FOR 60KG RAIL	R.D.S.O./T-8763	IRS. SPECIFICATION PROVISIONAL -2019	2
6	ELASTIC RAIL CLIP MK III	RDSO/T-3701	IRS T-31-2018	4
7	TAPPER WASHER (FOR GUARD RAIL)	R.D.S.O./T-5161	IS.226-1962	4
8	TAPPER WASHER (FOR GUARD RAIL)	R.D.S.O./T-5162	IS.226-1962	4
9	SINGLE COIL SPRING WASHER	R.D.S.O./T-10773	IRS T-42-1988	4
10	6mm GROOVED RUBBER PAD (FOR GUARD RAIL)	R.D.S.O./T-5163	IRS. SPECIFICATION FOR 6mm. THICK G.R. PAD (PROVISIONAL-1989)	4
11	305X300X25/30mm ELASTOMERIC PAD	R.D.S.O./B-1636/5	REV.-02 Dt-26/11/2012	2
12	TAPERED SPLIT PIN	CE's NO.22994/8	IS.226-1962	8
13	Φ28 HOOK BOLT347mm Length and 2 Nos NUT & 3 Nos. Washer	BASED ON R.D.S.O./B-1636/5	IS.226-1962	4
14	PACKING PLATE FOR GUARD RAIL 150X22X75		IS.226-1962	4
15	BOLT & NUT FOR GUARD RAIL	R.D.S.O./T-5164	IRS T-10-1968	2

Note: The above list excluding Sr No.1, 2 & 14 will be considered equal to 1 set of fittings. The Contractor shall supply spare set of fittings for 10% quantity of H Beam sleepers included in Schedule 'A'.

Section VII: Employer's Requirements

Section VII-3: Design (Civil & BLT)

EMPLOYER'S REQUIREMENTS – DESIGN (CIVIL & BLT)

1. INTRODUCTION

1.1 The Employer's Requirements - Design specifies the procedural requirements for the preparation of the design of the Permanent Works. These requirements are subdivided into those that are to occur during the Design Phase, those that are to occur during the Construction Phase, and those that are of general application.

1.2 In addition to the express requirements herein, the Contractor shall, whenever the Engineer so requests, provide information and participate in discussions that relate to design matters.

1.3 The Contractor shall engage the Designer who shall undertake and prepare the design of the Permanent Works and Temporary Works. The Contractor shall place his core design team at Gurgaon.

1.4 The Contractor shall ensure presence of Design team at Gurgaon at all times by staff whose seniority and experience are to the satisfaction of the Engineer and whose representative is available on the Site as necessary or as required by the Engineer.

1.5 The Contractor shall submit his Quality Assurance Plan as required at **Appendix 11** for the design required by the Contract.

1.6 The Contractor shall furnish Designer's Warranty in the format approved by the Employer.

1.7 The Design and Construction Standards shall be in conformity with the requirements of "Rules for Opening of a Railway or a Section of a Railway for Public Carriage of Passengers" and to the satisfaction of the Commissioner of Railway Safety whose sanction is mandatory for commissioning of the System.

2. REQUIREMENTS DURING DESIGN PHASE

2.1 The principal requirements of the Design Phase are the production of the Preliminary Design and General Arrangement Drawings, the Definitive Design and the Construction Reference Drawings.

2.2 Preliminary Design and General Arrangement Drawings

The Preliminary Design shall define the main structural elements. In addition, General arrangement drawing, general construction methods and documentation needed to develop the Definitive Design shall be submitted.

2.3 Definitive Design -Bridges, Viaduct, BLT and other Civil structures

2.3.1 Definitive Design shall be the design developed to the stage at which all elements of the structures are fully defined and specified and in particular:

a) Calculation and analysis are complete;

b) All main and all other significant elements are delineated;

c) All tests and trials and all selection of materials and equipment are complete;

d) Shall take full account of the effect on the Permanent Works of the proposed methods of construction and of the Temporary Works.

e) Interface Management Plan (IMP).

2.3.2 During the preparation of the Definitive Design, the Contractor shall complete all surveys, investigations and testing necessary to complete the design of the Permanent Works.

2.4 The Contractor shall sub-divide the proposed Definitive Design into Design Packages to be submitted in advance of the Definitive Design Submission and to be identified in the Design Submission Programme. The Design Packages are to relate to the significant and clearly identifiable parts of the proposed Definitive Design and shall address the design requirements as described herein. The Design Packages shall facilitate the review and understanding of the Definitive Design as a whole and shall be produced and submitted in an orderly, sequential and progressive manner.

2.5 Separate Definitive Design Submissions may be prepared for those major elements to be procured by sub-contract and which sub-contracts include design. Where such work is to be procured by the Contractor on the basis of outline design, design briefs and performance specifications, such documents may be submitted as Definitive Design Submissions.

2.6 Upon issue of the Notice in respect of the Definitive Design Submission, the Contractor shall complete the design in all respects and produce the Construction Reference Drawings, the purpose of which is to illustrate all the Permanent Works and to be the drawings governing construction.

2.7 Construction Reference Drawings shall fully detail for the construction of the elements covered by the Definitive Design and shall show in full the works to be constructed.

3. REQUIREMENTS DURING CONSTRUCTION PHASE

3.1 The principal requirements relating to design during the Construction Phase are the production of Working Drawings, the preparation of technical submissions as required under the Contract, the compilation of the Final Design and the production of the As-Built Drawings.

3.2 Working Drawings shall be prepared as required under the Contract. They shall be endorsed by the Contractor as being in accordance with the Construction Reference Drawings.

3.3 The Contractor shall endorse the submissions required under the contract that "all effects of the design comprising the submission on the design of adjacent or other parts of the works have been fully taken into account in the design of these parts"

3.4 At least 3 months but not more than 6 months prior to the anticipated date of substantial completion of the Works, the Contractor shall submit the Final Design to the Engineer.

3.5 The Final Design is the design of the Permanent Works embodied in:

a) the latest revisions of the documents comprised in the Definitive Design, taking account of comments in the schedules appended to Notices of No Objection

b) the latest revisions of the Construction Reference Drawings;

c) the calculations (see Clause 11 herein); and

d) such other documents as may be submitted by the Contractor at the request of the Engineer to illustrate and describe the Permanent Works and for which a Notice has been issued.

3.6 The Contractor shall maintain all records necessary for the preparation of the As-Built Drawings. Upon completion of the Works or at such time as agreed to or required by the Engineer, the Contractor shall prepare drawings which, subject to the Engineer's agreement, shall become the As-Built Drawings. All such drawings shall be endorsed by the Contractor as true records of the construction of the Permanent Works and of all temporary works that are to remain on the site. The Contractor shall also show the locations of utilities exposed and retained as directed.

4. DESIGN INTERFACES WITH INTERFACING CONTRACTORs

The Contractor shall co-ordinate all design and installation work with the Interfacing Contractors as described in Appendix 5, Section VII-9: Appendices, Part 2 – Employer's Requirements. The Contractor shall co-ordinate with all Interfacing Contractors to produce a detailed programme of access dates, equipment delivery routes and occupation periods for each work area.

5. DESIGN SUBMISSIONS: -

5.1 PRELIMINARY DESIGN AND GAD SUBMISSION

The preliminary design shall provide initial design documents for review and shall be sufficiently detailed to show the element of the design main and documents required for preparation of the definitive design. It shall also include:

a) the quality assurance plan for design

b) a review of the outline design criteria

c) the submission of design manuals

d) the submission of one licensed copies of proposed software

e) the submission of specifications proposed for the work

f) the identification of design codes and standards

g) the CAD procedures

h) an alignment review

i) the preliminary construction methodology

j) the design submission programme (update)

k) the utility diversion plan

l) proposed site surveys and other field surveys

m) a review of permanent land requirement

n) the preliminary ground treatment

o) GAD of bridges after carrying out site survey and architectural drawings of stations

p) The preliminary reinstatement drawings.

5.2 DEFINITIVE DESIGN SUBMISSION

5.2.1 GENERAL

The Definitive Design Submission shall be a coherent and complete set of documents properly consolidated and indexed and shall fully describe the proposed Definitive Design. In particular, and where appropriate, it shall define:

a) the dimensions of all major features, structural elements and members;

b) all materials;

c) potential forces and movements due to all possible loadings and actions on the structures, and their accommodation;

d) all second order effects;

e) the layout and typical details of reinforcement in structural concrete members;

f) the locations and nature of all relevant joints and connections and details thereof;

g) Standard details;

h) location, geometry and setting-out of all main elements and features;

i) electrical and mechanical services and equipment and their interaction with the structures;

j) provisions and proposals for construction interfacing with the Interfacing Contractors;

k) Erection / launching scheme;

l) utilities to be diverted /supported;

m) Traffic or other civic service affected.

5.2.2 DRAWINGS

The Definitive Design Submission shall include drawings that shall illustrate the proposed Definitive Design and in particular shall include, without limitation:

a) general arrangements;

b) layouts and details of structural elements;

c) associated fittings;

d) slopes and earthworks;

e) structural and surface drainage;

f) existing and proposed utilities;

5.2.3 CONTRACT SPECIFICATION

The Specification included in the Outline Design Specifications (ODS) - Civil & BLT and Outline Construction Specifications (OCS) - Civil & BLT for Civil Works shall be amplified so as to specify comprehensively the design and construction of the Permanent Works.

5.2.4 DESIGN MANUAL

The Design Manual shall incorporate all design requirements, standards, codes, loading cases, permissible movements and deflections, limit states, design stresses and strains, material properties and all other documents or matters which are relevant to and govern the design. The Design Manual shall refer to all materials, codes and standards used, making clear their specific applications. The Design Manual shall be produced so that it can be used by those involved in the preparation or review of the design of the Permanent Works as a comprehensive reference text and efficient working document.

5.2.5 INTERFACE REPORT ON INTERFACING CONTRACTORS

This will include the following:

(i) Details of the design and construction of the Works adjacent to other contracts.

(ii) Details of provisions for the Interfacing Contractors, indicating arrangements for accesses, fixings, casting-in, openings, supports and the like;

(iii) updated interface management plan relating to design integration and co-ordination.

5.2.6 TESTING AND COMMISSIONING REPORT

Details of proposals for testing and commissioning procedures for all relevant elements and equipment contained in the Permanent Works.

5.2.7 SUPPORTING DOCUMENTS

The Definitive Design Submission shall be accompanied by the following documents, which will be considered by the Engineer in his review of the Definitive Design Submission. Where relevant or required, these documents shall be accompanied by a design note stating clearly how information has been used in the design of the Permanent Works.

5.2.8 GEOTECHNICAL INTERPRETATIVE REPORT

A report including site investigation results and covering the geotechnical interpretation of site investigation work including that undertaken by the Contractor in sufficient detail to confirm and justify parameters used in the bridges and other structures foundation and geotechnical designs. The report shall include the full logs and descriptions of confirmatory boreholes drilled by the Contractor.

5.2.9 SURVEY REPORT

A report on all survey work undertaken by the Contractor, including checks on mapping, survey stations, co-ordinates and setting-out. Updated topographical and survey drawings shall also be included.

5.2.10 UTILITIES REPORT

A report giving details of arrangements and working methods in respect of the existing utilities, including protection measures, diversions, reinstatements and programme allowances.

5.2.11 TEMPORARY WORKS DESIGN REPORT

A report which provides sufficient information on the design of the Temporary Works to allow the Engineer to assess their effects on the Permanent Works and to enable these to be taken into account in the review of the Definitive Design.

5.2.12 INSTALLATION ANALYSIS REPORT

A report containing a stage-by-stage construction / installation sequence for all structures / equipment.

5.2.13 CONSTRUCTION METHOD STATEMENT

A report which provides sufficient information on the methods of construction and Contractor's Equipment to allow the Engineer to assess their effects on the Permanent Works and to enable these to be taken into account in the review of the Definitive Design.

5.2.14 PROJECT SCHEDULE REVIEW

i. The Contractor shall, prior to submitting the Definitive Design Submission, review the Project Schedule against the current version of the Design Submission Programme.

ii. In the event that the Contractor considers that there are any discrepancies or inconsistencies between the Design Submission Programme and the Project Schedule, the Contractor shall submit with the Definitive Design Submission its proposed revisions to the Project Schedule such that the discrepancies or inconsistencies are removed.

iii. The Contractor shall provide details of submissions of the proposed Working Drawings and their anticipated timing during the Construction Phase and shall identify information required from or actions to be undertaken by the Employer or others which are necessary to permit the completion of the design of the Permanent Works and the Working Drawings. Desired Dates for the receipt required by the Contractor of such information or for the completion of such actions shall be included with appropriate justification.

5.2.15 NOTICES ON DEFINITIVE DESIGN SUBMISSION

The Contractor may make Definitive Design Submissions and seek separate Notices in respect of:

(i) The temporary works for construction of the bridges

(ii) Major elements as identified under Clause 2.6 herein.

The issue of such separate Notices under (i) and (ii) above shall be conditional upon the Contractor having demonstrated, to the satisfaction of the Engineer, that the effect of each structure on other structures, utilities, etc., has been fully accommodated in the design.

6. DESIGN SUBMISSIONS - CONSTRUCTION REFERENCE DRAWINGS SUBMISSIONS

6.1 The Construction Reference Drawings shall be derived directly from the Definitive Design and shall detail and illustrate in full the Permanent Works. The Construction Reference Drawings shall form part of the Working Drawings to be used for construction purposes.

6.2 Prior to any Construction Reference Drawings Submission, the Contractor shall prepare a full list of Construction Reference Drawings in order to demonstrate, to the satisfaction of the Engineer, that such Construction Reference Drawings will be sufficient in extent to cover the construction of the whole of the Permanent Works.

6.3 Unless otherwise required by the Engineer, the Construction Reference Drawings need not include bar bending schedules, bar reference drawings, fabrication or shop drawings as well as other schedules or erection drawings which are to be provided by the Contractor during the Construction Phase.

6.4 The latest Construction Reference Drawing for which Notice has been issued by the Engineer shall be drawn on a tracing film duly signed by the Designer and the Contractor and shall be submitted to the Engineer for his approval. The Engineer will issue Notice in respect of such drawings, endorse them and return to the Contractor. The Contractor shall endorse such drawings as "Good For Construction (GFC)" and shall issue them to the Site for execution of the works.

7. DESIGN SUBMISSIONS – CONSTRUCTION PHASE

7.1 The Contractor shall prepare proposed Working Drawings such as site sketches, bar bending schedules, bar reference drawings, fabrication and shop drawings, construction erection sequences and the like. All such drawings shall be based on Construction Reference Drawings and shall comply with the requirements of the Contract. Working Drawings shall be submitted to the Engineer for his approval.

7.2 If the Working Drawings are considered in order, the Engineer shall issue Notice in respect of such drawings, endorse them and return to the Contractor. On the endorsement by the Engineer, the original will forthwith be returned to the Contractor as the Working Drawings. The Contractor shall endorse such drawings as "Good For Construction (GFC)" and shall issue them to the Site for execution of the works.

7.3 The contractor shall finalize details of the excavation scheme and installation sequence of primary support system and submit such finalized details to the Engineer for review. The proposed excavation scheme and primary support system requirement and installation sequence shall not adversely affect the final lining.

7.4 The Contractor shall finalise details of the proposed method of construction and submit such finalised details to the Engineer for review. The proposed method shall have no adverse effects on the partially completed Permanent Works and shall ensure the Works are statically and, if appropriate, aerodynamically stable.

7.5 The Contractor shall undertake and submit a stage by stage construction sequence and the effect of any Temporary Works and the Contractor's Equipment on the Permanent Works. This analysis shall be in sufficient detail to demonstrate that the Contractor's proposals are safe and have no adverse effects upon any parts of the Permanent Works.

7.6 As-Built Drawings, endorsed by the Contractor shall be submitted to the Engineer for agreement in accordance with Clause 5.5 of the GCC and in electronic format using a commercially available CAD program.

8. DESIGN SUBMISSIONS - REVIEW PROCEDURES

8.1 Submissions of Design Data shall be made and reviewed by the Engineer. The form and detail of the review shall be as determined by the Engineer and will not release or remove the contractor's responsibility for the design under the contract.

8.2 The issue of a Notice shall be without prejudice to the issue of any future Notices.

8.3 The Contractor shall, prior to the submission of the Design Data, obtain all required and/or statutory approvals that relate to that submission including, where appropriate, the approval of the Concerned Government Authorities and utility undertakings, and demonstrate that all required approvals have been obtained.

8.4 All submissions shall be accompanied by two original copies of a `Design Certificate' as set out in Attachment D1 hereto and signed by the Contractor and the Designer.

9. DESIGN SUBMISSION PROGRAMME

9.1 The Contractor shall prepare the Design Submission Programme which is to set out fully the Contractor's anticipated programme for the preparation, submission and review of the Design Packages, the Definitive Design Submission and the Construction Reference Drawings Submissions and for the issue of Notices in relation thereto.

9.2 The Design Submission Programme shall:

a) be consistent with and its principal features integrated into the Works Programme, and show all relevant Key Dates;

b) identify dates and subjects by which the Engineer's decisions should be made;

c) make adequate allowance for periods of time for review by the Engineer and other review bodies;

d) make adequate allowance for the design and development of specialist works;

e) include a schedule identifying, describing, cross-referencing and explaining the Design Packages into which the Contractor intends to divide the Definitive Design and Construction Reference Drawings; and

f) indicate the Design Interface and Co-ordination periods for each Interfacing Contractor.

10. PROGRAMME FOR SUBMISSIONS DURING THE CONSTRUCTION PHASE

In accordance with Clause 4 of the Employer's Requirements - General, the Contractor shall identify submissions required during the Construction Phase.

11. CALCULATIONS

11.1 Unless otherwise required by the Engineer, calculations relevant to the Definitive Design and Construction Reference Drawings shall be submitted for review with the respective Design Packages or Submissions. The Engineer may require the submission of applicable software including in house software programmes/

worksheets developed by the Contractor, computer input and programme logic for its review prior to the acceptance of the computer output.

11.2 The Contractor shall prepare and submit a comprehensive set of calculations for the Definitive Design in a form acceptable to the Engineer. Should the design of the Permanent Works be revised thereafter and such revision renders the calculations as submitted obsolete or inaccurate, the Contractor shall prepare and submit the revised calculations.

11.3 Similarly, the Contractor shall submit such further calculations as have been prepared in connection with the Construction Reference Drawings. Calculations to be included as part of the submission herein shall comprise the up-to-date calculations in respect of the Definitive Design, the Construction Reference Drawings and such further calculations which the Contractor has prepared during the production of Working Drawings.

11.4 The Contractor shall submit all calculations necessary to support proposals relating to the construction methods.

12. DOCUMENTS REQUIREMENTS

12.1 Drawings shall be prepared generally to A1 size, but to A0 size where appropriate.

12.2 The Contractor shall submit 03 copies of his design and/or drawings for review by the Engineer. After receipt of "No Objection" from the Engineer's Representative, the Contractor shall submit 06 copies of design and/or drawing for the use of the Engineer.

12.3 The submission of drawings should be as per **Appendix 9** of the Employer's Requirements.

12.4 The contractor to provide *one* licensed working software copy being used by its DDC to Employer/Engineer's design department maintained for the entire contract period.

13. Detail Design Consultant (DDC) for Ballastless Track (BLT) System

13.1 Upon award of the Contract, the Contractor shall engage Detail Design Consultant for design of BLT. The Contractor shall submit details of DDC proposed to be engaged for Design of Ballastless track system for the approval of the Engineer. DDC shall be engaged within twelve months of the Commencement Date.

13.2 DDC shall have the experience of design of BLT of at least 10 Km length having satisfactory working performance under mixed traffic conditions with at least 22 tonne axle load and at an operational speed of at least 100 kmph for at least 5 years since the date of its operation as on date of opening of the Tender.

13.3 DDC shall submit experience certificate for design of ballastless track system issued by the user railway administration. The certificate shall specifically indicate that the designer has designed ballastless track system (including fastening system) of at least 10 Km length. The certificate shall clearly state that ballastless track system is having satisfactory working performance under mixed traffic conditions with at least 22T axle load and at an operational speed of at least 100Kmph. The certificate shall state the date of start of operation on ballastless track system and the duration for which ballastless track system has been in continuous operation.

In case the user railway administration is from foreign country and the certificate is issued in language other than English, the supporting documents shall be translated into English. The translation of the certificate shall be either stamped by Embassy/High Commission of India or Partner Countries of Hague convention may submit these documents with "Apostille" stamp. The experience certificate issued by foreign user railway administration in English shall also be either stamped by Embassy/High Commission of India or submitted with "Apostille" stamp.

Note:

The qualifications of DDC given above are based on Railway Boards letter No. EBS/CB-I/BLT/Committee dated 10.03.2023. If the criteria given in Railway Boards letter is modified by Railway Board / concerned government authority / RDSO, the same will be followed. However, the modified criteria will not be stricter than the criteria given above.

13.4 DDC proposed to be engaged shall submit details containing, but not limited to, the name of line in which the system is in use for minimum 5 years, details of user railway administration such as name of the Railway administration and its contact person, address, telephone number, E-mail id etc.

13.5 The Contractor shall submit test report of the proposed fastening system from a reputed independent institute/laboratory. The test report shall be accompanied with the drawing of the fastening system including its components which have been tested and reported upon. The Contractor shall propose the same fastening system for which test report has been submitted. The testing shall be done for Cat 'C' as specified in EN-13481 Pt-1:2012 & EN-13401 Pt-5:2017 for 60Kg UIC rail section. The Contractor shall also submit a statement showing compliance or otherwise, in juxtaposition to each Clause and Sub-Clause as specified in EN-13481 Pt-1:2012 & EN-13481 Pt-5:2017.

The above Specifications are based on Railway Boards letter No. EBS/CB-I/BLT/Committee dated 10.03.2023. If the Specifications given in Railway Boards letter are modified by Railway Board / concerned government authority / RDSO, the same will be followed. The Contractor shall design and construct the BLT system as per the modified Specifications without any additional cost to the Employer.

13.6 The Contractor shall submit detailed design and drawings of ballastless track for viaduct including fastening system, derailment prevention arrangement, arrangement for provision of ducts for signal/telecommunication/electrical in longitudinal and transverse direction, transition system, drainage system with construction procedure & maintenance /repair procedure, QAP etc. to the Engineer for approval.

13.7 The Contractor shall indemnify HORCL and HRIDC against any claims from any other party in connection with the intellectual property rights of the drawings and design/fastening system/ballastless track system or any other documents submitted by the Contractor or any other patent rights.

ATTACHMENT D 1

DESIGN CERTIFICATE

This Design Certificate refers to design submission no. .... , which comprises of Definitive Design submission / Construction Reference Drawings submission, working drawing submission scheduled in the attached transmittal, in respect of:

(Description of Permanent Works to which the submission refers)

DESIGNER'S STATEMENT:

We certify that:

a) the outline designs, design briefs and performance specifications of those elements of the Permanent works as illustrated and described in the documents scheduled in the attached transmittal, complies with the Outline Design Specifications (ODS) - Civil & BLT and other contract provisions.

b) an in-house check has been undertaken and completed in accordance to approved Quality Assurance Plan (QAP) to confirm the completeness, adequacy and validity of the design of the Permanent Works as illustrated and described in the documents scheduled in the attached transmittal.

c) all necessary and required approval relating to the design of the Permanent Works, as illustrated and described in the documents listed in the attached transmittal, have been obtained.

d) all effects of the design comprising the submission on the design of adjacent or other parts of the works have been fully taken into account in the design of those parts.

Signed by Designer's Authorised Representative

Name : ....

Position : ....

Date : ....

CONTRACTOR'S CERTIFICATE:

The Certifies that all design has been performed utilizing the skill and care to be expected of a professionally qualified and competent designer, experienced in work of similar nature and scope. This further certifies that all works relating to the preparation, review, checking and certification of design has been verified by us and the design proposed by the designer has been accepted by us.

Signed by Contractor's authorised representative

Name : ....

Position : ....

Date : ....

Note 1

The Contractor shall insert one of the following, as applicable:

(i) the Contractor's Technical Proposals

(ii) the Contractor's Technical Proposals and Design Packages Nos. .... for which a Notice of No Objection has been issued.

(iii) Design Packages Nos. ....…... for which a Notice of No Objection has been issued if such Design Packages develop and amplify the Contractor's Technical Proposals.

(iv) The Definitive Design

SAMPLE DESIGN/DRAWING TEMPLATE

(a) 'Design Quality Assurance' by designer & contractor:

DESIGN QUALITY ASSURANCE			
The responsibility of control, check and verification of accuracy, correctness, completeness, integration and full compliance of contract provisions in respect of design analysis and drawings rests with the design consultants and the contractor.			
By Designer			**By Contractor**
Sig. :	Sig. :	Sig. :	Sig. :
Date. :	Date. :	Date. :	Date. :
Name :	Name :	Name :	Name :
Designed by	Checked by	Approved by	Accepted By

(b) Notice of 'No Objection' from the Engineer:

Notice of 'No Objections' from the Engineer			
Notice of "No Objections" from the Engineer is being accorded for design Principles. However, the overall responsibility for the detailing and design accuracy lies with Design and Build Contractor.			
	REMARKS		
Design Engineer (GC/HORC)	Reviewed		
Senior Design Expert (GC/HORC)	Reviewed		
Chief Design Expert (GC/HORC)	Reviewed		
DPD (GC/HORC)	Reviewed & comments as marked on drawing		

Section C

[Contractor to attach copies of necessary and required approvals]

Section VII: Employer's Requirements

Section VII-4: Construction (Civil & BLT)

Contents

EMPLOYER'S REQUIREMENTS – CONSTRUCTION (Civil & BLT)

1. CONTRACTOR'S SUPERINTENDENCE

The Contractor shall submit a Staff Organization Plan in accordance with the Attachment C-1

This plan shall be updated and resubmitted whenever there are changes to the staff. The plan shall show the management structure and state clearly the duties, responsibilities and authority of each staff member.

The Contractor's Representative and his associates/supervisors shall have experience and qualification appropriate to the type and magnitude of the Works as per Attachment C-2. Full details shall be submitted of the qualifications and experience of all proposed staff to the Engineer for his approval.

2. CONTRACTOR'S TEMPORARY WORKS DESIGN

The Contractor shall, prior to commencing the construction of the Temporary Works, submit a certificate to the Engineer signed by him certifying that the Temporary Works have been properly and safely designed and checked and that the Contractor has checked the effect of the Temporary Works on the Permanent Works and has found this to be satisfactory.

2.1 UTILITIES

a) Refer Employer's Requirements – Functional and Appendix-10 of Section VII-9: Appendices, Employer Requirements.

2.2 STRUCTURES, ROADS AND OTHER PROPERTIES

a) The Contractor shall immediately inform the Engineer of any damage to structures, roads or other properties.

2.3 SITE LABORATORIES

a) The Contractor shall provide, erect, and maintain in a clean, stable and secure condition a laboratory, equipped for the routine testing of cement, aggregate, concrete and soil samples and for the storage and curing of concrete cubes or cylinders only. This laboratory shall be located at the Contractor's principal work site or at a location agreed to by the Engineer. Detailed requirements for this laboratory are set out in Appendix 12 to these Employer's Requirements.

3. TESTING

3.1 GENERAL

a) The Contractor shall provide and perform all forms of testing procedures applicable to the Works and various components and the interfacing of the Works with the other Contract works and shall conduct all necessary factory, site and acceptance tests.

b) All testing procedures shall be submitted at least thirty (30) days prior to conducting any Test. The Testing procedures shall show unambiguously the extent of testing covered by each submission, the method of testing, the Acceptance Criteria, the relevant drawing (or modification) status and the location.

c) The testing Procedures shall be submitted, as required, by the Contractor during the duration of the Contract to reflect changes in system design or the identification of additional testing requirements.

d) The Engineer shall have the facilities for monitoring all tests and have access to all testing records. Ample time shall be allowed within the testing programmes for necessary alterations to equipment, systems and designs to be undertaken, together with re-testing prior to final commissioning.

e) The Contractor is reminded that at some point, the High Voltage Power Supply system will be energised and the additional precautions for the safety of staff and co-ordination of activities after power-on shall be anticipated in its testing and commissioning programmes.

f) All costs associated with the Testing shall be borne by the Contractor, unless otherwise specified, including the services of any specialised personnel or independent assessors. The Contractor shall also bear any expenses incurred due to resetting caused by defects or failure of equipment to meet the requirements of the Contract in the first instance. No such testing shall relieve the Contractor from any obligation or responsibility

g) All testing equipment shall carry an appropriate and valid calibration labels.

3.2 BATCHES, SAMPLES AND SPECIMENS

a) A batch of material is a specified quantity of the material that satisfies the specified conditions. If one of the specified conditions is that the material is delivered to the Site at the same time, then material delivered to the Site over a period of a few days may be considered as part of the same batch if in the opinion of the Engineer there is sufficient proof that the other specified conditions applying to the batch apply to all of the material delivered over the period.

b) A sample is a specified quantity of material that is taken from a batch for testing and which consists of a specified amount, or a specified number of pieces or units, of the material.

c) A specimen is the portion of a sample that is to be tested.

3.3 SAMPLES FOR TESTING

a) Samples shall be of sufficient size and in accordance with relevant Standards to carry out all specified tests.

b) Samples taken on the Site shall be selected by, and taken in the presence of, the Engineer and shall be suitably marked for their identification. An identification marking system should be evolved at the start of works in consultation with the Engineer.

c) Samples shall be protected, handled and stored in such a manner that they are not damaged or contaminated and such that the properties of the sample do not change.

d) Samples shall be delivered by the Contractor, under the supervision of the Engineer, to the specified place of testing. Samples on which non-destructive tests have been carried out shall be collected from the place of testing after testing and delivered to the Site or other locations instructed by the Engineer.

e) Samples which have been tested may be incorporated in the Permanent Works provided that:

   I. the sample complies with the specified requirements.

II. the sample is not damaged; and

III. the sample is not required to be retained under any other provision of the Contract.

f) Additional samples shall be provided for testing if in the opinion of the Engineer :

I. material previously tested no longer complies with the specified requirements; or

II. material has been handled or stored in such a manner that it may not comply with the specified requirements.

3.4 TESTING

a) The Contractor shall be responsible for all on-site and off-site testing and for all in-situ testing. All appropriate laboratory tests shall be carried out in the Contractor's laboratory, unless otherwise permitted or required by the Engineer. Where the laboratory is not appropriately equipped and/or staffed for some tests, or if agreed to by the Engineer, tests may be carried out in other laboratories provided that:

i. they are accredited for the relevant work to a standard acceptable to the Engineer; and

ii. particulars of the proposed laboratory are submitted to the Engineer for his consent.

b) In-situ tests shall be done in the presence of the Engineer.

c) Equipment, apparatus and materials for in-situ tests and laboratory compliance tests carried out by the Contractor shall be provided by the Contractor. The equipment and apparatus shall be ISI marked as far as possible and maintained by the Contractor and shall be calibrated before the testing starts and at regular intervals as permitted by the Engineer. The equipment, apparatus and materials for in-the situ tests shall be removed by the Contractor as soon as practicable after the testing is complete.

d) The Contractor shall be entitled in all cases to attend the testing carried out in the Employer's or other laboratories, to inspect the calibration certificates of the testing machines and to undertake the testing on counterpart samples. Testing of such samples shall be undertaken in laboratories and particulars of the laboratory proposed shall be submitted to the Engineer for consent prior to the testing.

e) Attendance on tests, including that by the Engineer, Contractor and Designer, shall be as laid down in the Quality Assurance procedures.

3.5 COMPLIANCE OF BATCH

a) The results of tests on samples or specimens shall be considered to represent the whole batch from which the sample was taken.

b) A batch shall be considered as complying with the specified requirements for a material if the results of specific tests for of the specified properties comply with the specified requirements for the properties.

c) If additional tests are permitted or required by the Engineer but separate compliance criteria for the additional tests are not stated in the Contract, the Engineer shall determine if the batch complies with the specified requirements for the material on the basis of the results of all tests, including the additional tests, for every properties.

3.6 RECORDS OF TESTS

a) Records of in-situ tests and laboratory compliance tests carried out by the Contractor shall be kept by the Contractor on the Site and a report shall be submitted to the Engineer within seven (7) days, or such other time stated in the Contract or in the Quality Assurance Programme, after completion of each test. In addition to any other requirements, the report shall contain the following details:

i. material or part of the Works tested;

ii. location of the batch from which the samples were taken or location of the part of the Works;

iii. place of testing;

iv. date and time of tests;

v. weather conditions in the case of in-situ tests;

vi. technical personnel supervising or carrying out the tests;

vii. size and description of samples and specimens;

viii. method of sampling;

ix. properties tested;

x. method of testing;

xi. readings and measurements taken during the tests;

xii. test results, including any calculations and graphs;

xiii. specified acceptance criteria; and

xiv. other details stated in the Contract.

b) Reports of tests shall be signed by the site agent or his assistant, or by another representative authorised by the Contractor.

c) If requested, records of tests carried out by the Employer's staff or by the Engineer shall be given to the Contractor.

4. RECORDS

4.1 DRAWINGS PRODUCED BY THE CONTRACTOR

a) Drawings produced by the Contractor including drawings of site layouts, Temporary Works, etc. for submission to the Engineer shall generally be to A1 size. They shall display a title block with the information as detailed in Appendix 9 to these Employer's Requirements. The number of copies to be submitted to the Engineer shall be as stated in the Contract, or as required by Engineer.

4.2 PROGRESS PHOTOGRAPHS

The Contractor shall provide monthly progress photographs and drone survey report along with video which have been properly recorded to show the progress of the works to the Engineer. The photographs shall be taken on locations agreed with the Engineer to record the exact progress of the Works. Survey by drone for the Works shall be carried out every month and submitted to the Engineer.

a) The Contractor shall mount each set of each month's progress photographs in a separate album of a type to which the Engineer has given his consent, and shall provide for each photograph two typed self-adhesive labels, one of which shall be mounted immediately below the photograph and one on the back of the photograph. Each label shall record the location, a brief description of the progress recorded and the date on which the photograph was taken.

b) All photographs shall be taken by a skilled photographer whose name and experience shall be submitted to the Engineer for consent and approval received. Processing shall be carried out by a competent processing firm to the satisfaction of the Engineer.

c) The Contractor shall ensure that no photography is permitted on the Site without the agreement of the Engineer. Contractor should be aware of the local regulations and conditions with regard to Photography.

5. MATERIALS

a) Materials and goods for inclusion in the Permanent Works shall be new unless the Engineer has consented otherwise. Preference shall be given to local materials where available. Approved Manufacturers/Suppliers of few important items have been given in Section VII-8: Tender Drawings and Documents. These materials shall be procured only for these manufacturers/Suppliers.

b) Certificates of tests by manufacturers which are to be submitted to the Engineer shall be current and shall relate to the batch of material delivered to the Site. Certified true copies of certificates may be submitted if the original certificates could not be obtained from the manufacturer.

c) Parts of materials which are to be assembled on the Site shall be marked to identify the different parts.

d) Materials which are specified by means of trade or proprietary names may be substituted by materials from a different manufacturer which has received the consent of the Engineer provided that the materials are of the same or better quality and comply with the specified requirements.

e) Samples of materials submitted to the Engineer for information or consent shall be kept on the Site and shall not be returned to the Contractor or used in the Permanent Works unless permitted by the Engineer. The samples shall be used as a mean of comparison which the Engineer shall use to determine the quality of the materials subsequently delivered. Materials delivered to the Site for use in the Permanent Works shall be of the same or better quality as the samples which have received consent.

6. PROVISIONS FOR INTERFACING CONTRACTORS

Interface responsibilities mentioned in Appendix–5 shall be followed by the Contractor.

7. RESTORATION OF AREAS DISTURBED BY CONSTRUCTION.

Unless otherwise directed by the Engineer, any areas disturbed by the construction activity, either inside or outside the Project Right of Way, shall be reinstated as follows:

All areas affected by the construction work shall be reinstated to their original condition, with new materials, including but not necessarily limited to, sidewalks, parking lots, access roads, roads, adjacent roads properties, footpath, kerb stone, boundary wall, grill, fencing, grill, any type of structures (underground & above ground), bore well, horticulture and landscaping. Grass cover shall be provided for any bare earth surface areas, along with proper provisions for surface drainage.

8. TAKING OVER OF WORKS / SECTIONS

8.1 Inspection

a) General

Within seven (7) days of receipt of the Contractor's written application for a Taking-Over Certificate, pursuant to Sub-Clause 10.1 of the General Conditions of Contract, the Engineer, in the company of the Contractor, will inspect the Works or Section covered by the application, as per the requirements described in this Sub-Clause. During the joint inspection, the Works or Section will be examined and relevant documentation will be reviewed. The Engineer will prepare a written list of outstanding items, if any, to be completed or corrected before issuance of the Taking-Over Certificate and a separate written list of items to be completed or corrected during the remainder of the Contract orthe Defects Notification Period. The list shall include an agreed date of correction for each deficiency.

The Contractor shall also obtain written confirmation from all applicable Interfacing Contractors that all interfacing matters have been concluded.

If there are no outstanding items to be completed or corrected before the Taking Over ofthe Works or a Section, the Contractor shall submit to the Engineer all guarantees, warranties, final certifications or similar documents or both as are required under the Contract.

b) Static Inspection

The inspection listed in the following table shall be conducted by the Engineer, in coordination with Interfacing Contractors as necessary.

The Contractor shall prepare and submit for review and approval by the Engineer a Static Inspection Plan detailing and explaining how the Contractor will plan, perform and document all tests and inspections that shall be conducted to verify and validate the Works. The Static Inspection Plan shall consist of a narrative description supported by graphics, diagrams and tabulations as required.

Structure	**Inspection Item**		**Inspection Method**		
			Confirmation of "As-Built" Records	**Visual Inspection**	**Measurement Test Check**
Earthwork	Formation width	At every 100m on straight line, at every 20m on curved line, at	✓		✓

Structure	Inspection Item		Inspection Method		
			Confirmation of "As-Built" Records	Visual Inspection	Measurement Test Check
		each terminal point of structures			
	Cross section	At every 100m on straight line, at every 20m on curved line, at each terminal point of structures.	✓		✓
	Retaining wall	List of location of retaining walls	✓	✓	
	Construction	Soil test records, compaction records, CBR & deformation modulus (Ev_2) records, construction photos	✓		
	Blanket	Blanket material test records, compaction test records, CBR & deformation modulus (Ev2) test records.	✓		
		Thickness	✓		✓
	Structures Crossing	List of structures crossing the Railway (earth cover, overhead clearance, etc.)	✓		✓
	Drainage system	Drainage works at embankment/cutting, drainage diagram	✓		✓
Bridges/ Viaduct	Formation width	At each bridge	✓		✓
	Construction	Quality records of aggregate used, reinforcement,	✓		

Structure	Inspection Item		Inspection Method		
			Confirmation of "As-Built" Records	Visual Inspection	Measurement Test Check
		concrete quality control data, measurement records of cast-in-situ piles/ open foundation etc.			
	Repairing of structures	Records of repaired parts of structures	✓	✓	
	Rebar cover	Records of measurement of rebar cover	✓		
	Clearance under girder/slab	Above roads/rail	✓		✓
	Abutment/ pier structures/ RCC box etc.	All structural Drawings & Records.	✓	✓	
	Concrete strength	Schmidt hammer tests	✓		✓
	List of bridges	List of bridges	✓	✓	
	Pile load test	Pile load test results	✓		
	Steel Girder	Material test record, fabrication, welding & trial assembly records, dead load camber in OWG	✓		✓
	Bearings	Acceptance test record	✓	✓	

Structure	Inspection Item		Inspection Method: Confirmation of "As-Built" Records	Inspection Method: Visual Inspection	Inspection Method: Measurement Test Check
	Track on OWG	Fabrication record of H-beam sleeper, acceptance test record of rails & track fittings, Track parameters at every sleeper location	✔		✔
	BLT on viaduct	Quality control record of aggregate, reinforcement steel & concrete, Inspection certificate and acceptance test records of rails & fittings/ fastenings, track parameters at every sleeper location, record of welding parameters, ultrasonic testing & finishing tolerance measurements of welds	✔		✔
	Load test	Load test parameters of superstructure (OWG /CG /PSC girders)	✔		✔
		Load test parameters of skew RCC box	✔		
Station	Platform length, width	At every 10m on straight line, at every 5m on curved line, control points of curve	✔		✔
	Clearance of isolated and continuous	All structures	✔		✔

Structure	Inspection Item		Inspection Method: Confirmation of "As-Built" Records	Inspection Method: Visual Inspection	Inspection Method: Measurement Test Check
	structures on platform as per SOD				
	Staircase and pavement	Results of stair width measurement	✔	✔	
	Drainage of platform & yard	Drawings, Section & slope at every 20m	✔		✔
	Safety fence, etc.	List of facilities (clearance from platform end to fixed/movable fence, etc.)	✔	✔	
Protective facilities	Fire protection	Fire extinguisher layout and numbers	✔	✔	
	Abutment/ Pier protection	Drawings	✔	✔	
	Slope protection works	List, location and Drawings of slope protection works	✔	✔	

After Static Inspection of the Works as mentioned above the Contractor shall submit the Inspection Report in the agreed format in four (4) signed copies to the Engineer for review and approval.

8.2 Remedial Action and Re-inspection

Within twenty-eight (28) days of receipt of a written application for a Taking-Over Certificate, the Engineer shall proceed in accordance with Sub-Clause 10.1 of the General Conditions of Contract.

8.3 Taking Over Certificate

If the Engineer does not issue a Taking-Over Certificate, but gives instructions in accordance with sub-paragraph (ii) of Sub-Clause 10.1 of the General Conditions of Contract, the Contractor shall, when he considers the work specified by the Engineer completed, give written notice to the Engineer and the Contractor.

The Contractor shall submit documents required by Commissioner of Railway Safety (CRS) and shall accompany him during his inspection along with necessary records.

9. Sub-Contractor for Fabrication, Assembly & Launching of Open Web Girders (OWG), Composite Girder Bridges/Viaduct

9.1 Upon award of the Contract, the Contractor shall engage Sub-Contractor for fabrication, assembly & launching of Open Web Girders (OWG) and Composite Girder Bridges. The Contractor shall submit details of Sub-Contractor proposed to be engaged for fabrication, assembly & launching of OWG and Composite Girder Bridges. Sub-Contractor shall be engaged within 60 days of issue of LOA.

9.2 Sub-Contractor to be engaged shall have the experience of execution of bridge work consisting of fabrication, assembly and launching of at least one span of Open Web Girders (OWG)/Bowstring Girder of 45.7m or longer spans in Railway/Metro/RRTS or Road Over Bridge (ROB) over Railway/Metro/RRTS in a single contract during last seven years.

9.3 Sub-Contractor to be engaged shall submit experience certificate issued from the Employer (owner of the Work)/Concessionaire.

9.4 The Contractor/ Sub-Contractor must own RDSO approved workshop or must submit an undertaking to the effect that he will enter into a MOU with RDSO approved vendor workshop in Part-A for fabrication of Open Web Girders.

9.5 The Contractor is required to enter into a legally enforceable agreement with the Sub-Contractor within 60 days of approval of Sub-Contractor and submit a copy of the agreement to the Engineer. The agreement must specify the specific role and responsibility of the Sub-Contractor.

10. Sub-Contractor for Construction of Ballast less Track System

10.1 Upon award of the Contract, the Contractor shall engage Sub-Contractor for Construction of ballastless Track System. The Contractor shall submit details of Sub-Contractor proposed to be engaged for Construction of ballast less Track System for the approval of the Engineer.

10.2 Sub-Contractor to be engaged shall have experience of construction of ballastless track system i.e.

Execution of at least one contract which involves execution of minimum 2.0km length of ballastless track that has been successfully or is substantially completed with in the last seven years before the deadline for submission of the bids.

OR

Execution of at least two contracts each of which involves execution of minimum 1.0 km length of ballastless track that has been successfully or is substantially completed within the last seven years before the deadline for submission of the bids.

10.3 Sub-Contractor to be engaged shall submit experience certificate for construction of ballast less track system issued by the user railway administration.

In case the user railway administration is from foreign country and the certificate is issued in language other than English, the supporting documents shall be translated into English language. The translation of Certificates / documents in foreign language shall be done by the licensed translator. The Contractor must submit copy of license issued by the competent authority in their country of origin.

10.4 Proposed Sub-Contractor shall submit details containing, but not limited to the name of line in which the system has been constructed/under construction, details of user railway administration such as name of the Railway administration and its contact person, address, telephone number, E-mail id etc.

10.5 Upon approval of the Sub-Contractor, the Contractor is required to enter into legally enforceable agreement with the Sub-Contractor within 60 days of approval of designer and submit a copy of the agreement to the Engineer. The agreement must specify the specific role and responsibility of the Sub-Contractor.

10.6 Construction of BLT by the Sub-Contractor shall not be started unless agreement with the Sub-Contractor is submitted to the Engineer.

ATTACHMENT - C-1

MINIMUM ORGANISATION STRUCTURE REQUIRED & *PENALTY FOR NON-DEPLOYMENT*

The figures indicated in Table below are the minimum number of Project-Personnel required which are to be deployed as per the minimum level of supervision. The qualification/experience of such Project personnel is given under Attachment-C-2.

S. No.	*Designation of Project Personnel*	*Minimum no. of Project-Personnel required*	*Penalty for Non-deployment per week or part thereof per person*
1.	Contractor's Representative/ Project Manager	As per Section III, EQC	*Rs 1,00,000/-*
2.	Deputy Project Manager (Viaduct)	As per Section III, EQC	*Rs 40,000/- for first 3 months and Rs. 80,000/- thereafter*
3.	Deputy Project Manager (Formation)	1	*Rs 40,000/- for first 3 months and Rs. 80,000/- thereafter*
4.	Deputy Project Manager (Bridges & station)	1	*Rs 40,000/- for first 3 months and Rs. 80,000/- thereafter*
5.	Planning Engineer	2	*Rs 40,000/- for first 3 months and Rs. 80,000/- thereafter*
6.	Senior Quality Assurance /Quality Control Expert	As per Section III, EQC	Rs 40,000/- for first 3 months and Rs. 80,000/- thereafter
7.	Quality Assurance /Quality Control Expert	2	-
8.	Civil Engineer (Formation)	2	-
9.	Civil Engineer (Bridge)	2	-
10.	Civil Engineer (Viaduct)	4	-
11.	Civil Engineer (Station)	1	-
12.	Civil Engineer (Fabrication & launching of steel OWG & CG)	2	-
13.	Procurement Manager	1	-
14.	Health & Safety Expert	2	Rs 40,000/- for first 3 months and Rs. 80,000/- thereafter
15.	Environmental Expert	1	Rs 40,000/- for first 3 months and Rs. 80,000/- thereafter
16.	Surveyor	3	-
17.	Civil Engineer (Concrete Expert)	1	-

NOTES:-

i. The Contractor shall deploy resources as per the above-mentioned table. The Contractor shall also confirm to deploy manpower over and above the minimum numbers indicated above, if the work so requires.

ii. Deleted

iii. The performance of project personnel deployed will be evaluated periodically by the Engineer during the contract period. In case the performance of any of the project personnel is not satisfactory, the Contractor shall replace them with good personnel immediately as per directions of the Engineer.

iv. The personnel at Sr.No.1, must be deployed by Commencement Date. Personnel at Sr. No.2, 3, 4,5,6, 14 & 15 in the above table must be deployed within 30 days of Commencement Date. Non adherence to these provisions shall attract penalty as indicated in the table above.

v. The resources indicated in table above are for peak requirement. All resources need not be mobilized simultaneously for entire duration of the contract. The Contractor shall mobilize the resources as per the deployment programme approved by the Engineer.

vi. In case of non-deployment of project personnel, the penalty shall be imposed as indicated above and deducted from Contractor's running / final bills. The decision of the Engineer in this regard shall be final and binding.

ATTACHMENT C-2

Minimum level of supervision & qualification/ experience of Project Personnel is as follows:

S. No.	*DESIGNATION*	*QUALIFICATION*	*EXPERIENCE LEVEL*
1.	Contractor's Representative/ Project Manager	Graduate in Civil Engineering	Minimum total experience of 10 years out of which, minimum 2 years as In-charge in projects of Railway/ DFC/ Metro/ RRTS/ Highway /Expressways.
2.	Dy. Project Manager (Viaduct)	Graduate/ Diploma in Civil Engineering	Minimum total experience of 06/08 years out of which minimum 03/05 years in relevant filed of projects of Railway/ DFC/ Metro/ RRTS/ Highway /Expressways.
3.	Dy. Project Manager (Formation)	Graduate/Diploma in Civil Engineering	Minimum total experience of 06/08 years out of which minimum 03/05 years in relevant filed of projects of Railway/ DFC/ Metro/ RRTS/ Highway /Expressways
4.	Dy. Project Manager (Bridges & station)	Graduate/Diploma in Civil Engineering	Minimum total experience of 06/08 years out of which minimum 03/05 years in relevant filed of projects of Railway/ DFC/ Metro/ RRTS/ Highway /Expressways
5.	Planning Engineer	Graduate in Civil Engineering	Minimum total experience of 05 years out of which minimum 01 years in relevant field in planning of Infrastructure projects.
6.	Senior Quality Assurance /Quality Control Expert	Graduate / Diploma in Civil Engineering	Minimum total experience of 05/07 years out of which minimum 02/04 years in QA (Field) in Infrastructure Projects.
7.	Quality Assurance (QA) /Quality control Expert	Graduate / Diploma in Civil Engineering	Minimum total Experience of 03/05 years out of which minimum 02/03 years in *QA (Field) in* Infrastructure Project
8.	Civil Engineer (Formation)	Graduate / Diploma in Civil Engineering	Minimum total experience of 03/05 years out of which 2 year experience in relevant field in projects of Railway/ DFC/ Metro/ RRTS/ Highway /Expressways
9.	Civil Engineer (Bridge)	Graduate / Diploma in Civil Engineering	Minimum total experience of 03/05 years out of which 2 year experience in relevant field in *projects of Railway/ DFC/ Metro/*

S. No.	*DESIGNATION*	*QUALIFICATION*	*EXPERIENCE LEVEL*
			RRTS/ Highway /Expressways.
10.	Civil Engineer (Viaduct)	Graduate / Diploma in Civil Engineering	Minimum total experience of 03/05 years out of which 2 year experience in relevant field in *projects of Railway/ DFC/ Metro/ RRTS/ Highway /Expressways.*
11.	Civil Engineer (Station)	Graduate or Diploma in Civil Engineering	Minimum total experience of 03/05 years out of which 2 year experience in relevant field in *projects of Railway/ DFC/ Metro/ RRTS/ Highway /Expressways.*
12.	Civil Engineer (Fabrication & launching of steel OWG)	Graduate or Diploma in Civil Engineering	Minimum total experience of 03/05 years out of which 2 year experience in relevant field in *projects of Railway/ DFC/ Metro/ RRTS/ Highway /Expressways.*
13.	Procurement Manager	Graduate in Engineering / Diploma in procurement	Minimum total Experience of 05/07 *years* out of which 2 year experience in procurement in Infrastructure Project.
14.	Health & Safety Expert	Bachelor degree in any science stream with one-year full time Diploma in Industrial Safety. (Or) Diploma in Engineering with one year full time Diploma in Industrial Safety. (Or) Graduate in Engineering with one year full time Diploma in Industrial Safety	Minimum total experience of 02/03 years for with relevant experience of 01/02 years (degree/diploma) in infrastructure projects.

S. No.	***DESIGNATION***	***QUALIFICATION***	***EXPERIENCE LEVEL***
15.	Environmental Expert	Graduate in Science with one year PG Diploma in Environment Science/Management (Or) Graduate in Environmental Engineering (Or) Bachelor degree in any engineering stream with Master's degree in Environmental Science or one year PG Diploma in Environment Science/Management	Minimum total post qualification experience of 02 years out of which 01 years relevant experience in infrastructure projects
16.	Surveyor	Diploma in Civil Engineering / ITI	Minimum total Experience of 01/02 years in survey work for *linear* Infrastructure project
17.	Civil Engineer (Concrete Expert)	Graduate in Civil Engineering	Minimum total experience of 05 years out of which minimum 03 years in relevant field in Infrastructure projects.

NOTES:

1. The CVs of concerned personnel shall be submitted to the Engineer for approval. No person mentioned in table above shall be deployed in the project without Engineer's approval.
2. Relaxation in qualification / experience can be given by the Engineer in exceptional cases where candidates have got high level of professional competency. Decision of the Engineer in such cases shall be final and binding.

ATTACHMENT C-3

MINIMUM REQUIREMENT OF THE DDC'S ORGANIZATIONAL STRUCTURE

The DDC shall submit an Organisation Chart together with clear description of the responsibilities of each member within the overall works programme.

S. No	Designation	Numbers	Experience
1	Team Leader	01	Graduate degree in Civil Engineering having experience not less than 10 years and would have handled minimum 02 projects as Team Leader of similar nature & complexity.
2	Bridge Design Expert	01	Graduate degree in Civil Engineering with total experience of 10 years and minimum 05 years of relevant experience in the concerned field and would have handled minimum 01 project involving railway bridge involving deep foundation.
3	Embankment Design Expert	01	Graduate degree in Civil Engineering with total experience of 10 years and minimum 5 years of relevant experience in the concerned field and would have handled minimum 01 project involving railway/highway embankment of minimum 6 m height.
4	Rail Structure Interaction (RSI) Design Expert	01	Graduate degree in Civil Engineering with total experience of 10 years and minimum 3 years of relevant experience in the concerned field and would have handled minimum 02 projects involving RSI study of railway bridge having minimum length of 100m.

NOTES:

1. Sufficient documentary proof to substantiate the qualification and work experience shall be submitted. The Contractor shall submit proposal of DDC experts having experience as mentioned above to the Engineer for approval before deployment.
2. The requirement given above is minimum. The Contractor shall be required to supplement the above mentioned design team as per requirement of the Works so as to adhere to the timelines given in Appendix-2- Contract Key Dates and Completion Date, Section VII-9: Appendices, Part 2- Employer's Requirements under the Contract.
3. Design expert at item No. 4 shall not be required for the entire period of the project and may be deployed as per the requirement.

ATTACHMENT C-4

MINIMUM RESOURCES PROPOSED FOR THE PROJECT- PLANTS & EQUIPMENTS

The figures indicated below are the minimum number of equipment required.

S. No.	Types of Equipment Required for the Work	Minimum No. of Unit of Equipment Required for the Work
1.	Vibratory Roller (10 T)	4
2.	Pugmil/Crusher(200MT/hr)	1
3.	Concrete Batching Plant	2 (Combined. capacity of 2 batching plant minimum 90 cum/hr.)
4.	Concrete Boom Placer	*2*
5.	Stationary Concrete Pumps (36 cum/hr)	2
6.	Survey Instruments (Total Station)	2
7.	Lab Testing equipment- fully equipped for site tests.	As per Appendix 12 of Section VII-9: Appendices, Part 2- Employer's Requirements
8.	Digital Level (Leica, Sokia)	3

Notes:

1. These resources are for peak period of each activity. All plants and equipment need not be mobilized simultaneously. Plants and equipment as required as per the progress of the work shall be brought at site in advance as directed by the Engineer.
2. The Contractor must have a tie up for fabrication of steel bridge girders included in this contract with RDSO approved plant/workshop in Part-A.

Part 2-Employer's Requirements

Section VII-5: Employer's Requirements -Outline Design Specifications (ODS) – Civil & BLT

Section VII-5: Employer's Requirements -Outline Design Specifications (ODS) – Civil & BLT

TABLE OF CONTENTS

1 INTRODUCTION

This part lays down the specifications/criteria for design of civil structures i.e., Viaduct, bridges, stations, embankments, retaining walls, Ballastless Track, RE wall and other structures.

The broad parameters covered in these specifications are listed below:

1. Design Requirements
2. Material Parameters (Concrete, Reinforcement steel & Structural Steel etc.)
3. Design Parameters
4. Loading Consideration (Dead Load, Super imposed Dead Load, Footpath Live Load, Railway Vehicular Load, Temperature Loads, etc.)
5. Load Combinations
6. Allowable stresses
7. Design Methodology
8. List of Design Codes and Standards

2 OUTLINE DESIGN SPECIFICATIONS-GENERAL

The bridges, stations and other structures to be designed in C-5 Package are mentioned in the Scope of Works. The design works include the preparation and approval of GADs/architectural drawings, Definitive Design and Construction Design for structures as per the Employer's Requirement- Design.

Initially GADs of bridges shall be prepared by the Contractor after carrying out detailed topographical survey based on conceptual GADs. ROW shall be taken as per conceptual Plan and L-section provided in Tender drawings. These GADs will be sent to the Site for checking feasibility of construction by Engineer's Representative and Contractor's Representative. The initial GADs shall be modified incorporating remarks of construction feasibility and submitted to the Engineer along with the preliminary design calculations. After approval of the Engineer, GADs shall be submitted to the stakeholders for approval, if any. Getting approval of GAD from the concerned stakeholders is the responsibility of the Contractor. The Contractor shall address all the queries of the stakeholders. However, the Engineer/ Employer will assist the Contractor in obtaining approval from the concerned stakeholders. The Contractor shall attend any meeting/presentation/joint site visit with stakeholders, as per the requirement, for the approval of GADs. After approval of the stakeholders, the GAD shall be finally approved by the Employer.

2.1 Employer's Inputs

The Employer shall furnish following documents to the Contractor: -

a) Conceptual Plan and L-section of the main & connectivity line

b) Conceptual ESP of station yards

c) Conceptual GAD of bridges

d) Conceptual GAD of viaduct

e) Conceptual layout plan for stations

f) Geo-technical investigation reports

2.2 Codes & Standards

For loadings, load combinations, analysis, and design of structures, all relevant IRS, IS, IRC and other relevant codes shall be followed.

The list of relevant codes and standards, listed in these specifications, is only tentative. The Contractor shall follow provisions of appropriate codes and standards in force for items which are not covered in these specifications.

All codes & standards shall be of latest revision including all amendments & corrections.

2.3 Design Life

The design life of a structure is that period for which it shall be designed to fulfill its intended function.

The Contractor is required to submit a report demonstrating the approach in design, construction and selection of material so as to achieve the design life as specified.

The design life of each structure, facilities and systems shall be as follows:

a) Structures of the Civil works for Railway/Road Loading

The design life of viaduct, bridges and retaining walls (if any) shall be 100 years.

b) Structures of the Building works

The design life of all building and other structures shall be 50 years.

c) Mechanical, Electrical and Plumbing (MEP)

The design life of MEP services including water supply, drainage services and fire protection services etc. shall be 30 years.

d) Ventilation and Air-conditioning (VAC)

The design life of all VAC facilities, systems and services shall be 10 years. The design life of window AC shall be 5 years.

2.4 Maximum Moving Dimensions (MMD) and Clearances

The bridges and other structures shall be designed to cater for double stack container with high rise OHE. The Maximum Moving Dimensions, Structure Gauge and Clearances shall be as per IR Schedule of Dimensions for Broad Gauge.

2.5 Geo-technical investigation

Geo-technical investigation reports included in the Tender Document are indicative in nature and the Contractor shall carry out independent detailed GT investigations as per codal provisions. However, if there is a wide variation (>20%) in the bearing capacity of the soil / pile capacity compared to GT report of nearest bore hole given in the Tender document, the same shall be brought to the knowledge of the Engineer and a confirmatory (repeat) bore bole shall be done to ascertain bearing capacity/pile capacity. The result that is minimum of the two Boreholes carried out by the Contractor shall be adopted for design.

In case, bearing capacity assessed after drilling of Boreholes by the Contractor is less than the value shown in the Tender, the value obtained by the Contractor shall be adopted for design.

a) Liquefaction

Liquefaction shall be considered as per IS 1893-Part-1. The design ground water table shall be used for liquefaction potential calculation. The moment magnitude Mw to be taken in design shall be 7.0. The factor of safety shall be more than 1.0 to ascertain that the strata is not liquefiable.

b) Design Ground Water Table

The ground water table (Base value) shall be considered as maximum (in terms of RL) of ground water table data published/recorded by/in

(a) Central Ground Water Board (CGWB),

(b) Ground water table reported in Geotechnical report provided in Tender Documents,

(c) Ground water table encountered by the Contractor during GT investigation.

The design ground water table shall be taken as minimum 3.0m higher than the Base value for evaluation of effects for liquefaction design purposes.

2.6 Differential Settlement

Differential Settlement between two adjacent bridge piers shall be as follows:

a) 12mm for Long Term Settlement;

b) 6mm for Short Term Settlement

Differential settlement shall be considered only in the design of continuous structures, if any.

2.7 General Design Requirements

a) The Project entails construction of BG double-track electrified railway lines capable of handling "25t loading -2008" double stack container for maximum train speed of upto 160 km/h. The project is a feeder route to DFC also. The embankment and cutting shall be designed for "DFC loading (32.5t axle load)". Bridge and viaduct substructures shall be designed for "DFC loading (32.5t axle load)"and superstructure shall be designed for "25t loading – 2008" unless specified otherwise in the Contract.

b) All levels shall be quoted in metres correct to three decimal places and shall be with reference to Mean Sea Level (MSL) Datum India. The rail level on a track shall refer to the top of the inner rail of the UP Line i.e. line going from Prithla to Sonipat.

c) The Contractor shall comply with the provisions of IR Schedule of Dimensions with regard to the clearance over the existing IR network.

d) Horizontal and vertical alignment has been given in the Conceptual Plan and L-Section drawings. Proposed Right of Way (ROW) has been also marked on these drawings. The Contractor should check the feasibility at site and may propose any minor modifications, if required.

e) All structures shall be designed and detailed to withstand earthquake forces for Seismic Zone IV.

f) Exposure conditions shall be considered as 'moderate' for all type of structures/bridges. However, in case of Nallah crossing (upto 50m on either side of the edge of Nallah), the exposure condition may be treated as "Severe".

g) Minimum Grade of reinforcement steel shall be Fe 500D conforming to IS 1786.

h) Backfill on approaches of Minor Bridge shall be placed in accordance with IRS Substructure Code. Approaches of Viaduct and Major Bridges (i.e. bridges having span equal to or more than 12 m) shall be provided transition system as per RDSO report GE:R-50 as shown in Sketch No. GC-HRIDC-SK-GEN-019.

i) The data like bridge length, size, barrel length, type of crossing, total waterway and indicative span configuration etc. in respect of the proposed road/ waterway bridges has been shown in the conceptual GAD of the bridges. The bridge opening (Horizontal and Vertical) shall not be less than that indicated in the Conceptual GADs.

j) RCC drains shall be designed where existing DFC/KMP and new HORC embankment overlaps, for drainage of storm water from both the embankments.

k) In case of viaduct and bridges on pile foundation, bored cast in-situ concrete piles of minimum diameter 1.2m shall be designed unless otherwise mentioned in the drawing. Number and depth of piles shall be as per sub-soil conditions and design requirements.

l) Inspection platform all-round the abutment caps/pier caps shall be designed along with access ladder.

m) Trolley refuge on bridges shall be designed as per provisions of IRSOD/IRPWM.

n) Side pathway shall be provided on all the girder bridges on outer side of the tracks. Suitable arrangement shall be designed to maintain continuity of pathway throughout the length of bridge and to reach the formation at approach.

o) In case, the bridge is at a location where the Right of Way is restricted, special type of abutment / pier / return wall / wing wall shall be proposed subject to approval of the Engineer.

p) Bridges shall have standard RDSO span lengths. PSC superstructure can be adopted upto 18.3 m clear span only.

q) The embankment on approaches of bridges shall be protected by pitching with CC blocks of suitable sizes, over 15cm thick consolidated gravel bed, encased in cast-in-situ RCC grid frames of suitable cross section having opening size of 1.75m x 1.75m.The pitching shall be provided for a length of 30m on both approaches in case of major bridges & 15m on both approaches in case of minor bridges. For viaduct pitching shall be provided for a length of 30 m on the approach of A1 abutment. Toe wall shall be designed at the end of the embankment slope as shown in Tender drawings.

r) Inspection steps (1m wide) on either side of formation shall be designed with CC of M20 grade as shown in Tender drawings.

s) Adequate provision shall be kept for inspection and replacement of bearings without major disruption to railway operations or any activity underneath the bridge.

t) The approach roads to the RUBs shall be provided from RCC box to ROW of HORC for the width equal to clear opening of RCC box in concrete of M35 grade .

u) Crash Barriers / medians / footpaths / railings shall be provided as per the requirements of IRC Codes.

v) Height gauge shall be provided at Road Under Bridges (RUB) on all approach roads as per approved Design.

w) Provision for signages shall be kept on both side of RUBs.

x) Drainage system shall be designed for RUBs where the road level in RUB is below the natural ground level in accordance with Section VII-6, Outline Construction Specifications, Part-2 Employer's Requirements. Protection works / ancillary works shall be designed for all RUBs as shown in the Tender drawings.

y) Necessary provisions for OHE mast shall be kept on bridges.

z) Compensated Ruling Gradient for the Section is 1 in 150. Station yard gradients shall be as shown in the Conceptual ESPs.

3 OUTLINE DESIGN SPECIFICATIONS - EARTHWORK IN FORMATION

3.1 General

This part lays down criteria for design of formation in embankment/cutting.

3.2 Details of Structures to be designed

The Contractor shall design formation in embankment/cutting for various heights as per approved L-section. Design of embankment/cutting shall include, but not limited to, the following: -

a) Design of formation for "DFC loading (32.5t axle load)"

b) Slope stability analysis and design of protection measures for erosion control

c) Design of drainage system- longitudinal and cross drains including catch water drains in cuttings.

d) Design of Trolley refuge

e) Design of opening for future utility crossings with MS pipe of 323.9 mm outer diameter.

f) Any other item which is required for complete design of formation in embankment/cutting.

3.3 Design Criteria

3.3.1 For design of formation, the "Comprehensive Guidelines and Specifications for Railway Formation: RDSO/2020/GE: IRS 0004", issued by RDSO (hereinafter written as RDSO Guidelines) shall be followed. The geometric parameters of embankment/cutting shall also conform to Indian Railway Schedule of Dimensions (IRSOD) and Indian Railway Permanent Way Manual (IRPWM). Blanket material shall conform to RDSO Guidelines. Additional cess width of one (01) m on both left and right side of formation shall be provided in station area (i.e. from platform end to 200 m beyond SRJ of last turnout on both sides of station) to lay cable ducts etc.

3.3.2 The design criteria for design of embankment/cutting slopes shall be as under

a) A minimum side slope of 2H:1V for embankment shall be adopted up to 4m height. For higher embankments (more than 4m height.), the slopes shall be designed. However, side slope shall not be steeper than 2H:1V.

b) Both 'End-of-Construction' (EOC) and 'Long-Term' (LT) stability with most adverse drainage conditions shall be considered in design of slopes.

c) Design shall be carried out using effective stress analysis method both for EOC and LT stability conditions, adopting realistic values of shear strength and pore water pressure parameters.

d) Width of berm shall be adequate to suit the mechanical compaction of earth with heavy rollers. However, berm width shall be kept minimum 2m on banks and 4m in cuttings.

e) Erosion Control

i. The slopes of embankments and cutting shall be protected against erosion by providing a protective vegetative cover comprising perennial turf forming grass.

ii. The species of grass shall be compatible with the local soil and climatic conditions.

iii. The materials and techniques proposed by the Contractor shall be suitable for the slope height and angle, soil type and climatic conditions and shall perform its function with minimum maintenance requirements.

iv. Coir netting shall be used for turfing of slopes of embankment/cuttings higher/deeper than 4.0m in addition to the vegetation cover to be provided as per (i) above.

v. The coir netting shall not be lighter than 600 g/sqm. It shall conform to IS: 15869 'Open weave Coir Bhoovastra-Specification' and laid as per IS: 15872 'Application of Coir Geotextiles (coir woven Bhoovastra) for Rainwater Erosion Control in Roads, Railway Embankments and Hill Slopes-Guidelines' and IRC: 56.

vi. The Contractor shall water and maintain the vegetation cover provided on slopes for a period of 12 months from date of Taking Over.

f) Ground Improvement

Suitability of subsoil below formation shall be ensured before starting of earthwork in formation as per RDSO guidelines. Ground improvement shall be adopted in case soft soil is encountered after investigations.

As per initial GT investigations following locations may encounter soft soil:

S. No.	**Starting Chainages (km)**	**End Chainage (km)**	**Formation Length (km)**
1	(-)0.125	0.050	0.275
2	3.685	4.385	0.700
3	7.745	8.045	0.300
4	10.200	10.600	0.600
5	10.800	11.375	0.575
6	11.480	11.545	0.075
7	18.210	19.210	1.000
8	20.220	20.420	0.100
Approximate length = 3.625km			

Note: These locations are tentative. Exact locations of weak sub soil shall be identified by the Contractor after detailed GT investigations.

3.3.3 Drainage Arrangement

i. Top of the formation shall be finished to cross slope of 1 in 30 from centre of formation to both sides in case of single/ double line. However, in case of multiple lines, the cross slope shall be towards cess/drain.

ii. In the double track section, the longitudinal drain between two tracks shall not be provided outside station yards.

iii. In station yard a system of covered/underground RCC longitudinal and cross drains of adequate section shall be designed to ensure efficient drainage as shown in Tender drawings. The Contractor shall submit a drainage plan for approval of the Engineer. Such plans shall be sufficiently detailed. The longitudinal drains shall be extended as necessary to lead the water clear of the Works to natural drainage courses, culverts or any other suitable outlets.

iv. In cuttings, a system of catch water drains of adequate capacity on both sides shall be designed to intercept the surface runoff of adjoining areas from entering into the cutting and to lead the surface runoff safely away from cutting. In addition, longitudinal side drains of adequate capacity on both sides of formation shall be designed to cater to the surface runoff from slopes and formation. Typical Section of cuttings has been shown in Tender drawings.

v. In high/deep embankments/cuttings (height/depth > 6m), a system of precast RCC longitudinal drain of adequate capacity shall be designed along the toe of berm and RCC chute (at about 50 m interval) to collect and lead the surface runoff safely away from the toe of embankment or to side drains in cutting. A concrete chamber shall be provided at the junction of longitudinal berm drain and chute. In embankments, chute shall be extended by about 1.0m beyond the toe of embankment to avoid erosion near the toe. At locations where retaining wall is provided, suitable outfall arrangement shall be provided to avoid erosion of retaining wall foundation.

vi. All cast-in-situ drains shall be designed with RCC of M25 grade.

vii. All the drains shall slope towards the nearest culvert or natural low ground or natural outlets existing nearby where the water shall be discharged with appropriately designed outfall arrangement duly consented by the Engineer.

3.3.4 Trolley Refuge

Trolly refuge shall be designed as shown in Tender drawing. It shall be provided at 400m center to center on each Up and Dn tracks in a staggered manner in case of double line section except platform area. In case of single line connectivity, Trolley Refuge shall be provided at an interval of 200m centre to centre.

3.3.5 MS Pipe

The pipe shall be of 323.9mm outer diameter, fabricated as per IS: 3589 from mild steel plates 5.6 mm thick conforming to IS: 2062 and shall be provided with cement mortar protective lining & coating on inside & outside as per Annexure A of IS: 3589. The length of pipes shall not be less than 6 -8 m.

Pipeline shall be laid as per RDSO guidelines on pipeline crossings under railway track (Report No. BS-105).

3.4 Submittals

Prior to the start of construction operations, the Contractor shall submit to the Engineer all relevant documents, drawings, calculations and data including, but not limited to the following, and shall obtain the approval of the Engineer for the proposed materials, design, construction methods and quality control procedures:

a) Geotechnical investigation reports and evaluation of sub-surface conditions along the alignment.

b) Report detailing the identification of borrow areas for formation, blanket material, prepared subgrade. Geotechnical investigation reports for borrow areas duly indicating the soil properties of the proposed borrow areas.

c) Material test reports for embankment fill, prepared sub-grade and blanket.

d) Cross-section of embankment/cutting along the alignment, at every 20 m interval.

e) Slope stability calculations. Analysis of the stability and settlement of formation and design of remedial measures, if required. Details of earthwork design solutions and criteria used.

f) Details of construction equipment.

4 OUTLINE DESIGN SPECIFICATIONS – VIADUCT & BRIDGES

4.1 General

This part lays down specifications for the design of bridges. The Bridges in HORC Project comprise of simply supported Prestressed Girders (U)/ Steel Composite Girders / Open Web Girders (OWG)/RCC Box Bridges/Culverts with RCC sub-structure and open/deep foundation.

Minimum Centre to Centre distance between two tracks shall be kept as 5.3m according to IR-SOD(BG).

All the bridges shall be provided with bridge number plaque, painting of HFL and bridge boards, where required.

Embankment on minor bridge approaches shall be provided protection measures for a length of 15m as shown in Tender drawings.

Embankment on major bridge approaches and viaduct approach shall be provided protection measures for a length of 30m as shown in Tender drawings.

4.2 Details of Structures to be designed

The structures to be designed and constructed under C-5 Package have been grouped in following six categories:

a) Viaduct

b) Bridges with superstructure of Composite Plate Girders (CG)

c) Bridges with superstructure of Open Web Girder (OWG) with concrete deck for providing Ballastless/ ballasted track

d) Bridges with superstructure of PSC U- slab

e) RCC Box bridges

f) RCC Pipe Bridges

4.2.1 Viaduct

Viaduct for double track shall consist of steel composite superstructure Long Welded Rail (LWR) on Ballastless track (BLT).

HORC viaduct is crossing under DFC Br.No.87. The Contractor shall comply with the requirements of DFC as mentioned in in-principle approval letter No. DFCC/Noida Unit/DMIC/HRIDC/8228 dated 03/06/2023 from DFC attached in Tender documents.

Viaduct elements to be designed by the Contractor includes, but not limited to, the following: -

i. Superstructure for ballastless track and side pathway at deck level

ii. Abutments & abutment cap including foundations & wing/return walls

iii. Piers & pier caps including foundations

iv. Spherical bearings, bearing pedestals, inspection platforms including arrangements for access from track.

v. Provision of jacking arrangements on abutment caps & pier caps for lifting of superstructure

vi. Seismic arrestors in pier/abutment cap

vii. Trolley refuge

viii. Supports for placing OHE mast for traction system of 2x25kV

ix. Protection work at abutment A1

x. Inspection steps on approaches

xi. Drainage arrangements

xii. Arrangement for supporting signaling & telecom cables and other utilities.

xiii. Emergency staircase from pathway to ground

xiv. Ground improvement technique/procedures, if required according to the GT data and design requirements along with the method of verification of the bearing capacity after implementation of ground improvement technique.

xv. RSI Analysis for permitting LWR

xvi. Ballastless track system including transition with ballasted track on A1 side approach

xvii. Steel fencing between two tracks to prevent trespassing.

xviii. Construction methodology and launching scheme (including casting of deck slab)

xix. Any other item which is required for complete design and construction of the viaduct.

4.2.2 Bridges with superstructure of Composite Plate Girders (CG)

This group includes 06 Nos. of bridges (Br No. 04, 28, 30, 34, 68 & 69) having superstructure of steel CG. For Br No.28 and Br. No. 68, only composite girders are covered in this group. OWG portion of Br.No.28 and Br. No.68 is covered in Sub-Clause 4.2.3.

Bridge elements to be designed by the Contractor includes, but not limited to, the following: -

i. Composite girder superstructure for bridge No. 28 & 68 for ballastless track

ii. Abutments & abutment caps including foundations & wing/return walls

iii. Piers & pier caps including foundations

iv. Load on bearings, design and drawings of bearings including bearing pedestals, inspection platforms including arrangements for access from track.

v. Provision of jacking arrangements on abutment caps & pier caps for lifting of superstructure

vi. Seismic arrestors in pier/abutment cap

vii. Trolley refuge and man refuse on bridges as per latest IR standards

viii. Provision of supports for placing OHE mast for traction system of 2x25kV

ix. Protection works of abutments

x. Inspection steps on approaches of bridges

xi. Side pathway on bridges for maintenance (Arrangement for pathway shall be provided as per RDSO drawings No. CBS-0046).

xii. Drainage arrangements

xiii. Arrangement for supporting signaling & telecom cables and other utilities.

xiv. Ground improvement technique/procedures, if required according to the GT data and design requirements along with the method of verification of the bearing capacity after implementation of ground improvement technique.

xv. RSI Analysis for permitting LWR

xvi. Ballastless track system including transition with ballasted track on approaches

xvii. Construction methodology and launching scheme (including casting of deck slab)

xviii. Any other item which is required for complete design and construction of the bridges.

4.2.3 Bridges with superstructure of Open Web Girder (OWG) with concrete deck for providing Ballastless/ ballasted track

This group includes 04 Nos. of bridges (Br. Nos. 17,28,45 & 68) having steel OWG superstructure with concrete deck for providing BLT/ Ballasted track.

Bridge elements to be designed by the Contractor includes, but not limited to, the following: -

i. Superstructure (OWG with deck for BLT/Ballastless Track).

ii. Abutments & abutment caps including foundations & wing/return walls

iii. Piers & pier caps including foundations

iv. Spherical bearings, bearing pedestals, inspection platforms including arrangements for access from track.

v. Jacking arrangements on abutment caps & pier caps for lifting of superstructure

vi. Seismic arrestors in pier/abutment cap

vii. Trolley refuge and man refuge on bridges as per latest IR standards.

viii. Support for placing High Rise OHE mast for traction system of 2x25kV, wherever required

ix. Protection works of abutments

x. Inspection steps on approaches of bridges

xi. Side pathway on bridges for maintenance

xii. Drainage arrangements

xiii. Arrangement for supporting signalling & telecom cables and other utilities

xiv. Ground improvement technique/procedures, if required according to the GT data and design requirements along with the method of verification of the bearing capacity after implementation of ground improvement technique.

xv. RSI Analysis for permitting LWR

xvi. Ballastless track system including transition with ballasted track on approaches

xvii. Construction methodology and launching scheme (including casting of deck slab)

xviii. Any other item which is required for complete design and construction of substructure.

Note: In case BLT /ballasted track on OWG is not considered feasible due to site conditions or any other reason, standard RDSO drawings of OWG for "DFC loading (32.5t axle load)" shall be followed for the superstructure. Item No.(i) & (xvi) mentioned above will not be required to be designed and in that case the payment against Milestone CD 1.4.2 under Cost Centre CD1-Design of Price Schedule shall not be made.

4.2.4 Bridges with superstructure of PSC U- slab

This group includes 03 Nos. of bridges (Br No. 12, 63 & 69) having superstructure of **PSC U- slab (**post tensioned). Bridge elements to be designed by the Contractor includes, but not limited to, the following:-

i. Abutments & abutment caps including foundations & wing/return walls

ii. Piers & pier caps including foundations

iii. Seismic arrestors in pier/abutment cap

iv. Protection works of abutments

v. Inspection steps on approaches of bridges

vi. Drainage arrangements

vii. Arrangement for supporting signaling & telecom cables and other utilities

viii. Ground improvement technique/procedures, if required according to the GT data and design requirements along with the method of verification of the bearing capacity after implementation of ground improvement technique.

ix. Construction methodology

x. Any other item which is required for complete design and construction of the bridges.

4.2.5 RCC Box Bridges

This group includes the bridges with RCC Box fit for "DFC loading (32.5t axle load)".

Bridge elements to be designed by the Contractor includes, but not limited to, the following: -

i. RCC Box

ii. Wing wall, return wall, drop wall, curtain wall, protection works

iii. Inspection steps at approaches of bridges

iv. Ground improvement technique/procedures, if required according to the GT data and design requirements along with the method of verification of the bearing capacity after implementation of ground improvement technique

v. Construction methodology

vi. In case of RUB, drainage arrangement, height gauge and approach road

vii. Any other item which is required for complete design of RCC box bridge

4.2.6 RCC Pipe Bridges

This group includes one bridge (Br. No.1) with RCC pipe fit for "DFC loading (32.5t axle load)".

Bridge elements to be designed by the Contractor includes, but not limited to, the following: -

i. Standard Reinforced NP-4 class concrete pipes shall be provided as per IS:458

ii. Concrete face wall

iii. Rigid collar Joints between the prefabricated pipe lengths

iv. Protection Works.

4.3 Design Requirements

a) Viaduct

i. The superstructure shall consist of composite girder of standard RDSO span length of 24.4m or more and one non-standard span near abutment A2. Superstructure shall be designed for "25t Loading-2008" considering ballastless track with LWR/CWR. However, sections of various components of superstructure adopted shall not be less than the sections adopted in the corresponding RDSO standard drawing. Load on side pathway shall be considered as per IRS Bridge Rules.

ii. The substructure and foundation of bridges shall be designed for DFC loading (32.5T loading) as per IRS Bridge Rules and other relevant codes. For the purpose of design of substructure and foundation, dead load of superstructure shall be taken 120% of dead load of superstructure designed for 25T loading. The substructure and foundation of bridge shall also be designed for 25T loading with double stack container.

iii. Substructure shall consist of wall type or separate pier under each track as shown in Tender drawings.

iv. The foundation of proposed elevated viaduct shall be designed with deep foundation at locations shown in Tender drawings.

v. A pathway of 1.0 m width with railing shall be provided at deck slab of level girders, on outer sides of the tracks, as shown in the Tender drawings. Space below the openable pathway slab shall be used as duct for cables. Arrangements shall be designed on the viaduct for providing electrical/ telecommunication cables and other utilities as required.

vi. Provision of OHE masts / portal for both the tracks shall be kept on all the pier/abutment caps.

vii. Provision of Signal Post and junction box for both tracks shall be provided on superstructure as shown in Tender drawings.

viii. Steel fencing between two track to prevent trespassing shall be designed.

ix. Viaduct shall be designed to accommodate curvature of the track alignment.

x. Viaduct shall be designed for permitting LWR / CWR.

xi. Hand railing of pathway, trolley/man refuge and inspection platforms shall be metallized with same specifications as that of steel girders. The design shall be such that it can be easily maintained and replaced, if required.

xii. Arrangements for enabling inspection of superstructure and bearings shall be provided as per RDSO report BS-113.

xiii. Spherical bearings shall be designed for all spans. Bearing type for each girder shall be fixed, longitudinal guided, transverse guided and free. All bearings shall be easily replaceable without major disruption to railway operations or to any activity underneath the viaduct. Bearings shall be placed on bearing pedestals designed in accordance with applicable codes. Appropriate jacking points, on the pier/abutment cap in consideration with the requirements of the superstructure for lifting, shall also be provided. The bearings shall be sandwiched between two true horizontal surfaces. Steel Wedge shall be provided to cater to longitudinal slope of superstructure, wherever required. Minimum thickness of steel wedge shall be 12mm and shall be more on the other side as per the requirement of the gradient. Higher size single plate shall be used for fabrication of wedge plate.

xiv. Expansion/Movement Joints and other necessary measures to control shrinkage and thermal effects shall be incorporated in the structural design so that the performance of the viaduct structures are not adversely affected during normal working conditions. Movement joints shall be designed to be easily maintained and replaceable.

xv. Minimum depth of foundation of bridges shall be scour depth plus 1.75m below the bed level.

xvi. The water from deck shall be taken down from pier with adequately designed drainage system using GI pipes and bends.

b) Bridges with Superstructure of Composite Plate Girder (CG)

i. This group includes 06 Nos. of bridges (Br No. 04, 28, 30, 34, 68 & 69) having superstructure of steel CG. Standard RDSO drawings for “25t Loading-2008” will be used for superstructure of CG (except for Br. No.28 & 68 where BLT is proposed).

Superstructure of these bridges shall conform to standard RDSO drawings for “25t Loading-2008” or shall be desiged as given below:

S. No.	Bridge No.	Span	Reference RDSO Drawings/Remarks
1.	04	24.4 m	B-11751 series
2.	28	18.3m	To be designed with BLT
3.	30	30.5 m	B-11754 series
4.	34	24.4 m	B-11751 series

5.	68	18.3m	To be designed with BLT
6.	69	18.3m	B-11753 series

However, where standard RDSO drawings are used, the Contractor shall verify the adequacy of RDSO standard drawings of CG for double stack containers.

Minimum Grade of deck slab in composite girders shall be maximum of M-35 or that mentioned in RDSO drawings.

ii. The substructure and foundation of bridges shall be designed for DFC loading (32.5T loading) as per IRS Bridge Rules and other relevant codes. For the purpose of design of substructure and foundation, dead load of superstructure shall be taken maximum of dead load of corresponding standard RDSO superstructure for DFC loading (32.5 T loading) or 120% of dead load of superstructure designed for 25T loading. The substructure and foundation of bridge shall also be designed for 25T loading with double stack container.

iii. Bridges shall be designed to accommodate curvature of the track alignment, wherever required.

iv. Bridges shall be designed for permitting LWR / CWR.

v. Metallized side pathway with hand railing shall be provided on bridges on outer side of Up & Down track as per RDSO drawing No. CBS-0046. Adequate arrangement shall be made on the bridges for providing electrical/ telecommunication cables and other utilities as required.

vi. Hand railing of pathway, trolley/man refuge and inspection platforms shall be metallized with same specifications as that of steel girders. The design shall be such that it can be easily maintained and replaced, if required.

vii. Arrangements for enabling inspection of superstructure and bearings shall be provided as per RDSO report BS-113.

viii. Spherical bearings shall be designed for all composite girders. Bearing type for each girder shall be fixed, longitudinal guided, transverse guided and free. All bearings shall be easily replaceable without major disruption to railway operations or to any activity underneath the viaduct. Bearings shall be placed on bearing pedestals designed in accordance with applicable codes. Appropriate jacking points, on the pier/abutment cap in consideration with the requirements of the superstructure for lifting, shall also be provided. The bearings shall be sandwiched between two true horizontal surfaces. Steel Wedge shall be provided to cater to longitudinal slope of superstructure, wherever required. Minimum thickness of steel wedge shall be 12mm and shall be more on the other side as per the requirement of the gradient. Higher size single plate shall be used for fabrication of wedge plate.

ix. Expansion/Movement Joints and other necessary measures to control shrinkage and thermal effects shall be incorporated in the structural design so that the performance of the bridge/structures are not adversely affected during normal working conditions. Movement joints shall be designed to be easily maintained and replaceable.

x. Height Gauges shall be provided on approach roads on both sides of RUBs. Height gauge for road-under-bridges shall be as per RDSO drawing no. RDSO/M- 0001. If RDSO drawing is not applicable, the Contractor shall design height gauge for the required span considering road width & applicable loading. However, the section of height gauge shall not be less than RDSO drawing No. RDSO/M-0001. Height gauge shall be provided with reflecting strip & height warning signs as per standard practices.

xi. Minimum depth of foundation of bridges shall be scour depth plus 1.75m below the bed level.

xii. The water from deck shall be taken down from pier with adequately designed drainage system using GI pipes and bends.

xiii. Provision of OHE most/portal for both tracks shall be provided on pier cap, as required.

c) Bridges with superstructure of Open Web Girder (OWG) with concrete deck for providing Ballastless/ ballasted track

i. OWG for span 30.5, 45.7m and 76.2m span shall be designed for "25t Loading-2008" with BLT/ ballasted track with LWR/CWR suitable for double stack container. The configuration of OWG to be designed shall be kept similar to that of RDSO standard OWG for 32.5t axle load for double stack container. RCC deck shall be provided over stringers with shear connector arrangement. Specification of all materials like steel, welds etc. shall be as per below mentioned RDSO drawings. All field connections in OWG shall be with HSFG bolts. Grade of bolts to be used shall be of property class 8.8. The weight of the steel structure shall not be less than that of corresponding standard RDSO OWG for "25t Loading-2008".

ii. STAAD/Midas or any equivalent software shall be used for analysis and design of OWG. All the joints shall be designed by FEM software like IDEA StatiCa or equivalent. The software proposed to be used shall be got approved from the Engineer. Manual design shall also be performed for the truss member design and connection design along with the checks done by software. Excel sheet for manual calculations shall be submitted along with the software files. All the steel drawings shall be prepared using Tekla software.

iii. Metallized side pathway and man refuge for maintenance shall be provided similar to arrangement shown in RDSO drawing No. CBS-0045 and CBS-0028, respectively, on one side of each OWG (i.e. outer side).

iv. The design of OWG with ballasted deck/ballastless track shall also be got checked from a third party consultant of repute or RDSO. The third party consultant proposed to be deployed shall be got approved from the Engineer. Design and drawings duly proof checked by third party consultant shall be submitted to the Engineer for approval. The cost of third party consultancy shall be borne by the Contractor.

v. Third party consultant engaged shall be the reputed consultant with minimum 5years of experience in steel bridge design and should have successfully completed design and drawing of at least one OWG for railway loading of minimum 45.7m span. The checking by third party consultant shall be done with a software other than that used in the original design by DDC. Design and drawings of launching scheme and temporary structures shall also be got checked by the third party. Getting approval of launching scheme from the concerned stakeholders shall be the responsibility of the Contractor.

vi. The Contractor shall submit the detailed design by the DDC and third party consultant for approval by the Engineer. The Contractor shall also make available to the Engineer, all the software used by the DDC of the Contractor and third party consultant for proof checking and approval.

vii. In case BLT/ballasted track on OWG is not considered feasible due to site conditions or any other reason, following standard RDSO drawings shall be followed for the superstructure:

S. No.	Span	Reference RDSO Drawings/Remarks
1	30.5m	B-17061 to B-17078 or any other design drawing provided by the Employer.
2	45.7 m	B-17081 to B-17098 or any other design drawing provided by the Employer.
3	61.0 m	B-17121 to B-17138 or any other design drawing provided by the Employer.
4	76.2 m	B-17101 to B-17118 or any other design drawing provided by the Employer.

Notes for above Table:

a. RDSO drawings shall be with latest revision.
b. All connections in OWG shall be with HSFG bolts even if it is riveted shown in the above drawings. HSFG bolts shall be of property class 8.8.
c. Spherical bearings shall be used instead of roller rocker bearings shown in the RDSO drawings. The Contractor shall design and carry out modifications to RDSO drawing of L0/L0' joints of OWG for accommodating spherical bearings and shall get it approved from Chief Bridge Engineer (CBE), Northern Railway/ Nominated Authority of the Employer.
d. Side pathway and man refuge for maintenance shall be provided as per RDSO drawing No. CBS-0045 and CBS-0028, respectively, on one side of the truss.

e. Arrangement for prevention of train droppings on road/rail users underneath the track shall be provided.

viii. These bridges shall be desiged to permit LWR / CWR.

ix. The substructure and foundation of bridges shall be designed for DFC loading (32.5T loading) as per IRS Bridge Rules and other relevant codes. For the purpose of design of substructure and foundation, dead load of superstructure shall be taken maximum of dead load of corresponding standard RDSO superstructure for DFC loading (32.5 T loading) or 120% of dead load of superstructure designed for 25T loading. The substructure and foundation of bridge shall also be designed for 25T loading with double stack container.

x. Bridges shall be designed to accommodate curvature of the track alignment, wherever required.

xi. Provision of OHE masts/portal for both the tracks shall be provided on all pier / abutment caps.

xii. Hand railing of pathway, trolley/man refuge and inspection platforms shall be metallized with same specifications as that of steel girders. The design shall be such that it can be easily maintained and replaced, if required.

xiii. Adequate arrangement shall be made on the bridges for providing electrical/ telecommunication cables and other utilities as required. Specifications and guidelines of the owning agencies in such cases shall be followed.

xiv. Arrangements for enabling inspection of superstructure and bearings shall be provided as per RDSO report BS-113.

xv. Spherical bearings shall be designed for all OWG. Bearing type for each girder shall be fixed, longitudinal guided, transverse guided and free. All bearings shall be easily replaceable without major disruption to railway operations or to any activity underneath the viaduct. Bearings shall be placed on bearing pedestals designed in accordance with applicable codes. Appropriate jacking points, on the pier/abutment cap in consideration with the requirements of the superstructure for lifting, shall also be provided. The bearings shall be sandwiched between two true horizontal surfaces. Steel Wedge shall be provided to cater to longitudinal slope of superstructure, wherever required. Minimum thickness of steel wedge shall be 12mm and shall be more on the other side as per the requirement of the gradient. Higher size single plate shall be used for fabrication of wedge plate.

xvi. Expansion/Movement Joints and other necessary measures to control shrinkage and thermal effects shall be incorporated in the structural design so that the performance of the bridge/structures are not adversely affected during normal working conditions. Movement joints shall be designed to be easily maintained and replaceable.

xvii. Height gauge for road-under-bridges shall be as per RDSO drawing no. RDSO/M-0001. If RDSO drawing is not applicable, the Contractor shall design height gauge for the required span considering road width & applicable loading. However, the section of height gauge shall not be less than RDSO drawing No. RDSO/M-0001. Height gauge shall be provided with reflecting strip & height warning signs as per standard practices.

xviii. Minimum depth of foundation of bridges shall be scour depth plus 1.75m below the bed level.

xix. The water from deck shall be taken down from pier with adequately designed drainage system using GI pipes and bends.

d) Bridges with Superstructure of PSC U-slab

i. Superstructure to be adopted shall conform to standard RDSO drawings for "25t Loading-2008". Following standard RDSO drawings for "25t Loading-2008" will be used for PSC superstructure.

S. No.	Span	Reference RDSO Drawings
		25t loading
1	12.2m	B-10281 series (**PSC U-slab)**

However, the Contractor shall verify the adequacy of the above RDSO standard drawings for double stack containers.

ii. The substructure and foundation of bridges shall be designed for DFC loading (32.5T loading) as per IRS Bridge Rules and other relevant codes. For the purpose of design of substructure and foundation, dead load of superstructure shall be taken maximum of dead load of corresponding standard RDSO superstructure for DFC loading (32.5 T loading) or 120% of dead load of superstructure designed for 25T loading. The substructure and foundation of bridge shall also be designed for 25T loading with double stack container.

iii. Height Gauges shall be provided on both approach roads on sides of RUBs. Height gauge for road-under-bridges shall be as per RDSO drawing no. RDSO/M- 0001. If RDSO drawing is not applicable, the Contractor shall design height gauge for the required span considering road width & applicable loading. However, the section of height gauge shall not be less than RDSO drawing No. RDSO/M-0001. Height gauge shall be provided with reflecting strip & height warning signs as per standard practices.

iv. Minimum depth of foundation of bridges shall be scour depth plus 1.75m below the bed level.

v. The water from deck shall be taken down from pier with adequately designed drainage system using GI pipes and bends.

e) RCC Box

i. Bridges shall be designed for “DFC loading (32.5t axle load)”. In addition, the design shall consider the loading standards as applicable to the type of the crossing/existing road or Class A/Class 70R loading as per IRC 6-2017, as the case may be.

   Standard RDSO drawing for box culvert shall be followed if available. Minimum Grade of concrete in RCC Box shall be maximum of M-35 or that mentioned in RDSO drawings.

   If standard RDSO drawing is not available for desired sizes/fill height, box shall be designed by the Contractor. However, the thickness of walls and top & bottom slabs shall not be less than that shown in the Tender drawings and reinforcement of the box shall not be less than the closest available box size & fill height of RDSO drawing.

ii. Size of the Box openings (minimum required) has been shown in the conceptual GADs. Height of box shown includes clear height and wearing coarse of 150mm. Overall height of box may vary as per site requirement and actual road/ground profile.

iii. The barrel length of the culvert shall be decided based on the fill height and ROW.

iv. In case of RUB, the top of bottom slab of RCC box shall be below the natural ground level of the approach road. However, road level and vertical clearance above the road shall be maintained as shown in Tender drawings. Any variation due to site conditions as mentioned above shall be got approved from the Engineer.

v. Fill Depth shall be the height of fill from the bottom of the sleepers to the top of the box and shall be inclusive of depth of ballast and depth of soil fill as per IRS Concrete Bridge Code (CBC).

vi. All waterway bridges shall be protected by a well-designed flooring system. The concrete/CC block shall be protected by curtain wall at upstream side and drop wall at downstream side. The minimum depth of the curtain wall and drop wall shall be scour depth plus 1.75m below the bed level.

vii. Height Gauges shall be provided on both sides of RUBs. Height gauge for road-under-bridges shall be as per RDSO drawing no. RDSO/M- 0001. If RDSO drawing is not available for the road width, the Contractor shall design height gauge for the required span considering applicable loading. However, the section of height gauge shall not be less than RDSO drawing No. RDSO/M-0001. Height gauge shall be provided with reflecting strip & height warning signs as per standard practices.

f) RCC Pipe Bridges

i. Reinforced NP-4 class concrete pipes of diameter 300mm, 600mm, 900mm, 1000mm, 1200 mm and 1800mm are suitable for DFC Loading (32.5t axle loading) and shall be used subject to conditions mentioned below:
   a. Maximum cushion of 5.0m and minimum cushion of 900mm (including ballast cushion) below bottom of sleepers and above top of pipes shall be ensured.
   b. "Positive Projection Embankment Condition: Type -A Bedding- Earth foundation" shall be provided.

ii. Reinforced (NP-4 class) concrete pipes shall be provided as per IS: 458 "Precast concrete pipes (with and without reinforcement)".

iii. Laying conditions shall be as per IS:783-1985 "Code of practice for laying of concrete pipes".

iv. Pipe shall be extended well beyond the bank as shown in the Tender drawing.

v. Concrete face wall of suitable lengths shall be provided at the ends of pipe culvert.

vi. Protection Works.

4.4 Outline Design Criteria

This Outline Design criteria pertains to the Bridges for HORC Project.

a) ROADWAY AND RAILWAY CLEARANCES

The alignment of HORC crosses several existing roadways and existing railways. The general clearance requirements for these crossings shall be as follows:

(i) CLEARANCES FOR ROAD TRAFFIC

Vertical clearance for road traffic shall be higher of the values as per Clause 104.4.2 of IRC-5 plus 100 mm or as per Conceptual GAD or as per requirement of stakeholder, whichever is more

General Arrangement Drawings at road crossings shall be got approved from the concerned authorities/stake holders.

(ii) CLEARANCES FOR ROLLING STOCK

Clearance for railway traffic shall be as per Schedule of Dimensions of Indian Railways applicable for high rise OHE for double/triple stack container route. General Arrangement Drawing at railway crossings shall be got approved from the concerned Railway Authority.

b) MATERIALS PARAMETERS

i. CONCRETE

1) Grade of Concrete & Cover

Grade of concrete shall be minimum M-35 for RCC works and minimum M-20 for plain cement concrete including levelling course.

In case of foundation, cover shall be taken as 75mm for all conditions of exposure. For substructure, cover shall be taken as 50mm.

2) Cement

The minimum cementitious material content, maximum water-cement ratio, total chloride content by weight of cement shall be as per IRS-CBC.

3) Density

Density of concrete shall be 2500 kg/m^3 for PSC and RCC, 2500 kg/m^3 for Plain cement concrete and 2600 kg/m^3 for Wet concrete.

4) Poisson's Ratio

Poisson's ratio for all grades of concrete shall be 0.15.

5) Thermal Expansion Coefficient

Coefficient of thermal expansion shall be considered as 11.7 x10-6/ ^{o}C in accordance with IRS-Bridge Rules.

6) Time-Dependent Characteristics of Materials

Long-term losses should be calculated in accordance with IRS- CBC.

The design shall be done according to construction sequence to be adopted in site.

ii. REINFORCEMENT STEEL

High strength deformed (HYSD) reinforcement bars of minimum Fe-500D grade, conforming to IRS-CBC & IS 1786 shall be used.

Young’s Modulus = 200,000 MPa

Yield Stress(fy) = 500 MPa.

Density = 7850 kg/m^3

Reinforcement shall fulfill the criteria laid down in IRS Seismic code for earthquake resistant design of Railway bridges.

iii. STRUCTURAL STEEL (FOR OPEN WEB /COMPOSITE BRIDGES & OTHER STRUCTURES IF ANY)

Structural steel shall be used for OWG, composite girders and for miscellaneous use such as railing, supporting utilities, coverings etc.

1) Structural Steel for Open Web/Composite Bridges

(a) General

Structural steel conforming to IS: 2062(Grade E250 – B0, E350 – B0) shall be adopted.

Fabrication shall be done as per the provisions of IRS B1 (Fabrication Code).

Design of steel structures shall be done as per IRS steel Bridge Code.

IRC Code: 22 shall be referred for steel-concrete composite construction.

Welding shall be done following IRS Steel Bridge Code, IRS welded Bridge code or relevant IS codes for welding.

(b) Young's Modulus shall be taken as 21100 kg/mm^2 as per IRS- Steel Bridge Code.

(c) Density: 7850 kg/m^3

(d) Poisson's Ratio: 0.30 as per IS 800

(e) Thermal Expansion Coefficient: $12x10^{-6}/^{o}C$ as per IS 800

Note: In case design of any component/member is done using foreign code, material shall confirm to the specifications of the relevant foreign code.

2) Structural Steel for Miscellaneous Use

The design of miscellaneous structure shall be done as per IS: 800 and related provisions.

Hollow steel sections for structural use shall be as per IS: 4923.

Steel tubes for structural purpose shall be as per IS: 1161.

Steel for General Structural Purposes (Grade E250 – B0, E350 – B0) shall be as per IS: 2062.

c) LOADS TO BE CONSIDERED FOR DESIGN

For loadings, load combinations, analysis, and design of structures, all relevant IRS, IS, IRC and other relevant codes shall be followed.

The superstructure, bearing, substructure and foundation will be checked for one track loaded condition as well as multiple/all track loaded conditions as well as for single span and two adjacent spans loaded conditions, as the case may be.

Design of structures shall take into account construction methodology/ construction sequence to be adopted during execution.

The analysis and design will be carried out for all possible cases of rolling train loads. All the supporting structures such as superstructure, bearings, substructure and foundations shall be checked for all possible load combinations.

Following are the major loads to be taken into consideration for analysis and design of structures as prescribed in IRS-Bridge Rules up to latest up-to-date correction slip.

i. DEAD LOAD

Dead load shall be based on the actual cross section area and unit weights of materials and shall include the weight of the materials that are structural components of the bridge and permanent in nature.

ii. SUPER IMPOSED DEAD LOAD (SIDL)

Superimposed dead load include all the weights of materials on the structure that are not structural elements but are permanent. It includes weight of track from BLT/ballast/sleepers/rails/ fasteners/ cables/parapet/ hand-rail OHE mast/ cable trough/ Signaling equipment etc.

iii. SHRINKAGE & CREEP

Shrinkage and Creep effects will be calculated as per IRS CBC.

iv. LIVE LOAD (LL)

(a) Railway Vehicular Load

Live load shall be followed as per Clause 2.3 of IRS Bridge Rules.

(b) Dynamic Augmentation

CDA will be considered as specified in IRS Bridge Rule.

(c) Footpath Live Load

Footpath live load shall be taken as per IRS Bridge Rules

(d) Longitudinal Force

Longitudinal force shall be followed as per Clause 2.8 of IRS Bridge Rules.

Tractive force of one track and braking force of another track will be taken in the same direction to produce worst condition of loading.

As per IRS-Bridge Rules, in transverse / longitudinal seismic condition, only 50% of gross tractive effort/braking force will be considered.

Dispersion, of longitudinal forces is not allowed as per IRS Bridge Rules except during checking of Rail stress.

(e) Forces due to curvature and eccentricity of track

The forces due to curvature and eccentricity of track is to be considered as per IRS: Bridge Rules.

Centrifugal forces shall be considered to act at a height of 3m (same as in case of DFC loading) above rail top level on the safer side as it is not defined in Bridge Rules for double stack containers.

(f) Racking Force

The horizontal transverse force due to racking as specified in IRS-Bridge Rules is applicable to design.

v. Earth/Surcharge load

Earth pressure and surcharge load/pressure shall be taken as per the provisions of IRS Substructure & Foundation Code.

vi. TEMPERATURE EFFECTS

(a) Temperature

- Overall Temperature (OT)

The loads shall be considered as per IRS-Bridge Rules and IRC:6. Temperature variation of + 35°C shall be considered, details of which are given below

Maximum Temperature considered as per Annex. F of IRC 6: +49°C

Minimum Temperature considered as per Annex. F of IRC 6: -0.4°C

Temperature variation as per Clause 215.2 of IRC 6 will be =

49-(-0.4)/2+10=34.7°C say 35°C.

- Differential Temperature (DT)

  The provision given in IRC 6, shall be considered to compute effect of differential temperature gradient.

(b) Rail Structure Interaction (RSI)

Movement and rotation of girders on viaduct and bridges can impact the track design significantly and the limitations posed by the safe performance of the track can impact significantly the design of components of bridges/viaduct. Therefore, design of viaduct/bridges and track require extensive interaction between the viaduct/bridges designer and the track designers.

Rail structure interaction [RSI] analysis for continuing Continuous Welded Rail/Long Welded Rail over bridge shall be carried out as per provisions of "IRS Bridge Rules" and the following guidelines issued by the RDSO:

1. BS 114 (version-2): "RDSO Guidelines for carrying out Rail-Structure Interaction studies on Indian Railway" for ballasted deck bridges.
2. BS 119 (version-2): "RDSO Guidelines for carrying out Rail-Structure Interaction studies on Metro Systems " for ballastless deck bridges (bridges with slab track).

The following shall be adhered to:

a. Track resistance in loaded and unloaded conditions for ballasted or unballasted deck shall be obtained from cl. 2.8.2.4.3 of IRS Bridge Rules. As per the clause, the recommended values for track stiffness for ballasted tracks are 50 KN/m and 25 kN/m for loaded and unloaded track respectively. The recommended values for track stiffness for unballasted tracks are 60 kN/m and 40 kN/m for loaded and unloaded track respectively.
b. The elastic limit is 2 mm for ballasted tracks and 0.5mm for ballastless track.

c. The track stiffness can be modified by suitably changing the clamping force applied by the track fastening system, if required from RSI considerations.

d. The deck temperature variation, to be used for analysis, shall be derived from the ambient temperature given in Annexure- F of IRC 6-2017. For co-relation between the ambient temperature and deck temperature the provision of cl. 6.1.3 of en.1991.1.5.2003 may be used

e. The rail temperature variation, to be used for analysis, shall be obtained from the nearest SSE/P. Way depot of Indian Railways.

f. Maximum additional stresses in rail in tension as well as compression on account of rail-structure interaction shall be within the permissible limits as prescribed in cl. 2.8.2.4.3 of IRS Bridge Rules. The limit prescribed in the document shall be used as it is and no benefit on account of lesser axle load of actual rolling stock shall be permitted.

g. The provisions of Displacements of Bridge Elements as mentioned in the guidelines and UIC 774-3R shall be adhered to.

h. For ballastless track, the checks must be performed for break in rail continuity due to unusual conditions such as fractures or for maintenance purposes.

i. The longitudinal design force for the substructures and foundations shall be the longitudinal force specified in the IRS Bridge Rules (without dispersion) or the longitudinal force obtained from RSI analysis, whichever is more.

j. In the case of track on curve, staged detailed analysis shall be performed. For bridges on straight alignment, simplified analysis will suffice.

k. The software and general methodology to be used for carrying out Rail Structure interaction analysis must be validated as per guidelines given in UIC 774-3R before adopting the same.

l. Representative stretches must be chosen for carrying out Rail-Structure interaction which shall include special spans. The same shall be approved of by the Engineer.

RSI shall be carried out by RSI expert engaged by the Contractor and approved by the Engineer. RSI expert shall have minimum 3 years of experience of RSI for bridges or viaduct.

vii. WIND LOAD (WL)

The wind load shall be calculated as per IRS: Bridge Rules and IS: 875 (Part 3).

Vb = Basic wind speed = 47m/s for Delhi Zone

viii. SEISMIC FORCE (EQ)

The purpose of this section is to summarize the methodology and the assumptions that shall be used for the seismic analysis.

(a) Seismic Design

Seismic design philosophy as stated in IRS Seismic Code shall be considered. HORC project area lies in Seismic Zone IV of seismic map of India. The peak ground acceleration denoted as zone factor is taken as 0.24 for zone IV.

(b) Definition of Seismic Input

Spectral Acceleration (Sa/g vs T) as prescribed in IRS Seismic code, shall be used for seismic load computation.

(c) Horizontal Seismic Coefficient

The horizontal seismic design coefficient shall be calculated as per following expression

Ah = (Z/2) * (I/R) * (Sa/g)

Where,

Ah	=	horizontal seismic coefficient to be considered in design
Z	=	peak ground acceleration or zone factor = 0.24
I	=	importance factor = 1.5
R	=	response modification factor as per Table 3
Sa/g	=	Average acceleration coefficient

(d) Response Reduction Factor

Response Reduction Factor "R" shall be as per IRS Seismic code Table -3.

Note: In addition to the response reduction factor, reinforcement detailing of Piers/Portal Piers and joints with pier cap and foundations shall conform to ductility/capacity design requirements as per Annexure-B of IRS Seismic Code.

(e) Vertical Seismic Coefficient

The vertical seismic coefficient shall be 2/3 of horizontal seismic coefficient.

(f) Computation of Fundamental period of vibration

The fundamental time period shall be calculated by any rational method of analysis. Each pier is considered as a single degree of freedom oscillator with mass placed at the Centre of Gravity (COG) of the deck.

The time period can also be calculated as per IRS Seismic Code.

(g) Direction Combinations

The seismic forces shall be assumed to come from any horizontal direction. For this purpose, two separate analyses shall be performed for design seismic forces acting along two orthogonal horizontal directions. The design seismic force resultant (that is axial force, bending moment, shear force and torsion) at any cross section of a bridge component resulting from the analysis in the two orthogonal horizontal directions shall be combined according to IRS Seismic Code.

When vertical seismic forces are also considered, the design seismic force resultants at any cross-section of a bridge component shall also be combined as mentioned in IRS Seismic Code.

In case of abutment design, Seismic force on soil mass behind the abutment and confined between the retaining wall shall also be considered in addition to dynamic increment in earth pressure.

(h) ERECTION TEMPORARY LOADS (ETL)

Erection forces and effects shall be considered as per IRS-Bridge Rules.

The weight of all permanent and temporary materials together with all other forces and effects which can operate on any part of structure during erection shall be considered in design. The loads arising from most onerous conditions of the construction methods adopted is awaited from the Contractor.

Special care shall be taken that no damage is caused by the construction contractor to the permanent structure. In case of any hole etc., drilled in permanent structural element, the same will be made good by using non-shrink, expansive, high strength grout and its strength shall be better than the structural element and will have to be demonstrated.

(i) DERAILMENT LOADS (DR)

Checks shall be made in accordance with the IRS-Bridge Rules.

(j) FORCES ON PARAPET

The parapets shall be designed to resist lateral horizontal force & a vertical force of 150 kg/m applied simultaneously at the top of the parapet as per Clause 2.10 of IRS Bridge Rules.

(k) DIFFERENTIAL SETTLEMENT (DS)

Differential Settlement (post construction) between two adjacent bridge piers shall be as follows.

12mm for Long Term Settlement

6mm for Short Term Settlement

Differential settlement shall be considered only in the design of continuous structures, if any.

(l) BUOYANCY LOADS

The design of the foundation shall be done considering design ground water table as per Sub-Clause 2.6 (b) of Outline Design Specification- General.

In case of river bridges, stability check and calculation of base pressure, full buoyancy shall be considered on submerged portion of substructure and foundation up to HFL or LWL as the case may be, irrespective of the type of soil on which the foundation will rest.

Hydro dynamic forces will be considered as per IRS Seismic code.

(m)WATER CURRENT FORCES

Water current force in submerged portion of substructures and foundations shall be calculated as per IRS Bridge Substructure & Foundation Code.

(n) VEHICLE COLLISION LOAD (VCL)

The vehicle collision load on piers shall be as per IRC: 6.

All structure near railway track shall be checked for accidental impact from derailed trains as per IRS Bridge Rules as per Addendum & Corrigendum Slip No. 48 dated 22.06.2017.

(o) VIBRATION EFFECT

Effect of vibration due to movement of train on bridge structure will be taken into consideration. This will be checked in dynamic analysis.

d) LOAD COMBINATIONS

Provisions of IRS-CBC shall be followed. The partial load factors and load combinations shall be as per IRS-CBC.

Notes:

ULS-Ultimate Limit state.

SLS-Serviceability Limit state

Wind load and earthquake loads shall not be assumed to be acting simultaneously.

Load combination for Road Vehicle collision shall be as per IRC 6 but design of members under vehicle collision load combination shall be carried out as per IRS CBC.

i. The Superstructure/bearing, sub-structure and foundation will be checked for one track loaded condition as well as multiple/all track loaded condition, for single span and both spans loaded conditions, as the case may be.

ii. Design of bridge shall be done considering the construction methodology/ construction sequence to be adopted during execution.

iii. The analysis and design will be carried out for all possible cases of rolling train loads. All the structures, such as superstructure, bearings, substructure and foundations shall be checked for the most onerous cases.

e) DESIGN CHECK FOR REINFORCED CONCRETE STRUCTURE

Design of all RCC structures shall be done as per IRS CBC for Serviceability Limit State (SLS) and Ultimate Limit State (ULS)

If prestressing is to be used in any structural member, it shall be checked as per relevant clauses of CBC.

f) DESIGN CHECK FOR STEEL/COMPOSITE STRUCTURE

The design of steel structure shall be done as per IRS Steel Bridge Code/IRS-Welded Bridge Code. In case of steel structure, IRS-steel bridge code shall be followed. While designing for composite action IRC :22 shall be referred.

g) DURABILITY & CRACK WIDTH

(a) DURABILITY

Provision of IRS-CBC shall be followed. The exposure condition is Moderate and in case of Nallah crossing the exposure condition may be treated as "Severe".

(b) CRACK WIDTH CHECK

For SLS Combination, crack width in reinforced concrete members shall be calculated as per IRS-CBC.

The allowable crack width shall be as per exposure conditions given in IRS-CBC.

(c) DEFLECTION

Deflections shall be taken into account as per IRS: CBC while checking appearance, efficiency of the structure and minimum specified clearances. Clause no. 13 of IRS CBC shall be kept in view while calculating deflection/deformation. Permissible values of deformation shall also be in accordance with provision of UIC-776-3R.

h) FATIGUE

Fatigue phenomenon shall be analyzed for those structural elements that are subjected to repetition of significant stress variation (under traffic load).

(a) PRESTRESSED/REINFORCED CONCRETE STRUCTURE

The fatigue shall be checked as per IRS-CBC. However, fatigue check for prestressed concrete structures does not need to be performed as long as the whole section (from top to bottom fiber) remains under compression under SLS load combination.

(b) STEEL/STEEL COMPOSITE STRUCTURES

IRS-Steel Bridge Code (up to latest correction slip) / IRS-Welded Bridge code shall be adopted for fatigue check of structural steel members and connections.

Annual Traffic Density for fatigue checks shall be considered as 50 GMT (Gross Million Tonnes per annum) per track (i.e. 100 GMT for two tracks).

Simplified approach method given in Clause 14 of Appendix-G of IRS Steel Bridge Code(Fatigue Assessment of steel bridges) shall be followed for fatigue assessment.

4.5 Drainage

The drainage of bridge deck shall be designed to cater to the maximum envisaged rainfall intensity and suitable longitudinal and transverse slope shall be provided. Moreover, the provisions of IRS-CBC shall be followed.

The top of soffit slab will be profiled so as to collect the run-off water at multiple points by providing a cross slope of 2.5%. Drainage pipes will be provided to collect the run-off.

4.6 Bearing System

(a) Type of Bearing System

Spherical bearings shall be designed as per IRC: 83 part-IV.

(b) Replaceability of Bearings

While finalizing the proposed bearing system, it shall be kept in mind that accessibility and replacement of each part of bearing are of paramount importance as the design life of bearings is shorter than that of the structure. Keeping in view the above cited criteria, all the bearings, pedestals and pier caps will be detailed for replacement of bearings in the future. The girders/end diaphragms shall be designed to facilitate the operations of jacks during maintenance as per clause IRS-CBC.

(c) Uplift

If required a holding-down device connecting the deck and the pier head shall be placed in order to prevent the deck from overturning. The holding-down device may be integrated in the bearing system or be a separate system constituted of bars embedded in pier cap and bridge with appropriate details, permitting translation/rotation. Other systems can also be foreseen.

Due to the lack of appropriate guidelines in Indian codes, the design criteria for holding down device (upward force limit requiring holding down device, design formulas) will be taken from the latest international practice.

4.7 Substructure System

(a) Pier Cap

For designing the pier cap as corbel the provisions of IRS-CBC should be followed. In case of shear span to effective depth ratio being more than 0.6, pier cap will be designed as flexural member.

Height of pedestal should be in between 150mm and 350mm.

The Pier cap shape shall be suitable at transition pier supporting different types of superstructure instead of providing raised/column pedestal over pier cap.

(b) Piers

The effective length of a cantilever pier for the purpose of slenderness ratio calculation will be taken as per IRS-CBC.

The design of pier shall be done as per IRS CBC.

Ductile detailing is mandatory. Shear reinforcement & ductile detailing shall be done as that of RCC column.

4.8 Foundation System

4.8.1 Foundation shall be designed as per IRS Bridge Substructure & Foundation Code, IRS Concrete Bridge Code, Manual on the design and construction of well foundation, IS- 2911, IRC-78.

4.8.2 Soil replacement may also be resorted, if the difference of bearing pressure and bearing capacity is upto 30%, keeping other practical aspect and site conditions in mind.

4.8.3 Pile Foundation

a) Foundation analysis and design will be based on IRS Code for Substructure & IRC-78. The forces applied by the pier are transferred to the bottom of the pile cap for this purpose. Reactions in pile are calculated using rivet theory. Various specific assumptions made for the pile and pile cap design are as follows:

i. Bored-cast-in-situ multiple pile groups will be adopted.

ii. Minimum 1.2m diameter (unless specified otherwise in tender drawing) bored cast-in-situ vertical piles in soil/rock have been contemplated for the foundation of piers. Minimum number of pile in each pile cap shall be 4.

iii. For piles and pile caps, load combinations shall be considered as per IRS-CBC, Table-12. The various specific assumptions made for the pile and pile cap design including pile load testing shall be as per IS: 2911, IRC-78 and IRS-Bridge Sub-structure and Foundation Code.

iv. For pile bearing capacity, all SLS Load combinations as per IRS-CBC will be considered.

v. Increase in vertical load capacity of pile shall be as per IS 1893-Part-1.

vi. The lateral load capacity of pile shall be evaluated by using empirical formulae given in IS: 2911 (Part-1/ section-2).

vii. Initial load tests on test pile shall be conducted as per IS: 2911 - Part IV. Initial test shall be conducted for a load of 2.5 times as per the safe load based on static formula.

viii. The working load on pile for vertical and horizontal loads shall be verified through routine load tests during construction.

ix. In case of multiple pile system, spacing between the piles shall not be less than 3 times the diameter of pile in soil and 2.5 times the diameter when founded on rock.

x. In general, the top of pile cap shall be kept about min 500mm below the existing ground level and weight of the earth cover will be applied on top of pile cap when unfavorable. The earth cover on pile cap for any favorable effect (stability, soil horizontal capacity.) will be neglected.

xi. In case the location of foundation (all types) is within Load Impact Line of nearby passing load(rail/road) then the effect of surcharge (dead load + live load) corresponding to that passing load shall be taken into account.

b) Structural Design

i. Pile design shall be done according to IRS CBC. However, for crack control in piles, it will be clarified that actual axial load will be considered to act simultaneously.

ii. Where there is a risk of liquefaction, the lateral soil resistance of the liquefied layer will be taken as zero.

iii. Pile cap shall be designed based on IRS –CBC. No support from soil below pile cap shall be considered.

iv. The thickness of the pile cap shall be kept minimum 1.5 times diameter of the piles for multiple-pile group.

v. The structural design and crack width check of the pile cap shall be carried out as IRS CBC.

vi. Minimum reinforcement in pile caps at top shall be at least 0.12% in each direction in case of compression and in case of tension, it shall not be less than 0.2%.

c) Soil Structure Analysis

When designing element forces or estimating displacements the soil stiffness and other parameters shall be assessed based on the design ground water table.

4.8.4 Well Foundation

Well Foundation shall be designed as per IRS Bridge Substructure & Foundation Code, IRS Concrete Bridge Code, IRS manual on the design and construction of well and pile foundations (1985) & IRC: 78.

a) Depth of Foundation

The depth of foundations shall be adequate to provide stability against overturning and sliding. Only 50% of the passive earth pressure that can be mobilised on the sides of the well foundations below max. scour level shall be considered while considering stability against overturning. The choice of type and shape of well foundation will depend 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.

b) Shape and Cross-Section of Wells

i. The well shall be circular or double D shape.
ii. The dredge hole should be large enough to permit dredging.
iii. The steining thickness should be sufficient to enable sinking without excessive kentledge and provide adequate strength against forces acting on the steining, both during sinking and service. The well steining should also be designed to withstand the earth pressures acting only on two opposite sides or only on diametrically opposite quadrants under conditions of sand blowing. The effect of heap of earth dumped near the well during sinking shall also be taken into account.
iv. It should accommodate the base of the substructure.
v. The overall size should be sufficient to transmit the loads safely to the soil without exceeding its allowable bearing pressure.
vi. It shall allow rectification of the tilt and shift of the well without damaging the well.

c) Loading

Wells shall be designed to resist the worst condition due to possible combination of the following loads, as may be applicable, with due regard to their direction and point of application.

Vertical Loads:

i. Self-weight of well.
ii. Buoyancy
iii. Dead load of superstructure, substructure.
iv. Live load, and
v. Kentledge during sinking operation

Horizontal Forces:

i. Braking and tractive effort of moving vehicles.

ii. Forces on account of resistance of bearings.

iii. Forces on account of water current or waves.

iv. Centrifugal force, if the bridge is situated on a curve.

v. Wind forces or seismic forces.

vi. Earth pressure.

vii. Other horizontal and uplift forces due to provision of transmission line tower (broken wire condition) etc.

d) Tilt And Shifts

As far as possible wells shall be sunk without any tilt and shift. A tilt of 1 in 100 and shift of D/40 subject to a minimum of 150 mm shall be taken into account in the design of well foundation (D is the width or diameter of well).

If greater tilts and shifts occur, their effects on bearing pressure on soil, steining stresses, change in span etc. should be examined individually.

e) Cutting Edges

Cutting edge shall be properly anchored to the well curb. When there are two or more compartments in a well the bottom of the cutting edge of the intermediate walls may be kept about 300 mm above the cutting edge of the outer wall to prevent rocking.

f) Well Curb

It should transmit the superimposed load to the bottom plug without getting overstressed and it should offer minimum resistance to sinking. The slope to the vertical of the inner faces of the curb shall preferably be not more than 30 degrees. In sandy strata, it may be upto 45 degrees. An offset on the outside (about 50 mm) may be provided to ease sinking. The curb shall invariably be of reinforced concrete of minimum M 35 with a minimum reinforcement of 72 kg/m^3 excluding bond rods. In case blasting is anticipated, the inner face of the curbs shall be protected by steel plates or any other means to sufficient height.

g) Well Steining

Well steining shall be built of RCC with cement concrete not weaker than M-25 grade. Sufficient bond rods shall be provided to bond the units of the steining during the progress of construction. Bond rods shall be distributed evenly on both faces of steining and tied up by providing adequate horizontal hoop reinforcement~~.~~

h) Bottom Plug

A bottom plug shall be provided for all wells and its top shall be kept 300 mm above the top edge of the inclined face of the curb. The concrete used for the bottom plug when placed under dry conditions shall generally be of M20 proportions and it shall be placed gently in one operation. When the concrete is placed under water, the quantity of cement shall be increased by 10% and it shall be placed by tremie or skip boxes under still water condition.

i) Top Plug

A 300 mm thick plug of cement concrete M-20 grade shall be provided over the hearting which shall normally be done with sand.

j) 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.

k) Design and analysis

The design of well foundations shall be carried out for either of the following two situations:

i. Wells surrounded by non-cohesive soils, below maximum scour level and resting on non- cohesive soils:

For wells resting on non-cohesive soils like sand and surrounded by the same soil below a maximum scour level, the design of foundations shall be checked by both Elastic Theory and Ultimate Resistance Methods as given in Appendix V of IRS Bridge Substructure and Foundation code.

ii. Wells surrounded by cohesive soils or mixed strata below maximum scour level and resting on any strata viz. Cohesive soil, non–cohesive soil or rock:

For wells founded in clayey strata and surrounded by clay below max. scour level, the passive earth pressure shall be worked out by C & Ø parameters of the soil as obtained from UU (unconsolidated undrained) test.

In wells through clayey strata, the skin friction will not be available during the whole life of the structure, hence support from skin friction should not be relied upon.

l) Settlement of well foundation

The settlement of well foundation may be the result of one or more of the following cases :

i. Static loading,
ii. Deterioration of the foundation structure;
iii. Mining subsidence and
iv. Vibration subsidence due to underground erosion and other causes.

Catastrophic settlement may occur if the static load is excessive. When the static load is not excessive, the resulting settlement may be due to the following:

i. Elastic compression of the foundation structure;
ii. Slip of the foundation structure relative to the soil;
iii. Elastic deformation or immediate settlement of the surrounding soil and soil below the foundation structure ;
iv. Primary consolidation settlement of the surrounding soil;
v. Primary consolidation settlement of the soil below the foundation structure.
vi. Creep of the foundation structure under the constant axial load; and
vii. Secondary compression of the surrounding soil and soil below the foundation structure.

If a structure settles uniformly, it will not theoretically suffer damage, irrespective of the amount of settlement. In practice, settlement is generally non-uniform. Such non-uniform settlements induce secondary stresses in the structure. Depending upon the permissible extent of these secondary stresses, the settlements have to be limited. Alternatively, if the estimated settlements exceed the allowable limits, the foundation dimensions or the design shall be suitably modified.

m) Wells Founded In Cohesionless Soil :

For wells constructed in cohesionless soils, the settlement due to dead load of sub-structure will take place by the time the construction is completed and the necessary adjustment in the final level can be made before erection of the girder. In such cases, settlement shall be evaluated only for the dead load of the super-structure.

n) Wells Founded In Cohesive Soil :

When wells are founded in cohesive soil, the total settlement will be computed as per the provisions of clause 6.4 of IRS Bridge Substructure & Foundation code.

4.9 Open Foundation

4.9.1 Open foundation shall be designed as per IRS Bridge Substructure & Foundation Code & IRS-CBC.

4.9.2 The depth of open foundation shall not be less than 1.75m below the anticipated scour level or below the lowest ground level in case of no scour. The top of open foundation shall be kept at least 0.5m below the anticipated scour level or below the lowest ground level in case of no scour. Foundation shall not rest on compressible soils.

4.9.3 The width of open rectangular foundation shall be so adjusted that the resultant of all the forces on the base of foundation shall fall within the middle third.

4.10 Ground Improvement

4.10.1 Ground improvement needs to be done at open foundation locations where allowable bearing capacity is less than the actual bearing pressure at the base of the structure/ foundation and at locations where strata is prone to liquification. Ground improvement shall be done by soil replacement method.

4.10.2 Soil replacement may be proposed where susceptibility for liquification is upto 4m depth below the ground. For liquefaction depths more than 4 m, deep foundation shall be provided depending upon the site requirement. Soil replacement shall be done at least 500mm below the liquification depth. Width/length of soil replacement shall be at least equal to width/length of foundation plus twice the depth of replacement below founding level. After ground improvement SBC at the base of foundation shall be verified by SPT and plate load test.

4.11 Codal Reference

The IRS Codes shall be followed in principle. Although main clauses have been mentioned in the ODS, the other relevant clauses as available in the IRS codes shall also be followed, whenever applicable. If provisions are not available in IRS, the order of preference shall be as follows, unless specified otherwise:

For railway loading related issues:

I. UIC Codes

II. Euro Codes

III. Any other code, which covers railway loading.

For other Design/ detailing related issues:

I. IS Codes

II. IRC Codes

III. EURO Codes

IV. AASHTO Codes

V. Any international code with approval of the Engineer.

5 OUTLINE DESIGN SPECIFICATIONS -: STATIONS

5.1 General

Concept Plan of the station building has been provided in the Tender drawings. The Contractor shall prepare the detailed architectural design and drawings of the station. The structural design of buildings and other works as mentioned in the Design Requirement Criteria shall be done by the Contractor as per the requirements briefed hereunder.

This Outline Design Specification (ODS) is applicable for station buildings and other Civil works.

5.2 Details of Structures to be designed

The Contractor shall prepare and submit architectural drawings of various stations. Various architectural alternatives shall be prepared for the station building with better aesthetics, pleasing appearance, durability and environment friendliness.

The Contractor shall design station buildings and structures at three stations namely Prithla, Silani & IMT Sohna.

The design of station shall include, but not limited to, the following -

i. Station cum S&T and Electrical Service Buildings

ii. Cast-in-Situ RCC Platform wall with pre-cast coping, platforms, platform shelter, mini platform shelter, water booths, toilets and seating arrangements at platforms

iii. Water supply system

iv. RCC/ RE retaining walls within station yards

v. Platform and Yard drainage

vi. Subway for inter-platform transfer including stairs & ramp with self supporting covering lift wells and waterproofing system.

vii. Bore well, pump house, pipe connections, underground & overhead water storage tanks

viii. Septic tank and soak pits for toilets of station buildings and platforms

ix. RCC portico

x. Approach road to stations

xi. Ticket counter

xii. RCC pre cast fencing at end platforms

xiii. Signal hut and other service buildings

xiv. Circulating area and landscaping

The design of station building shall include, but not limited to, the following: -

i. Architectural and structural design

ii. Plumbing arrangement

iii. Arrangement for ventilation

iv. All other building services as necessary for functioning of the station as per NBC 2016

5.3 Design Requirements

5.3.1 Layout Criteria

i. The layouts of the stations, as prepared & provided by the Employer are indicative. The Contractor shall develop the layout so as to comply with the Employer's Requirements.

ii. Architecture and profile of all buildings shall conform to local aesthetics, cultural ethos, local architecture and environment and shall be subject to consent and approval of the Engineer.

iii. The functional and structural design of all the station buildings shall be carried out as per provisions of National Building Code 2016 and the by-laws of the local authorities to the extent of their applicability.

iv. Structural design of subway shall be carried out as per provisions laid for RCC Box bridges.

v. Method of structural analysis shall be appropriate for the structure or component to be analysed and shall be carried out by the Contractor using well established software duly consented by the Engineer. However, critical designs shall be supported by manual checks.

vi. Dynamic analysis shall be performed to obtain the design seismic force by Response Spectrum Method as per latest IS 1893. Analysis of framed structure shall be carried out considering fixed support at top of pile cap / Open foundation Structural design of building shall confirm to codal provision of IS 456, IS 4326 and IS 13920. Design of water retaining structure shall confirm to codal provision of IS 3370.

vii. Loading due to earthquake shall be assessed based on the provisions of IS: 1893 (Part I) and IRS seismic code, with latest revision.

viii. Loads and load combinations shall be for most unfavorable effects and shall comply with relevant Indian Standards including IS: 456 and IS:800.

ix. Overall stability and serviceability requirements shall be checked in accordance with the provisions of relevant Indian Standards.

x. All the buildings shall have provision for concealed ducts/pipes for wiring of telecom facilities in addition to the wiring for power supply and distribution. Concealed ducts/pipes for wiring of telecom & power supply facilities shall be provided in consultation with the Engineer.

xi. False ceiling shall be proposed at a clear height of about 3m in the rooms with air-conditioning facilities with a view to help in energy conservation.

xii. Station signages shall be designed as per IR standards.

xiii. Benches at platform shall be four-seater bench with backrest, with seat partition as per RDSO drawing no. RDSO/WKS/2018/2.

5.3.2 VAC Requirements for Station Building

Ventilation of station building shall be provided as per provisions of ISHARE / National building Code except for Signalling/ Telecommunication / UPS/ IPS/ Battery Rooms.

5.3.3 Other requirements

The minimum requirement of the facilities for Operation and Maintenance shall be as specified below: -

i. Amenities for persons with disability (PwD) shall be provided as per as per extant Railway Board instructions/guidelines. All platforms shall be accessible for disabled passenger on wheelchair. Tactile tiles shall be provided on platforms, subway, entry & exit and other places to guide the visually impaired person as per the Railway Board guidelines.

ii. In stairs, riser shall be kept maximum as 150mm (net height) and tread minimum as 300 mm (clear width) in the station area and inter-platform connectivity.

iii. Approach roads shall be designed for 450 commercial vehicle /day & for a design period of 30 years or more as per IRC:58-2015. Approach road shall have VDC of minimum thickness 250 mm.

iv. Covered underground RCC water storage tanks shall be provided at all the station having minimum capacity of 50,000 litres. Effective depth of tanks shall be kept about 1.5 m to 2.0 m.

v. RCC overhead water storage tanks shall be provided for a capacity of 20,000 litres at all the stations over RCC staging of suitable height as per requirements.

vi. Platform-

   a) All platforms shall be high level.

   b) Platform surface shall be smooth and provided with fiber reinforced Vacuum Dewatered Concrete (VDC) flooring of minimum M35 grade.

   c) End platforms shall be provided a slope of about 1:60 away from the track.

d) Platform coping shall be of approximate size of 1125mmx530mmx100mm prefabricated from M-35 or higher-grade concrete by vibro compaction in a factory under controlled environment.

e) Effluent from drinking water taps etc. shall be collected and disposed of safely through underground drainage system.

vii. Two underground HDPE pipes of 150mm dia with manholes at about 25 m interval along the length of platform shall be provided for electrical and S&T wiring etc.

Stairs and ramps shall be provided with self-supporting covering in accordance with Section VII-6: OCS.

5.4 Outline Design Criteria

5.4.1 Objective

The objective is to lay down the structural analysis & design of the proposed station building. It also incorporates the design process to establish the overall design philosophy to be adopted in the Analysis and design.

5.4.2 Statutory Requirements

The design of the Civil Structure will comply with the requirements of the following:

i. National Building Code.
ii. Local Building Regulations.
iii. Bureau of Indian standard codes.
iv. Indian Railway Standard
v. International codes as applicable.
vi. Any other regulation as per requirements.

5.4.3 Structural Design Requirement

The main considerations followed for the design of structure are:

i. Structure safety and stability.
ii. Functional suitability
iii. To meet the demands of aesthetics conceived by the architect.
iv. Availability of material, equipment and expertise.
v. Constructability and ease of maintenance.
vi. Durability.
vii. Economy

5.4.4 Structural Arrangement

The proposed building is considered to be of RCC frame structure with Isolated/ Strip /Raft/Pile foundations.

5.4.5 Loads

The structural members are loaded with various loads combinations during its services conditions. The loads on the structure are taken for analysis and design as per the relevant latest IS codes of practice.

i. Dead load as per IS: 875 (Part-1)

ii. Imposed live load as per IS: 875(Part-2)

iii. Wind loads as per IS: 875(Part 3)

iv. Seismic Loads as per IS: 1893

Dead loads comprise of the self-weight of all permanent construction including walls, slabs, beams, columns, water proofing treatment, water tanks, staircase, floor finish etc. Other super imposed loads shall be considered. The structure would be designed for earthquake resistance as per IS 1893, with due consideration for the structural detailing as per provisions of IS 13920 and SP 34.

(a) Dead Load (DL)

Dead load shall be based on the actual cross-sectional area and unit weights of materials and shall include the weight of structural members of the station building.

(b) Super Imposed Dead Load For NON-TRACK Area (SIDL)

For platform slabs, the following loads in SIDL shall be taken:

i. Floor finishes load shall be assumed minimum 3.6kN/m^2 uniform load as per architectural requirement.

ii. Suspension load shall be assumed minimum 2.0kN/m^2 uniform load (Suspension load will be considered as the load of false ceiling and services etc. This load will be considered wherever is applicable.

iii. Light partition wall load shall be assumed minimum 1.0kN/m^2 uniform load.

For concourse area, the following loads in SIDL will be considered:

i. Floor finishes load shall be assumed minimum 3.6kN/m^2 uniform load as per architectural requirement.

ii. Load due to additional fill in the toilets (brick bat) shall be considered as per architectural drawing.

iii. Suspension load shall be assumed minimum 2.0kN/m^2 uniform load (Suspension load will be considered as the load of false ceiling and services etc. This load will be considered wherever is applicable.

iv. Loads due to escalator / lift will be considered as per manufacturer's detail.

v. Light partition wall load shall be assumed minimum 1.0kN/m^2 uniform load.

vi. Loads due to solar panel shall be considered as 30 kg/m^2.

Notes:

The walls loading will be taken based on actual location shown in architectural drawings. External wall load/glazing load will be taken as per details provided in architectural drawings. It is proposed to take 230 mm thick brick wall with 20 mm thick plaster on either side. However, the same shall not be taken less than 2.4kN/m^2.

Above loads intensities are minimum loads to be considered in design, Actual load may be higher as per detailed architectural drawings.

(c) Live loads (LL)

Live loads shall generally follow the requirements of National Building Code and IS 875:(Part 2), except where the loadings given below are more severe:

(d) Earthquake Loads (EQ)

Location of proposal site lies in Zone IV. The design parameters shall be taken as per IS-1893.

Seismic Ductile detailing:

i. For RCC structures as per IS: 13920

ii. For other structures as per IS: 4326

(e) Wind Loads (WL)

Wind Loads (longitudinal & transverse) shall be calculated in accordance with IS 875: Part 3.

Design wind speed Vz(m/s) = 50m/s (As per NBC)

(f) Construction and Erection Loads (ER)

The weight of all temporary and permanent materials together with all other forces and effects which can operate on any part of structure during erection shall be taken into account. Allowances shall be made in the permanent design for any locked in stresses caused in any member during erection.

(g) Temperature Load (TL)

As per IS: 456. Temperature gradient shall be considered as per IRC-6, if applicable.

(h) Shrinkage & creep

Shrinkage & creep strain shall be evaluated as per IS: 456 for plain and RCC structures and IS: 1343 for prestressed concrete structures.

(i) Earth Pressure (EP) & Water pressure (WP)

In the design of structures or part of structures below ground level, such as retaining walls and underground pump room/ water tanks etc. the pressure exerted by soil or water or both shall be duly accounted for. When a portion or whole of the soil is below the free water surface, the lateral earth pressure shall be evaluated for weight of soil diminished by buoyancy and the full hydrostatic pressure. (As per IS: 875-part 5).

All foundation slabs / footings subjected to water pressure shall be designed to resist a uniformly distributed uplift equal to the full hydrostatic pressure. Checking of overturning of foundation under submerged condition shall be done considering buoyant weight of foundation.

If any of the structure supporting railway loading is subjected to earth pressure, the loads and effects shall be calculated in accordance with IRS substructure code.

(j) Surcharge Load (SL)

In the design of structures or the parts of the structures below ground level, such as retaining walls & underground pump room/ water tank etc. the pressure exerted by surcharge from stationary or moving load, shall be duly accounted for. For the area approachable by road traffic, the minimum live load surcharge shall be taken as 24 kN/m^2.

(k) Other Forces and Effects

As per IS: 456.

5.4.6 Deflection Criteria

The deflection limitations as per IS: 456 for Plain and RCC Structures.

5.4.7 Settlement (DS)

Maximum and differential settlement shall not exceed, as provided in Table 1 of IS: 1904. The allowable settlement for pile group is 25mm (as per IS 2911-part 4).

5.4.8 Lateral Sway

The lateral sway at the top of the building due to wind loads should not exceeds H/500, where 'H' is the height of the building.

5.4.9 Load combinations

For loadings, load combinations, analysis, and design of structures, all relevant IRS, IS, IRC and other relevant codes shall be followed.

i. For steel structures, the load combinations shall be as per IS: 800.

ii. For RCC structures / elements, shall be as per Table 18 of IS: 456.

5.4.10 Materials

i. Cement

For plain and reinforced concrete structures cement shall be used according to IS: 456. For PSC structures IS: 1343 shall be used.

ii. Concrete

The minimum grade of concrete shall be as per IS: 456 for Plain and RCC structures and IS: 1343 for PSC structures.

Concrete & Short term modulus of elasticity (Ec) shall be as per IS: 456 in case of Plain and Reinforced Concrete structures and as per IS: 1343 for Pre-stressed concrete structures.

The modular ratio for concrete grades shall be taken as per Annex B of IS: 456.

iii. Density

(a) 25 kN/m^3 for Reinforced concrete & Prestressed concrete

(b) 25 kN/m^3 for Plain concrete

(c) 26 kN/m^3 for wet concrete

For density of strands and all other materials, the densities shall be considered as per IS Codes.

iv. Structural Steel

Structural steel used shall conform to following:

(a) Hollow steel sections as per IS: 4923

(b) Steel for general Structural Purpose as per IS: 2062

(c) Steel tubes for structural purpose as per IS: 1161

(d) Design of steel structure will be governed by IS 800. In case of composite (steel- concrete) structure it will be governed by IS: 11384 & IS: 3935

(e) Fabrication shall be done in accordance with IS: 800

v. Reinforcement Steel (Rebars)

High strength deformed (HYSD) reinforcement bars of Fe-500D grade, conforming to IS 1786 and Clause 4.5 & 7.1.5 of IRS-CBC shall be used.

Young's Modulus = 200,000 Mpa

Yield Stress(fy) = 500 MPa.

Density = 78.5 kN/m3

5.4.11 Reinforcement Detailing Reinforcement Detailing

All reinforcement shall be detailed in accordance with IS: 456 & SP: 34 for plain and reinforced concrete structures and IS: 1343 for PSC structures.

The ductile detailing of seismic resisting RC elements shall comply with ductile requirements of IS: 13920.

5.4.12 Durability

Durability of concrete shall be as per IS: 456 for Plain & RCC, as per IS: 1343 for PSC elements and as per IS: 800 for steel structures.

5.4.13 Cover to Reinforcement

From durability consideration, exposure condition is assumed to be moderate. The clear cover to main reinforcement shall be considered in the design, satisfying durability & 2 hrs. fire rating requirement, which shall be as follows (clause No. 26.4.2, Clauses 21.4-,26.4.3 and Fig 1 of IS 456-2000)

A	Footing	50 mm
B	Columns	40 mm
C	Floor/Roof Beams	30 mm
D	Floor /Roof Slab	25 mm
E	Lintel Beams, Chajja & Loft	15 mm
F	Staircase Waist Slab & Landing	25 mm
G	Plinth Beam	40 mm
H	Walls	25 mm

5.4.14 Fire Resistance Period

All the structural elements shall be designed for a minimum period of fire resistant of 2 hour. The minimum element thickness for fire resistance shall be as per IS: 456 for concrete structures and as per IS: 800 for steel structures.

5.4.15 Crack width Check

All structural concrete elements shall be designed to prevent excessive cracking due to flexure, early age thermal and shrinkage. Flexural crack width shall be checked in accordance with IS: 456 for Plain and RCC structures and IS: 1343 for PSC structures. Crack width should not exceed 0.25 mm unless otherwise specified. Crack width for water retaining structure 0.2 mm as IS 3370.

5.4.16 Computation Methods – Modelling, Analysis, Design & Detailing

i. Modelling

The structure is idealized as a 3-D space frame model using the software packages STAAD pro/ Midas. The masonry wall is used as filler wall and not cast monolithically with structure. Hence this is not modelled in the analysis. In this packages slab loads are applied as a floor loads. Wall loads are applied as UDL on beams. Self – weight is added in the software to have member loads.

The analysis of the proposed structure would be carried to

(a) Analyse to ensure elastic behaviour and fulfilment of serviceability criteria for un-factored load combination.

(b) Analyse to ensure adequate structural integrity for factored load combinations

(c) Obtain static displacements and rotations at various nodes.

(d) Obtain resultant member forces like bending moments, shear forces and axial forces.

(e) Support reactions (axial force and moment) coming on foundations.

ii. Control of Deflection (Vertical)

The deflections of a structure or part thereof shall not adversely affect the appearance or efficiency of the structure or finishes or partitions. The deflections shall generally be limited to the following (Clause 23.2 of IS 456-2000):

(a) The final deflections due to all loads including heat effects of temperature, creep and shrinkage and measured from the as-cast level of the supports of floors, and all other horizontal members, should not normally exceed span/250.

(b) The deflection including the effects of temperature, creep and shrinkage occurring after erection of partitions and applications of finishes should not normally exceed span/350 or 20 mm whichever is less. When deflections are required to be calculated, the method given in Appendix – B of IS: 456-2000 will be used.

5.4.17 Design Philosophy

To meet the design life and durability requirements, codal provisions specified in clause 8.0 and table 5 of IS: 456- 2000 will be followed for reinforced Concrete Elements. All structural elements would be designed according to the Limit State Method as specified in IS: 456: 2000. M 35 grade of concrete shall be considered for design of all structural member. Along with specified analysis package, design sheets in MS Excel format shall be submitted as per Employer's requirement.

i. Design OF FLOOR / ROOF SLAB

All floor/roof slabs be designed in accordance with Annex- D of IS: 456-2000 with corners held down. Cranking of reinforcement at the support will be provided. Torsion reinforcement will be provided at corners of the slab as per clause D-1.8 of Annex-D of IS: 456-2000.

The beams shall be designed for the envelopes of maximum bending moment and shear force for the load combination that gives the maximum stresses using the STAAD Pro2006 software as per the requirements of IS 456-2000. The critical members would be check manually also. Main reinforcement will not be bent-up and hence shear reinforcement shall be in the form vertical stirrups only.

ii. Design Of Columns:

The columns shall be designed for vertical load (reduced in accordance with clause 3.2 of IS: 875 (part-2-1987) and uniaxial or biaxial bending depending on its location. Effective length of the column will be in accordance with Annex- E of IS: 456:-2000, considering fixed end on both ends. Minimum diameter of longitudinal steel is 12mm and that for ties is 8mm. The columns shall be designed for the envelopes of maximum value as per STAAD Pro/Etab. The critical members would be check manually also.

iii. Design Of Footings

Assume 10% of the vertical load from the column as the self-weight of the footing a preliminary step for the design. The same shall be checked after designing the footing dimensions. The plan size of the footing will be determined on the basis of the SBC of the soil. The design pressure at the base of the footing shall be determined by algebraic addition of the pressure due to vertical load and that the due to moment at the base of the column. The design pressure shall be less than SBC of soil except when seismic load are considered, Where SBC can be increased as per Table-1 of IS: 1893-2016.

Base pressure = (P/A)+/-(Mx/Zx) +/- (My/Zy)

Where,

P = Vertical load on the footing;

A = Plan area of the footing;

Mx and My = Bending moment at the base of the column along the X and Y directions;

Zx and Zy = Sectional modules of the footing along the X and Y directions = $ab^2/6$ or $ba^2/6$; and

a & b are the dimensions of the footing.

The footing shall be designed in accordance with clause 34 of IS:456-2000. The footing will be checked for the following:

(a) Bending moment at a section on the face of the column /pedestal

(b) Shear force at a section at a distance equal to effective depth of the footing from the face of the column or pedestal.

(c) Bearing stress on the footing due vertical load of the column.

(d) Punching shear on the footing due to vertical load of the column.

The reinforcement will be determined as a rectangular section in accordance with Annex-G of IS:456-2000 and SP-16.

iv. Design Of Lintel Beams, Chajja & Loft

The lintel beams will be designed for:

(a) Weight of brick masonry above the lintel level

(b) Load from RCC Chajja attached to the lintel.

(c) Torsion moment due to eccentricity of the Chajja/loft.

Lintel beam shall have a minimum bearing equal to the thickness of the wall on which it is supported or the depth of the lintel beam, whichever is greater. It shall be designed as a simply supported rectangular section. Chajja/loft will be designed as a cantilever slab.

v. Design Of Staircase

The Internal staircase shall be designed in accordance with clause 33 of IS: 456-2000. The Staircase is slab type without stringer beam. The waist slab shall be designed as a simply supported rectangular section. The size of main reinforcement steel shall not be less than 12mm. The staircase would be analysed, designed & detailed as per the provisions of SP-34.

vi. Design Of Overhead Water Storage Tanks

Overhead water storage tanks shall be designed to sustain the water load at full tank condition as per the provisions of IS: 3370 (Part 1- Part4).

vii. Expansion & Construction Joints:

Seismic Expansion joints are recommended when structure exceeds 45m length. The width of the joints is being calculated as per Clause7.11.3 of IS-1893 .

viii. Detailing

The reinforcement layout should take into account the strength requirements as well as the economy of construction.

Following are the requirements of good detailing:

(a) Reinforcement detailing should be simple for fabrication and placing.

(b) Cracking of concrete should be within the permissible limits

(c) There should not be any free paths for propagation of cracks without being traversed by reinforcement

(d) Joints and discontinuities should be capable of withstanding the same forces as the adjoining sections

(e) Reinforcement should not deviate excessively from the direction of tensile stresses

(f) Reinforcement steel of same type and grade shall be used as main reinforcement in a structural member.

(g) Provisions of IS: 456, IS 13920 and IS: SP 34 will be followed for the purpose of detailing of reinforcement.

5.4.18 Design of Underground water storage tanks

Underground water storage tanks at stations shall be designed as a water retaining structure based on IS: 3370. Underground water tank would be designed to sustain the following two cases-

(a) Tank full and No earth fill

(b) Tank empty and active earth pressure acting from outside.

Various types of loadings shall be considered in the design of the underground tank. The side walls shall be subjected to earth pressure. Wherever encountered, horizontal pressure due to water table shall also be considered. Stability of water tank shall be checked against buoyancy and foundation raft shall be designed for the worst of buoyant force and soil pressure.

The tank shall also be designed for surcharge loading if any. Water proofing treatment shall be done on the external surface as well as in the internal surface.

5.4.19 Masonry Walls

All Masonry walls shall be treated as non-structural infill panels and shall be treated as one way / two way slab panels spanning between adjoining beams and columns to check structural safety. Masonry walls shall be designed as un-reinforced masonry as per IS: 1905 and IS: 4326. Shear connector reinforcement between walls & beams and walls & columns shall be provided for external wall while the internal partition walls shall be connected with roof slabs/beams using dry packing mortar between top of walls and soffit of slab / beam.

5.4.20 Subway And Lift Wells

Subway shall be designed to cater to DFC loading (32.5T) from the tracks along with the other loads from the platform. The requirements/criteria laid down in clause 4.1 & 4.2 for the design of Box bridges shall be followed for the design of Subway. Subways and lift wells shall be placed on firm strata. Conceptual base arrangement has been shown in Tender drawings.

5.5 Codal Preference

The design shall be carried out as per provision of these design specifications. Reference shall be made to the following codes for any additional information:

Order of preferences of codes shall be as follows:

(a) Bureau of Indian Standard codes

(b) Indian Railway standard

(c) National Building Code

(d) IRC

(e) BS or Euro Codes

(f) AASHTO

(g) Any international code with approval of HRIDC.

6 OUTLINE DESIGN SPECIFICATIONS: RETAINING WALLS

6.1 General

This part lays down criteria for design of Retaining Wall.

6.2 Details of Structures to be designed

The Contractor shall design the retaining walls of various heights that are required in this Package.

Retaining wall is required to be provided at some of the locations along the alignment due to limited availability of ROW. On DFC side (i.e. on RHS) of main line or connectivity line, no retaining wall shall be provided except at locations where private land/any structure falls between HORC ROW and DFC/KMP ROW.

Minimum grade of concrete for cast in-situ retaining wall shall be M 35. Reinforced Earth wall (RE wall) shall not be permitted in railway embankments.

6.3 Design Criteria

a) The earth retaining structures, if required, shall be designed as per IRS Bridge Substructure and Foundation Code as per the following criteria:

   i. In case the location of the earth retaining structure is within Axle Load Impact Line, it shall be designed for earth pressure as well as surcharge due to DFC loading (32.5T axle load).

   ii. In case the location of the earth retaining structure is beyond the Axle-Load Impact Line, it shall be designed for retaining the earth.

b) Joints between the segments shall be properly designed for required lap length also.

c) Expansion joints shall be provided at an interval not exceeding 30m.

d) Benefit of passive earth pressure shall not be considered upto foundation bottom level while checking for stability of retaining wall.

7 REINFORCED EARTH WALLS (RE WALLS)

7.1 General

Reinforced Earth Walls shall be designed as per IRC: SP:102-2014. In addition to normal principles of design of earth retaining structure, Reinforced Soil Structures shall consider the interaction between soil and reinforcement.

Properties of retained soil/fill and test to classify the reinforcement shall be determined before proceeding with design. Angle of internal friction of reinforced earth fill shall not be less than 30degree. Lateral earth pressure shall be evaluated based upon the category of reinforcement as extensible or inextensible.

Soil reinforcement to be used shall be of Polymeric strip elements or metallic strip type.

Facing elements shall be of precast reinforced concrete panels with good architectural finish.

7.2 Analysis

The analysis shall be conducted in two parts:

i. External Stability
ii. Internal Stability

External Stability shall address the stability of the reinforced block as a unit, while Internal Stability shall address the transfer of lateral pressures to reinforcement and related mechanisms involved. "Tie back wedge method" and the "coherent gravity method" shall be used for analysing internal stability. Reduction in lateral pressure and tension due to cohesion shall not be considered and neglected since cohesion may be lost under certain conditions.

Limit state approach using partial safety factors shall be used for design of reinforced soil structures and structural elements also.

7.2.1 External Stability

External stability of the reinforced soil mass/block is checked for three different conditions: -

i. Bearing and tilt failure

The design of a Reinforced Soil Wall must ensure sufficient margin against bearing and tilt failure, with a Factor of Safety of at least 1.4. If bearing capacity is not adequate, ground improvement measures must be undertaken. Excavation in front of walls after construction is prohibited. Beam and anchor rods at the toe of the wall shall be adopted, if required, to ensure adequate lateral resistance towards sliding.

ii. Sliding and overturning

Factor of Safety towards sliding and overturning due to lateral pressures imposed should be adequate. FS of at least 1.2 in the limit state should be achieved.

iii. Global stability

The design of a Reinforced Soil Wall must ensure global stability, with a Factor of Safety (FS) of at least 1.30 under static conditions and 1.10 under dynamic/earthquake loads, considering un-factored load. The analysis shall check for possible failure modes, including the possibility of deep-seated failure. Global stability analysis shall be carried out using standard software capable of modelling reinforcement, different wall geometries, and failure modes.

7.2.2 Internal Stability

i. Tie Back Wedge Method

The maximum ultimate limit state tensile force T to be resisted by a particular layer of reinforcement is the summation of lateral pressure arising due to self-weight of the fill, surcharge caused by external loading, strip loading applied on top of the fill, and shear applied at the contact of the strip loading. Tensile force per running length can be calculated using the expression in IRC:SP:102-2014.

ii. Coherent Gravity Method

For the ultimate limit state and serviceability, the lateral earth pressure coefficient K is taken as Ko at the top and linearly reducing to Ka at 6.00 m and below this depth. In case of inextensible reinforcement, the lateral earth pressure coefficient Ko at top should be taken as 1 - sin (ø) to Ka at 6 m depth. Tensile force per meter adherence capacity of the reinforcement and long-term rupture should be checked.

For both the methods described, global stability checks should be carried out in addition to local stability checks. As far as rupture is concerned, it should be ensured that the strength of the reinforcement at the end of the design life is greater than the tensile force to be resisted.

The check for rupture should be carried out for both methods (tie-back and coherent gravity). The minimum length of reinforcement shall be 0.7 H or 3 m, whichever is more, where H is the design height of the RS Retaining Wall.

Some reinforced soil walls use a passive block at the end of the reinforcement to derive the benefit of passive resistance in resisting tension. However, full passive resistance should not be taken in design since the strain required to mobilize it is large. Only 20% of passive resistance may be included in design calculations.

7.3 Partial Safety Factors for Material and Load

Partial safety factors for material and load shall be as per Clause 5.3 of IRC: SP102-2014.

7.4 Serviceability and Settlements

Settlement of the founding soil and compression of the reinforced mass contribute to the total settlement of a reinforced soil structure. Settlement of the founding soil can be estimated by conventional theories. Post construction settlement should not exceed 100 mm for discrete panels/blocks.

Facing should be able to cope with internal compression. The fascia should resist safe vertical movements of 1 in 150. Differential settlement of 1 in 100 is considered safe for discrete concrete panel facings (1 in 500 for full height panels).

7.5 Spacing and Layout of Reinforcement in Reinforced Soil Walls

The spacing of reinforcement in reinforced soil walls should be established based on design principles and adhere to the guidelines provided in Clause A2 of MORTH-2013.

The vertical spacing of primary reinforcement should not exceed 800 mm for all types of reinforcement. The maximum height of facing above uppermost reinforcement layer and below the lowermost reinforcement layer does not exceed 400mm in case of panels.

While the primary reinforcement carries tensile forces in the reinforced fill, secondary reinforcement may be required to protect the slope face from local sloughing and instability depending on the facia configuration. If secondary reinforcement is used, stability near the slope face should be checked separately.

8 OUTLINE DESIGN SPECIFICATIONS: BALLASTLESS TRACK (BLT)

8.1 General

i. HORC proposes to adopt BLT systems, which are proven and successful operation worldwide in railways. The proven design may require some modifications to suit HORC conditions.

ii. Operating Regime on HORC:

a) Axle load and Speed

Traffic Type	Axle Load	Speed
Goods Train	25T	100 kmph
Passenger Train	22.5T	160 kmph

b) Electric Traction (Minimum) : 2 x 25 kV AC.

c) Track Circuits : AFTC/DC.

d) Gauge : Broad Gauge BG, Nominal (1673mm)

e) Ambient Temperature : (-) 15˚C to 50˚C.

f) Rail Temperature : (-) 15˚C to (+) 76˚C.

g) Humidity : 100%

Note: The temperature range shall be commensurate with other provisions / guidelines through codes / manuals / specific circulars.

8.2 Design Requirements

i) BLT shall be designed for the following:-

a. Goods Traffic - 25T axle load & speed 100 kmph

b. Passenger Traffic- Main line for 22.5T axle load & speed 160 kmph (for passenger traffic)

ii. Dynamic augment may be taken as 2.5 (as prevailing on IR).

iii. Spacing of supports to rails – preferably at every 60 cm (wherever rails are supported on sleepers/ discrete supports) so that the permissible bending stress in rails are not exceeded beyond stipulated values. No joint shall be permitted in track on BLT and the transition portion. The values of permissible bending stress are as under:-

For LWR section – 25.25 km/mm².

iv. Upward reaction / pressure from support base shall be clearly mentioned in design.

v. Design shall be as per relevant codes of practice such as BIS, EN, IRS, IRC and

UIC with latest revision/ edition. If for any item/work, above mentioned codes are not relevant, best available Engineering practice / International codes shall be mentioned.

vi. Design & detail of suitable Transition System for smooth transition from ballasted track to BLT on both ends shall be part of the design of ballastless track.

vii. Design and detail of Expansion / Construction Joints in BLT at suitable intervals shall be part of the design of ballastless track.

viii. Technical parameters required for foundation of BLT shall be suitably considered for site conditions and shall be mentioned in the design along with their test code & procedure, A design monograph of varying sub-grade characteristics, if applicable, to be provided by the firm / designers.

ix. Concrete for RCC structures shall comply with relevant para of Indian Standard IS: 456-2000 & IRS-Concrete Bridge Code taking care of relevant durability clause for expected life of RCC structures as per clause 15.1.3 of IRS-Concrete Bridge.

x. BLT may get submerged during heavy rainfall. Suitable arrangement shall be provided for ensuring that BLT functions properly under submerged conditions. Provision of adequate cross slope for drainage purposes and suitable measures to prevent ingress of water must be considered. Design of proper drainage arrangements, preferably sub-surface drains for BLT shall also be part of design. Top surface of BLT shall have surface finish with proper cross slope such that there is no stagnation of water over it.

xi. No appreciable cracks or settlements or separation of parts shall be developed during service in the BLT leading to impaired service or failure. Minimum reinforcement must be ensured to achieve design crack width of 0.1 mm notwithstanding any provision in codes.

xii. BLT shall be designed for almost maintenance free conditions except replacement of worn-out fastening components after their service life is over. 10% of the fastening components and other replacement items which are likely to be worn out / damaged, shall be supplied as spares for need based replacement in this work. The offer shall be inclusive of the cost of 10% fastening components as spare. No additional cost shall be paid for the spares.

xiii. Stable formation is required to be provided below BLT as per the RDSO guidelines (No. RDSO/2020/GE: IRS-0004). Minimum bearing capacity at subgrade top level of 10 tons/sq.m shall be ensured.

xiv. The proposed system shall be easy to repair and expeditious to restore in case of damage due to derailment. The time & material requirement for repair shall be clearly defined along with detailed procedure of repair.

xv. A scheme giving details of the curing arrangements shall be submitted by the designer to ensure curing in conformity to the IRS- concrete Bridge Code and best international practices.

xvi. Adequate corrosion protection measures must be included in design to minimize corrosion of fastening components of proposed system for ballastless track. Test report of the proposed fastening system shall be submitted as per EN 13146-6: 2012 –Test methods for fastening system – Effect of severe environmental conditions and corrosion test shall be done as per EN ISO 9227/ASTM B117-11, Corrosion tests in artificial atmospheres – salt spray tests or as per international standards in practice.

xvii. The design shall be cost-effective, serving all functional requirements expected of BLT.

xviii. Any other factor considered necessary by the designer.

Changes in the above parameters (ii) and (iii) may be considered, in case the Contractor is able to support it with the relevant documents and codes as per practice in other Railways.

8.3 Track Details

BLT for HORC shall be designed for following track details:-

i. Rail section: Rail profile shall conform to UIC 60 (R260) and Rail material shall conform to IRS-T-12-2009 class-'A' including manufacturing and testing in accordance with IRS-T-12-2009 with latest amendments.
ii. Schedule of Dimensions (SOD) and Maximum Moving Dimension (MMD) of Indian Railways for BG shall be followed.
iii. Rail cant at Rail seat (inward): 1 in 20.
iv. Traffic: Mixed – passenger & freight.
v. During service if some parameter goes out in case of any unforeseen circumstances, the leeway / margin available to correct the parameter. Vertical: +10 mm / - 3mm, Horizontal: ± 3 mm.
vi. Design temperature range: 70 degree celsius variation of rail temperature as per zone & chart of Indian Railway Permanent Way Manual and 40 Degree variation of ambient temperature.
vii. Long welded rails (LWR) are to be used. The entire ballastless track shall be designed as LWR including viaduct and its approaches. The proposed design of BLT shall take into consideration the forces due to LWR and interaction of LWR.
viii. It should be possible to do in-situ AT/Flash Butt welding as per the Indian Railways welding manuals.
ix. Track tolerances: Track tolerances over BLT when installed and later during service under floating condition shall be as under.

Note: The temperature range shall be commensurate with other provisions / guidelines through codes / manuals / specific circulars.

TABLE NO: 1

S. No.	Parameter	Installation	Service

1	Gauge (with reference to 1673 mm measured below 14 mm rail top) for straight track and for curve up to the radius of 350 m.	± 1mm	± 3mm
2	Cross level on straight and curved track	± 1 mm	± 3mm
3	Variation in versine on curved track(20 m chord with half overlapping)	± 3 mm	± 6mm
4	Vertical alignment over a 3.6 m chord	± 1 mm	± 6 mm
5	Lateral alignment over a 7.2 m chord	± 1 mm	± 3 mm
6	Twist on 3.6 m base	± 1mm	± 5mm

The above installation parameters are not sacrosanct and the Contractor can also advise their own limits for the above parameters along with basis for suggesting the changes. Variation in horizontal alignment, vertical alignment, versine, twist and gauge shall not exhibit cyclic pattern.

8.4 Traction Details

HORC has Overhead Electric (2x25kV) traction. The BLT design shall have adequate electrical insulation for correct performance of signalling and traction equipment even in flooded condition during monsoon and the design should take care of return current as per traction.

8.5 Signalling Details

For signaling, the track circuiting is provided through the rails. The BLT system should take care of the same with adequate insulation. A minimum electrical resistance of 4 Ω per km as per Indian railway signaling manual needs to be ensured.

8.6 Derailment Guards

Suitable arrangements for prevention of derailment in tunnels/ viaducts as per instructions issued by Indian Railway from time to time in the form of derailment slab/ block shall be provided to keep the derailed wheels in confined space and prevent damage in case of derailment. The derailment guard should be constructed between the rails so that it permits less sway of the rolling stock away from the track. The lateral clearance between derailment guard and face of running rail should be as per IRPWM-2020including all updated correction slips published by IR with latest amendments and clear of fastenings to permit installation, replacement and maintenance. Derailment guard shall be designed such that in case of derailment:

i. The wheels of a derailed vehicle under crush load, moving at maximum speed are retained on the viaduct or tunnel etc.
ii. Damage to track and supporting structures is minimum.

8.7 Ballastless Track Structure

Track shall be laid on cast in situ/precast reinforced plinth or slab or sleepers, herein after referred to as the "Track slab". The track slab shall be designed as plinth beam or slab type ballastless track structure with derailment guards. It shall accommodate the base plates of the fastening system. The minimum depth of concrete below the base plate should be decided based upon characteristics of underlying base and the design of the fastening system in general, track slab/sleeper on which the fastening and rail are to be fitted shall:

i. Resist the track forces.
ii. Provide a level base for uniform transmission of rail forces.
iii. Have geometrical accuracy and enable installation of track to the tolerances laid down.
iv. Ensure drainage.
v. Resist weathering.
vi. Be construction friendly, maintainable and quickly repairable in the event of a derailment. The Repair and Maintenance methods shall be detailed in the Maintenance Manual.

Ensure provision for electrical continuity between consecutive plinths/slabs/sleepers by an appropriate design.

8.8 Performance Required of Fastening System

8.8.1 General

i. The fastening shall be designed to hold the two rails of the track strongly to the supporting structure in upright position by resisting the vertical, lateral and longitudinal forces (including thermal forces) and vibrations.
ii. The fastening shall be with a proven track record. Fastening system should have satisfactory performance record of minimum 5 years in service in BLT on any established railway system. In this regard, supplier should submit certificate of performance from user railways administration including proof of use of the fastening system.
iii. The fastening shall provide insulation to take care of return current traction system.

Fastening shall satisfy the required performance norms as stated in the following paragraphs.

8.8.2 Technical Performance Requirements of Fastening

The fastening shall-

i. Have design service life of 15 years in general. However, individual components of the fastening system can be designed for 500 GMT or 15 years whichever is less.

ii. Anchor bolts or studs used for fixing base plate to the concrete should not be required to be replaced during service life. Its components must not suffer any degradation during service life to a degree so as to affect the performance and safety of the track. Full service life is to be attained under the following condition-

a. Atmospheric ultraviolet radiation

b. Proximity of track up to 10 km from salt water source

c. Contact with oil, grease or distillate dropped from track vehicles

d. Continuous exposure to water/toilet droppings from rail coaches.

iii. Hold the rails to gauge and at the correct inclination within, tolerances laid down against horizontal forces generated by vehicles in motion especially on curves, and wheel set hunting, alignment irregularities and thermal forces.

iv. Permit quick and easy installation and replacement with special tools.

v. Be capable of vertical adjustment during service life up to 12mm using shims.

vi. Given severe corrosive environment, fall of distillate matter from trains over track, requirement of ease of cleaning of concrete slab and fasteners in platform section, it is preferable to have fastening system with fewer parts/components and less creeping surface.

vii. Detailed calculations for the number of anchor bolts required on tangent and curved tracks shall be furnished by the contractor and approved by the Engineer.

viii. For all the fastening components as per approved assembly, the contractor shall furnish detail drawings, specifications and inspection & test plan to the Engineer.

ix. The Contractor shall furnish the 'Installation and Maintenance Manual' which shall be approved by the Engineer.

8.9 Testing of fastening system

The testing of fastening system including its components is to be done for Cat "C" requirement as specified in EN-13481- part-1 & EN-13481-Part-5 (Latest Version) to suit HORC project requirements with 60 kg rail section. The test plan and testing criteria of Fastening system should meet the permissible values in IRPWM 2020 including all updated Correction slips published by IR. The test report should be accompanied with the drawing of the fastening system including its component which have been tested and reported upon.

8.10 Random Testing of fastening system

The Engineer shall get the random testing of the fastening system after it has been supplied from a reputed test lab and system should be able to meet the requirements as mentioned in this document. Cost of the same shall be borne by the Contractor.

8.11 RSI studies for Viaduct proposed to be laid with BLT

The Contractor should submit RSI studies for viaduct proposed to be laid with BLT as per IR instructions for assessment of the continuity of LWR proposed over viaduct as per UIC 774-3R, BS 114 & Indian Railway Bridge Rules and design the BLT accordingly as per RSI studies.

8.12 Spares

The Contractor shall supply spare track fastening components equal to 10% of the total requirement for the permanent works.

8.13 Maintenance and Performance Monitoring

The defect liability period will be 3 years from the date of opening of traffic.

After construction of ballastless track, Engineer/Employer will monitor the performance jointly with the Contractor on a quarterly basis & for three years. The performance monitoring will be based broadly upon following parameters:

i. Efficacy of fastening: Fastening system should be able to maintain track geometry (gauge, cross level, loose fittings etc.) at all times within track tolerances during services without any components breakage, excessive wear & tear.
ii. Track tolerances to be maintained at the time of construction & during trial/service should be as per para 7.3.
iii. Any track settlement which impairs the functionality of track.
iv. Any visible crack of width more than as stipulated in IRS Concrete Bridge Code-para 10.2.1 in concrete/ RCC portion of slab which impairs the functionality of ballastless track.
v. Efficacy of drainage system e.g. the slope and drains constructed should function properly even during monsoon period.
vi. Any special observation.

8.14 Third Party checking of BLT design

The design of BLT system shall be got checked by the third party engaged by the Contractor and approved by the Engineer. Duly proof checked design and drawings shall be submitted to the Engineer for final approval. The cost of third party checking shall be borne by the Employer.

Third party engaged by the Contractor shall has experience of designing/proof checking for atleast 5years of BLT which is in operation for a minimum length of 10km, with minimum operational axle load of 22T and operational speed of 100km/h.

9 RAILS

9.1 General Requirements

All the rails to be laid in the track structure shall be Flat Bottom Rails as per specifications: IRS T12-2009 including up to date correction slips. Only new rails will be used for the permanent works. The broad requirements are as below:

Rail Steel Grade: R350

Rail Section Profile: As per Appendix-II (Revised) of IRS T12-2009 for 60E1

Class of Rail: A

Length of Rails: 13m/26m

Rail Ends: Undrilled

Colour Code: As per Appendix IV of IRS T12-2009

9.2 Class of Rails

All running rails shall be brand new Class 'A' rails.

Guard rails may be new Class 'IU' rails

9.3 Rail Manufacturer

The rails shall be procured from RDSO approved manufacturer.

9.4 Rail Steel Parameters

Rail steel of Grade R350 and of 60E 1 section shall conform to the chemical composition & mechanical properties as specified in IRS T12-2009 specifications of Indian Railways.

9.5 Rail Section, Marking & Dimensions

Rails of 60E1 as per Appendix-II (revised) of IRS T12-2009 shall conform to the dimensions, dimensional tolerances including geometrical defe**cts,** markings and shall be subjected to **t**he measurements and tests specified therein.

While handling and transportation of rails, guidelines issued by IR on this important aspect shall be strictly followed. This, among other things includes providing suitable dunnage/spacers to protect rails against point contact and the protection of rail ends. Availability of proper facilities for handling of rails at rehandling points shall be ensured.

A method statement describing in detail the precautions that will be taken during handling and transport of rails and the supervision that will be exercised in ensuring compliance of the right procedures, will be submitted to the engineer for his approval.

The engineer at his discretion will inspect the rails on arrival at site against any bruising, rubbing nicks and any other damage, reject them and order for their removal from site, if found damaged.

The guidelines issued vide RDSO drawing no. RDSO/T-6219 will be strictly followed.

Normally only standard-length rails should be used for the permanent works. The shorter rails may be permitted, if they are not more than 2m shorter than the standard length subject to the proviso that such rails should be supplied in pairs to be used opposite each other. However, number of such rails should not exceed 10% of the total requirement for permanent works.

9.6 Defect Free Rails

The rails must be free from all detrimental defects having an unfavourable effect on the behaviour of the rails in service, such defects include, among others, surface defects & internal defects like cracks of all kinds, flaws, piping, or lack of metal, hot or cold marks, seams, scabs, protrusions etc.

The rails having defect beyond the specified limits, shall be rejected.

9.7 Inspection and Acceptance

M/s RITES shall be the inspecting agency for rails. Inspection/testing charges shall be borne by the Contractor.

The representative(s) of the Engineer and the Employer shall be entitled to observe, by day or night, the method of manufacture and to be present at all tests relating to all batches of casting for this project and to examine the results obtained from such tests.

The manufacturer shall, at his own expense or at the expense of the Contractor, supply all templates & gauges, prepare and supply test pieces and sample of steel, sample of rails, and supply labour and apparatus/equipment, for testing which may be required by the inspecting agency for carrying out all tests as specified in IRS T12-2009 specs, and render reasonable assistance in execution of such tests as desired by the inspecting agency.

9.8 Method of Payment

Calculated weight of rails as given in appendix II (revised) of IRS-T12-2009 shall be regarded as actual weight of rails and payment shall be made as per these weights.

9.9 Warranty

The Contractor shall provide warranty as per the provisions of IRS-T12-2009.

10 CONTINUOUSLY WELDED RAIL (CWR) OVER VIADUCT

10.1 General

Rail panels, after laying in track, shall be welded to make Continuously Welded Rail (CWR) track for as much length as possible, for which the Contractor shall prepare the CWR plans for the approval of the Engineer in advance under design submission schedule in accordance with the design principles/provisions contained in IRPWM.

10.2 Rail Laying Temperature

10.2.1 The project length falls in temperature zone IV in India as per fig.3.6 in IRPWM. The de-stressing temperature will be determined on the basis of the data furnished in figure 3.6 of IRPWM.

10.2.2 CWR track lengths installed outside this temperature range shall be de-stressed.

10.2.3 Neutralization of the stresses in the rails during construction shall be carried out as required by the provisions of the IRPWM.

10.2.4 Rails after de-stressing shall be checked by a non-destructive rail stress measuring equipment to verify the correctness of the de-stressing temperature. The Contractor shall arrange such testing equipment in adequate numbers on its own, which shall also be made available to the Engineer for this purpose. The details of the equipment and its performance characteristics will be submitted to the Engineer and his approval obtained before it is put to use.

10.2.5 The Contractor shall submit detailed process of neutralisation of stresses in the rails during construction ensuring that the rails in track remain de-stressed in the prescribed temperature range and shall form part of CWR plans submitted by the Contractor in accordance with 10.1 above.

10.3 Welding of Rails

10.3.1 Only rail panels having a length of not less than 260m except approved by the Engineer would be installed in the track which shall be converted to CWR through in-situ welding. In-situ welding shall also be carried through mobile flash butt welding plants. Conversion of single rails to 260m long panels would be done on cess using flash butt welding plant. Rails would be welded as per the provision of Indian Railway's Manual for Flash Butt Welding of Rails-2012 (herein after referred as FBW Manual).

Locations where the use of Mobile Flash Butt welding is not practical, Alumino Thermic (A.T) SKV process may be used with prior permission of the Engineer. AT welding will be done as per the procedure and specifications laid down in the latest edition of Manual for Fusion Welding of Rails by the Alumino-Thermic Process read along with the latest amendment slips.

10.3.2 The use of rails with holes shall not be allowed unless specifically permitted by the Engineer for specific locations. Drilling of holes of different sizes would be required for the purpose of earthing, bonding etc. These holes would be drilled by the System

Contractor. All the interfacing requirements required for drilling holes shall, however, be part of the contractor's responsibility. Wherever holes in the rails are made, they shall be suitably hardened for their fatigue improvement by the Contractor using well established cold rail hole expansion technology. The methodology for the same shall have the prior approval of the Engineer.

11 CODES & STANDARDS

11.1 General

The Contractor shall carry out the design on the basis of the codes and specifications given below. The list of codes mentioned herein is only for guidance. The Contractor may supplement these codes and standards with the consent of the Engineer if in his opinion it is essential to do so to comply with the Employer's Requirements.

The Contractor shall be responsible for detailing in his design report and specifications the standards on which his materials and workmanship will be based and these will be of similar or higher standard than those listed below.

The Contractor shall also be responsible for getting the approval from the Engineer for the standards which he intends to apply for the detailing of his design and specifications additionally.

Apart from the basic data and specific requirements listed in the Employer's Requirement, all items of the Works shall be governed by the latest versions of the following codes and specifications as revised/corrected/amended (with latest correction slip) till the date of opening of the Tender. In case of contradiction in various codal provisions, the order of precedence shall be as follows:-

i. Specific provisions in the Employer's Requirements.
ii. IRS Codes and specifications
iii. IS Codes
iv. IRC Codes and specifications
v. International Codes

However, in case of ROBs and other highway loading related structures, IRC Codal provisions shall prevail over IRS Codal provisions. Notwithstanding the precedence specified above, the Contractor shall always seek advice from the Engineer in the event of any conflict for a final decision.

a) Loading Standards shall be as given in Design Requirements Criteria

b) Indian Railway Standard Codes and Specifications (IRS)

i. Bridge Rules
ii. Indian Railways Schedule of Dimensions (BG)
iii. Concrete Bridge Code
iv. Steel Bridge Code
v. B1- Specification for fabrication and erection of Steel girder bridges
vi. Welded Bridge Code
vii. Indian Railways Bridge Manual

viii. Indian Railways Permanent Way Manual

ix. Indian Railways Works Manual

x. Bridge Substructure & Foundation Code

xi. Well and Pile Foundation Code

xii. Seismic Code for Earthquake Resistant Design of Railway Bridges

c) RDSO Guidelines

i. BS-113 Guidelines for providing Arrangements for Bridge Inspection

ii. Comprehensive Guidelines and Specifications for Railway Formation: RDSO/2020/GE: IRS 0004

iii. BS-11 4 RDSO guidelines for carrying out rail-structure interaction studies on Indian Railways

iv. BS-126 Guidelines for continuation of LWR/CWR over ballasted deck bridges on Indian Railways

v. Report No. GE: R-50: Transitional System on approaches of bridges issued by RDSO.

vi. Report No. BS-111: Guidelines for use of High Strength Friction Grip (HSFG) bolts on bridges on Indian Railways.

vii. Guidelines for design of Spherical and Cylindrical bearings (in case of Steel Bridges).- Letter No.: RDSO/CBS/Bearing dated 22-06-2011

viii. RDSO drawing for H beam sleepers

ix. BS110 (R) - RDSO guidelines for steel girders

d) Indian Road Congress (IRC) Codes and Specifications

i. IRC: 5 Standard Specifications and Codes of Practice for Road Bridges Section – I – General features of design.

ii. IRC: 6 Standard Specifications and Codes of Practice for Road Bridges –Section – II – Loads and Stresses – Seismic provisions of this standard are to be adopted for the bridge design.

iii. IRC:112 Code of Practice for Concrete Road Bridges

iv. IRC: 22 Standard Specifications and Codes of Practice for Road Bridges Section – VI – Composite Construction.

v. IRC: 24 Standard Specifications and Codes of Practice for Road Bridges – Section V, Steel Road Bridges.

vi. IRC: 54 – Lateral and Vertical Clearances for Vehicular Traffic.

vii. IRC: 83 (Part – III) – Standard Specifications and Codes of Practice for Road Bridges – Section – IX – Bearings Part – III, Pot, POT cum PTFE Pin and Metallic Guide Bearings.

viii. IRC: 83 (Part – IV) – Standard Specifications and Codes of Practice for Road Bridges – Section – IX- Bearings Part – IV, Spherical and Cylindrical

ix. IRC-78: Sub-structure for Road Bridges.

x. IRS-87: Design and erection of false work for road bridges.

xi. Specifications for Road and Bridge Works issued by Ministry of Road Transport & Highways (MORTH).

e) Indian Standards Codes and Specifications (IS)

i. IS: 456 Plain and reinforced concrete - code of practice

ii. IS: 800 Code of practice for General Construction Steel

iii. IS: 875 Code of Practice for Design Loads Part 1, 2 3, 4& 5 (Other than Earthquake)

iv. IS: 1080 Design and construction of shallow foundations in soils (other than raft ring and shell)

v. IS: 1364 Hexagon Head Bolts, Screws & nuts of product grades A & B Part 1 (part 1 Hexagon, Head Bolts (size range M 1:6 to M64)

vi. IS 1367 Threaded Steel Fasteners

vii. IS: 13920 Ductile detailing of reinforced concrete structures subjected to seismic forces code of practice

viii. IS: 1489 Specification for Portland pozzolana cement (Fly ash based)

ix. IS: 1786 High strength deformed steel bars and wires for concrete reinforcement

x. IS: 1893 Criteria for Earthquake Resistant Design of structures

xi. IS: 1904 Design and construction of Foundations in soils: general requirements.

xii. IS: 2062 Specifications for weldable Structural steel

xiii. IS: 2502 Code of Practice for Bending and Fixing of Bars for Concrete Reinforcement

xiv. IS: 2911 Design and Construction of Pile Foundation- Code of practice Part 1Concrete Pile- Section 2 Board Cast-in-situ-piles

xv. IS 2911 Design and Construction of Pile Foundation- Code of practice Part 4 Load test on piles

xvi. IS: 2950 Design and construction of raft foundations

xvii. IS: 3935 Code of Practice for Composite Construction

xviii. IS: 4326 Code of practice for Earthquake resistant design and construction of Buildings

xix. IS: 4923 Hollow steel sections for structural use -specification

xx. IS: 8009 Calculation of settlements of shallow foundations

xxi. IS: 269 Specifications of OPC cement

xxii. IS: 9103 Specifications of Concrete admixtures

xxiii. IS: 11384 Code of practice for Composite Construction in Structural Steel and Concrete

xxiv. IS: 12070 Code of practice for Design and construction of shallow foundation on Rocks

xxv. IS: 14593 Design and Construction of Bored Cast-in-Situ Piles Founded on Rocks.

xxvi. IS 455Specifications for Portland Slag cement

f) International Standards

i. UIC Code 774-3 (R) Track and Bridge Interaction

ii. UIC Code 772-2 (R) Code for the use of rubber bearings for rail bridges

The list of standards given above is only indicative. The Contractor shall follow provisions of appropriate codes and standards in force for items which are not covered in the codes mentioned in foregoing paras.

{XXXX}

Section VII: Employer's Requirements
Section VII-6: Outline Construction Specifications (OCS) -Civil & BLT

Chapter 1. GENERAL-CIVIL

1.1 GENERAL:

1.1.1 These Specifications contained herein shall be read in conjunction with other tender documents.

1.1.2 All Materials, works and construction operations for civil works shall conform to the following manuals**:**

a) Indian Railways Permanent Way Manual

b) Indian Railway Bridge Manual

c) Indian Railway Works Manual

d) Indian Railway Schedule of Dimensions

e) Indian Railways Unified Standard Specification (Formation Works, Bridge Works and P.Way Works), Indian Railways Unified Standard Specification for Works and Material 2010, Indian Railways Unified Standard Schedule of Rates 2019 and , Indian Railways Unified Standard Schedule of Rates -2010

f) The relevant IRS Specifications referred to in the above documents listed at (a), (b), (c), (d) & (e)

g) CPWD Specifications, Vol 1&2 – 2019 for building works and Delhi Schedule of Rates (DSR) 2021

h) In case of any contradiction in the various codal provisions, the order of precedence shall be as follows:-

i. IRS Codal provisions

ii. IRC Codal provisions

iii. IS (BIS) Codal provisions

1.1.3 The Work shall be carried out in accordance with the "Good for Construction" drawings and designs as would be issued to the Contractor by the Engineer duly signed and stamped by him. The Contractor shall not take cognizance of any drawings, designs, specifications, etc. not bearing Engineer's signature and stamp. Similarly, the Contractor shall not take cognizance of instructions given by any other Authority except the instructions given by the Engineer in writing.

1.1.4 The work shall be executed and measured as per metric units given in the Schedule of Quantities, drawings etc. (FPS units where indicated are for guidance only).

1.1.5 Absence of terms such as providing, supplying, laying, installing, fixing etc in the descriptions does not even remotely suggest that the Contractor is absolved of such providing, supplying etc. unless an explicit stipulation is made in this contract. The Employer shall bear no costs of materials, labour, equipment, duties, taxes, royalties etc.

1.1.6 The specifications may have been divided into different sections / sub-heads for convenience only. They do not restrict any cross-references. The Contractor shall take into account inter-relations between various parts of works/trades. No claim shall be entertained on the basis of compartmental interpretations.

1.1.7 Reference to the Standard Codes of Practice:

a) The contractor shall make available at site all relevant Codes of practice as applicable.

Legends	**Definition**
IRS	Indian Railway Standards
IR specifications	Indian Railways Unified Standard Specification (Formation Works, Bridge Works and P.Way Works) and, Indian Railways Unified Standard Specification for Works and Material 2010
IS	Indian Standards
IRC	Indian Road Congress
CPWD	Central Public Works Department
RDSO	Research Designs and Standards Organisation
UIC	International Union of Railways (UIC, French: Union international des chemins de fer)
MORTH	Ministry of Road Transport and Highways
EN	European Standard
ISO	International Organization for Standardization
ASTM	American Section of the International Association for Testing and Materials
BS	British Standard

1.1.8 Alternative or additional codes and standards proposed by the contractor shall be internationally recognized codes and shall be equivalent to or better than, Indian Standards issued by the Bureau of Indian Standards or any other Indian professional body or organization, subject to being, in the opinion of the Employer’s Representative, suitable for incorporation or reference into the specifications.

1.1.9 Contractor to Provide:

The Contractor shall provide and maintain at site throughout the period of works the following at his own cost and without extra charge, except for the items specified in the Bill of Quantities the cost being held to be included in the Contract Rates:

a) General works such as setting out, site clearance before setting out and on completion of works. All weather approach roads to the site office should also be constructed and maintained in good condition.

b) All labour, materials, plant, equipment and temporary works, Overhead charges as well as general liabilities, obligations, insurance and risks arising out of GCC, required to complete and maintain the works to the satisfaction of the Engineer.

c) Adequate lighting for night work, and also whenever and wherever required by the Engineer.

d) Temporary fences, barricades, guards, lights and protective work necessary for protection of workmen, supervisors, engineers, General public and any other persons permitted access to the site. Contractor shall provide proper signages as directed. All fences, barricade shall be painted with colour shades as specified by the Engineer. The barricading should be of adequate height to ensure visual obstruction of work from public view.

e) All equipment, instruments, labour and materials required by the Engineer for checking alignment, levels, slopes and evenness of surfaces measurements and quality etc.

f) Design mixes and testing them as per relevant clauses of specifications giving proportion of ingredients, sources of aggregates and binder along with accompanying trial mixes. Test results to be submitted to the Engineer for his approval before adoption on works.

g) Cost of Preparation and compliance with provision of a quality assurance control program.

h) Cost of safeguarding the environment.

i) A testing laboratory as specified *in Appendix 12, Section VII-9: Appendices, Part 2-Employer's Requirements* by the Engineer equipped with the ISI marked *apparatus*, materials and competent trained staff required for carrying out tests, as specified in the relevant sections of the specifications.

1.1.10 Quality Assurance & Quality Control:

a) The work shall conform to high standards of design and workmanship, shall be structurally sound and aesthetically pleasing. The Contractor shall conform to the Quality standards prescribed, which shall form the backbone for the Quality Assurance and Quality Control system.

b) At the site, the Contractor shall arrange the materials, their stacking/storage in appropriate manner to ensure the quality. The Contractor shall provide all the necessary equipment and qualified manpower to test the quality of materials, assemblies etc., as directed by the Engineer. The tests shall be conducted at specified intervals and the results of tests properly documented. In addition, the Contractor shall keep appropriate tools and equipment for checking alignments, levels, slopes, and evenness of the surfaces.

c) The Engineer shall be free to carry out such tests as may be decided by him at his sole discretion, from time to time, in addition to those specified in this document. The Contractor may provide the samples and labour for collecting the samples. Nothing extra shall be payable to the Contractor for samples or for the collection of the samples.

   i. The test shall be conducted at the Site laboratory that may be established by the Contractor or at any other Standard Laboratory selected by the Engineer.

   ii. The Contractor shall transport the samples to the laboratory for which nothing extra shall be payable. In the event of the Contractor failing to arrange transportation of the samples in proper time the Engineer shall have them transported and recover two times the actual cost from the Contractor's bills.

   iii. All testing shall be performed in the presence of the Engineer. Testing may be witnessed by the Contractor or his authorised representative if permitted by the Test House. Whether witnessed by the Contractor or not, the test results shall be binding on the Contractor.

d) The Engineer shall have the right at all times to inspect all operations including the sources of materials, procurement, layout and storage of materials, all equipment including the concrete batching and mixing equipment, and the quality control system. Such an inspection shall be arranged, and the Engineer's approval obtained prior to starting of the particular item of work. This shall, however, not relieve the Contractor of his responsibilities. All materials which do not conform to these specifications shall be rejected and shall be removed from the site immediately. The Engineer shall have the powers to cause the Contractors to purchase and use materials from any particular source, as May in the Engineer's opinion be necessary for the proper execution of work.

1.1.11 Training

The Contractor shall arrange the following trainings for all his concerned persons and 30 persons of the Engineer and the Employer together:

a) 3 days training for fabrication of welded steel girders for railway including one day for practical demonstration at site.

b) 2 days training for concrete, testing, scaffolding and formwork including one day for practical demonstration at site.

c) 2 days training on embankment construction and testing

The Contractor shall bear all the expenditure for training including boarding, lodging, airfare, transport, and remuneration of trainers. Training place shall be provided by the

Employer free of cost. However, the Contractor shall bear the expenditure for refreshments and meals for all the participants during the training period. The syllabus of training and the names of the trainers shall be submitted to the Engineer for approval. Training shall be imparted only by those trainers who are approved by the Engineer.

1.1.12 Dimensions:

a) Figured dimensions on drawings shall only be followed and drawings to a large scale shall take precedence over those to a smaller scale. Special dimensions or directions in the specifications shall supersede all others. All dimensions shall be checked on site prior to execution.

b) The dimensions where stated do not allow for waste, laps, joints, etc. but the Contractor shall provide at his own cost sufficient labour and materials to cover such waste, laps, joints, etc.

c) The levels, measurements and other information concerning the existing site as shown on the drawings are believed to be correct, but the Contractor should verify them for himself and also examine the nature of the ground as no claim or allowance whatsoever will be entertained on account of any errors or omissions in the levels or the description of the ground levels or strata turning out different from what was expected or shown on the drawings.

1.1.13 Setting out of Works:

The Contractor shall set out the Works indicated in the Contract. The Contractor shall provide suitable stones with flat tops and build the same in concrete for temporary benchmarks. All the pegs for setting out the Works and fixing the levels required for the execution thereof shall, if desired by the Engineer, likewise be built in masonry at such places and in such a manner as the Engineer may direct. The Contractor shall carefully protect and preserve all benchmarks and other marks used in setting out the works. The contractor will make overall layout of complete work and get it checked from engineer. The cost of all operations of setting out including construction of benchmarks is deemed to be included in the quoted rates.

a) All the survey work except leveling work shall be carried out using total stations with one second accuracy. The leveling work shall be carried out using Auto level.

b) The triangulations point given by concerned organization before start of work shall be maintained during execution and handed over back to concerned organization after completion of work.

1.1.14 Materials:

a) Source of Materials:

It shall be the responsibility of the contractor to procure all the materials required for construction and completion of the contract. The contractor shall indicate in writing the source of materials well in advance to the Engineer, after the award of the work and before commencing the work. If the material from any source is found to be unacceptable at any time, it shall be rejected by the Engineer and the contractor shall forthwith remove the material immediately from the site as directed by the Engineer.

b) Quality:

All materials used in the works shall be of the best quality of their respective kinds as specified herein, obtained from sources and suppliers approved by the Engineer and shall comply strictly with the tests prescribed hereafter, or where tests are not laid down in the specifications, with the requirements of the latest issues of the relevant Indian Standards.

c) Sampling and Testing:

All materials used in the works shall be subjected to inspection and test in addition to test certificates. Samples of all materials proposed to be employed in the permanent works shall be submitted to the Engineer at least 45 days in advance for approval before they are brought to the site.

Samples provided to the Engineer for their retention are to be labeled in boxes suitable for storage. Materials or workmanship not corresponding in character and quality with approved samples will be rejected by the Engineer.

Samples required for approval and testing must be supplied sufficiently in advance if required quality and number to allow for testing and approval, due allowance being made for the fact that if the first samples are rejected further samples may be required. Delay to the works arising from the late submission of samples will not be acceptable as a reason for delay in completion of the works.

Materials shall be tested before leaving the manufacturer's premises, quarry or resource, wherever possible. Materials shall also be tested on the site and they may be rejected if not found suitable or in accordance with the specification, notwithstanding the results of the tests at the manufacturer's works or elsewhere or test certificates or any approval given earlier.

The contractor will bear all expenses for sampling and testing, whether at the manufacturer's premises at source, at site or at any testing laboratory or institution as directed by the Engineer. No extra payment shall be made on this account.

d) Dispatch of materials:

Materials shall not be dispatched from the manufacturer's works to the site without written authority from the Engineer.

e) Test certificates:

All manufacturer's certificates of test, proof sheets, etc. showing that the materials have been tested in accordance with the requirement of this specification and of the appropriate Indian Standard, are to be supplied free of charge on request to the Engineer.

f) Rejection:

Any materials that have not been found to conform to the specifications will be rejected forthwith and shall be removed from the site by the Contractor at his own cost within two weeks or as instructed by the Engineer.

g) The Engineer shall have power to cause the Contractors to purchase and use such materials from any particular source, as may in his opinion be necessary for the proper execution of the work.

1.1.15 Storing of Materials at site:

All materials used in the works shall be stored on racks, supports, in bins, under cover etc. as appropriate to prevent deterioration or damage from any cause whatsoever to the entire satisfaction of the Engineer.

The storage of materials shall be in accordance with IS 4082 "Recommendation on stacking and storage or construction materials on site" and as per IS 7969 "Safety code for handling and storage of building materials".

The materials shall be stored in a proper manner at places at site approved by the Engineer. Should the place where material is stored by the Contractor be required by the Employer for any other purpose, the Contractor shall forthwith remove the material from that place at his own cost and clear the place for the use of the Employer.

1.1.16 Water:

a) Water from approved source:

Potable water only shall be used for the works. Contractor shall have his own source of water duly approved by Engineer. The water shall be free from any deleterious matter in solution or in suspension and be obtained from an approved source. The quality of water shall conform to IS 456.

b) Storage:

The Contractor shall make his own arrangements for storing water, if necessary, in drums or tanks or cisterns, to the approval of the Engineer. Care shall be exercised to see that water is not contaminated in any way.

c) Testing:

Before starting any concreting work and wherever the source of water changes, the water shall be tested for its chemical and other impurities to ascertain its suitability for use in concrete for approval of the Engineer. No water shall be used until tested and found satisfactory. Cost of all such Tests shall be borne by the contractor.

1.1.17 Workmanship:

a) All works shall be true to level, plumb and square and the corners, edges and arises in all cases shall be unbroken and neat.

Any work not to the satisfaction of the Engineer or his representative will be rejected and the same shall be rectified, or removed and replaced with work of the required standard of workmanship at no extra cost.

1.1.18 Load Testing on Completed Structures

a) Load Testing of superstructure, in case of major bridges with OWG/ composite girders/ PSC girders and minor bridges with skew shall be done by the Contractor as per the directions of the Engineer. Payment of span load testing shall be made under relevant item of Schedule-D.

b) During the period of construction or within the defect liability period the Engineer may at his discretion order the load testing of any completed structure or any part thereof if he has reasonable doubts about the adequacy of the strength of such structure for any of the following reasons:

i. Results of compressive strength on concrete test cubes falling below the specified strength.

ii. Premature removal of formwork.

iii. Inadequate curing of concrete.

iv. Overloading during the construction of the structure or part thereof.

v. Carrying out concreting of any portion without prior approval of the Engineer.

vi. Honey combed or damaged concrete which in the opinion of the Engineer is particularly weak and will affect the stability of the structure to carry the design load, more so in important or critical areas of the structure.

vii. Loss of camber in OWG beyond permissible range as specified by Railway Board/RDSO.

viii. Any other circumstances attributable to alleged negligence of the contractor which in the opinion of the Engineer may result in the structure or any part thereof being of less than the expected strength.

c) All the loading tests shall be carried out by the Contractor strictly in accordance with the instructions of the Engineer, as per IRS:CBC and IRC:SP-51. Such tests shall be carried out only after expiry of minimum 28 days or such longer period as directed by the Engineer.

d) The structure shall be subjected to the load as approved for SLS condition in the design. This load shall be maintained for a period of 24 hours before removal. Incremental loading shall be done in accordance with IRC: SP-51, unless otherwise directed by the Engineer.

In case the recovery of the structure is not as per codal provisions, the structure shall be considered to have failed the test and shall be deemed to be unacceptable.

e) In such cases the portion of the work concerned shall be taken down or cut out and reconstructed to comply with the specifications. Other remedial measures may be taken to make the structure secure at the discretion of the Engineer. However, such remedial measures shall be carried out to the complete satisfaction of the Engineer. Again, Load test shall be conducted as per codal provisions.

f) All costs involved in carrying out the tests (except integrity test for piles) and other incidental expenses thereto shall be borne by the contractor regardless of the result of the tests. The contractor shall take down or cut out and reconstruct the defective work or shall take the remedial measures instructed at his own cost.

If the load testing is instructed on any ground other than mentioned in (i) to (ix) of Cl. 1.1.18(b), the cost of the same shall be reimbursed to the Contractor, if the result of the tests are found to be satisfactory.

g) In addition to the load tests mentioned in Sub-Clause 1.1.18 (b), non-destructive test methods such as core test and ultrasonic pulse velocity test shall be carried out by the contractor at his own expense if so desired by the Engineer. Such tests shall be carried out by an agency approved by the Engineer and shall be done using only recommended testing equipment. The acceptance criteria for these tests shall be as per provisions in the relevant Indian/International standards and as approved by the Engineer.

1.2 STRUCTURAL WORK:

1.2.1 Unless specified, only controlled concrete with design mix and weigh batching is to be used for the work.

1.2.2 Minimum cement content specified in the codal specifications is purely from durability point of view. Larger content of cement shall have to be provided if demanded by mix design.

1.2.3 Provision of cement slurry to create bond between plain / reinforced concrete surface and subsequent applied finishes shall not be paid extra.

1.2.4 Mix design using smaller aggregates of 10mm down shall also be done in advance for the use in the junction having congested reinforcement.

1.2.5 Procedure of mixing the admixtures shall be strictly as per the manufacturer's recommendations if not otherwise directed by the Engineer.

1.2.6 All the water tanks and other liquid retaining concrete structures shall undergo hydro-testing.

1.2.7 Special benches shall be provided at site for stacking reinforcement bars of different sizes.

1.2.8 Formwork for beams of RCC areas shall be designed in such a way that the formwork of the adjacent slabs can be removed without disturbing the props / supports of the beams.

1.2.9 *Deleted*.

1.2.10 Formwork is required for full height at all locations. Special precaution for such tall formwork shall be taken to ensure its safety. Extra costs for such formwork shall be deemed to have been included in the price quoted against relevant items.

1.2.11 In the mobilization period, the contractor shall carry out expeditiously and without delay the following works:

i. Material testing and mix designs of concrete as contemplated in the specifications.

ii. Setting up of full-fledged site laboratory as per the requirements of these specifications.

iii. Any other pre-requisite items required for final execution.

iv. Site office for the use of the Engineer staff.

v. Casting yard with full facilities.

1.2.12 Deleted

1.3 SUPPLY OF PROGRES PHOTOGRAPHS AND ALBUMS (DIGITAL):

The work covers the supply of digital photographs to serve as a permanent record of various stages/facets of work needed for authentic documentation as approved by the Engineer.

The photographs shall be of acceptable quality and they shall be taken by a professionally competent photographer with camera having the facility to record the date of the photographs taken in the soft copy. Each photograph in the album shall be suitably captioned and dated.

The photographs and materials shall form a part of the records of concerned organization and same cannot be supplied to anybody else or published without the written permission of concerned organization.

1.4 SUPPLY OF VIDEO CDs:

The work consists of taking video films of important activities of the works as directed by the Engineer during the currency of the Project and editing them to a video film of playing time not less than 60 minutes. It shall contain narration of the activities in English by a competent narrator. The edition of the film and script of the narration shall be approved by the Engineer.

Drone Survey - of the whole package for inspection and monitoring of structures shall be done by the Contractor once in a month.

The record of progress (photographs and videos) shall be submitted to the engineer on a monthly basis or as directed by engineer.

1.5 SURVEY WORK:

The said work involves at the very start of work taking-over of reference point from the Engineer, establishment of control points, triangulation points, bench marks, grid layout for all the structures maintaining horizontal and vertical control within the permissible limits, incorporating changes (if any), submission of full data in the tabulation form and survey drawings including setting and layout of various works during the progress of work and matching of the station area track alignment with the alignment of the approaches at station ends and incorporating the changes (if any).

1.6 BARRICADING

The work covers barricading for the work done along the median and areas affecting road traffic and other areas like casting yard, batching plant, storage and other working area. All barricading shall be done at own cost by the Contractor. The detailed scope of work is as follows:

i. Providing and installing the barricade of the design and type as shown in the Tender Drawings furnished as per the approved plan firmly to the ground and maintaining it during the progress of work.

ii. Dismantling of barricading and other temporary installations from the site and cleaning the site as per direction of Engineer upon completion and acceptance of work.

iii. Providing earthing of Barricades.

iv. Providing Lighting on the periphery of Barricades for Direction illumination.

1.7 FINISHING WORK:

1.7.1 The Contractor shall incorporate seismic considerations of anchoring and isolation in the design and detailing of the finishes as directed by the Engineer. The element to be anchored shall have its motion suitably restrained whilst at the same time it shall be suitably isolated so as not to be affected by the deformations/ vibrations of the building during Construction.

1.7.2 **Sub-Contractor:**

Works as listed below and those dealing with proprietary materials/ products may be carried out by the Contractor through the Sub-Contractors as may be approved by the Engineer in writing. The Sub-Contractors must be firms of repute and long standing, having adequate experience and complete facilities to carry out all items of work required for completion as per Specifications and expected quality to the satisfaction of the Engineer. The Sub-Contractor must also have personnel experienced in preparing shop drawings. All such works, not limited to the following, shall be carried out under the direct supervision of the manufacturers of the proprietary materials/ products or their trained and accredited licensee.

i. Bearings

ii. Fabrication, assembly and launching of steel OWG & CG

iii. Ballastless track

iv. Fabrication of H beam sleepers and track fittings/fastenings

1.7.3 **Responsibility for Shop drawings, Samples and Mock-ups:**

Approval of shop drawings, samples and mock-ups for the various components shall not absolve the Contractor of his responsibility of completing the work to the specifications, standards, tests for performance and guarantees given in these documents and to a quality of finish as desired by the Engineer.

1.7.4 **Cleaning:**

Surfaces on which finishes are to be provided shall be cleaned with water jets or oil free compressed air or power tools with wire brushes and detergents all as approved by the Engineer.

1.8 Applicable Codes, Standards & Publications for Structural & Architectural Work:

The more important Codes, Standards and Publications to Contract are listed here under:

Any other code/publication, if found necessary by the engineer, may be referred to for such works. The latest revision along with all corrections slip & amendments shall only be followed

Sr. No.	Code No.	Code Name
General		
1.	IS: 875	Code of Practice for design loads (other than earthquake) for buildings and structures
2.	IS: 122 (part 4)	Methods of measurement of buildings and Civil engineering works-Stone masonry
3.	IS:1237	Specification for cement concrete flooring tiles
4.	IS: 1322	Bitumen felts for water proofing and damp-proofing
5.	IS: 1893	Criteria for earthquake resistant design of structures
6.	IS: 2185 (Part 1)	Concrete masonry units: Hollow and solid concrete
7.	IS: 2185 (Part 2)	Concrete masonry units: Hollow and solid light weight
8.	IS: 2185 (Part 3)	Concrete masonry units: Autoclaved cellular aerated concrete blocks
9.	IS: 2572	Code of Practice for construction of hollow concrete block Masonry
10.	IS: 3414	Code of practice for design and installation of joints in Buildings
11.	IS: 3462	Specification for unbacked flexible PVC flooring
12.	IS: 5318	Code of practice for laying of flexible PVC sheet and tile Flooring
13.	IS: 6408 (Parts 1,2)	Recommendations for modular co-ordination in building

Sr. No.	Code No.	Code Name
		Industry-tolerances
14.	IS: 8183	Bonded mineral wool
15.	IS:10958	General check list of functions of joints in building
16.	IS:11817	Classification of joints in buildings for accommodation of dimensional deviations during construction
17.	IS:11818	Method of test for laboratory determination of air permeability of joints in buildings
18.	IS:12440	Precast concrete stone masonry blocks
19.	CPWD	Specifications with up-to-date correction slips
20.	BS:476 (Part 7)	Method for classification of the surface spread of flame of Products
21.	BS:476 (Part 20)	Method of determination of the fire resistance of elements of construction (general principles)
22.	BS:476 (Part 22)	Methods for determination of the fire resistance of non-load bearing elements of construction
23.	BS: 1245	Specification for metal door frames (steel)
24.	BS: 3261	Specification for unbacked flexible PVC flooring
25.	BS:3261: Part 1	Homogeneous flooring
26.	BS:5215	Specification for one-part gun grade polysulphide-based Sealants
27.	BS:5606	Guide to accuracy in building
28.	BS:5725 (Part 1)	Specification for panic bolts and panic latches mechanically operated by a horizontal push-bar
29.	BS:6093	Code of practice for the design of joints and jointing in building construction
30.	BS:8200	Code of practice for the design of non-load bearing external vertical enclosure of building
31.	ASTM C 332	Specification for light weight aggregate for insulating Concrete
32.	ASTM C 635	Specification for the manufacture, performance and testing of metal suspension systems for acoustical tile and lay-in panel ceilings
33.	SP 7	National Building Code of India
34.	SP 23 (S&T)	Hand Book on Concrete Mixes
Bitumen		
35.	IS:702	Industrial Bitumen
36.	IS:3384	Specification for bitumen primer for use in waterproofing and damp-proofing
Building Construction Practices		
37.	IS: 1838 Parts I and II.	Specifications for preformed fillers for expansion joint in concrete pavements and structures

Sr. No.	Code No.	Code Name
38.	IS: 1946	Code of Practice for use of fixing devices in walls, ceilings, and floors of solid construction.
39.	IS: 3414	Code of Practice for design and installation of joints in buildings.
40.	IS: 6509	Code of Practice for installation of joints in concrete pavements.
41.	IS: 11134	Code of Practice for setting out of buildings.
42.	IS: 11433	Parts I and II. Specifications for one part Gun grade polysulphide based joint sealant
43.	IS: 12200	Code of Practice for provision of water stops at transverse construction joints in masonry and concrete dams
44.	NBC-2016	National Building Code
Cement		
45.	IS:269	33 grade ordinary Portland cement
46.	IS: 455	Portland Slag Cement
47.	IS: 650	Specification for standard sand for testing cement
48.	IS: 1489 (Part 1)	Portland pozzolana cement: Fly ash based
49.	IS: 1489 (Part 2)	Portland pozzolana cement: Calcined clay based
50.	IS: 3535	Method of Sampling Hydraulic Cements
51.	IS: 4031	(Parts 1 to 13) Methods of physical tests for hydraulic cement
52.	IS:4032	Methods of chemical analysis of hydraulic cement
53.	IS: 6925	Methods of test for determination of water-soluble chlorides in concrete admixtures
54.	IS:8042	White Portland Cement
55.	IS: 8112	Specification for 43 grade ordinary Portland cement
56.	IS:12269	Specification for 53 grade ordinary Portland cement
57.	IS: 12330	Specification for sulphate resistant Portland cement
58.	IRS: T40	Indian Railways standard specification for special grade cement for use in concrete sleepers
Concrete		
59.	IS:456	Code of practice for plain and reinforced concrete
60.	IS: 457	Code of practice for general construction of plain and reinforced concrete for dams and other massive structures
61.	IS: 460 (Part I TO III)	Specification for Test Sieves
62.	IS: 516	Methods of tests for strength of concrete
63.	IS: 1199	Methods of sampling & analysis of concrete
64.	IS: 1200	Methods of measurement of building and civil engineering
65.	IS: 1343	Code of practice for prestressed concrete

Sr. No.	Code No.	Code Name
66.	IS: 1607	Methods of Test Sieving
67.	IS:2386	Parts I-VIII. Methods of tests for aggregates for concrete.
68.	IS:2430	Methods of Sampling of Aggregates of Concrete
69.	IS:2438	Specification for roller pan mixer
70.	IS:2514	Specification for concrete vibrating tables
71.	IS:2571	Code of practice for laying in-situ cement concrete Flooring
72.	IS:2645	Specifications for integral cement water proofing Compounds
73.	IS:2722	Specifications for portable swing batchers for concrete (double bucket type)
74.	IS:2770	Methods of testing bond in reinforced concrete part I pull out test
75.	IS:3025	Methods of sampling and test (physical and chemical) for water & waste water
76.	IS:3370	Code of practice for concrete structures for storage of Liquids
77.	IS:3935.	Code of practice for composite construction
78.	IS:4326	Code of practice for earthquake resistant construction of Building
79.	IS:6925.	Methods of test for determination of water soluble chlorides in concrete Admixtures
80.	IS:7242	Specifications for concrete spreaders
81.	IS:7251	Specifications for concrete finishers
82.	IS:7861	Parts I & II. Code of practice for extreme weather concreting
83.	IS:7969	Safety code for handling and storage of building materials
84.	IS:8989	Safety code for erection of concrete framed structures
85.	IS:8142	Methods of test for determining setting time of concrete by penetration resistance
86.	IS: 9103	Specification for admixtures for concrete
87.	IS: 9013	Method of making, curing and determining compressive strengths of accelerated cured concrete test specimens
88.	IS: 9284	Method of test for abrasion resistance of concrete
89.	IS:10262	Recommended guidelines for concrete mix design
90.	IS: 4926	Code of Practice ready mixed concrete needs to be included in list

Sr. No.	Code No.	Code Name
91.	MORTH	Specifications for Road and Bridge Works, Ministry of Road Transport and Highways (Roads Wing)
92.	SP 34	Handbook on Concrete Reinforcement and Detailing
93.	IRS	Concrete Bridge Code
94.	IRC 112	Code of Practice for Concrete Road Bridge
95.	IRC 83 (Part 4)	Standard Specifications and code of practice for road bridges Section IX Bearings (Spherical & Cylindrical)
96.	ASTM-C-94	Ready Mix Concrete
Construction Plant and Machinery		
97.	IS: 1791	Specification for batch type concrete mixers
98.	IS: 2505	General requirements for concrete vibrators: Immersion type.
99.	IS: 2506	General requirements for screed board concrete vibrators.
100.	IS: 3366	Specification for pan vibrators
101.	IS: 3558	Code of Practice for use of immersion vibrators for consolidating concrete
102.	IS: 4656	Specifications for form vibrators for concrete.
103.	IS: 4925	Specification for concrete batching and mixing plant.
104.	IS: 11993	Code of Practice for use of screed board concrete vibrators.
Formwork		
105.	IS: 4990	Specifications for plywood for concrete shuttering work
106.	IRC: 87	Guidelines for the design and erection of false work for road bridges.
107.	IS: 806	Code of practice for use of steel tubes in general building construction.
108.	IS: 1161	Specification of steel tubes for structural purposes.
109.	IS: 1239	Specification for mild steel tubes, tubular and other wrought steel fittings
Gypsum and Gypsum Board		
110.	IS: 2095	Gypsum plaster boards
111.	IS: 2542 (Part 1/Sec to 12)	Methods of test for gypsum plaster, concrete and products: plaster and concrete

Sr. No.	Code No.	Code Name
112.	IS: 2542 (Part 2/Sec 1to 8)	Methods of test for gypsum plaster, concrete and products: Gypsum products
113.	IS: 2542 (Part1)	Gypsum building plaster: Excluding premixed lightweight plaster
114.	IS: 2547 (Part 2)	Gypsum building plaster: Premixed lightweight plaster
Handling and Storage		
115.	IS:4082	Recommendation of Stacking and Storage of construction materials
116.	IS:8348	Code of practice for stacking and packing of stone slabs for transportation
117.	IS:8759	Code of practice for maintenance and preservation of stones in building
Instruments for Testing Cement and Concrete		
118.	IS:5513	Specification for vicat apparatus.
119.	IS:5514	Specification for apparatus used in Le-Chatelier test.
120.	IS:5515	Specification for compaction factor apparatus.
121.	IS:7320	Specification for concrete slump test apparatus.
122.	IS:7325	Specification for apparatus to determine constituents of fresh concrete.
123.	IS:10080	Specification for vibration machine.
124.	IS:10086	Specification for moulds for use in tests of cement and concrete.
125.	IS:10510	Specification for vee-bee consistometer.
	Joint Fillers	
126.	IS:1838 (Part 1)	Preformed fillers for expansion joint in concrete pavements and structures (non extruding and resilient type): Bitumen impregnated fibre
Paints and Coatings		
127.	IS:102	Ready mixed paint, brushing, red lead, non-setting, priming

Sr. No.	Code No.	Code Name
128.	IS:109	Ready mixed paint, brushing, priming, plaster, to Indian Standard Colour No. 361 and 631 white and off white.
129.	IS:218	Creosote and anthracene oil for use as wood preservatives
130.	IS:347	Varnish, shellac, for general purpose
131.	IS:348	French Polish
132.	IS:2074	Ready mixed paint, air drying, red oxide-zinc chrome, priming
133.	IS: 4833	Methods of field testing of preservatives in wood
134.	IS:10013 (Parts 1 to 3)	(Part -1) Water soluble type wood preservatives
135.	IS:10013 (Parts 1 to 3)	(Part-2) Acid-copper-chrome preservative
136.	IS: 10013 (Part 1 to 3)	(Part-3) Copper-chrome-boron wood preservative
137.	BS:6496	Specification for powder organic coatings for application and stoving to aluminium alloy extrusions, sheet and preformed sections for external architectural purposes, and for the finish on aluminium alloy extrusions, sheet and preformed sections coated with powder organic coatings
138.	BS:EN:10152	Specification for electrolytically zinc coated cold rolled steel flat products. Technical delivery conditions
139.	ASTM A 164-71	Specification for electrodeposited coatings of zinc on steel
Pigment for cement		
140.	BS:1014	Specification for pigments for Portland cement and Portland cement products
Reinforcement & Structural Steel		
141.	IS:206	Code of Practice for use of Steel Tubes in General Building Construction
142.	IS:210	Grey Iron Castings
143.	IS:280	Mild steel wire for general engineering purposes

Sr. No.	Code No.	Code Name
144.	IS:432	Part I. Mild steel and medium tensile steel bars. Part II Hard drawn steel wire.
145.	IS:451	Technical Supply conditions for Wood Screws
146.	IS:806	Code of practice for use of steel tubes in general building construction
147.	IS:815	Classification coding of covered electrodes for metal arc welding of structural steels
148.	IS:1239	Specification for mild steel tubes, tubulars and other wrought steel fittings
149.	IS 1343	Code of Practice for Prestressed Concrete
150.	IS:1363	Black hexagon bolts, nuts and lock nuts and black hexagon screws.
151.	IS:1365	Slotted countersunk screws.
152.	IS:1566	(Part I) Specifications for hard-drawn steel wire fabric for Concrete reinforcement
153.	IS:1786	Specification for high strength deformed steel bars and wires for concrete reinforcement.
154.	IS:2502	Code of Practice for bending and fixing of bars for concrete reinforcement.
155.	IS:2629	Recommended practice for hot-dip galvanising of iron and steel.
156.	IS:2751	Code of Practice for welding of mild steel plain and deformed bars for reinforced concrete construction.
157.	IS 4000	Code of practice for high strength bolts in steel structures
158.	IS:4759	Hot-dip zinc coating on structural steel and other allied products.
159.	IS:5525	Recommendations for detailing of reinforcement in reinforced concrete works
160.	IS:9417	Recommendations for welding cold-worked steel bars for reinforced concrete construction.
161.	IS:14268	Uncoated stress relieved low relaxation steel class 2 for Prestressed concrete

Sr. No.	Code No.	Code Name
162.	IS:226	Structural steel (Standard Quality)
163.	IS:800	Code of practice for use of structural steel in general building construction.
164.	IS:813	Scheme of symbols for welding
165.	IS:814	Covered electrodes for metal arc welding of structural steel. (Part I & Part II)
166.	IS:816	Code of practice for use of metal arc welding for general construction in mild steel.
167.	IS:822	Code of practice for inspection of welds.
168.	IS:961	Structural steel (High Tensile)
169.	IS:1024	Code of practice for use of welding in bridges and structures subject to dynamic loading.
170.	IS:1030	Carbon steel casting for General Engineering Purposes
171.	IS:1120	Coach Screws
172.	IS:1367	Technical Supply Conditions for Threaded Fasteners
173.	IS:1161	Steel tubes for structural purposes.
174.	IS:1182	Recommended practice for radiographic examination of fusion welded butt joints in steel plates.
175.	IS:1915	Code of Practice for Steel Bridges
176.	IS:2016	Plain Washers
177.	IS:2062	Structural steel (Fusion welding quality)
178.	IS:3063	Single Coil Rectangular Section Sprint Washers for Nuts, Bolts and Screws
179.	IS:3443	Crane Rail Sections
180.	IS:3757	Specification for high tensile friction grip bolts
181.	IS:5624	Specification for foundation bolts
182.	IS:3600	Code of practice for testing of fusion welded (Part I) joints and weld metal in steel
183.	IS:4923	Hollow steel sections for structural use.

Sr. No.	Code No.	Code Name
184.	IS:6227	Code of practice for use of metal arc welding in tubular structure.
185.	IS:801	Code of practice for use of cold formed light gauge steel structural members in general building construction.
186.	IS:811	Specifications for cold formed light gauge structural steel sections.
187.	IS:8500	Structural steel Micro alloyed (Medium and high strength qualities)
188.	IS:8910	General requirements of supply of weldable structural steel
189.	IS:9595	Recommendations for metal arc welding of carbon & carbon- manganese steels.
190.	IS 16172	Reinforced Couplers for Mechanical Splices of Bars in Concrete
Sand		
191.	IS:383	Coarse and fine aggregates from natural sources for concrete.
Scaffolding		
192.	IS:2750	Specification for steel scaffoldings
193.	IS:3696 (Part 1)	Safety Code of scaffolds and ladders: Scaffolds
194.	IS:3696 (Part 2)	Safety Code of scaffolds and ladders: Ladders
195.	IS:4014 (Part 1)	Code of practice for steel tubular scaffolding: Definition and Materials
196.	IS:4014 (Part 2)	Code of practice for steel tubular scaffolding: Safety regulations for scaffolding
197.	IRC:87	Guidelines for the design and erection of falsework for Road bridge
Sealants		
198.	IS: 10959	Glossary of terms for sealants for building purposes
199.	IS: 11433 (Part 1)	One part grade polysulphide base joint sealant: General requirements
200.	IS: 11433 (Part 2)	One part grade polysulphide base joint sealant: Methods of test

Sr. No.	Code No.	Code Name
201.	IS: 13055	Methods of sampling and test for anaerobic adhesives and sealants
202.	BS: 5889	Specification for one part gun grade silicone based sealants.
Wood		
203.	IS: 303	Plywood for General Purposes
204.	IS: 848	Synthetic resin adhesives for plywood (phenolic and aminoplastic)
205.	IS: 1141	Seasoning of Timber – Code of Practice
206.	IS:1328	Veneered decorative plywood
207.	IS: 1659	Blocks Boards
208.	IS: 2046	Decorative thermosetting synthetic resin bonded laminated sheets
209.	IS: 2202 (Part 1)	Wooden flush door shutters (solid core type): Plywood face panels
210.	IS: 2202 (Part 2)	Wooden flush door shutters (solid core (type): Particle face panels and hardboard face panels
Bearing		
211.	IRC: 83 Part-II	Standard specifications and code of practice for road bridges Elastomeric Bearings
212.	IRC: 83 Part-III EN 1337gh	Standard specifications and code of practice for road bridges Pot Bearings
213.	IRC: 83 Part-IV	Standard Specifications and Code of Practice for Road Bridges (Section – IX) Bearings (Spherical and Cylindrical)
Piling		
214.	IS: 2911 (All Parts)	Bored Cast in-situ Concrete Piles
215.	IRC: 78	Standard specifications and code of practice for road bridges Foundation And Substructure
All Indian Railway & RDSO Standards, any other code or publication as approved by engineer in-charge		
Metal		
216.	IS: 276	Austenitic manganese steel castings
217.	IS: 733	Wrought aluminium and aluminium alloy bars, rods and sections for general engineering purpose.
218.	IS: 737	Specifications for wrought aluminium and aluminium alloy sheet and strip for general engineering purpose.

Sr. No.	Code No.	Code Name
219.	IS: 3614 (Part 1)	Specification for fire check doors: Plate metal covered and rolling type
220.	IS: 3614 (Part 2)	Specification for metallic and non-metallic fire check doors: Resistance test and performance criteria
221.	IS: 7196	Specification for Hold Fasts
222.	ASME set 2 Part A	Ferrous Material Specification
223.	ASTM B 221	Specification for aluminum-alloy extruded bars, rods, wires, shapes, and tubes
224.	BS: 4873	Specification for Aluminum alloy windows
225.	BS: 7352	Specification for strength and durability performance of metal hinges for side hanging applications and dimensional requirements for template drilled hinges.
226.	BS EN: 10143	Specification for continuously hot-dip metal coated steel sheet and strip. Tolerances on dimensions and shape
Stone and Facings/Linings		
227.	IS:1121-(Parts 1 to 4)	Methods of test for determination of strength properties of natural building stones
228.	IS:1121-(Parts 1 to 4)	(Part-1 Compressive strength)
229.	IS:1121-(Parts 1 to 4)	(Part-2 Transverse strength)
230.	IS:1121-(Parts 1 to 4)	(Part-3 Tensile strength)
231.	IS:1121-(Parts 1 to 4)	(Part-4 Shear strength)
232.	IS:1122	Method of test for determination of true specific gravity of natural building stones.
233.	IS:1123	Method of identification of natural building stones.
234.	IS:1124	Method of test for determination of water absorption, apparent specific gravity and porosity of natural building stones.
235.	IS:1125	Method of test for determination of weathering of natural

Sr. No.	Code No.	Code Name
		building stones
236.	IS:1126	Method of test for determination of durability of natural building stones.
237.	IS:1127	Recommendations for dimensions and workmanship of natural building stones for masonry work.
238.	IS:1128	Specification for Limestone (Slabs and Tiles)
239.	IS:1129	Recommendation for dressing of natural building stones.
240.	IS:1130	Specification for marble (blocks, slabs and tiles)
241.	IS:1597 (Part 2)	Code of practice for construction of stone masonry Ashlar masonry
242.	IS:1706	Method for determination of resistance to wear by abrasion of natural building stones
243.	IS:1805	Glossary of terms relating to stones, quarrying and dressing
244.	IS:3620	Specification for laterite stone block for masonry
245.	IS:3622	Specification for Sandstone (slab & tiles)
246.	IS:4101 (Part 1)	Code of practice for external facing and veneers: stone Facing
247.	IS:4101 (Part 2)	Code of practice for external facing and veneers: Cement concrete facing
248.	IS:4101 (Part 3)	Code of practice for external facing and veneers: Wall tiling and mosaics
249.	IS:4121	Method of test for determination of water transmission rate by capillary action through natural building stones
250.	IS:4122	Method of test for surface softening of natural building stones by exposure to acidic atmospheres
251.	IS:4348	Method of test for determination of permeability of natural building stones
252.	IS:5218	Method of test for toughness of natural building stones
253.	IS:8381	Recommended practice for quarrying stones for construction purposes
254.	IS:14223 (Part 1)	Polished building stones: Granite

Sr. No.	Code No.	Code Name
255.	BS: 8298	Code of practice for design and installation of natural stone cladding and lining
256.		All Indian Railway & RDSO Standards, any other code or publication as approved by Engineer in-charge

Chapter 2. EARTHWORK IN FORMATION, HUME PIPES AND RETAINING WALLS

2.1 FORMATION IN EMBANKMENT/CUTTING

a) Earthwork in formation and blanketing shall be carried out as per RDSO specification No. RDSO/2020/GE: IRS-004 September 2020 "Comprehensive Guidelines and Specifications for Railway Formation" and in accordance with the approved drawings.

b) The contractor shall arrange suitable borrow areas at his own cost and get them approved from the Engineer before using soil from such borrow areas.

c) Soils mentioned in Clause 3.7 (a) of the RDSO Guidelines shall not be used.

d) SQ-1 type of soils shall not be used in prepared subgrade and top layer of subgrade.

e) MDD in laboratory shall be determined by using Heavy Proctor test as per IS 2720 Part- 16.

f) MDD achieved in the field compaction trial shall not be less than 98% of the MDD achieved in laboratory.

g) Degree of compaction of soil in prepared subgrade/top layer of subgrade shall not be less than 98% of MDD achieved in field as a result of Field Compaction Trial.

h) Degree of compaction of soil in lower layer of subgrade shall not be less than 97% of MDD achieved in field as a result of Field Compaction Trial.

i) Before undertaking turfing, extra earthwork on slopes of embankment shall be cut to final design profile, dressed and compacted with vibratory rollers of approved capacity and make as per RDSO guidelines.

j) Blanketing material shall be as per RDSO Guidelines.

k) The type of tests, frequency and acceptance criteria for quality check of earthwork and blanketing shall be as given in Chapter 7 of RDSO Guidelines.

2.2 Utility Pipes

MS pipe of 323.9 mm outer diameter conforming to IS:3589, shall be provided at about 500m interval throughout the alignment in embankments for crossing future utilities. Pipe shall be laid as per RDSO Report NO. BS-105 of October'2009 "Guidelines on Pipe Line Crossing Under Railway Track".

2.3 Retaining Walls and Side Slopes

Dimensional tolerance shall be +/- 2 mm. Shuttering/formwork for cast-in-situ retaining wall shall be adequate to permit construction of retaining walls upto 3 m height in single pour. In case, construction of retaining wall upto 3 m height in single pour is found impracticable, the Contactor shall take specific approval of the Engineer for the proposed Shuttering/form work. Wherever retaining wall is required to be constructed for retaining formation slope, retaining wall shall be constructed first. Thereafter, earthwork in formation shall be done behind the retaining wall (in layers with mechanical compaction leaving space for backfill) up to the height of retaining wall. Extra earthwork on slope towards retaining wall shall be cut in 1:1 slope and backfill shall be provided behind retaining wall in layers with mechanical compaction as per RDSO Guidelines. Thereafter, earthwork above the height of retaining shall be taken up as per approved method statement.

Chapter 3. BRIDGES

3.1 General

3.1.1 Scope of Specifications

This specification shall be applicable for carrying out bridge works.

3.1.2 Applicable Standards

The applicable standards shall be as follows:

a) Indian Railway Standard Codes and Specifications (IRS)

i. Bridge Rules

ii. Concrete Bridge Code

iii. Steel Bridge Code

iv. Well and Pile Foundation Code

v. Fabrication Specification No. B1-2001

vi. Specification No. B-2 for Steel Structures (other than Girder Bridges)- Part 3.

vii. Welded Bridge Code

viii. Bridge Sub-structure & Foundation Code

ix. Specification No.M-28, Classification, testing and approval of metal arc welding electrodes for use-Indian Railway

x. Specification No.M-29, Classification, testing and approval of submerged arc welding with flame combination.

xi. Indian Railways Unified Standard Schedule of Rates - 2019

xii. Indian Railways Unified Standard Specification (Formation Works, Bridge Works & P.Way Works) - 2019

xiii. Indian Railways Permanent Way Manual (IRPWM)

xiv. Indian Railways Works Manual (IRWM)

xv. Indian Railways Bridge Manual (IRBM)

xvi. Indian Railways Engineering Code

xvii. Manual on the design and construction of Well and Pile foundations

xviii. Indian Railways Schedule of Dimensions (BG)

xix. IRS Seismic code for Earthquake Resistant Design of Railway bridges.

b) RDSO Guidelines

i. BS-113 Guidelines for providing Arrangements for Bridge Inspection

ii. Comprehensive Guidelines and Specifications for Railway Formation: RDSO/2020/GE: IRS 0004.

iii. Report No. GE: R-50: Transitional System on approaches of bridges

iv. Report No. BS-111: Guidelines for use of High Strength Friction Grip (HSFG) bolts on bridges on Indian Railways

v. Guidelines for design of Spherical and Cylindrical bearings (in case of Steel Bridges).- RDSO/CBS/Bearing dated 22-06-2011

vi. RDSO drawings for H-beam sleepers

vii. Report No. BS 115 : Guidelines for Composite Construction Including Stud Shear Connectors

c) Indian Standards Codes and Specifications (IS)

i. IS: 456 Plain and reinforced concrete - code of practice

ii. IS: 800 Code of practice for General Construction Steel

iii. IS: 875 Code of Practice for Design Loads Part 1, 2 3, 4& 5 (Other than Earthquake)

iv. IS: 1080 Design and construction of shallow foundations in soils (other than raft ring and shell)

v. IS: 1367 Technical Supply Conditions for Threaded Steel Fasteners

vi. IS: 13920 Ductile detailing of reinforced concrete structures subjected to seismic forces code of practice

vii. IS: 1489 Specification for Portland pozzolana cement (Fly ash based)

viii. IS: 1786 High strength deformed steel bars and wires for concrete reinforcement

ix. IS: 1904 Design and construction of Foundations in soils: general requirements.

x. IS: 2062 Specifications for weldable Structural steel

xi. IS: 2502 Code of Practice for Bending and Fixing of Bars for Concrete Reinforcement

xii. IS: 2911 Design and Construction of Pile Foundation - Code of practice Part1 Concrete Pile- Section 2 Bored Cast-in-situ-piles

xiii. IS: 2911 Design and Construction of Pile Foundation- Code of practice Part1 Concrete Pile- Section 4 Precast Concrete Piles in Prebored Holes

xiv. IS 2911 Design and Construction of Pile Foundation- Code of practice Part 4 Load test on piles

xv. IS: 2950 Design and construction of raft foundations

xvi. IS: 3935 Code of Practice for Composite Construction

xvii. IS: 4923 Hollow steel sections for structural use -specification

xviii. IS: 1161 Steel Tubes for Structural Purposes- specifications

xix. IS: 8009 Calculation of settlements of shallow foundations

xx. IS: 269 Specifications of OPC cement

xxi. IS: 9103 Specifications of Concrete admixtures

xxii. IS: 12070 Code of practice for Design and construction of shallow foundation on Rocks

xxiii. IS: 14593 Design and Construction of Bored Cast-in-Situ Piles Founded on Rocks.

xxiv. IS 455 Specifications for portland slag cement

d) Other Standards

i. CPWD specifications, (Vol 1 & 2) -2019

ii. Delhi Schedule of Rates, (Vol 1 & 2) - 2021

iii. UIC Code 772-2 (R) Code for the use of rubber bearings for rail bridges

iv. IRC:83-2018 (Pt. II) - Standard Specifications and Code of Practice for Road Bridges (Section – IX) Bearings (Elastomeric Bearings)

v. IRC:83-2014 (Pt. IV) - Standard Specifications and Code of Practice for Road Bridges (Section – IX) Bearings (Spherical and Cylindrical)

vi. ISO 6892 – Tensile Testing of Metallic Materials

vii. ISO 13918-2008 – Welding- Studs and Ceramic Ferrules for Arc Stud Welding

3.2 Bridge Works: Substructure

3.2.1 GENERAL

a) Coverage

The Specifications given in this chapter deal with items pertaining to all types of foundations for bridges and bridge superstructure viz., Piers, abutments, wing walls, bed blocks and ballast walls / dirt walls.

3.2.2 Setting out for foundations

a) Setting out for Minor Bridges and Culverts

Shall be carried out by a competent / qualified engineer, employed by the Contractor and checked by the Engineer's representative for all bridges and culverts. Contractor shall provide necessary instruments, linear tapes, pegs etc.

The setting out for foundations and sub-structure shall be carried out with a theodolite and steel tapes / Invar tapes in case of works not involving deep foundations or standing water.

All levels will be measured using a precise levelling instrument. Errors in location of piers / abutments and fixing levels shall be within following limits.

Linear Measurements	±5 mm
Levels	±3 mm

b) Setting out for Major Bridges and Viaduct

i. Locations of piers and abutments along with the centre line of the bridge should be accurately laid out by establishing one or more base lines as directed and a system of pegs and posts. Also sufficient reference pegs and pillars should be established for checking the positions with ease during progress of work. Reference Bench Marks for levelling should be established nearby on a permanent structure or on a pillar to be built up in vicinity.

ii. The principal reference lines and level pegs should be established at easily accessible locations. They include-

1) Longitudinal Centre line

2) Transverse Centre lines of abutments and piers

3) Tangent points of the curve at either end, if alignment is on a curve.

iii. For Bridge Works involving deep excavations, pile driving or well sinking and / or where there is standing water, use of base line is obligatory. They should be preferably at right angle to centre line of bridge, with one on either end on high bank in case of long bridges or on one side bank of bridge for shorter ones.

iv. In case of major bridges and viaduct of length exceeding 1000 m, base lines and reference towers will have to be established. Provision of all assistance in form of measuring instruments, linear tapes as may be required by the surveyor, technical and skilled staff and labour required to assist them, fixing pegs, pillars and towers including all building materials and maintaining and guarding them including supply of all materials, tools and plant shall be done by the Contractor at his cost. Nothing extra will be payable to them on this account. Important points to be observed in this activity are:

1) Linear Measurement shall be carried out with invar tape or electronic distance measuring instruments

2) Spring balances shall be used for giving specified tension to the tape. Tape readings shall be corrected for tension, temperature and slope.

3) Concrete pillars with steel plates fixed over them shall be located at intermediate points (at tape lengths) and ends.

4) Reference pillars at pier and abutment position along centre lines and reference pillars on base lines shall be to standards to be prescribed by the Engineer. During construction, since centre line pillars at abutment / pier locations will be disturbed, reference pillars and lines shall be fixed around each structure by the Contractor under Site Engineer's supervision. Reference

diagrams at Annexures 4/1 and 4/2 and Clause 401 of IRBM shall be referred to for more details.

3.3 Soil Exploration

Soil exploration and test shall be carried out conforming to Indian Railways Codes and Specifications according to soil type, foundation type and site requirement.

3.4 Earthwork in excavation

Excavation shall be made only to the exact depth as approved by the Engineer. In the event of excavation having been made deeper than that shown on the drawing or as ordered by the Engineer, the extra depth shall be made up with M10 concrete in case of foundation resting on soil and with concrete of the same grade as that of the foundation, in case of foundation resting on rock.

3.4.1 Method Statement

The Contractor shall submit Method Statement for carrying out the work of excavation in foundations and flooring etc. suiting to local ground conditions and safety measures conforming to IS: 3764 (Excavation Work- Code of Safety) to the Engineer for approval. The work shall be carried out strictly in accordance with the approved Method Statement and drawings.

3.4.2 Site Clearance

Site clearance shall be done as per the Contract.

3.4.3 Setting Out

After the site has been cleared, the limits of excavation shall be set out true to lines, curves, slopes, grades and sections as shown on the drawings or as directed by the Engineer. The Contractor shall be responsible for the setting out of works and the establishment and maintenance of benchmarks, other marks & stakes as long as in the opinion of the Engineer, they are required for the work.

a) Excavation shall be carried out in all types of soil encountered at site and to the lines, levels and profiles shown on the drawings that have NONO from the Engineer. The Work shall be carried out by the Contractor in such a way as to avoid soil erosion and groundwater pollution, accidents in habitational or frequented places, disturbance to the surrounding ground or structures, accident to workmen and any other untoward incident. Fencing, caution signages with red lights and other safety measures shall be employed to avoid accidents. Where necessary, signal men shall be employed to guide the movement of people, vehicles and equipment.

b) The work shall be carried out in a careful manner to ensure that the exposed surfaces are as sound as the nature of the material permits and that no point shall protrude inside the lines shown on the Drawings.

c) The Contractor shall be responsible for the safety and stability of all excavations performed by him or under his control. In case of any slips or blows in the excavation, the same shall be cleared by the Contractor at his own cost.

d) The Contractor shall notify the Engineer without delay of any permeable strata, joints, faults, fissures or unusual ground conditions encountered during excavation and any excavation instability and/or collapse.

e) The Contractor shall ensure that no air pollution takes place during excavation, storage and transportation of earth/spoil by providing suitable measures such as appropriate cover and the like.

f) The Contractor shall carry out ground stabilization measures without delay before and/or after excavation, if required.

g) The Contractor shall make provision for all shoring, de-watering, dredging, bailing out or draining water whether subsoil or rain or other water and the excavation shall be kept free of water while concrete work is in progress until the Engineer considers the work well set. The sides of trenches shall be kept vertical and the bottom level throughout or properly stepped as directed by the Engineer. No extra payment shall be made on this account.

h) De-watering shall be carried out by suitable means with adequate stand-by arrangements as may be approved by the Engineer. The Contractor shall be deemed to have satisfied himself with regard to feasibility of all aspects of de-watering including site constraints due to existing structures. Though the method of de-watering is left to the Contractor, he shall be required to submit method statement of de-watering scheme including requisite justifications to obtain approval from the Engineer.

i) Approval of the Engineer, however, shall not relieve the Contractor of the responsibility of adequacy and appropriateness of de-watering and protection arrangements for the quality and safety of the work.

j) The Contractor shall erect and maintain during progress of works temporary fences/ barricading around the work area with all safety measures as shown in Reference Information/Reports. The excavations near habitations, public movement areas and all works along the roads shall be provided with proper caution signs and marked with red lights, reflectors at night to avoid accidents. The Contractor shall take all adequate protective measures to see that excavation operations do not affect or damage adjoining structures.

k) Disposal of muck: The surplus excavated material (that cannot be used in the Works), shall be treated as contractor's property. The contractor shall be free to take away and make use of this surplus excavated material in the manner he wishes to, including disposal in spoil dumps or elsewhere as approved by the Engineer/concerned parties and regulating authorities. The employer takes no responsibility for the arrangement of dumping areas and these will have to be arranged by the Contractor at his own cost. The Contractor is required to carry out detailed survey to identify dumping areas, clearances required, leads involved etc. The quoted rates shall be deemed to have taken all these factors into account. The excavated material that can be used in the Works, shall be temporarily stockpiled, if required, in a dump site as proposed by the contractor and agreed by the Engineer and the concerned regulating authorities. Any royalty, if to be paid to local authorities on the excavated material, is to be borne by the Contractor at his own cost irrespective of whether the excavated material is used for the Works or being used for any other purpose or being disposed off as surplus. Truck drivers shall be trained and educated by the Contractor to follow the traffic rules.

l) The Contractor shall ensure that traffic management on roads and railways is carried out in accordance with Sub-Division 6070 of the General Specifications.

3.4.4 Excavation beyond True Lines and Levels

If due to any cause whatsoever excavations are carried out beyond their true line and level, the Contractor shall make good excavation at his own cost to the required line and level with the appropriate grade of filling or with concrete subject to the NONO from the Engineer.

3.4.5 Backfill to Structures

a) Prior to commencement of backfill, the Contractor shall submit Method Statement for carrying out work such that the optimum use may be made of excavated material and obtain approval from the Engineer. The proposals shall include details of the compaction plant and methods for adjusting the moisture content of the material.

b) No filling shall commence until approval has been received from the Engineer.

c) The Contractor shall not backfill around structures until the structural elements have attained adequate strength.

d) The backfill material shall be selected excavated material, thoroughly compacted mechanically in layers not exceeding 300mm loose thickness to achieve a density of at least 90% of the maximum dry density.

3.4.6 Tolerance

Permissible Tolerance for excavation

Item	Standard value (mm)
Finished depth of excavation	±25
length/width	0 to +50

3.5 Ground Improvement

Based on the subsoil details obtained from GT investigations and the loading expected to be applied by the structure, foundation design shall be carried out including sizing and settlement analysis. Ground improvement may be required in the following cases:

a. The net loading intensity of the foundation exceeds the allowable bearing capacity.
b. Resultant settlement exceeds the acceptable limits for the structure.

c. Loose cohesionless subsoil susceptible to liquefaction during earthquakes specially under high water table condition.

3.5.1 Ground Improvement by Soil Replacement method:

Soil up to the depth prone for liquefaction shall be cut below the founding level in required width. Upon completion of the excavation, bottom surface shall be levelled and compacted with heavy vibratory roller. All necessary safety precautions shall be ensured during excavation to protect the cut slopes.

Thereafter it shall be refilled with clean coarse sand/gravel in layers with mechanical compaction using heavy vibratory roller until the design founding level is reached. The sand/gravel layers used for filling shall be compacted to a minimum of 70% of the Density Index (Relative Density) as obtained in accordance with IS 2720 Part- 14. After ground improvement by soil replacement, safe bearing capacity shall be assessed by conducting Plate Load test. Sand/gravel for soil replacement shall be well grade-C_u>7 and fines (passing 75 micron) shall be less than 5%.

3.6 Bored cast in-situ Piling

Piling shall be carried out by hydraulic piling rig.

3.6.1 Method **Statement**

The Contractor shall submit Method Statement for carrying out the work of piling. The work shall be carried out strictly in accordance with the approved Method Statement, Manual on the design and construction of Well and Pile foundations, the Specification and the Drawings.

3.6.2 Materials

a) **Concrete**

Piles shall be constructed in accordance with the details shown in the drawings using the grade of concrete indicated, produced and placed in accordance with provisions of Annexure OCS-1 of these specifications.

b) **Reinforcement Steel**

Reinforcement steel shall comply with the provisions of Annexure OCS-2 of these specifications.

c) **Temporary Casings**

Temporary casings, as approved by the Engineer, shall be used to maintain the stability of pile bore hole. Temporary casings shall be free of distortion and shall be of uniform cross-section throughout each continuous length. During concreting, they shall be free of internal projections and encrusted concrete which may prevent proper formation of the pile.

d) **Stabilizing Material**

Natural drilling mud like bentonite shall not be used. The stabilizing fluid having polymer as approved by the Engineer shall be used.

3.6.3 Pile Installation

a) General

i. Bored cast-in-situ concrete piles shall conform to IS 2911 (Part 1/ Section 2), where not contravening to the following provisions. Based on borehole reports and drawings, installation of piles shall be carried out as per pile layout drawings, installation criteria, approved Method Statement and instructions of the Engineer. Any changes to the pile design, based on test-piles results, bore-hole data or soil conditions encountered during boring, shall be as instructed by the Engineer.

ii. The equipment and accessories for installation of piles shall be selected giving the due consideration to the sub-soil conditions, ground water conditions and type of founding material. These shall be of standard type and shall have been approved by the Engineer.

iii. Before installing the initial test pile, the Contractor shall finalise the pile testing arrangement and obtain approval of the Engineer.

iv. It is envisaged that the working piles shall be installed after the successful completion of the initial pile load test.

v. In case the Contractor desires to install the working pile, pending successful completion of initial pile load test, he may be permitted to do so, provided he gives undertaking to the Engineer to bear all associated risks and costs involved to make up for the short falls in the pile capacity, in the event of the failure of the initial pile load tests to establish specified ‘Design Ultimate Load’ carrying capacity of initial test pile.

vi. The Engineer reserves the right to reject any pile which in his opinion is defective on account of less carrying capacity, structural integrity, position, alignment, concrete quality etc. Piles that are defective shall be pulled out or left in place as judged convenient by the Engineer, without affecting the performance of adjacent piles. The Contractor shall install additional piles to substitute the defective piles, as per the directions of the Engineer, at no additional cost to the Employer. Further, the cost of additional piles and increase in the pile cap size, if any, on account of additional piles, shall be borne by the Contractor.

vii. Each pile shall be identified with a reference number and shall be as shown in the Drawings. The convenience of installation may be considered while scheduling the sequence of piling in a group.

viii. 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.

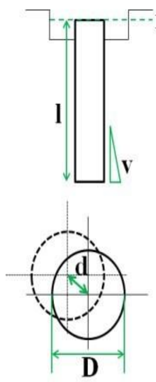
ix. Level marks shall be accurately painted on each pile immediately after its installation. Subsequently, if any pile displays any tendency to heave up due to installation of other piles or due to any other reasons, the same shall be reinstalled firmly as per the directions of the Engineer without any additional cost.

x. The Contractor shall record all the information during installation of piles, including pile-bore observations before concreting each pile. The data sheet for recording pile data shall be as approved by the Engineer. On completion of each pile installation, pile record shall be submitted to the Engineer within two days of completion of concreting of the pile.

b) Control of Position and Alignment

Piles shall be installed as accurately vertical as possible. The permissible tolerances with respect to position and inclination/alignment are as shown below:

Tolerances

No	Item	Permissible tolerance	Figure
1	Level of top i.e. Cut-off-Level (m)	-25mm to 25mm	
2	Position of the head in plan at Cut-off-Level (d)	75mm or less	
3	Embedded depth in bearing stratum (l)	Design value or more	
4	Diameter of the pile (D)	Design value or more	
5	Variation from vertical at Cut-off-Level (v)	1.5% or less	

c) Pile Boring

i. Boring Operation:

- Boring operations shall be done by rotary hydraulic feed drilling rigs with reverse mud circulation or other suitable boring methods that have been approved by the Engineer. The boring or drilling equipment shall have suitable and adequate accessories for boring or drilling through all types of strata expected at site.
- The size of cutting tools shall not be less than the diameter of the pile by more than 75 mm. However, the pile bore shall be of the specified size.
- The boring centre shall be aligned with the pile centre and the boring machine shall be installed so as not to move or incline. The sides of the bore-hole shall be stable throughout.
- Working level shall be above the Cut-off-Level. After the initial boring of about 1.0 m, temporary guide casing of suitable length shall be lowered in the pile bore for vertical pile. The diameter of guide casing shall be such as to give the necessary finished diameter of the concrete pile. The centre line of the guide casing shall be checked before continuing further boring. Guide

casing shall be minimum of 3.0 m length. Additional length of casing may be used depending on the condition of the strata, ground water level etc.

- The temporary guide casing (if provided) shall be withdrawn cautiously, after concreting is done up to the required level. While withdrawing the casing, concrete shall not be disturbed.
- For providing permanent MS liner, Clause 709.1.4 of IRC:78 shall be complied with. Whenever stricter provision has been given in the drawings, the same shall be followed.
- If boring operation becomes difficult before reaching the predetermined depth, further plan of action shall be submitted by the Contractor and approval shall be obtained from the Engineer for the same. The piles shall be founded on rock or other suitable strata as approved by the Engineer.

ii. Maintaining the bore hole:

- For maintaining bore hole wall while boring, a stabilizing material, according to the soil shall be used and the level of the stabilizing fluid shall be maintained at not less than 3.0 m above the ground water level or at such other level as will ensure that the fluid pressure is at all times in excess of pressures exerted by the soils and external groundwater. The stabilizing fluid shall be under constant circulation till start of concreting. The level of stabilizing fluid for all piles shall be recorded by the Contractor and reported to the Engineer, including the confirmation of the bore-hole wall shape after boring. Where temporary casings or an alternative method for maintaining stability of a boring are used, these shall be subject to the Engineer's approval.
- Consistency of the stabilizing material suspension shall be controlled throughout concreting operations in order to keep the bore stabilized, as well as to prevent concrete getting mixed up with the thicker suspension of the mud.
- When the boring is done by rotary drilling rigs, the verticality of Kelly bar shall always be maintained. In the soil layer such as sandy soil layer where the bore hole tends to collapse, care shall be taken to ensure the drilling bucket does not hit the hole wall. While boring in the founding soil layer, the drilling bucket shall be raised at appropriate speed to prevent loosening of the soil by suction.

iii. Stabilizing material management:

In addition to the requirements that are already stated, the following shall be considered:

- The stabilizing material shall be controlled so as to prevent pile-bore wall collapse and ensure the quality and shape of the concrete.
- While boring, the Contractor shall periodically check the properties of the stabilizing material and control the management items (specific gravity, marsh funnel viscosity, pH, etc.) to be within the values set in the Method Statement that has been approved by the Engineer.
- Stabilizing fluid shall be approved by the Engineer, thoroughly mixed with clean fresh water along with the required Polymer like CMC, to form a suspension meeting the specification requirements as submitted to and consented by the Engineer.
- The frequency of testing stabilizing material and the method and procedure of sampling shall be proposed by the Contractor and approved by the Engineer prior to the commencement of piling work.
- Prior to concreting a pile, the Contractor shall take measures to remove any heavily contaminated stabilizing material which could impair the free flow of concrete from the tremie pipe. Placing of concrete shall proceed only with due modification as per consent of the Engineer.
- All reasonable steps shall be taken to prevent the spillage of stabilizing fluid in areas outside the immediate vicinity of boring.

iv. Confirmation of bearing stratum for termination level:

- Confirmation of the support layer shall be carried out by boring depth and comparing excavated soil and soil survey material. Also, the pile designated as per approved Method Statement or by the Engineer shall receive necessary confirmation.
- The boring depth shall be measured at two or more places to the bottom of the hole immediately after completion of boring operations. The results shall be reported promptly.
- A protocol shall be maintained regarding the strata at the founding level, Standard Penetration Test (SPT) value, percent core recovery, Unconfined Compressive Strength (UCS) from the nearest borehole, socketing horizon, flushing of pile bore, time interval between end of boring and start of concreting, bentonite density prior to the commencement of concreting.

v. Cleaning of pile bore just after boring:

- After completion of the pile bore up to the required depth, the pile bore shall be cleaned of loose, disturbed or re-moulded soil from the base of the pile.
- The cleaning shall preferably be achieved by three stages flushing of slurry using airlift technique, as per approved Method Statement. The bottom of the pile bore shall be thoroughly cleaned by airlift technique. Cleaning shall ensure that the pile bore is completely free of sludge or bored material, debris of rock or boulder etc. Necessary checks shall be made to ensure the thorough cleaning of the pile bore.
- Concreting operations shall not proceed if the contaminated stabilizing material at the bottom of the pile bore possesses a density of more than 1.12 g/ml. The stabilizing material sample shall be collected from the bottom of pile bore. For this a solid cone shall be lowered by a string to the bottom of pile bore. A sampler tube closed at top with a central hole (hollow cylinder) is lowered over the cone, then a top cover shall be lowered over the cylinder. Care shall be taken for proper fittings of assembly to minimise the leakage, while lifting the cone assembly to the ground surface. The slurry collected in the sampler tube shall be tested for density and sand content.
- When the boring is done by rotary drilling rigs, cleaning-bucket attached to the Kelly shall be used for cleaning the bore. Wherever stabilizing material is used, after using the cleaning-bucket, the bore shall be flushed with fresh slurry.
- The Contractor shall measure the final depth after this cleaning and confirm its effect by comparing with the depth at the end of boring.

vi. Cleaning of pile bore just before concreting:

- Pile bore shall be cleaned by fresh stabilizing material through tremie pipe or as specified in the Method Statement, before (in case delay in concreting after the completion of bore) and after placing the reinforcement cage and just before the start of concreting. Pile boring shall be inspected and approved by the Engineer, in accordance with approved Method Statement, before concreting.
- The Contractor shall measure the final depth after this cleaning, when there is a delay in concreting after completion of the bore, for knowing the casting pile length, and confirm its effect by comparing with the depth at the end of boring.

vii. Other relevant considerations for pile boring:

- Care shall be taken not to harm a recently concreted pile due to driving the casing nearby before the concrete has sufficiently set in that pile. The danger of doing harm is greater in compact soils than in loose soils.

- For bored holes, the finishing and cleaning of the bore, lowering of reinforcement cage and concreting of the pile for full height must be accomplished in one continuous operation without any stoppage.
- Pumping from a boring shall not be permitted unless approval has been issued by the Engineer.
- A pile excavation shall be backfilled without delay where a rapid loss of drilling fluid occurs and no further excavation at the location of that pile shall be carried out until the Engineer's approval is obtained.
- After each pile has been cast, any empty bore which may remain shall be protected and carefully backfilled as soon as possible to the satisfaction of the Engineer.
- Carriage and Disposal: The bored spoil material and contaminated mud and bentonite slurry shall be disposed at the designated areas identified by the Contractor and as per the procedure approved by the Engineer and as mandated by other relevant Contract provisions.

d) Concreting

i. Cast-in-Situ pile concreting shall conform to provisions of Annexure OCS-1 of these Specifications and the relevant provisions of IS 2911 (Part 1/ Sec 2), where not in contravention to the following provisions.

ii. Concreting shall not be done until the Engineer is satisfied that the termination level of pile, is as per the installation criteria and the Method Statement that has been approved by the Engineer.

iii. Concrete in the pile shall be coherent, rich in cement with high slump and restricted water cement ratio. The slump of concrete shall vary between 150 mm to 180 mm for bored piles. For long or large diameter piles, use of retarding plasticiser in concrete is desirable.

iv. The time interval between the completion of boring and placement of concrete in pile bore shall not exceed 6 hours. In case the time interval exceeds 6 hours, the pile bore shall be abandoned. However, the Engineer may allow concreting provided the Contractor extends the pile bore by 0.5 m beyond the termination level and clean the pile bore. The entire cost of all operation and materials for this extra length shall be borne by the Contractor.

v. The concrete shall be properly graded, self-compacting and shall not get mixed with soil, excess water, or other extraneous matter. Special care shall be taken in silty clays and other soils which have the tendency to squeeze into the newly deposited concrete and cause necking. Adequate head of green concrete shall be maintained to prevent inflow of soil or water into the concrete.

vi. Concreting shall be done by tremie method. The operation of tremie concreting shall be governed by IS 2911 (Part 1/ Sec 2). Stabilizing material shall be maintained sufficiently above the ground water level, as specified elsewhere in this Specifications.

vii. Concreting by tremie shall continue to allow the initial pours of concrete, mixed with stabilizing fluid, sludge and cut spoils from the bore to overflow and the consistency and quality of the overflowing concrete is comparable to that of design mix. The length of overflow shall be decided by the Engineer.

viii. It shall be ensured that the volume of concrete poured is at least equal to the theoretically computed volume of the pile shaft being cast.

ix. The tremie shall have uniform and smooth cross-section inside. The tremie shall be water-tight throughout its length and have a hopper attached at its head by a water-tight connection. All tremie tubes shall be scrupulously cleaned before and after use.

x. While concreting the tremie shall be withdrawn slowly ensuring adequate height of concrete outside the tremie pipe at all stages of withdrawal.

xi. An adequate quantity of concrete within the pipe shall be maintained at all times to ensure that the pressure from it exceeds that from the water or drilling fluid.

xii. The tremie pipe shall be lowered to the bottom of the bore-hole, allowing water or stabilizing material to rise inside it before pouring concrete. The tip of the tremie pipe shall not be separated from the bottom of the hole more than necessary (when plunger is used, it is about 0.2 m or less from the hole bottom)

xiii. The tremie pipe shall always be kept full of concrete and shall penetrate well into the concrete in the borehole, at least 2 m or more, with adequate margin of safety against accidental withdrawal if the pipe is surged to discharge the concrete.

xiv. During concreting, the cycle time of concreting, concreting volume, concrete placement height and the height of the tremie pipe tip in concrete shall be checked for all the piles and reported in a format that has been approved by the Engineer.

xv. To prevent the reinforcement cage from floating during placement of concrete, appropriate countermeasures shall be made in advance, as per the Method Statement that has been approved by the Engineer. The same shall be monitored for all piles and reported.

xvi. Temporary casings, when used, shall be extracted carefully to the satisfaction of the Engineer, whilst the concrete is sufficiently workable to ensure it is not disturbed or lifted, and the reinforcement cage does not get disturbed. During extraction, sufficient quantity of concrete shall be maintained inside the casing to overcome the pressure from external water, soil or stabilizing material and to ensure that no reduction in section by way of necking or shearing of concrete and contamination of the pile takes place.

xvii. Segregation of the ingredients shall be prevented. The displacement or distortion of reinforcement during concreting shall be avoided. If the concrete is placed inside precast concrete tubes or consists of precast sections, subject to the approval of the Engineer, these shall be free of cracks or other damage before being installed.

xviii. While concreting uncased piles, voids in concrete shall be avoided and adequate head of concrete shall be maintained to prevent inflow of soil or water into the concrete. It is also necessary to take precautions during concreting to minimise the softening of the soil by excess water. Uncased cast- in-situ piles shall not be allowed where mudflow conditions exist.

xix. Where concrete is placed in dry borings, measures, subject to approval of the Engineer, shall be taken to avoid segregation and bleeding and to ensure that the concrete at the bottom of the pile is not deficient in grout.

xx. Where enlarged bases are required, as per site conditions and as approved by the Engineer, these shall be mechanically formed and shall be concentric with the pile shaft within a tolerance of 10% of the shaft diameter and shall not be smaller than the required dimension. The sloping surface of the frustum forming the enlargement shall make an angle of not less than 55° to the horizontal.

xxi. Grouting at base of pile shall be done wherever the results of proof coring (in case of rock), sonic logging and/or loading test etc. confirm that there is a void/ sludge at the pile base. The grouting shall be done with cement slurry under suitable pressure after concrete in the pile attains the desired strength, if required by the Engineer. For this purpose, conduit pipes with easily removable plugs at the bottom end shall be placed in the bore along with reinforcement cage before concreting

3.6.4 Top of Concrete in Pile, Cut-off-Level (COL):

a) Cut-off-Level of piles shall be as indicated in the drawings.

b) The top of concrete in pile cast shall be above the Cut-off-Level by 1.0 m (minimum) and as per the Method Statement, to remove all laitance and weak concrete and to ensure good concrete at Cut-off-Level, for the proper embedment into the pile cap. Any exceptions, due to contingent situation, will be subject to the approval of the Engineer.

c) Preparation of pile head: The area surrounding the piles shall be excavated up to the bottom of the pile caps. After seven days of concreting of pile, the exposed part of concrete above the COL shall be removed or chipped off and made rough at COL. In case a part of extra-pile concrete before curing is handled, the Contractor shall obtain prior approval from the Engineer. The projected reinforcement above COL shall be properly cleaned and bent carefully, only where required, to the required shape and level to be anchored into the pile cap as per the drawing. While finishing the pile head, care shall be taken to ensure no harmful damage, such as cracks, occurs in the concrete. The pile top shall be embedded into the pile cap as per the Drawings. All loose material on the top of pile head after chipping to the desired level shall be removed and disposed as per contractual procedure and as directed by the Engineer.

3.6.5 Reinforcement Steel

a) Reinforcement steel, along with its inspection and testing shall conform to Annexure – OCS-2 of these Specifications, along with IS 2911 (Part 1/ Sec 2) and used as per the drawings.

b) The reinforcement shall be assembled before placing in the moulds and all hoops and links shall be of uniform length firmly wired into position. Ends of helical reinforcement, if used, shall be firmly secured. Diagonal fork spacers shall be of a pattern that has been approved by the Engineer.

c) Lap joints in main longitudinal bars will be permitted only when, in the opinion of the Engineer, each bar cannot be supplied in one complete length. Where permitted, joints shall be provided at agreed centres, designed to develop the full strength of the bar across the joint, provided with adequate links or stirrups and staggered in position from those of adjacent longitudinal bars or as indicated in the drawings, subject to the approval of the Engineer.

d) The 'L' bends in the reinforcements at the bottom of the piles shall not be provided to avoid the formation of soft toe.

e) Jointing of Reinforcement Steel for Piles: Only lap joints shall be provided as shown in the drawings.

f) Lowering of the reinforcement cage:

i. The reinforcement cage shall be properly aligned with the pile core and kept vertical without collapsing the hole wall. In lowering of the reinforcement cage, it shall avoid deformations, damages, etc. by using reinforcing material as necessary. In the lap joint part of the reinforcement cage, the upper and lower cages shall be in a straight line, with the joints tightly bound.

ii. Proper cover to reinforcement and central placement of the reinforcement cage in the pile bore shall be ensured by use of suitable concrete spacers or rollers cast specifically for the purpose, as directed by the Engineer. The longitudinal reinforcement shall project above Cut-off-Level as indicated in the drawings.

iii. After lowering of the reinforcement cage, the height of the top end of the reinforcement shall be measured and reported. The axes of the reinforcement cage and the pile core shall be matched, checked and reported.

3.6.6 Breaking off of Piles

If any pile already cast requires breaking due to subsequent change of Cut-off-Level, then the same shall be carried out, not before seven days of casting without affecting the quality of existing pile, such as loosening, cracking etc., and to the satisfaction of the Engineer.

3.6.7 Pile Caps

The ground shall be excavated, levelled, prepared and then layers of coarse aggregate and blinding concrete shall be constructed below pile cap. The pile cap shall then be cast as per the Drawings and conforming to Annexure OCS-1 and Annexure OCS-2 of these Specifications, subject to tolerances mentioned therein.

3.6.8 Tests on Piles

a) General

When preparing for conducting a pile test, the Contractor shall follow the requirements of the various acts, orders, regulations and other statutory instruments that are applicable to the work for the provision and maintenance of safe working conditions and shall in addition make such other provision as may be necessary to safeguard against any hazards that are involved in the testing or preparations for testing.

b) Load Test on Piles

i. Sub-Clause 3.6.8 (e) to Sub-Clause 3.6.8 (g) of these Specifications covers the requirements for initial vertical load and routine vertical load tests on reinforced concrete single vertical piles of specified diameter to assess their vertical load carrying capacities. All pile load testing shall conform IS 2911 (Part 1/ Sec 4)

ii. Full details of the equipment proposed to be used, the test setup and pile testing scheme along with detailed design, drawings shall be submitted to the Engineer, before making arrangements to carry out the tests, for obtaining his approval. Approval of the Engineer shall also be obtained after the test setup is complete, prior to commencement of loading.

iii. The work shall include mobilization of all necessary equipment, kentledge, anchor piles and rock anchors, or combination of kentledge and anchor piles and rock anchors, providing necessary engineering supervision and technical personnel, skilled and unskilled labour as required, to carry out the complete pile testing and submission of test reports.

iv. In all cases, the Contractor shall ensure that when the hydraulic jack and load measuring device are mounted on the pile head the whole system will be stable up to the maximum load to be applied.

v. Necessary means shall be provided to enable dial gauges to be read from a position clear of the kentledge stack or test frame in conditions where failure in any part of the system due to overloading, buckling, loss of hydraulic pressure and so on might constitute a hazard to personnel.

vi. The hydraulic jack, pump, hoses, pipes, couplings and other apparatus to be operated under hydraulic pressure shall be capable of withstanding a test pressure of one and a half times the maximum working pressure without leaking.

vii. The maximum test load or test pressure expressed as a reading on the gauge in use shall be displayed and all operators shall be made aware of this limit.

viii. Where kentledge is used, the Contractor shall construct the foundations for the kentledge and any cribwork, beams or other supporting structures in such a manner that there will not be differential settlement, bending or deflection of an amount that constitutes a hazard to safety or impairs the efficiency of the operation. The kentledge shall be adequately bonded, tied or otherwise held together to prevent it falling apart, or becoming unstable because of deflection of the supports. The weight of kentledge shall be greater than the maximum test load and if the weight is estimated from the density and volume of the constituent materials, an adequate factor of safety against error shall be allowed.

ix. It is essential that all the equipment and instruments are properly calibrated both at the commencement and immediately after the completion of tests, so that they represent true values. If the Engineer desires, the Contractor at his own cost shall arrange for calibration of the instruments in presence of the Engineer, at a laboratory having Engineer's approval, and the test report and calibration certificate shall be submitted to the Engineer.

x. The complete jacking system including the hydraulic jack, hydraulic pump and pressure gauge shall be calibrated as single unit. The complete unit shall be calibrated over its complete range of travel for increasing and decreasing loads same as that of test loads. The calibration certificate shall be submitted to the Engineer.

xi. The reaction load to be made available for the test shall be at least 25% greater than the maximum jacking force. The reaction system as relevant shall be designed for the total reaction load. All reaction loads shall be stable and balanced during all operations of testing. During testing, stability of reaction system shall be ensured.

xii. The vertical displacement of pile shall be measured using dial gauges having a least count of 0.01 mm.

xiii. Load test shall be conducted at pile Cut-off-Level (COL). If the water table is above the COL, the test pit shall be kept dry throughout the test period by suitable dewatering methods.

xiv. In case of initial vertical load test, where the water table level is higher than the COL, the Contractor may use anchor piles and rock anchors for testing purposes. The Engineer, at his discretion, may decide to raise the COL above water table.

xv. All operations in connection with pile load test shall be carried out in a safe manner to prevent exposure of the people to hazard and also to ensure the safety of manpower and material.

xvi. Test record and report for pile load tests shall be as per IS 2911 (Part 1/ Sec 2) and as approved by the Engineer. The reports shall be submitted to the Engineer immediately on completion of each test.

xvii. Two fixed independent benchmarks shall be established as reference points at least 15 m from the test pile to monitor the settlements.

xviii. If any initial pile load test gets abandoned and is not successfully completed, then the Contractor shall install another test pile and repeat the initial test after correcting the fault, at his own cost.

xix. On completion of a test all equipment and measuring devices shall be dismantled, checked and either stored so that they are available for use in further tests or removed from the Site.

c) Test Pile Installation

i. Piles shall be installed as per Sub-Clause 3.5.3 herein above.

ii. Pile installation data as applicable shall be furnished along with the load test results to the Engineer.

d) Types of Tests

i. Initial vertical (compression) load test and lateral load test shall be carried out on test piles, which are not to be incorporated in the work, to assess the 'Ultimate Load Capacity of Pile' before the commencement of the installation of working piles.

ii. The test piles shall have the same design details as of the working piles typically adopted in the predominant soil profile in that area.

iii. Routine vertical (compression) load test and lateral load test shall be conducted to verify the load carrying capacity of working pile.

iv. Pile integrity test shall be carried out on each pile by:

a. The Low Strain Method as per IS 14893 to verify the structural integrity, shape and continuity of pile as detailed in Sub-Clause 3.6.8(i).

b. Cross Hole Sonic Logging test as per ASTM D 6760

e) Number of Tests:

i. **Initial pile-load tests:** The number of load tests shall be as per IS 2911 (Part 4). Number of tests shall be minimum 1% of total number of piles at each bridge location but not less than one (01) test at each bridge. The number may be increased up to 2% depending upon the nature, type of structure and sub-strata condition.

ii. **Routine pile-load tests:** The number of load tests shall be as per IS 2911 (Part 4). Number of tests shall be minimum 1% of total number of piles at each bridge location but not less than one (01) test at each bridge. The number may be increased up to 2% depending upon the nature, type of structure and sub-strata condition.

iii. Initial and routine tests shall be suitably increased for important structures or cases with large variation in the subsurface strata as directed by the Engineer.

iv. Pile load tests shall be carried as per IS 2911 (Part 4).

f) Testing-Piles

i. The testing-piles for routine load test shall be identified by the Engineer. For initial load test, testing-pile shall be installed as a test-pile, separate from working piles, as directed by the Engineer.

ii. A minimum time period of four weeks shall be allowed between the time of pile casting and testing. Testing-pile head shall be prepared for testing purposes only, one week after casting the pile.

iii. Testing-piles shall be cut off at the proper level and provided with a proper cap, to provide a plane bearing surface for the test plate and for proper arrangements for seating of the jack and dial gauges.

g) Static Vertical Load Test

i. The tests shall conform to IS 2911 (Part 4).

ii. Equipment and Test Setup

- A steel plate of adequate thickness and not less than 50 mm shall be centered on the pile cap to prevent it from getting crushed under applied load. The size of the circular test plate shall not be less than the pile size nor less than the area covered by the base of the hydraulic jack(s).
- The datum bars shall be supported on immovable supports, preferably of concrete pedestals or steel sections, placed sufficiently far away from the test pile. The distance shall not be less than 3 times the diameter of testing-pile and in no case less than 2 metres from the edge of testing-pile. These supports shall be placed at an adequate depth below ground to be unaffected by ground movements.

iii. Loading System

The test load on pile shall be applied by means of hydraulic jack(s) which obtain reaction in one of the ways mentioned in Cl.7.1.3 of IS 2911 (Part 4).

The measurement of strains for load monitoring may also be done by load cell connected to a digital read out unit.

iv. Test Procedure

- Application of Load:- The test should be carried out by applying a series of vertical downward incremental load each increment being of about 20 percent of safe load on the pile. For testing of raker piles it is essential that loading is along the axis.
- This is applicable for both initial and routine test. In this method application of increment of test load and taking of measurement or displacement in each stage of loading is maintained till rate of movement of the pile top is not more than 0.2mm/h or until 2 h has elapsed, whichever is earlier subject to a minimum of 1 h. The test load shall be maintained for 24 h.
- Duration of vertical loading shall be as per Cl. 7.2 of IS 2911 (Part 4)
- Settlement:- Settlement shall be recorded as per Cl. 7.1.4 of IS 2911 (Part 4).

- The safe vertical load on single pile for the initial test shall be as per Cl. 7.1.5 of IS 2911 (Part 4).
- Items to be measured:

  The following items shall be measured:

  - Time;
  - Applied pressure;
  - Applied load;
  - Displacement at the pile head;
  - Movement of reaction devices;
  - Others, as decided by the Engineer.
- Commencement, interruption and completion of the test:
  - The test shall be commenced after ensuring the conditions surrounding the site, preparations of all equipment and the suitability of the weather condition.
  - If any abnormal conditions are noticed during the test, the test shall be interrupted promptly. The test can only be resumed when the cause of the abnormal condition has been detected and rectified.
  - The test shall be completed when the objectives of the test shall have been achieved, or when it is judged that abnormal conditions make it impossible to continue the test.
- Loading on the pile shall be continued till as given in IS 2911 (Part 4).

h) Lateral load tests – Lateral load tests shall be carried out on test pile as well as on working pile safe load capacity determined as per Clause 8 of IS 2911 (Part 4).

i) Pile Integrity Test :

a) Low Strain Method-

i. Pile integrity test shall be carried out on each pile by The Low Strain Method as per IS 14893:2001. In case of large diameter piles, the tests shall be conducted at 5-6 places to cover the entire section of the pile.

ii. The tests shall be conducted on piles whose length is correctly recorded or on test piles where available, to determine the value of stress wave velocity and characteristic or reference signal for comparing the signals for testing subsequent piles.

iii. The area surrounding the pile should be free from standing water and kept dewatered during the tests. The pile head should be accessible.

iv. Testing should be free of work likely to cause disturbance. The cast-in-situ piles should not be tested normally before 14 days of casting.

v. The test piles, if available at site, can be used to determine the pulse velocity and characteristic or reference signal generated. Where no test pile is available information can be obtained from cast piles whose length is accurately recorded.

vi. Methodology for Low Strain Integrity test:

- This is a system of assessing the integrity of piles by the use of low stress wave imparted to the pile shaft and is also known as Sonic Integrity or Sonic Echo Test. A small metal/hard rubber hammer is used to produce a light tap on top of the pile. The shock traveling down the length of the pile is reflected back from the toe of the pile and recorded through a suitable transducer/accelerometre (also held on top of the pile close to the point of impact) in a computer disk or diskette for subsequent analysis. The primary shock wave which travels down the length of the shaft is reflected from the toe by the change in density between the concrete and sub-strata. However, if the pile has any imperfections or discontinuities within its length these will set up secondary reflections which will be added to the return signal.

- The reflected stress wave can be monitored using either processing technique, the observed signals are amplified and converted into digital display as velocity versus length or frequency versus mobility records, providing information on structural integrity of piles. The stress wave velocity and approximate pile lengths are provided as input for the integrity testing. The stress wave velocity is dependent on the Young's modulus and mass density of pile concrete. This value generally lies between 3000-4000 metre per second depending on the grade of concrete used (M15-M25).

b) Cross Hole Sonic Logging Test-

i. Pile integrity test by Cross Hole Sonic Logging test as per ASTM D 6760 shall be carried out on each pile.

ii. Following methodology shall be adopted for Cross Hole Sonic Logging test:

1) **Sonic Logging Tubes**

i) All piles shall be provided with sonic logging tubes cast into it.

ii) The tubes shall be manufactured from steel and shall extend 0.5m above the pile head and 0.5m above the pile toe. The tube shall have an internal diameter not exceeding 50mm, except for one tube in each pile, where it shall be of internal diameter 150mm minimum in order to allow for coring of the concrete at the base of the pile.

iii) Four tubes shall be required for each pile.

2) **Proof Coring**

i) For piles founded in rock, proof coring shall be done, for all piles. At least 7 days after the pile has been cast, but before carrying out any sonic logging test, a core of concrete and rock from the founding materials shall be taken.

ii) For piles founded in soil, proof coring shall be done only for piles with anomalous sonic logging test results. The core shall be taken from the base of the 150mm diameter sonic logging tube using a triple tube core barrel and shall have a minimum diameter of 50mm.

iii) The scanning of the pile toe for its integrity by measuring the propagation time of transmitted waves between the vertical tubes and the pile toe/founding strata shall also be carried out.

3) **Sonic Logging Equipment**

i) The equipment shall be properly maintained and calibrated.

ii) Where necessary, means shall be provided to centralize the probes within the tubes, so that variation in the separation of the emitter and receiver resulting from clearance between the probes and the tubes does not occur.

4) **Test Procedure**

The tubes shall be filled with water. The tests shall be repeated for each pair of tubes, i.e. three runs for a pile with three tubes and six runs for a pile with four tubes.

5) **Analysis of Test Results**

i) A report shall be prepared for each pile tested. The photographic record of the oscilloscope displays shall be analysed in detail.

ii) A deviation from the record to be expected from a pile constructed entirely of sound concrete and without defect shall be reported. The report shall indicate the nature, location and severity of the defect and recommendations shall be made for further testing. The implication of the existence of the defect on the performance of the pile shall be evaluated.

6) **Submission of Results**

Immediately after testing, a signed copy of all the raw data of a pile shall be given to the Engineer. A test report shall be submitted to the Engineer within 3 days after testing.

7) **Anomalous Sonic Logging Test Results**

i) The piles with anomalous sonic logging results shall be rejected at the Engineer discretion unless the Contractor is able to demonstrate that the pile integrity is acceptable through proof coring.

ii) In case of piles founded on rock, if the results of sonic logging test and/or proof coring (and/or pile load test) confirm or indicate the existence of void, sludge or the like between the pile toe and rock, the Engineer shall reject such piles or pile group, or alternatively, as per geotechnical expert's advice, shall require the Contractor to clean and grout between the pile toe and rock.

8) **Grouting of Pile after Testing**

Upon completion of sonic logging test, the access tubes and sonic coring holes, if any, shall be grouted using an approved concrete mix or an approved grout mix.

9) **Others**

Anything not specified hereinabove shall be referred to in the most current version of ASTM D6760.

3.6.9 Sampling, Testing, Inspection, and Acceptance Criteria Including Construction Tolerances of Piles

i. Frequency of sampling, testing and quality assurance including the method of conducting the tests, acceptance criteria and construction tolerances shall be as mentioned herein above and included in the Method Statement that has been approved by the Engineer. The tests shall be performed and reported as per the Method Statement that has been approved by the Engineer.

ii. Forcible corrections for any deviations shall not be made to concrete piles.

iii. Data Reporting and processing

- The assessment of structural integrity is based on two equally important aspects:
  - ➢ Quality of signals, and
  - ➢ Accurate analysis and interpretation of signal.
- Piles requiring remedial measures should be so marked immediately on completion of the field integrity testing and rectification measures selected.
- The final report should include signals of each integrity test and structural condition of piles.

iv. Submission of Results: Immediately after testing, a signed copy of all the raw data of a pile shall be given to the Engineer. A test report shall be submitted to the Engineer within 3 days after testing.

3.6.10 Safety

The Contractor shall adopt appropriate method and practice conforming to IS 5121 (Piling and other deep foundation - Code of Safety) suiting to local ground characteristics.

3.7 WELL FOUNDATIONS

3.7.1 General

i. In case of larger than 12m in diameter and for wells to be sunk by using special equipment, supplemental instructions/ specifications will be necessary. For basic items of work such as Concrete (Plain or RCC) brick work, stone masonry etc which are incidental relevant items may be referred to.

ii. To facilitate sinking of well, steel cutting edge is fabricated and connected to a concrete well curb of required shape. Minimum grade of concrete for well curb shall be M 35 unless otherwise specified in Drawing or directed by Engineer. On top of the well curb, adequate height of well steining is cast and the process of sinking is carried out. After a portion of the well has been sunk, another height of well steining is cast on top of the previous section and further sinking carried out. This process is continued till the bottom level of the well reaches the founding level.

iii. At the top of the well steining, an adequately designed “well cap” is laid which transmits the loads and forces from the sub-structure (piers or abutments) to the foundations.

3.7.2 Equipment for sinking wells

Equipment shall be deployed for construction of well foundation as required and as directed by the Engineer in quality, performance and quantity. Generally, the following equipment’s may be required for the work:

i. Crane with grab buckets capacity 0.5 to 2.0 cum.

ii. Submersible pumps

iii. Air compressors, air locks and other accessories where pneumatic sinking of well is anticipated.

iv. Chisels of appropriate sizes

v. Aqua header for cutting rocky strata

vi. Driving helmets and accessories

vii. Concrete Mixer or Batching Plant; Pumps or skips and hoists; vibrators etc.

viii. Pre-arrangements for blasting equipment in case of unforeseen circumstances.

3.7.3 Well Steining

i. The dimensions, shape, concrete strength and reinforcement of the well `steining shall strictly conform to those shown on the drawings. The form work shall preferably be of MS sheets shaped and stiffened suitably. In case timber forms are used, they shall be lined with plywood or M.S. sheets.

ii. Steining built in the first lift above the well curb shall not be more than 2 metres high and in subsequent lifts it shall not exceed the diameter of the well or the depth of well sunk below the adjoining bed level at any time. For stability, the first lift of steining shall be cast only after sinking the curb at least partially for stability. Concreting of steining may be carried out in subsequent lifts of about 1.2, or 2 to 2.5 metres. Attempts should be made to minimise the number of construction joints. The concreting layers shall be limited to about 450 mm restricting the free fall of concrete to not more than 1.5m. Laitance formed at the top surface of a lift shall be removed to expose coarse aggregates before setting of concrete at the proposed construction joint. As far as possible, construction joints shall not be kept at the location of laps in the vertical steining bars.

iii. The steining of the well shall be built in one straight line from bottom to top such that if the well is tilted, the next lift of steining will be aligned in the direction of the tilt. The work will be checked carefully with the aid of straight edges of lengths approved by the Engineer. Plumb bob or spirit level shall not be used for checking verticality alignment. After sinking of a stage is complete, damaged portions if any, of steining at top of the previous stage shall be properly repaired before constructing the next stage.

iv. The height of steining shall be calibrated by making at least 4 gauges (two in traffic direction and two in a direction normal to traffic direction) distributed equally on the outer periphery of the well. Each gauge should be in the form of a 100mm wide strip painted on the well, with every metre mark shown in black paint and sub-mark at 10 cm intervals. The gauges shall start with zero at the bottom of the cutting edge. It will be in black or a white background. Marking of the gauges shall be done carefully with a steel tape.

v. After reaching the founding level, the well steining shall be inspected to check for any damage or cracks. The Contractor shall execute the remedial measures as directed by the Engineer before acceptance of the well steining. In case the well cannot be accepted even with any remedial measures, then the well shall stand rejected.

vi. Blasting may have to be resorted to in order to facilitate sinking through difficult strata, such as boulders and rocks etc. In case blasting is anticipated, protective / strengthening measures specified in clause 710.6 (IV) of IRC: 78 shall be taken. The grade of concrete and / or Bridge Sub-structure in bottom 3 metres of steining shall not be leaner than M 25 or as shown on the drawings.

vii. In case the bore hole data shows the presence of steeply dipping rock, chiseling may have to be resorted to so as to obtain proper seating of the foundation. For this purpose, the well may require to be dewatered completely under high air pressure inside the well. This process is known as pneumatic sinking. Pneumatic sinking may also have to be resorted to in cases where obstacles such as tree trunks, large sized boulders or hard strata etc. cannot be removed by open dredging. The necessity of adopting pneumatic sinking shall be decided by the Engineer.

viii. The curb and steining have to be specifically designed for special loadings when pneumatic sinking is adopted. Minimum grade of Concrete should, preferably be M 25.

ix. The specifications given in this chapter deal only with such items of work as are peculiar to the construction of wells. For the basic items of work such as concrete (pain and reinforced), brickwork, stone masonry, earthwork, etc which are also incidental to the construction of wells, the relevant specifications shall be followed.

3.7.4 Sinking wells for foundations

This specification pertains to the actual operation of sinking the well through various kinds of strata to the reduced level shown on the drawing, or to any other level as ordered by the Engineer, to enable it to be founded on a suitable foundation stratum.

a) Programme

The programme for sinking shall be so arranged that every well started during a working season is completed, plugged and sealed at top, and the pier or abutment over it built to a suitable height, within the same season, so as to be safe during the mansoon. In the event of the Contractor's failure to ensure this, any protective measure or other extra work involved in completing the unfinished portion in the next working season shall be done by the Contractor at his own cost.

b) Strata Variation

i. The Contractor may, at his own expense, make trial bores to ascertain the exact depth to which each well may have to be sunk. If any boring data are indicated at the tender stage, these may be taken as a general guide only, and the Contractor shall not be entitled to any compensation on account of variations in the strata as actually met with during sinking.

ii. The Contractor shall, during the course of the work, collect and hand over to the Engineer's representative samples of all the different strata passed through, including undisturbed samples, where so required by the Engineer. The cost of collection of these samples shall be paid by the Contractor.

iii. Cost for the sinking of wells through (a) Hard Rock, and (b) Soft rock & all soils are inclusive, and nothing extra shall be paid due to variation in the strata.

c) Level of commencement: Excavation

i. Where the existing ground level is higher than the level of commencement as specified above, open excavation shall be carried out to that level by the contractor at his own cost.

ii. If, for his own convenience, the Contractor commences sinking of a well from any level higher than that specified in sub-para (i) above, no payment shall be made to him for the extra depth of sinking resulting therefrom.

iii. When the well curb is ready for sinking, it shall be "pitched" by careful removal of the blocking timbers on which the cutting edge was so long supported. The timbers shall be removed after loosening the sand around each, and the removal shall be so phased as to maintain equality of pressure and thereby avoid tilting of the curb.

iv. After all the blocking timbers are removed, the soil from within the curb shall be excavated evenly over the whole internal area, excavating first in the centre and then working towards the circumference. In the case of double-D wells or twin octagonal wells, the excavation in both dredge holes shall progress simultaneously. The sinking shall be stopped when the top of the curb is about 15 cm above the ground, after which the building up of the initial lift (of say 1.5m height) of the steining shall be taken up.

d) Methods of Sinking:

i. All possible care shall be taken to ensure perfect verticality of sinking of the well curb and the first two lifts (or say 3m.) of the steining, since by doing so, the subsequent sinking to plumb becomes easier. The manner of sinking shall continue to be as followed for the well curb. The operation of sinking will, naturally, alternate with that of adding further lifts of steining, which may be done for two lifts in a sequence, except for the first two lifts which shall be done in two stages, with sinking done in between.

ii. The maximum depth of excavation below the level of the bottom of cutting edge of the well at any stage shall not generally exceed the internal diameter of the well.

iii. Where dewatering is resorted to and it gives rise, at any stage, to "blowing" of the surrounding soil into the bottom of the well, the dewatering shall be stopped forthwith and the water levels balanced to prevent further blowing, before attempting to remove the blown material from inside the well.

iv. In deep water, excavation shall be carried out with the use of grabs operated by winches, or preferably by cranes. Harder strata upto soft rock may be loosened by the use of heavy chisels, slung at a suitable angle. Removal of obstructions such as boulders and logs shall be done by employing divers.

v. Small charges of approved explosive may be used, with the written permission of the Engineer in the following circumstances: (1) To blast through rock or to break boulders, which cannot be done by any alternative method; and (2) To effect sinking, especially in the final stages, when the usual formation of a sump at the bottom of the dredge hole does not result in sinking. In the latter case, the charge of explosive shall be placed at the centre of the dredge hole and exploded to set up a tremor which will serve to help sinking of the well. Any damage caused to the well or to adjoining structure by the use of explosives shall be made good by the Contractor at his own expense.

vi. Where a considerable depth of rock is to be pierced through, and dry sinking i.e. without much water except what can be pumped out is not possible, it will be necessary to resort to pneumatic sinking. This requires the use of proper air locks and ancillary equipment, with special precaution observed for safety and certain modifications to the structure of the well to fit the air locks. Sinking of wells by such method shall be a matter of special agreement and covered by special specifications.

vii. Where two or more separate wells in a group are to be sunk, and the clear distance between any two wells is less than the diameter of the well, such wells shall be sunk alternately, each not having a lead of more than half the diameter over the other at any stage.

e) Use of Kentledge as Sinking Load

Kentledge shall be placed in an orderly and safe manner on the loading platform and in such a way that it does not interfere with the excavation of the material from inside the dredge hole and also does not in any way damage the steining of the well. Where tilts are present or there is a danger of well developing a tilt, the position of the kentledge load shall be regulated in such a manner as to provide greater sinking effort on the higher side of the well.

f) Use of Water Jetting

Water jetting, on the outside of the well may be employed for well sinking wherever necessary. Where stiff clayey strata is anticipated, small diameter water pipes are encased in the well with jet ends on periphery during casting of steining for this purpose.

g) Use of Explosives

Mild explosive charges may be used as an aid for sinking of the well only with prior permission of the Engineer. Blasting of any sort shall only be done in the presence of the Engineer and not before the concrete in the steining has hardened sufficiently and is more than 7 days old. When likelihood of blasting is predicted in advance, protection of the curb and the bottom portion of the well shall be done as per these specifications. After blasting operations are completed, the well curb and steining should be examined for any cracks and remedial measures taken.

i. The charges shall be exploded well below the cutting edge by making a sump so as to avoid chances of any damage to the curb or to the steining of the well. A minimum sump of 1 metre depth should be made before resorting to blasting. Use of large charges, 0.7 kg or above, may not be allowed except under expert direction and with the permission from the Engineer. Suitable pattern of charges may be arranged with delay detonators to reduce the number of charges fired at a time. The burden of the charge may be limited to 1 metre and the spacing of holes may normally be kept as 0.5 to 0.6 metre. All prevalent laws concerning handling, storing and using of explosives as per "Indian Explosives Act" shall be strictly followed.

ii. All safety precautions shall be taken as per IS:4081 "Safety Code for Blasting and related Drilling Operations", to the extent applicable, whenever blasting is resorted to. There should be no equipment inside the well nor shall there be any labour in the close vicinity of the well at the time of exploding the charges.

iii. If rock blasting is to be done for seating of the well, the damage caused by flying debris should be minimised by covering blasting holes by rubber mats before blasting.

iv. If blasting has been used after the well has reached the design foundation level, normally 24 hours shall be allowed to lapse before the bottom plug is laid.

Daily records of tilt and shift, with reference to the principal axes of the well, shall be maintained at the site, separately for each well, on the Proforma prescribed by the Engineer. Tilts shall be measured along the two axis of the bridge and RL (Reduced Levels) of the marks painted on surface of steining shall be taken. For determination of shift, locations of the ends of the two diameters shall be precisely measured along the two axis, with respect to the fixed reference points. A pair of wells close to each other will have a tendency to come closer during sinking (Tilting towards each other). Timber struts may be introduced in between the steining of these walls to prevent tilting. The Contractor shall further be responsible for maintaining a continuous record of the depth sunk in each working shift and of the types of strata passed through at the various depths, as well as any obstruction met with.

It shall be the Contractor's responsibility to sink the wells to the correct alignment, spacing and levels, based on the reference pillars and bench mark provided by the Railway. Unless otherwise specified the completed well shall not have a tilt of more than 1 in 80 in any direction or a shift of more than 5 per cent of the overall diameter or width of the well, as measured in either of the principal directions or 150mm in resultant direction, whichever is less. Where these tolerances are exceeded, the orders of the Engineer shall be sought. These tolerances shall be further subject to the condition that the stability of the foundation is not affected and that any modification thereby necessitated in the design of the substructure or superstructure shall be done at the cost of the Contractor.

Such acceptance shall be subject to

i. Calculations for foundation pressures and steining stresses after accounting for the tilt and shift and consequent relocation of superstructure on top being safe

ii. Remedial measures required for bringing stresses within permissible limits such as increasing dimension of well cap, providing dummy weights on well cap as well as redesign of structure above shall be carried out by the Contractor at no extra cost to the Employers and

iii. The Contractor shall agree to any reduction in rate for such defective work.

Tilt observed may, during the sinking, be corrected by one or more of the following methods, as approved by the Engineer:-

i. Loading kentledge eccentrically

ii. Carrying excavation at the bottom of the well deeper on the side which is higher.

iii. Providing heavy inclined struts bearing against the face of the well steining on the side towards which it leans.

iv. Jetting to reduce skin friction on the higher side, on the well periphery.

v. Pulling or pushing the well by approved methods.

vi. If the well is rejected, the Contractor will dismantle the defective well to the extent desired by the Engineer, at his cost. Further, the Contractor, at his risk and cost, will complete the bridge with modified span arrangements.

h) Seating of Well

When the well approaches the final depth of sinking, the exact height to which the last lift of steining is to be made up shall be decided before it is completed and sunk. When the well has reached the required level and stratum, it shall be properly seated by levelling, the area under the cutting edge. In the case of rock also, every effort shall be made to ensure even seating of the cutting edge, with the use of divers for cutting or benching the rock, as required. No extra payment shall be admissible for the bedding of wells in this manner. Any portion of the rock stratum where the cutting edge cannot be bedded shall be got cleared of the overlying material and filled subsequently with the concrete of the bottom plug.

On completion of the bedding of the well, the bottom of the dredge hole shall be got cleared of all spoil and left in a fit condition for laying of the bottom plug.

3.7.5 **Cutting edges for well curbs**

Unless otherwise specified, the cutting edges shall be fabricated out of new structural steel. The fabrication shall be done strictly in accordance with the detailed drawings and shall conform to the specifications.

Before being taken to the site, the cutting edge shall be assembled on level ground and verified for the accuracy of its shape and size. If in sections, the individual sections shall be match marked before being dismantled.

At the place for laying, necessary reference points to site the well accurately shall be fixed in advance, based on the permanent reference pillars on either bank or the base line provided on either or both banks. The ground shall be prepared by leveling to an even surface at the level from which sinking of the well is to be commenced.

On the prepared bed the cutting edge shall be placed and positioned accurately with respect to the reference points fixed. It shall be supported evenly and to true level on a series of blocking timbers, spaced sufficiently close together to withstand and distribute to the soil below the full weight of the cutting edge plus the weight of shuttering and concrete, without any unequal settlement. Where the cutting edge is in sections, any welding or riveting required shall be done after the cutting edge has thus been assembled to the correct lay out and level.

The cost for the cutting edge shall, include the cost of supply, fabrication, transporting and placing the cutting edge as specified above, to its correct lay out and level including site joining by welding or bolting / riveting with cover/ fish plates.

3.7.6 Well curbs and steining

The basic items of work shall conform to one or more of the following and relevant specifications as applicable: -

- Cement Concrete
- RCC

Concrete steining shall generally be cast in "lifts" not exceeding 2.0m in height, for the convenience of placing and consolidation without segregation. Sinking shall not be started till the depth of masonry or concrete to be sunk has set properly. In the case of concrete steining and RCC well curbs, the minimum periods as specified below shall be observed, unless any different period is prescribed by the Engineer, taking into account the local conditions or in the Contract.

For well curbs	**Minimum period**
Removal of outer shuttering	12 hours
Removal of inside shuttering	6 days
Commencement of sinking	7 days
For Steining	
Removal of outer or inside shuttering	6 hours
Resumption of sinking	48 Hours

In any case, the sinking shall not commence until the work that has been added on has been passed by the Engineer's representative and the commencement of sinking approved.

Bond Bars, bond flats, bottle nuts etc which are built into the steining will not be paid for separately, but no extra payment will be made for keeping these in the concrete or masonry work.

3.7.7 Plugging and finishing of wells

a) Bottom Plug

The concrete used for the bottom and top plugs of foundation wells shall be of the specified mix, conforming to Specification for Cement Concrete

Where the bottom plugging is to be done under water, the special provisions of "Under Water Concreting" shall be observed carefully; and it shall further be ensured that the water inside the well has first been brought to a steady level, and there is no flow of water into the well.

Before the concrete is placed, the bottom of the well shall be inspected carefully and cleaned of any debris etc. The concreting shall be done in such a manner as to ensure thorough and even filling to the desired level. In under-water work, divers shall be engaged for the purpose, as may be required.

After the concrete has set fully, water shall be pumped out completely or partially, as directed by the Engineer, to test whether the plugging has been satisfactory. If complete dewatering is done, any kentledge required to counteract buoyancy shall be provided before pumping out. In case appreciable leakage of water into the well is observed, the Contractor shall, at his own cost, arrange for its rectification by grouting etc.

b) Sand Filing

Sand filling shall commence after a period of 3 days of laying of bottom plug. Also, the height of the bottom plug shall be verified before starting sand filling.

Sand shall be clean and free from earth, clay clods, roots, boulders, shingles etc and shall be compacted as directed. Sand filling shall be carried out upto the level shown on the drawing, or as directed by the Engineer.

c) Top Plug

After filling sand upto the required level a plug of concrete of specified mix shall be provided over it as shown on the drawing, or as directed by the Engineer.

d) Well Cap

A reinforced cement concrete well cap will be provided over the top of the steining in accordance with the drawing. Form work will be prepared conforming to the shape of well cap. Concreting shall be carried out in dry condition.

The bottom of the well cap shall be laid preferably as low as possible, taking into account the water level prevalent at the time of casting. Bond rods of steining shall be anchored into the well cap.

3.7.8 **Tolerances**

The permissible tilt and shift shall not exceed 1 (horizontal) in 80 (vertical) and the shift at the well base shall not be more than 150mm in any resultant direction or 5% of the overall diameter or width as measured in the principal directions, whichever is less.

For the well steining and well cap the permissible tolerances shall be as follows:

i.	Variation in dimension	:	+50mm–10mm
ii.	Misplacement from specified position in plan	:	15mm
iii.	Surface irregularities measured with 3m straight edge	:	5mm
iv.	Variation of levels at the top	:	+ 25mm

3.7.9 Tests and Standards of Acceptance

The materials shall be tested in accordance with these Specifications and shall meet the prescribed criteria.

The work shall conform to these Specifications and shall meet the prescribed standards of acceptance.

3.8 Formwork

Form work for bridge foundations, sub structure and superstructures shall be as per IS-3696, IS-4014 and Annexure OCS-1. It includes all temporary or permanent forms required for forming the concrete of the shape, dimensions and surface finish as shown on the drawing or as directed by the Engineer, together with all props, staging, centering, scaffolding and temporary construction required for their support.

3.9 Substructure

3.9.1 Piers and Abutments

a) Concrete and reinforcement for piers and abutments shall conform to relevant sections of these specifications and drawings. In case of concrete piers, minimum grade will be M 35 unless otherwise specified / approved. The number of horizontal construction joints shall be kept to a minimum. Construction joints shall be avoided in splash zones unless specifically permitted by the Engineer and provided they are treated in accordance with special provisions. No vertical construction joint shall be provided. Shear connectors in the form of dowels or bond bars shall be provided at all horizontal joints as directed by the Engineer. The work shall conform strictly to the drawings or as directed by the Engineer.

b) In the case of tall piers and abutments, use of slipform will be preferred. The design, erection and raising of slip form shall be subject to special specifications which will be furnished by the Contractor. All specifications and arrangements shall be subject to the approval of the Engineer.

c) The surface of foundation / well cap / pile cap shall be scraped with wire brush and all loose materials removed. In case reinforcing bars projecting from foundations are coated with cement slurry, the same shall be removed by tapping, hammering or wire brushing. Care shall be taken to remove all loose materials around reinforcements. Just before commencing masonry or concrete work, the surface shall be thoroughly wetted.

d) In case of solid (non-spill through type) abutments, weep holes as shown on the drawings or as directed by the Engineer, shall be provided.

e) The surface finish shall be smooth, except the earth face of abutments which shall be rough finished or left as form finished.

f) In case of abutments likely to experience considerable movement on account of backfill of approaches and settlement of foundations, the construction of the abutment shall be followed by filling up of embankment in layers simultaneously with filter backing behind to the full height to allow for the anticipated movement during construction period before casting of superstructure.

g) *Transitional system as per guidelines of RDSO Report No. GE: R-50 shall be provided in railway bridge approaches of ballasted and non ballasted deck bridges having span equal to or more than 12.0m.*

3.9.2 **Pier Cap and Abutment Cap (Bed Blocks)**

a) Form work, Concrete and reinforcement shall conform to relevant paras of Concrete work & RCC of these specifications and the Drawings. Unless otherwise specified, minimum grade of concrete mix shall be M 35.

b) The locations and levels of pier cap / abutment cap / pedestals and bolts for fixing bearings shall be checked carefully to ensure alignment in accordance with the drawings of the bridge.

c) The surface of cap shall be finished smooth and shall have a slope for draining of water as shown on the drawings or as directed by the Engineer. For short span slab bridges with continuous support on pier caps, the surface shall be cast horizontal. The top surface of the pedestal on which bearings are to be placed shall also be cast horizontal.

d) The surface on which elastomeric bearings are to be placed shall be wood float finished to a level plane which shall not vary more than 1.5mm from straight edge placed in any direction across the area. The surface on which other bearings (steel bearings, pot bearings) are to be placed shall be cast about 25mm below the bottom level of bearings and as indicated on the drawings. Specified rich levelling mortar shall be provided over this at the time of placing of bearing.

3.9.3 **Dirt / Ballast Wall, Return Wall and Wing wall**

a) Dirt / ballast walls ,return wall & wing walls shall be in RCC. Minimum grade of concrete will be M35 unless otherwise specified. In case of cantilever return walls, no construction joint shall generally be permitted. Wherever feasible, the concreting in cantilever return walls shall be carried out in continuation of the ballast wall.

b) For concrete return and wing wall, the surface of foundation shall be prepared in the same manner as prescribed for construction of abutment. No horizontal construction joint shall be provided. If shown on drawing or directed by the Engineer, vertical construction joint may be provided. A vertical expansion gap of 20mm shall be provided in return wall / wing wall at every 10 metre intervals or as directed by the Engineer. Weep holes shall be provided as prescribed for abutments or as shown on the drawings.

c) Form work, reinforcement and concrete in dirt / ballast wall shall conform to relevant sections of these specifications.

d) The finish of the surface on the earth side shall be rough/form finish while the front face shall be smooth finished.

e) Architectural coping for wing wall / return wall in brick masonry shall conform to Drawings.

3.9.4 **Tests and Standards of Acceptance**

The materials shall be tested in accordance with these specifications and shall meet the prescribed criteria.

The work shall conform to these specifications and shall meet the prescribed standards of acceptance.

3.9.5 **Tolerances in Concrete elements**

a) Variation in cross-sectional dimensions: + 10mm, -5mm

b) Misplacement from specified position in plan: 10mm

c) Variation of levels at the top: + 10mm

d) Variations of reduced levels of bearing areas: + 5mm

e) Variations from plumb over full height: + 10mm

f) Surface irregularities measured with 3m straight edge

- All surfaces except bearing areas: 5mm
- Bearing areas: 3 mm

3.10 Bridge Work: Superstructure

3.10.1 **GENERAL**

a) Coverage

This chapter covers specifications for the following types of superstructures:

a) Viaduct

b) Bridges with superstructure of Composite Plate Girders (CG)

c) Bridges with superstructure of Open Web Girder (OWG) with concrete deck for providing Ballastless/ ballasted track

d) Bridges with superstructure of PSC U- slab

e) RCC Box bridges

(f) RCC Pipe Bridges

3.10.2 **RCC BOX Bridges**

All concrete works for RCC box shall conform to **Annexure OCS-1 & 2**.

3.10.3 **STEEL Open Web Girders (OWG) and Composite Plate Girders**

Fabrication and erection of steel girders shall conform to Annexure OCS-3.

Concrete and reinforcement for composite girders shall conform to **Annexure OCS-1 & 2.**

3.10.4 **PRE-STRESSED CONCRETE SLABS**

All prestressed works for bridges shall be carried out in accordance with Annexure OCS-1 to 4.

3.10.5 **Linking of Track**

Open web girders are proposed to be provided with ballastless/ballasted track & LWR/CWR.

a) OWG with BLT

For Open web girders where BLT is provided, the rails and fastening systems shall be procured and provided by the Contractor. Construction of deck slab for BLT shall be carried out as per specification

b) OWG with ballasted track

For Open web girders where ballasted track is provided, the Contractor shall construct only deck slab. Ballast and track are not in the scope of C-5 contractor and shall be provided by the Track contractor. Construction of deck slab shall be carried out as per specification

c) In case, it is decided to adopt standard RDSO spans with track on H-beam sleepers, Galvanised H-beam bridge sleepers shall be as per RDSO Drawing No. B-1636/4/R, 5 & 9. Zero toe load fastening shall be as per RDSO Drawing No. T-8759 to T-8765 for 60kg running rail and 52 kg guard rail. Both H-beam bridge sleepers and track fittings/fastenings shall be procured from RDSO approved source. Inspection of material shall be done by the Engineer or any other agency nominated by the Employer at factory premises before dispatch. The Contractor shall arrange for necessary inspection/testing of material at factory premises.

Linking of track on H-beam sleeper with 60 kg running rail and 52 kg guard rail shall include bending of guard rail, drilling of holes, cutting of rails, providing wooden wedge at the end of guard rail, provision of gang pathway of 6 mm thick MS chequered plate as per RDSO Drawing No. B-1636 /5 on H-beam sleeper and making track fit for normal sectional speed.

Both running rails and guard rails shall be procured from RDSO approved manufacturers and provided by the Contractor.

Chapter 4. STATION- CIVIL

4.1 General

Specification for various activities involved in station shall generally be in accordance with CPWD specification-2019 for Civil Works Volume 1 & 2, as amended up to date unless stated otherwise in these specifications. In case of any contradictory instruction in the specification, Engineer's decision shall be final & binding.

4.1.1 Earthwork

Earthwork in excavation and filling/backfilling in station buildings shall be carried out as per CPWD specifications. Soil for filling shall be arranged by the Contractor from outside the ROW. No Earth is to be taken from the Railway/HORC premises except surplus earth from excavation for the building.

4.1.2 Concrete Work

All plain and reinforced concrete works shall be carried out as per IS 456:2000 and Annexure OCS-1 and 2. Design Mix concrete as approved by the Engineer shall only be used.

4.1.3 Anti-Termite Treatment

Pre-Construction Anti-Termite Treatment shall be done as per clause 2.28 of CPWD specification 2019 Vol.-1. The chemical shall be approved by the Engineer and used as per the manufacturer's instructions/specification.

4.1.4 Plinth Protection

Plinth protection shall be 1000 mm wide all around the building, it comprises of 50mm thick M-25 concrete over 75 mm thick bed of dry brick aggregate of 40mm nominal size, grouted with fine sand. The outer edge or face edge shall be lined with with 2^{nd} class bricks laid on the edge and joints laid in cement mortar 1:4. It shall be laid to the required width and slope in outward direction.

4.1.5 Damp Proof Course (DPC)

Unless otherwise mentioned in the drawings, DPC will consist of 40 mm thick M25 CC with two coats of bitumen over it shall be provided as per clause 4.4 of CPWD Specification 2019 Volume-1.

4.1.6 Masonry Work

Fly ash bricks or cement concrete blocks (hollow/solid) confirming to the BIS or *brick* masonry *will* be used. All outer and load bearing walls shall be of minimum 230 mm thickness or more as per design, in cement mortar 1:6, all partition walls shall be 115 mm thick in cement mortar 1:4 as per Clause 6 of CPWD Specification Volume-I 2019.

4.1.7 Plaster

Plaster of 15-19mm thick in cement mortar 1:4 on all outer and inner walls except in ceiling. Inner walls shall be finally finished with POP. The underside of slabs shall be rendered smooth wherever required and finished with POP as per Clause 3 of CPWD Specification Volume-I 2019.

4.1.8 Painting

Two coats of synthetic enamel paint of 1st quality over a priming coat of Asian, Berger, Nerolac or equivalent brand and shade as approved by the Engineer, on all exposed steel and wooden surfaces.

4.2 Sanitary fittings/sewerage system:

4.2.1 Manholes

Manholes and junction chambers to be constructed by Contractor as per the design by the Contractor & approved by the Engineer and to be connected with RCC pipes of 150/200 mm dia. with each other and to septic tank or to existing sewerage arrangement (up to 30m from extreme outer wall of building in the direction of source to be connected), including obtaining necessary clearance from concerned authorities required from the same. In case sewage system is not be connected with trunk sewer, contractor will furnish appropriate design of septic tank for required number of users to be approved by the Engineer and will construct the Septic Tank accordingly.

4.2.2 Rainwater pipes

Adequate number of rainwater pipes of min 125mm dia, uPVC of approved quality and make as approved by the Engineer to be provided. Inlet of the rainwater pipe to be provided with shoe and CI gratings and at the outlets necessary protection to be done to prevent erosion of soil.

4.2.3 Soil and vent pipes

uPVC pipes of min 100 mm dia to be provided for soil and vent pipes including all branches of required degree, access door and other accessories as necessary for laying the pipes of approved quality and make as approved by the Engineer to be provided. Before embedding the pipes under the floor/platform the same will have to be tested against any leakage. Necessary floor traps, gully traps as essential will be provided. Storm water drain of suitable size to be provided as approved by the engineer.

4.2.4 Wash Basins, Sink and Water closet

Wash basins (Ceramic) of approved size, colour and make as per IS: 2556 (Part 1) and IS: 2556 (Part 4) shall be provided in ladies and gents toilet with shelf, looking glass and towel rails (CP Brass). Urinal in gent's toilet shall be of Bowl type with flushing rim & partition slab and in ladies toilet Squatting plate type (ceramic) of approved size and make as per IS: 2556 (Part 6) with ceramic flushing cisterns as shown in tender drawings. Water closet shall be Indian (Orissa type) as per IS: 2556 (Part3) / European type as per IS: 2556 (Part1) and IS: 2556 (Part2) with ceramic flushing cisterns as shown in tender drawings. Stainless steel/Ceramic sinks as per IS: 771 (Part2) of approved size and makes to be provided in battery rooms. All water services and sinks will be connected through bottle traps to concealed outlet pipe.

4.2.5 Water supply

a) Bore well shall be constructed as per IS 2800 Part 1 & Part 2. Chlorinators using common salt shall be provided at each tube well for chlorination of water.

b) Necessary layout for water supply distribution in the water booth, toilets and bathroom to be designed by the contractor and submitted for approval of the Engineer. All internal pipes shall be laid concealed in walls and tested for leakages for minimum 12m head of water. All GI pipes shall be of minimum class 'B.' All necessary taps, stop valve etc. of approved size and make to be provided by Contractor to make the toilets and kitchens functional including provision of RCC underground & overhead water tanks of designed capacity. This will include provision of float valve, copper/brass rod and plastic ball with inlet, outlet, overflow, washout connections etc. for the water tank complete in all respect. Taps in platform toilets & water booths shall be self-closing type.

4.2.6 Water proofing of roofs:

Water proofing of roof shall be carried out by the Contractor as approved by the Engineer.

4.2.7 Drip courses

Drip course of approved design shall be provided all around the building, chajjas etc.

4.3 Station cum S&T and Electric service building, S&T huts, Auto Location hut:

4.3.1 Finishes

a) **Interior finish**

Two coats of 1st quality oil bound distemper of approved shade over POP coating to make the surface smooth. 3rd coat may be done before handing over of assets.

b) Exterior finish

Two coats of 1st quality cement paint of approved shade over POP coating to make the surface smooth. 3rd coat shall be done before handing over of assets.

4.3.2 Flooring

a) **Substation room, Maintenance, Metering room, Store room etc.**

40mm thick, cement concreate flooring with M-25 CC laid in one layer finished with cement slurry to a true smooth surface with joints provided with glass strips of 4mm thick to form panels not exceeding 1200x1200mm, laid over 100mm thick CC M-10 over 100mm thick sand filling over well rammed and consolidated earth filling as per Clause 11.2 of CPWD Specification Volume-I 2019.

b) **Battery Room**

Acid proof tiles of size 198.5x198.5 mm & 10 mm thick conforming to IS 4457-1967 as approved by the Engineer over 10 m thick cement sand mortar 1:4(1 acid proof cement: 4 coarse sand), laid over 100mm thick CC M-10 over 100 mm thick sand filling laid over well rammed consolidated earth filing. Acid proof tiles shall also be provided in dado as per requirement up to minimum 1.5 m height as per Clause 11.14 of CPWD Specification Volume-I 2019.

c) **Staircase**

Kota Stone 25 mm thick to be provided in risers, treads and landings of steps laid on with neat cement slurry mixed with pigment to match the shade of kota stone including rubbing polishing complete on 20mm thick cement sand mortar 1:4. Skirting of same Kota Stone shall be provided upto minimum150 mm height. The work shall be done as per Clause 11.22 of CPWD Specification Volume-I 2019. Kota stone provided on riser & tread of steps shall be minimum 1.8 m long & shall cover full height/width of the step. Exposed end of kota stone on treads shall be rounded to provide nosing. Kota stone tile at other places shall be of minimum 600 mm x 600 mm size. Stone at edges can be cut in smaller sizes to fill up the residual areas.

d) **Verandah Flooring**

Kota Stone 25 mm thick flooring and 150 mm height skirting laid on with neat cement slurry mixed with pigment to match the shade of kota stone including rubbing polishing complete on 20mm thick cement sand mortar 1:4 over 100 mm thick CC M-10 over 100 mm thick sand filling laid over well rammed consolidated earth filing as per Clause 11.21 of CPWD Specification Volume-I 2019. Kota stone tiles shall be of minimum 600 mm x 600 mm size. Stone at edges can be cut in smaller sizes to fill up the residual areas.

e) **Toilets**:

Finished floor to be kept 25mm below the normal floor of the building. Minimum 300x300 mm size ceramic anti-skid floor tiles of minimum 12 mm thickness, 1st quality conforming to IS 13630-1993 of Kajaria, Nitco or similar make and shade and approved by Engineer laid over 20mm thick bed of cement sand mortar 1:4 using neat cement slurry and pointing of joints done with white cement mixed with pigment to match the shade of tiles over a base of 100mm thick CC M-10 laid over 100mm thick sand filling on well rammed and consolidated earth filling on ground floor as per Clause 11.15 of CPWD Specifications Volume-I 2019. On subsequent floors the tiles shall be laid directly on mortar bed. Glazed tiles of suitable size (300mmx300mm or 300mmx450mm) and minimum 06mm thickness confirming to IS 13630-1993 of Kajaria, Nitco or similar make, quality and shade as approved by the engineer to be provided on wall for full height up to ceilings over 13mm thick cement mortar 1:3. All the tiles to be laid with zero gap between them.

f) **Interlocking cum Axle Counter Rooms**

Interlocking/Axle counter room, Panel Room, IPS room, Tele/OFC room and other S&T structures-1st quality 600 x 600 mm vitrified floor tiles of minimum 12 mm thickness conforming to IS 15622 of Kajaria, Nitco or similar make and shade as approved by Engineer laid over 20 mm thick bed of cement sand mortar 1:4 using neat cement slurry and pointing of joints done with white cement mixed with pigment to match the shades of tiles over a base of 100mm thick CC M-10 over 100 mm thick sand filling on well rammed and consolidated earth filling for ground floor. On subsequent floors tiles shall be laid directly on mortar bed. Glazed tiles of suitable size (300mm x 300mm or 300mm x 450mm) and minimum 06mm thickness confirming to IS 15622 of Kajaria, Nitco or similar make, quality and shade as approved by the Engineer to be provided on walls in dado up to 90cm height from floor level or up to the window sill. All the tiles to be laid with zero gap between them as per Clause 11.15 & 11.16 of CPWD Specification Volume-I 2019.

Note:-

Color and make of all the flooring shall be as per the direction of the Engineer.

4.3.3 Door, Windows and Ventilation

a) **Door frames:**

Door frame shall be pressed steel door frames manufactured from mild steel sheets of specified thickness conforming to IS:2062 & 4351. Each frame shall consist of hinge jamb, lock jamb, head and angle threshold of size 50 x 25mm as per Clause 10.12 of CPWD Specification Volume-I 2019.

b) **Door Shutter**:

35 mm thick flush door shutter conforming to IS:2202 (Part1), non-decorative type, core of block board construction with stiles, rails & lipping of hard wood timber and well-matched commercial 3 ply veneering with vertical grains on both faces of shutters as per IS:710 with brass fittings of approved size and make as per requirement.

c) **Windows/Ventilators**

The frames of windows and ventilators shall be of powder coated aluminum (coating thickness 60-80 micron) with extruded built up standard tubular sections/ Z sections of approved make conforming to IS: 733 and IS:1285 fixed with dash fasteners of required dia and size with fully glazed shutters of 5 mm thick float glass provided with EPDM rubber/ neoprene gasket with complete fittings as per CPWD specifications Vol.-II.

d) Windows in relay room shall be of sliding type to provide insulation for effective air conditioning.

e) Anodised aluminium grills (minimum anodic coating of grade AC 15 as per IS:1868) of approved design/pattern, manufactured from standard sections shall be provided in the windows and ventilators. The grill shall be fixed to the window/ventilator frame with C.P brass/ stainless steel screws.

f) Necessary exhaust fan opening to be provided as required.

4.4 Station Building

4.4.1 Doors, Windows & Ventilators

a) **Exterior Doors**

Main entrance from circulating area to the station building shall be provided with fully glazed Aluminum Door. The remaining portion of entrance shall be provided with fixed glazing with aluminum frames as per approved drawing. The frames shall be manufactured from extruded aluminum alloy sections of standard sizes and designs as per IS 1948 and IS 1949 or as manufactured by Indian Aluminum Co. Ltd or approved equivalent. The alloy used shall conform to the IS designation HE9-WP of IS:733. Glazing shall be of 10 mm thick clear glass, horizontally tempered (toughened) as per DIN:1249 Part-12 with no tong or suspension mark and edges machined with no burrs or sharp surfaces. All Toughened Glass shall be heat soak test certified as per BS EN-14179-1.

b) **Door frames** of office of Station Master/SS//Waiting Rooms/Booking Office shall be of well-seasoned steam beech/2nd class of teak wood of minimum section 65mmx100mm.

c) **Door Shutter**

35 mm thick flush door shutter conforming to IS:2202 (Part1), non-decorative type, core of block board construction with stiles, rails & lipping of hard wood timber and well-matched commercial 3 ply veneering with vertical grains on both faces of shutters as per IS:710. These door shutters may be partially glazed as per requirement, as per drawing approved by the Engineer. Glazing shall be of glass pane of 5 mm thickness. Doors shall be finished with duco paint of desired shade and colour of melamine polished complete with all fittings including door closures.

d) **Windows/Ventilators**

The frames of windows and ventilators in the station building shall be of powder coated aluminum (coating thickness 60-80 micron) with extruded built up standard tubular sections/ Z sections of approved make conforming to IS: 733 and IS:1285 fixed with dash fasteners of required dia and size with fully glazed shutters of 5 mm thick float glass provided with EPDM rubber/ neoprene gasket with complete fittings as per CPWD specifications Vol.-II. Windows and ventilators shall be provided with anodised aluminium grills (minimum anodic coating of grade AC 15 as per IS:1868) of approved design/pattern & manufactured from standard sections. The grill shall be fixed to the window/ventilator frame with C.P brass/ stainless steel screws.

e) **Door/Window fittings**:

These shall be chromium plated brass, of size and make as approved by the Engineer.

4.4.2 Finishes

a) **Interior finish**

Two coats of 1st quality oil bound distemper of approved shade over POP coating to make the surface smooth. 3rd coat may be done before handing over of assets.

b) **Exterior finish**

Two coats of 1st quality cement paint of approved shade over POP coating to make the surface smooth. 3rd coat shall be done before handing over of assets.

4.4.3 Flooring and Dado

a) 1st quality 600 x 600 mm vitrified floor tiles of minimum 12 mm thickness conforming to IS: 15622 of Kajaria, Nitco or similar make and shade as approved by Engineer laid over 20mm thick bed of cement sand mortar 1:4 using neat cement slurry and pointing of joints done with white cement mixed with pigments to match the shade of tiles over a base 100mm thick CC M-10 laid over 100mm thick sand filling on well rammed and consolidated earth filling. On subsequent floors tiles shall be laid directly on mortar bed. Same floor tiles shall also be provided on walls in dado up to 200 mm height from floor level. All the tiles to be laid with zero gap between them over 13mm thick cement mortar 1:3. as per Clause 11.15 & 11.16 of CPWD Specification Volume-I 2019.

b) Toilets

Finished floor to be kept 25mm below the normal floor of the building. 300x300mm 1st class ceramic antiskid floor tiles of minimum 12 mm thickness conforming to IS 15622 of Kajaria or similar make and shade as approved by Engineer laid over 20mm thick bed of cement and sand mortar 1:4 using neat cement slurry and pointing with white cement mixed with pigment to match the shade of tiles laid over 100mm thick CC M-10 over 100mm thick sand filling on well rammed and consolidated earth filling. Glazed tiles of suitable size (300mm x 300mm or 300mm x 450mm) and minimum 06mm thickness conforming to IS 15622 of Kajaria or similar make, quality and shade as approved by the Engineer to be provided on walls for full height up to ceilings over 13mm thick cement mortar 1:3. Tiles shall be laid with zero gaps between them as per Clause 11.15 & 11.16 of CPWD Specification Volume-I 2019.

4.4.4 Ticketing Room

a) Booking Counter & Facia

Counters & facia to be made with Granite Top of approved shade 18mm thick laid with neat cement slurry and pointing with white cement mixed with pigment to match the shade of Granite slab including rubbing polishing complete on 20mm thick cement and sand mortar 1:3 on RCC shelf as per approved design.

b) Flooring & Skirting

1st quality 600 x 600 mm vitrified floor tiles of minimum 12 mm thickness conforming to IS: 15622 of Kajaria, Nitco or similar make and shade as approved by Engineer laid over 20mm thick bed of cement sand mortar 1:4 using neat cement slurry and pointing of joints done with white cement mixed with pigments to match the shade of tiles over a base 100mm thick CC M-10 laid over 100mm thick sand filling on well rammed and consolidated earth filling. On subsequent floors tiles shall be laid directly on mortar bed. Glazed tiles of suitable size (300mm x 300mm or 300mm x 450mm) and minimum 06mm thickness confirming to IS 15622 of Kajaria, Nitco or similar make, quality and shade as approved by the Engineer to be provided on walls in dado up to 90cm height from floor level or up to the window sill. All the tiles to be laid with zero gap between them over 13mm thick cement mortar 1:3. as per Clause 11.15 & 11.16 of CPWD Specification Volume-I 2019.

c) **Booking Window**

Booking window shall be of toughened sheet glass 10mm thick with a hole for intercommunications at suitable height above the countertop and a suitable gap between the partition and counter for collection of fare and issue of tickets, the partition being protected on the passenger side by aluminum grill of approved design.

d) **Portico**

At subway entrance a RCC portico of 12 m x 8.5 m size shall be provided as per approved drawing and Annexure-OCS-1 & OCS-2.

4.4.5 Subway & inter platform connectivity

a) **Flooring**

Flamed finish granite stone flooring in required design & pattern 18 mm thick to be provided in flooring jointed with neat cement slurry and pointing with white cement mixed with pigment to match the shade of granite stone including rubbing polishing complete on 20mm thick cement and sand mortar 1:4 as per Clause 11.31 of CPWD Specification Volume-I 2019. Granite stone tiles shall be of minimum 600 mm x 600 mm size. Stone at edges can be cut in smaller sizes to fill up the residual areas.

b) **Dado**

Glazed tiles of suitable size (300mm x 300mm or 300mm x 450mm) and minimum 06mm thickness confirming to IS 13630- 1993 of Kajaria, Nitco or similar make, quality and shade as approved by the Engineer to be provided on walls in dado up to 2.5 m height from floor level.

c) **Stairs & Ramps**

Flamed finish granite Stone 25 mm thick to be provided in risers, treads and landings of steps laid on with neat cement slurry and pointing with white cement mixed with pigment to match the shade of kota stone including rubbing polishing complete on 20mm thick cement and sand mortar 1:4 and 150 mm height skirting of same granite Stone as per Clause 11.31 & 11.22 of CPWD Specification Volume-I 2019. Granite stone provided on riser & tread of steps shall be minimum 1.8 m long & shall cover full height/width of the step. Exposed end of granite stone on treads shall be rounded to provide nosing. Granite stone tile at other places shall be of minimum 600 mm x 600 mm size. Stone at edges can be cut in smaller sizes to fill up the residual areas

d) **Railing**

Assembly and erection as per approved drawing on stairs, ramp & subway of Stainless steel of material grade SS 304 as per CPWD specification Vol.-1 2019.

e) **Covering for Stairs & Ramp**

Self-supported roofing system of colour coated Galvalume sheet shall be provided as approved by the Engineer. Material shall be of following specification, BMT 0.90mm to 1.00mm, APT 0.95mm Tolerance +/- 0.02mm thick, 605 mm width or as approved by the Engineer (Tolerance +/- 2mm).

The roofing system shall be without trusses, purlins or any ancillary support and shall be designed by the contractor and shall be got proof checked at his own cost from Govt. approved agencies.

f) **Waterproofing of Subway**

1) Waterproofing of subway shall be carried out by a manufacturer having minimum 10 years of experience in manufacturing waterproofing product of the type specified, able to provide test report showing compliance with the specifications, and able to provide on -site technical representation to advise on installation.
2) The installation shall be carried out either by the manufacturer or his approved applicator having experience of minimum 05 years in application of waterproofing products in underground structures. The waterproofing shall be carried out by manufacturer's applicators strictly in accordance with the recommendation of the manufacturer.
3) All components and elements, which are required to make the structures watertight, shall be demonstratable and proven to work together. There shall be a single source of responsibility and performance of the material and products. Specifically, material and water stops shall be manufactured out of virgin raw material and only form the same formulation of raw material. The manufacturer shall confirm full, demonstratable and proven compatibility of the entire waterproofing system in writing. The waterproofing system provided shall be installed without damage and protected against construction operations. The contractor shall carry out a trial application of the waterproofing and submit the report containing the details and method statement to obtain approval from the Engineer.
4) Waterproofing shall be provided on outside side of vertical walls and top slab.
5) Waterproofing scheme
   i. Outside of vertical walls and top slab shall be provided with spray applied liquid coating of minimum thickness 2.0 mm as per IS 16471 (Type A).
   ii. Construction joints in vertical walls shall be provided with PVC water stops as per IS 16471 (Type B).
   iii. Use of waterproofing admixture to the concrete of slabs and walls of subway
6) Spray applied liquid coating on external side of vertical walls and top slab
   i. System and properties of materials

      Fully bonded spray-applied liquid polymer two component, solvent free, hybrid polyurea polyurethane/ polyurea/ polyurethane applied elastomeric seamless membrane of minimum 2 mm Dry Film Thickness (DFT) shall be used. DFT shall be achieved in minimum 2 coats (of two different contrasting colors), over and above one coat of a solvent free two component epoxy primer which shall be compatible with the liquid polymer and from the same manufacturer. No sand broadcast layer is permitted in the system. The system must be such that it is thixotropic, can be applied by airless spray; as well as the same product shall be capable of being applied manually only for local detailing and patch repairs (maximum area 1 m^2). The product shall be applied in accordance with the manufacturer's instructions.

ii. The waterproofing membrane shall have following minimum properties:
  a. Tensil strength> 15MPa as per ASTM D 412.
  b. % Elongation>300% as per ASTM D 412.
  c. Bond strength on concrete > 2 MPa as per ASTM D 7234.
  d. Minimum crack bridging capability of over 2.0 mm.
  e. Specific Gravity of 1.15 (+/-10%)

iii. Code and standards for reference:

Code and standard Number	Code and Standard Title
ASTM D 412	Standard Test Methods for Vulcanized Rubber and Thermoplastic Elastomers - Tension
ASTM D 7234	Standard Test Methods for Pull-off Adhesion Strength of Coating on concrete Using portable Pull – off Adhesin Testers.

iv. Inspection
The thickness of spray applied liquid coating waterproofing membrane shall be checked for every 20 m^2 area of water proofing. The thickness at the point of checking shall not be less than 2 mm.

7) Construction joints in vertical walls
  i. The contractor shall construct his concrete works so as to minimize the likelihood of water penetration.
  ii. Before placing new concrete against concrete that has already hardened, the face of the old concrete shall be treated in accordance with manufacturer's recommendation.
  iii. Inside rendering shall not be accepted as a method of making joints watertight.
  iv. Water stops shall be of PVC strips. The water stops shall be installed so that they are securely held in their correct positions whilst the concrete is being placed. No holes shall be made through any water stop except were provided for by the manufacturer. Water stops shall be provided as per manufacturer recommendations. The contractor shall submit the method statement for providing water stops to the Engineer for approval.

8) Use of waterproofing admixtures in concrete of slabs and vertical walls of subway
Waterproofing admixtures shall be used in conjunction with other waterproofing components supplied by the same manufacturer, for example, water stops, achieve watertight structures.

9) Surface preparation
Waterproofing work shall commence only after obtaining approval from the Engineer. Application of waterproofing system shall only commence upon the completion of curing of concrete. All cracks on the exposed concrete surfaces of external structural members shall be effectively sealed before applying any waterproofing system. The Contractor shall ensure that surfaces to which

waterproofing is to be applied, shall be clean, dust-free and dry and shall be prepared fully in accordance with the manufacturer's recommendation. The waterproofing shall be carried out by the manufacturer's applicators strictly in accordance with the recommendations of the manufacturer and with accepted best practice in the trade.

4.4.6 Platform Covering

a) **Main Platform Shelter**

Main Platforms Shelters shall be fabricated from rolled steel sections conforming to IS:2062/4923. Roof shelter shall have arrangement for collection and safe outlet of rainwater. Shelter roofing shall be of aluminum sheet of 0.9 mm thickness.

b) **Mini Shelter**

All mini shelter shall be with seating capacity of 6 passenger as shown in Tender drawings. Roofing shall be with 6MM thick multiwall translucent Polycarbonate sheet both side UV protected bent in curved shape as shown in tender drawing.

c) **Shelter Flooring**

VDC flooring shall be provided under PF shelter as per Sub-Clause 4.4.7 of these specifications.

4.4.7 Platform Surfacing-

a) **VDC Flooring**

100mm thick fiber reinforced Vacuum Dewatered Concrete (VDC) flooring of grade M25 of stone aggregate 20 mm and downsize laid as specified in CAMTECH/2021/C/VDF/1.0 2021 of RDSO publication over 100mm thick CC M-10 over 100mm thick fine sand filling over well rammed and consolidated earth filling.

The area to be paved with VDC should be divided into suitable panels by fixing screed strips. The depth of screed strips should be equal to the combined thickness of base concrete and topping. Generally, no dimension of panel shall exceed 4 m in case of floor finish laid monolithically with the base concrete and 2m in case finish laid separately on a hardened base. Length of panel shall not exceed 1.5 times its breadth. Reinforcement shall be provided as per design. Before placement of base concrete sub-base shall be properly wetted.

Tactile path shall be provided at 1.8 m from the coping edge along the entire length of platform and at entrance & exit points of platform to station as per direction of the Engineer. Tactile floor tile shall have a minimum thickness of 10 mm excluding the flat top blister like domes or flat topped bars and shall conform to IS 4457 and IS 15622 and "Handbook for barrier free accessibility"-CPWD.

Note: The position of trenches and pipes for services such as water, drainage, electric, S&T etc. must be fixed before floor concreting starts.

b) **Platform slope**

For End platform cross slope of 1 in 60 to be provided away from the track while on island platform cross slope 1 in 60 to be provided from center of track towards the end of coping/Track side.

c) **Joints**

At panel interfaces groove of about 3-5 mm wide shall be cut in top surface in both lateral & longitudinal direction for prevention of cracks as per instruction of the Engineer. These grooves shall be filled with suitable sealant.

4.4.8 Water Booth-

a) **Water Booth Platform**

Granite Stone cladding with Granite Top of 20mm thick on with neat cement slurry mixed with pigment to match the shade of Granite including rubbing polishing complete on 20mm thick cement and sand mortar 1:3.

b) **Drainage & its covering-**

On island platform an underground drain of 125 -150 mm dia with manhole at suitable interval shall be provided to safely carry the effluent from water booths, PF shelters, toilets etc and on end platform underground/open drain with removable MS grating cover shall be provided on the far end of the platform as shown in the tender drawings.

c) **Duct For Utilities- HDPE pipes for Electrical and S&T**

These pipes shall be provided by the side of the drains. HDPE pipes shall conform to IS 4984.

d) **Taps**

Self-closing Taps with CP Brass/PTMT bib cock provided with quarter turn ceramic cartridges.

Miscellaneous items shall be as given below-

Item No.	Description of items	Material Spec.
1.	Orissa WC Pan (Indian Style) with low level dual flushing ceramic cistern	Ceramic
2-	European Type Wall Hung/Floor Mounted WC with seat, lid and low level dual flushing ceramic Cistern	Ceramic
3-	Water Jet/Health Faucet with European WC	CP Brass
4-	Ceramic Wash Basin with CP brass pillar Tap / with Quarter Turns Ceramic Cartridges.	Ceramic
5-	Tap (Toilet, Bath & WC) CP Brass/ bib cock provided with quarter turn ceramic cartridges	CP Brass
6-	Mirror (600 x 450mm) with each wash basin with PTMT glass shelf	PTMT
7-	Towel rail	CP Brass

Item No.	Description of items	Material Spec.
8-	Soap Rack for each wash basin	CP Brass

4.4.9 Waterproofing Application

Waterproofing materials shall be installed only by the manufacturer of the products or his approved applicator.

Application of waterproofing system shall only commence upon completion of curing of the concrete. The contractor shall ensure that surfaces to which waterproofing is to be applied shall be clean, dust free and dry and shall be prepared fully in accordance with the manufacturer's recommendation.

All cracks on exposed surfaces of external structural members shall be effectively sealed in accordance with the relevant clauses of the M & W specification before applying any waterproofing system. Inside rendering shall not be accepted as a method of making the joint watertight.

The Engineer may require the Contractor to carry out a trial application of the waterproofing materials for the proposed waterproofing system. No waterproofing works shall commence without the written consent of the Engineer. In case of liquid applied polymer membrane applied to roof slabs, the membrane shall be protected with 25mm thick extruded polystyrene boards, which shall be spot bonded to the membrane. A 6-mill polyethylene separating membrane. shall then be laid before covering with a protective concrete slab of lean concrete mix of minimum 75mm thickness.

Where the roof slab has been cast against a diaphragm or other face, the protective slab shall be provided with an up stand at the perimeter to provide a minimum 75mm concrete protection over the turned-up membrane. This is to ensure that the membrane termination is protected from damage or dislodging prior to backfill. Damaged or non-compliant sections of membrane shall be repaired in accordance with the manufacturer's recommendations and as accepted by the Engineer.

WATERPROOFING AT CONSTRUCTION JOINTS

Construction joints are to be constructed as follows

a. All construction joints in external slab and wall will be provided with PVC water stop located at the center of the element.
b. In the top surface of base and roof slabs at junction with diaphragm walls, a 25x25mmrecess will be cast in the slab and subsequently filled with a high performance water stop grout of the crystalline growth type.
c. All construction joints in external slab and walls will be cast with a25x25 recess on the outer face (expect the base slab where it will be provided on the upper face). The recess will be filled with a high performance water stop grout of the crystalline growth type.
d. All construction details and material are to be submitted to the Engineer for the approval.

4.4.10 WATERPROOFING TO BASE SLAB OF UNDERGROUND STRUCTURES

a. General

Concrete waterproofing admixture shall of the crystalline growth type. The admixture shall have a proven track record of successful application in similar conditions.

This admixture shall be applied to the full thickness of the base slab and extend to the sidewall of sumps and similar depression of the base slab to form a continuous water light surface.

b. Trials

Prior to construction, trial mixes are to be conducted under the supervision of the Engineer or his Representative and with the manufacturer present to confirm that the proposed mix conforms to strength, w/c ratio, slump, and other requirements. The trial mix concrete shall further have an average water permeability coefficient when tested at 28 days of not greater than 5x10-13 m/s under 5kgf/cm2 and an average penetration depth not greater than 15mm as measured by DIN 1048 Part 5:1991.

4.4.11 WATERPROOFING TO ROOF SLABS

The spray applied liquid polymer membrane shall be suitable for use in an ambient temperature range not greater than 40°C. It shall allow diffusion of water vapors to prevent any buildup of pressure between the membrane and substrate. The membrane shall meet or surpass the following requirements:

Total membrane thickness	2.5mm minimum dry film thickness and sprayed in a minimum of two coats of contrasting colors, with the second coat applied to the first coat only after the first coat has cured.
Tensile strength	4.0MPa minimum in any of the three orthogonal planes of the membrane
Membrane elongation at break	130% minimum
Peal adhesion to concrete (ASTMD4541)	2.0MPa minimum
Static crack bridging (tested to recognized international standard acceptable to the Engineer)	2mm minimum

The cured membrane shall be chemically resistant to the effects of hydraulic fluids, diesel fuel and diluted mineral acids etc.

The substrate shall be prepared and primed in strict accordance with the manufacturer's recommendations and requirements. The membrane shall be of a thixotropic nature and cold applied to ensure consistent thickness is achieved over all substrate irregularities.

The materials used must be based upon resin systems that do not react with moisture although the substrate should be dry during application.

The liquid polymer membrane shall be continued 1 meter down the vertical side of the roof slab where the roof is cast by bottom up sequence.

All components of waterproofing system shall be provided by one manufacturer. All materials must be supplied to site in unopened packaging, with batch numbers marked and corresponding manufacturer's certificates of conformity and must be used within the product's shelf life. All components of the system exposed to rain within the curing period shall be replaced unless agreed otherwise by the Engineer.

The membrane wet film thickness should be checked every 10 square meters during application of of each layer, using a pin or comb gauge. Destructive testing to measure dry film thickness shall be carried out on the cured membrane at every 100 square meters or at every working shift, whichever occurs sooner, and shall be made good to the satisfaction of the Engineer.

Tests to the acceptance of the Engineer shall be carried out on the cured membrane to identify any discontinuities in the membrane and to prove the integrity of the membrane.

Chapter 5. STATION- PLUMBING AND FIRE FIGHTING

5.1 Water Supply and Plumbing Works

5.1.1 Applicable Standards

The Contractor shall ensure the compliance to the following codes and standards:

IS 458	Specification for Precast Concrete Pipe
IS 783	Code of Practice for Laying of Concrete Pipes
IS 1172	Code of Basic Requirements for Water Supply, Drainage & Sanitation
IS 1239 (Part-1)	Steel Tubes, Tubulars and Other Wrought Steel– 2004 Fittings, Part 1: Steel Tubes
IS 1239 (Part-2)	Steel Tubes, Tubulars and Other Steel Fittings– 2011, Part 2: Steel Pipe Fittings
IS 1726	Specification for Cast Iron Manhole Covers & Frames
IS 3624	Specification for Pressure and Vacuum Gauges
IS 4984	Specification for Water Supply HDPE pipes
IS 7634 (Part 2)	Specification of Installation for Water Supply HDPE Pipes
IS 8110	Well screens and slotted Pipes.
IS 8329	Centrifugally Cast (spun) Ductile Iron Pressure Pipes for Water, Gas and Sewage
IS: 9439	Glossary of terms used in Water-well drilling technology.
IS 9523	Ductile Iron Fittings for Pressure Pipes for Water, Gas and Sewage
IS:11189	Method of Tubewell Development
IS 12288	Specification for Laying Ductile Iron Pipes
IS:12818	Unplasticized polyvinyl chloride (PVC-U) Screen and casing pipes for Borewell/tubewell specification
IS 16098 (Part-2)	Structured-wall Plastics Piping Systems for Non-Pressure Drainage and Sewerage
BIS - SP (QAWSM) 56	Location, operation and Maintenance of tube/bore wells - Guidelines

5.1.2 Storage Tanks for Water Supply

Storage tanks for water supply shall be constructed in accordance with IS 3370 (Part 1 &

Part 2) and as per drawings approved by the Engineer.

5.2 Plumbing and Firefighting

5.2.1 General

a) General Requirements

i. The workmanship shall be as per best industrial practices and shall conform to the specifications and Indian Standard Specifications in every respect and shall be as approved by the Engineer.

ii. All relevant certificates shall be submitted by the Contractor to show that the materials comply with the requirements and technical data specified in this document. The Engineer may require additional testing of materials to verify the compliance as per specifications for which the costs shall be borne by the Contractor.

b) Testing and Commissioning

i. Hydrostatic Pressure Testing of Pressure Pipes

ii. All pressurized pipelines shall be tested as specified in Sub-Clause 4.15, Part 9, Section 1 of NBC 2016.

iii. Testing of Non-Pressure Pipes

iv. All non-pressure pipelines shall be tested as specified in 'Manual on Water Supply and Treatment", CPHEEO.

c) Flushing

The Contractor shall be responsible to check that the water pipework is flushed and chemically cleaned against unwanted substances. Contamination may occur during storage of materials, due to surface oxides and mill scale, or the application of protective grease and oils. During the installation period, the pipework can become further contaminated by construction material debris such as welding and jointing materials, swarf and dust. The Contractor responsible for installing the system shall ensure that care is taken to limit the amount of dirt entering the system during installation.

d) Site Acceptance Test, Commissioning and Inspection

i. The Contractor shall submit the schedule and Method Statements for testing and commissioning of all plumbing & fire-fighting equipment, materials, goods and systems to the Engineer, as soon as possible after the award of the Contract. Tests shall be conducted in the presence of the Engineer to his satisfaction. The Contractor shall submit these to obtain approval from the Engineer.

ii. The Contractor is responsible to ensure that all testing equipment, materials and personnel are available at the appropriate time for testing. The Contractor shall prepare forms to record all test procedures and results for the review of the Engineer. These forms shall constitute a record of testing and they are aimed for assisting the Engineer in giving his review of operations, performances and functions for equipment, materials, goods and systems.

iii. During the installation phase of the project, the Contractor shall carry out initial testing and pre-commissioning of all plumbing and fire-fighting services and systems, followed by final commissioning. This shall include the pressure testing, flushing and cleaning of pipework,

iv. Method Statements shall be submitted for review to the Engineer allowing enough time for review, comment and re-issue.

v. The Contractor shall be responsible to take date stamped photographic records of testing and commissioning; in case the Engineer is unavailable to attend a test demonstration. These shall be produced by the Contractor and submitted to the Engineer along with testing and commissioning records for review or request to re-demonstrate.

5.2.2 Plumbing

a) Qualification

The plumbing works shall be carried out by the plumbing sub-contractor / plumber who holds a valid plumbing license issued by the Municipal authority or other competent authority as per Clause 3.3 under Section-2 Part -IX of NBC-2016. The Contractor shall keep constant liaison with all relevant authorities and shall be responsible for obtaining all approvals related to water supply, sewerage and drainage system. He shall also be responsible for co-ordination with other Interfacing Contractors.

b) Materials

i. Piping Materials

All materials shall comply with the following specifications, unless otherwise specified. If after tests, any materials, work or portions or work are found defective, the Contractor shall remove the defective material from the site, pull down and re-execute the works at his own cost to the satisfaction of the Engineer. To prove that the materials used are as specified, the Contractor shall furnish the Engineer with original invoice on demand.

1) Water supply pipes

Pipes for water supply shall be as follows –

(A) Ductile Iron (DI) shall conform to IS 8329 and fittings to IS: 9523. All pipe joints shall be with couplers or jointing fixtures as per respective IS codes and manufacturers recommendations

(B) HDPE pipes shall conform to IS 4984.

(C) GI pipes shall conform to IS 1239.

2) Sewage and drainage pipes

Sewage and drainage pipes shall be as follows –

(A) Non pressure HDPE pipes shall conform to IS 16098 Type B. Typical classification of pipes shall be double wall corrugated (DWC)SN8.

(B) RCC pipes shall be socket & spigot centrifugally spun conforming to IS 458 of NP-3 Class.

ii. Water supply pipeline

The Contractor shall install all piping and fittings in their final position in accordance with approved trial assemblies and as per drawings that have been approved by the Engineer. The installation shall be done as per CPHEEO/CPWD/IS specifications

1) DI pipes shall be laid as per IS 12288.

2) HDPE pipes shall be laid as per IS 7634 Part 2.

3) GI pipes

iii. Sewer and drainage pipeline

1) Structured wall plastic piping system shall be laid as per IS 16098.

2) Concrete pipes shall be laid as per IS 783.

3) Soil, waste water and drainage pipes from buildings shall be connected with sewerage and drainage systems through manholes to be constructed by the Contractor.

iv. Manholes

1) Manholes shall be constructed as specified in Part-9, Section-2 of NBC-2016.

2) Manholes shall be provided with cast iron covers and frames embedded in RCC slab or SFRC precast concrete covers as per drawing approved by the Engineer.

v. Disinfection of Storage Tanks

The Contractor shall arrange to disinfect the water storage tanks before commissioning. The water storage tanks shall first be filled with water and thoroughly flushed out. The storage tanks shall then be filled with water again and disinfecting chemical containing chlorine added gradually while tanks are being filled to ensure thorough mixing. Adequate amount of chlorine shall be used to give water a dose of 50 parts of chlorine to one million parts of water

5.2.3 Sourcing of water

i. Borewells

1) Location of bore-well shall be proposed by the Contractor for the Engineer's approval.

2) The Contractor shall provide borewells including borewell room, pumps,

pipeline and electric wire rope hoist for lifting and lowering of pumps as per drawings approved by the Engineer. The Contractor shall provide pipe line with valves, fittings and accessories from borewell to storage tank as shown in the drawings. The well screen and slotted pipe shall conform to IS 8110 Type D. Material of wire of screens shall be stainless steel (SS) of designation XO4Cr18Ni10 of IS 6528. The housing and casing pipe shall conform to IS 4270 or IS 12818. Borewell shall be provided with sluice valve, pressure gauge, non-return valve and flow meter. Borewell shall be constructed and tested as per IS 2800 Part 1 and Part 2. The Contractor shall furnish information after completion of the borewell as per IS 2800 Part 2 to the Engineer for approval. Provisions of IS:SP(QAWSM) 56 shall be followed for ground water exploration, siting, construction and development of borewell.

5.2.4 Storage tanks for water supply

The Contractor shall construct underground and overhead water storage tanks as per the drawings approved by the Engineer.

5.2.5 Water Supply distribution system

The Contractor shall provide water supply distribution system including piping, pumping, valves and fittings to the required gradients and profiles as the drawings approved by the Engineer. The Contractor shall follow provisions of "Manual on Water Supply and Treatment" published by the Central Public Health and Environment Engineering Organization, Ministry of Urban Development, Govt. of India, (CPHEEO), CPWD Specifications (Vol. 2) and NBC 2016 for carrying out and testing the works of water supply distribution system.

5.2.6 Yard Drainage System

The Contractor shall provide yard drainage as per the drawings approved by the Engineer. The Contractor shall follow provisions of "Manual on Storm Water Drainage Systems" published by CPHEEO, CPWD Specifications (Vol. 2) and NBC 2016 for carrying out the works of yard drainage system.

5.2.7 Sewage Disposal System

The Contractor shall provide sewage disposal as per the drawings approved by the Engineer. The Contractor shall follow provisions of "Manual on Sewerage and Sewage Treatment Systems" published by CPHEEO, IS SP-35 "Handbook on Water Supply and Drainage" and NBC 2016 for carrying out and testing the works of sewage disposal system.

5.3 Firefighting System

5.3.1 Handheld Fire Extinguishers

The firefighting extinguishers works shall consist of the following:

i. Distribution or installation of fire extinguisher shall be in accordance with IS 2190 or IS 15683.

ii. Hand appliances shall be installed in easily accessible locations with the brackets fixed to the wall by suitable anchor fasteners by skilled workmen.

iii. Each appliance shall be provided with an inspection card indicating the date of inspection, testing, change of charge and other relevant data.

iv. The extinguishers shall be treated for anti-corrosion internally and externally and painted with fire red paint. The paint shall be stove enamelled.

v. The description of extinguishers shall be marked with 2.5cm height in block letters within a triangle of 5cm each side.

vi. Fire extinguishers shall be counted in numbers and shall include installation of all necessary items required as given in the specifications.

5.3.2 Clean Agent Extinguisher

i. Clean agent type fire extinguishers i.e. stainless-steel body made shall be placed as per approved drawing.

ii. Clean agent fire extinguishers capacities as per city chief fire officer's recommendations & other suggestions shall be followed as per IS 15683.

iii. Clean agent extinguishers shall cover A, B & C type fire.

5.3.3 Dry Chemical Powder Extinguisher

i. The extinguisher shall be filled with grade 40 Mono Ammonium Phosphate (40%) from any approved manufacturer.

ii. The capacity of the extinguisher when filled with dry chemical powder as first filling as per IS 4308, Part II shall be 5 Kg ±2% or 10 Kg ±3%.

It shall be operated upright with a squeeze grip valve to control discharge. The plunger neck shall have a safety clip fitted with a pin to prevent accidental discharge. It shall be pressurised with dry nitrogen as expellant and shall be charged at a pressure of 15 Kg/cm^2.

5.3.4 Water Type Extinguisher (Gas Pressure Type)

i. The extinguishing medium shall be primarily water stored under normal pressure, and the discharge shall be by release of carbon dioxide gas from a cylinder.

ii. The capacity of extinguisher when filled up to the indicated level, shall be 9L±5%.

5.3.5 Mechanical Foam Type Fire Extinguisher

Mechanical foam fire extinguisher suitable for Class A and Class B fire shall be used for fire extinguishing. Foam being an effective smothering agent is used for liquid fires mainly. It shall react by flowing over the liquid fuel oil surface and isolating the fire from the air and shall also prevent re-ignition due to the foam stability.

Chapter 6. ROADWORK

6.1 CONTROL OF TRAFFIC

The contractor shall take all necessary precautions in co-ordination with and to the requirements of all the competent authorities concerned to protect the work from damage until such time as the seal coat or surface treatment has developed sufficient strength to carry normal traffic without any damage to it.

The new work shall be opened to traffic only after it is authorised by the Engineer.

The contractor shall submit a detailed traffic diversion/or control and regulation plan taking all safety measures during the course of work permitted by the concerned authorities to the Engineer for his consent before start of work.

The contractor shall take all precautions to avoid or minimise delays and inconvenience to road users during the course of the work. Where adequate detours or side tracks are available, traffic shall be temporarily diverted while the work is in progress depending on volume of traffic and subject to approval by Traffic Police. Adequate signs, signals, barriers and lamps for the warning and guidance of traffic shall be provided at all times during the course of the work till it is opened to traffic.

The Contractor shall take all reasonable precautions to protect traffic against accident, damage or disfigurement by construction equipment, tools, and materials, splashes and smirches of bitumen/ bituminous material or any other construction materials and shall be responsible for any claims arising from such damage or disfigurement.

Traffic signs erected shall be in accordance with the IRC Standards and/or as prescribed and approved by the Traffic Police Department.

6.2 GRANULAR SUB-BASE (NON-BITUMINOUS)

This work shall consist of laying and compacting well-graded material on prepared subgrade in accordance with the requirements of these specifications or as per MORTH standards. The material shall be laid in one or more layers according to lines, grades and cross-sections shown on the drawings.

6.2.1 Material

The Material to be used for the work shall be natural sand, moorum, gravel, crushed stone, or combination thereof depending upon the grading specified in MORTH specifications for Roads and Bridges. The material shall be free from organic or other deleterious constituents.

6.2.2 Physical requirements

The material shall have a 10 percent fines value of 50 KN or more (for sample in soaked condition) when tested in compliance with BS:812 (Part III). The water absorption value of the coarse aggregate shall be determined by IS:2386 (Part 3); if this value is greater than 2 percent, the soundness test shall be carried out on the material delivered to site as per IS:383. CBR Value shall be determined at the density and moisture content likely to be developed in equilibrium conditions which shall be taken as being the density relating to a uniform air voids content of 5 percent.

Table 6.2.1: Grading for Close-Graded Granular Sub-base Material

S.N.	IS Sieve Designation	Percentage by weight passing the IS Sieve		
		Grading I	Grading II	Grading III
1	75.0 mm	100	-	-
2	53.0 mm	80-100	100	-
3	26.5 mm	55-90	70-100	100
4	9.5 mm	36-65	50-80	65-95
5	4.75 mm	25-55	40-65	50-80
6	2.36 mm	20-40	30-50	40-65
7	0.425 mm	10-25	15-25	20-35
8	0.075	3-10	3-10	3-10
9	CBR Value (Minimum)	30	25	20

Note- Material passing 0.425 mm sieve for all the three gradings when tested according to IS:2720 (Part 5) shall have liquid limit and plasticity index not more than 25 and 6 percent respectively.

6.2.3 Strength of sub-base

It shall be ensured prior to actual execution that the material to be used in the sub-base satisfies the requirements of CBR and other physical requirements when compacted and finished.

6.2.4 Construction Operations

(i) Preparation of sub-grade

Immediately prior to the laying of sub-base, the sub-grade already finished or existing surface shall be prepared by removing all vegetation and other extraneous matter, lightly sprinkled with water if necessary and rolled with two passes of 80 – 100 KN smooth wheeled roller. Damage to the subgrade shall be made good before sub base is laid.

(ii) Spreading and compacting

The approved sub-base material shall be spread on the prepared sub-grade by a grader of suitable type and adequate capacity.

When the sub-base material consists of combination of materials, mixing shall be done mechanically by the mix-in-place method.

The equipment used for mix-in-place construction shall be approved equipment capable of mixing the material to the desired degree.

Moisture contents of the loose material at the time of compaction shall be checked in accordance with IS: 2720 (Part 7) and suitably adjusted.

Rolling procedure shall be as described under relevant Subsection except stated herein.

Rolling shall be continued till the density achieved is at least 98% of the maximum dry density for the material determined as per IS:2720 (Part 8).

6.3 WATER-BOUND MACADAM SUB-BASE/ BASE (NON-BITUMINOUS)

6.3.1 Description

The work shall consist of furnishing, placing, watering and compacting sub-base material mechanically interlocked by rolling and bounded together with screening and/ or binding material to the required degree on a prepared sub-grade/ sub-base or the existing surface as the case may be in accordance with these Specifications, and to the lines, levels, grades, dimensions and cross sections as shown on Drawings and/ or required by the Engineer.

6.3.2 Materials

a) Coarse aggregate

The coarse aggregates shall be hard and durable crushed stones, free from deleterious matter conforming to one of the gradings as set forth in Table 6.3.1, the physical requirements given in Table 6.3.2 subject to the Engineer's consent.

Table 6.3.1 Grading requirements of coarse aggregates

Grading	Size Range	IS Sieve Designation	Percent Passing by weight
1.	90 mm to 45 mm	125 mm	100
		90 mm	90-100
		63 mm	25-60
		45 mm	0-15
		22.4 mm	0-5

Grading	Size Range	IS Sieve Designation	Percent Passing by weight
2.	63 mm to 45 mm	90 mm	100
		63 mm	90-100
		53 mm	25-75
		45 mm	0-15
		22.4 mm	0-5
3.	53 mm to 22.4 mm	63 mm	100
		53 mm	95-100
		45 mm	65-90
		22.4 mm	0-10
		11.2 mm	0-5

Note: The compacted thickness for a layer with Grade 1 shall be 100 mm while for a layer with Grade 2, it shall be 75 mm.

Table 6.3.2

Physical requirements of coarse aggregates or water-bound macadam sub-base and base courses

S. No.	Test	Test Method	Requirement (Maximum)
1.	* Los Angeles Abrasion value	IS 2386 (Part-4)	50 per cent
2.	* Aggregate Impact value	IS 2386 (Part-4)	40 per cent
3.	Flakiness Index	IS : 2386 (Part-1)	15 per cent

* Aggregate may satisfy requirements of either of the two tests

b) Screenings

Screenings to fill voids in the coarse aggregate shall generally consist of the same material as the coarse aggregate or of gravel (other than round material) or moorum as approved by Engineer. However, where permitted non-plastic material such as moorum may be used for this purpose provided liquid limit and plasticity index of such material are below 20 and 6 respectively and fraction passing through 75 micron sieve does not exceed 10 percent.

As far as possible screenings shall conform to the gradings set-forth in Table 6.3.3 Screenings of type A shall be used with coarse aggregate of grade I of Table 6.3.1 Screenings of type A or B as specified shall be used with coarse aggregates of grading 2. Type B screenings shall be used with coarse aggregates of grading

TABLE 6.3.3

Grading for Screenings

Grading Classification	Size of Screenings	IS Sieve Designation	Percent by Weight Passing Sieve
A	13.2 mm	13.2 mm	100
		11.2 mm	95 -100
		5.6 mm	15 - 35
		180 micron	0 – 10
B	11.2 mm	11.2 mm	100
		9.5 mm	80-100
		5.6 mm	50 - 70
		180 micron	05 - 25

Binding material

Binding material to be used for water-bound macadam as a filler material meant for preventing ravelling, shall be a suitable material and having a Plasticity Index (PI) value of less than 6 as determined in accordance with IS : 2720 (Part-5).

6.3.3 Construction Method

a) Preparation of Sub-grade/ sub-base

(i) The surface of the sub-grade/ sub-base or existing surface shall be shaped and prepared to the lines, levels, grades, dimensions and cross sections as shown in drawings. Damage to or deterioration of sub-grade/ sub-base shall be made good before sub-base/ base is overlaid.

(ii) Inverted Choke

If water bound macadam is to be laid directly over the sub grade, without any intervening pavement or soling course, a 25 mm course of screenings or coarse sand shall be spread and compacted on the prepared subgrade before application of the coarse aggregate. In case of fine sand or silty or clayey sub grade, a 100 mm insulating layer of screenings or coarse sand shall be laid, the gradation of which will depend on drainage requirements. Alternatively, appropriate geosynthetics performing functions of separation and drainage layer may be used over the prepared sub-grade subject to the satisfaction of the Engineer.

(b) Spreading coarse aggregates

i. The coarse aggregates of specified size and grading shall be spread uniformly to proper profile in layers with each compacted layer thickness not more than 100mm for Grading 1 and 75 mm for Grading 2 and in a manner that prevents segregation into fine and coarse materials.

ii. Immediately following at spreading of the coarse aggregate, it shall be compacted to the full width by rolling with either the three- wheel- power -roller of 8 to 10 tonnes capacity or an equivalent vibratory roller. Initially, light rolling is to be done, which shall be discontinued when the aggregate is partially compacted with sufficient void space in them to permit application of screenings. The rolling shall begin from the edges and progress gradually towards the centre, only slight sprinkling of water may be done during rolling, if required.

iii. After the coarse aggregate has been lightly rolled to the required true surface, screenings shall be applied gradually over the surface to completely fill the interstices.

iv. The screenings shall be applied at a slow rate (in three or more applications) so as to ensure filling of all voids. Rolling and brooming shall continue with the spreading of the screenings. Damp and wet screenings shall not be used under any circumstances.

v. After spreading the screening and rolling the surface shall be copiously sprinkled with water, swept and rolled. Hand brooms shall be used to sweep the wet screening into the voids and to distribute them evenly. Additional screenings applied where necessary until the coarse aggregates are well bonded and firmly set for the entire depth.

vi. After the application of screenings and rolling, a suitable binding material shall be applied at a uniform and slow rate in two or more successive thin layers. After each application of binding material, the surface shall be copiously sprinkled with water and the resulting slurry swept in with brooms so as to fill the voids properly. The surface shall then be rolled by a 8-10 tonne roller.

(c) Tolerance

The finished sub-base/ base at any point shall not vary more than 15mm below and 12mm above the planned grade or adjusted grade with 3m straight edge applied to the surface parallel to the centreline of the road. With the template laid transversely the maximum permissible variation from specified profile shall be 12mm and 8mm respectively.

The sub-base/ base course completed in each day's work shall have an average thickness not less than the required thickness. Sub-base/ base course which does not conform to the above requirements shall be reworked.

6.4 B ITUMINOUS MATERIALS

6.4.1 Materials

Materials shall meet the requirements of the relevant IS Codes. These shall be of the following types.

a) Cut back Bitumen

Cut back bitumen shall be Rapid Curing (RC), Medium Curing (MC) or Slow Curing (SC) conforming to IS : 217.

b) Cationic Emulsion

Bitumen emulsions of the cationic type for roads shall conform to IS: 8887. Emulsified bitumen shall be Rapid Setting (RS), Medium Setting (MS), or Slow Setting (SS).

The physical and chemical requirements of the three types emulsions shall comply with the requirements specified in Table 1 of IS: 8887.

c) Paving Bitumen

Paving bitumen shall be conforming to IS: 73 and of the following two types:

Type 1 Paving bitumen from non-waxy crude shall satisfy the requirements given in Table 1 of IS: 73.

Type 2 Paving bitumen from waxy crude shall satisfy the requirements given in Table 2 of IS: 73.

The temperature at application of bituminous materials shall be maintained as per manufacturer's instructions and/or as directed by the Engineer's Representative.

An anti-stripping and bonding agent should be used in all final restoration road works. It should confirm to IS: 14982-2001 Specifications. The percentage can be from 0.5% to 1.25% by weight of bitumen content. The optimum dose can be ascertained using M.O.S.T. / BIS guidelines.;

6.4.2 Methods of Storage and Handling

Asphaltic material shall be handled and stored with due regard for safety and in such a way that at the time of use in the work the material conforms to the Specifications. Following precautions shall be taken while using these materials:

a) Work with these materials shall be carried out in good weather conditions and it shall be carried out in warm and dry weather, and not in wet or extremely cold weather.

b) Emulsified asphalt shall be handled with care and not subjected to mechanical shocks or extremes of temperature likely to cause separation of the asphalt. Emulsified asphalt showing sign of separation shall not be used.

c) During heating, no water or moisture shall be allowed to enter the boiler.

d) Heating of bitumen shall be done to the correct temperature range, as prescribed by the manufacturer for the grade used. The temperature shall be controlled with the use of a suitable thermometer, and the material shall be drawn and used while still at such temperature as is prescribed by manufacturer or in accordance with MOST specifications.

e) It shall be ensured that mixing of ingredients is through and all particles of aggregates are coated uniformly and fully.

6.5 TACK COAT

6.5.1 Description

This work shall consist of furnishing and applying bituminous material to a new WBM surface or to an existing road surface before laying another premix carpet layer over it.

6.5.2 Materials

Bitumen: This shall be straight-run bitumen of grade VG- 10 conforming to IS 73 specifications

(a) 0.75 kg/sqm on W.B.M./ W.M.M. Surface

(b) 0.50 kg/sqm on bitumen surface

6.5.3 Construction Methods

a) Cleaning Surface

Prior to the application of bitumen, all vegetation, loose sealing compound, caked mud, dust, dirt and foreign material shall be removed from the entire surface of the pavement by means of mechanical sweepers and blowers, otherwise with steel wire brushes, small picks, brooms or other implements as approved by the Engineer-in-Charge.

b) Weather Limitation

The tack coat shall not be applied nor any bitumen work done during rainy weather or when the surface is damp or wet or when the atmospheric temperature in the shade is not more than 16o C.

c) Application of tack coat material

Bitumen shall be heated in a boiler to a temperature of 165 deg. C to 175 deg. C and maintained at that temperature.

Hot bitumen shall be applied evenly to the clean, dry surface by means of a pressure sprayer at specified rate. Even and uniform distribution of bitumen shall be ensured. Bitumen shall be applied longitudinally along the length of the pavement.

6.6 B ITUMINOUS MACADAM

6.6.1 Description

The work shall consist of one or more applications of compacted crushed aggregates premixed with bituminous binder (suitable grade) to a primed non-bituminous surface or previously constructed bituminous surface and in conformity with the lines, grades, dimensions and cross-sections shown on the Drawings This shall comprise of a single course of 50mm to 75mm thickness as specified in the approve or as Directed by Engineer.

6.6.2 Materials

a) Bitumen

The bitumen shall be paving bitumen of suitable grade approved by the Engineer and conforming to IS: 73.

b) Additives

Adhesion and Ant-stripping agent shall be added to the bitumen subject to Engineer's consent at the required percentage of additive. The additive shall be thoroughly mixed with the bituminous material in accordance with the manufacturer's instructions.

c) Aggregates

Aggregates shall consist of clean and hard crushed stone free from dust, clay, dirt and any other deleterious matter. The physical requirements shall be as given in Table 6.6.1.

Aggregates shall conform to one of the two gradings given in Table 6.6.2 depending on the compacted thickness; the actual grading shall have the consent of the Engineer.

Table 6.6.1

Physical requirements of aggregates for bituminous macadam

S.No	**Test**	**Test Method**	**Requirement (maximum)**
1.	* Los Angeles Abrasion value	IS :2386 (Part-4)	40 per cent
2.	* Aggregate Impact value	IS :2386 (Part-4)	30 per cent
3.	Flakiness and Elongation Index Indices (Total)	IS : 2386(Part-1)	30 per cent
4.	Coating and Stripping of Bitumen aggregate mixtures	AASHTO T-182	Minimum retained coating 95%
5.	Soundness : (i) Loss with Sodium Sulphate 5 cycles (ii) Loss with Magnesium Sulphate 5 cycles		 12 percent 18 percent
6.	Water absorption	IS : 2386(Part-3)	2 per cent

* Aggregates may satisfy requirements for either of the two tests.

Table 6.6.2

Aggregate grading for bituminous macadam

IS Sieve Designation	**Per cent by weight passing the sieve**	
	Grading 1	**Grading 2**
45.0mm	100	-
26.5mm	75-100	100
22.4mm	60-95	75-100
11.2mm	30-55	50-85

IS Sieve Designation	**Per cent by weight passing the sieve**	
	Grading 1	**Grading 2**
5.6mm	15-35	20-40
2.8mm	5-20	5-20
90.0 micron		

Bitumen content for pre mixing shall be 4% by weight of total mix unless otherwise approved by Engineer.

6.6.3 Construction Methods

a) Weather and Control of Work

The work of laying shall not be undertaken during rainy or foggy weather or when the base course is damp or wet, or during dust storm or when the atmospheric temperature in shade is 15 degree C or less.

The Engineer may order work to cease temporarily on account of adverse weather, unsatisfactory condition of materials, equipment or any conditions which he considers may affect the work adversely.

b) Cleaning and Preparation of Surface

Prior to the application of binder, loose dirt and other objectionable material shall be removed from the surface to be treated by means of the power broom or blower or both. If this does not provide a uniformly clean surface, additional sweeping shall be done by hand, using stiff brushes or similar brooms. The areas inaccessible to the cleaning means shall be cleaned manually. The sweeping shall extend 200mm beyond each edge of the area to be treated.

Adherent patches of objectionable material shall be removed from the surface by steel scraper or other approved method and where the Engineer so directs the scraped area shall be washed down with water and hand brooms.

No application of bituminous material shall be undertaken until the surface has been cleaned to the satisfaction of the Engineer.

Before application of the bituminous material any necessary preliminary patching of the surface of the road (To fill in potholes.) shall be done to the complete satisfaction of the Engineer.

Tack coat shall be applied in accordance with these Specifications. Prime coat if required, shall conform to Subsection 6.5.

c) Plant and Equipment

All plant used by the Contractor for the preparation, hauling and placing of asphalt mixtures shall be subject to the consent of the Engineer and shall minimise smock, dust and noxious emission and odours. These shall generally meet the following requirements:

i. The mixing plant shall be a batching plant and shall have adequate capacity sufficient to supply the finisher on the road continuously when spreading the asphaltic mix at normal speed and required thickness.

ii. Scale for any weigh box shall be designed to be accurate to within 1% of the maximum load required and shall be fully automatically controlled.

iii. The Contractor shall provide and have at hand not less than ten 25 kilograms weights for frequent testing of all scales.

iv. Weigh box or hopper shall include a means for accurately weighing each bin size of aggregate in a weight box or hopper, suspended on scales, ample in size to hold a full batch without running over.

v. The asphaltic materials shall be stored in storage tanks designed to keep the temperature of the asphaltic material at maximum temperature of 110 degree C. The properties of the asphaltic material kept in that storage tanks shall be in good condition before mixing.

vi. The plant shall be provided with a circulating system to ensure continuous circulation between the storage tank and the mixer.

vii. The plant shall be provided with a cold bin for feeding the aggregates. Bin shall have a calibration gate and a mechanical means to insure uniform feeding of the aggregates into the drier as required by the Engineer.

viii. The rotary drier shall be capable of drying and heating the aggregates to the specified temperature.

ix. The plant shall be provided with plant screens capable of screening all aggregates to the specified sizes.

x. The plant shall include at least 3 hot bins for storing the aggregates fed from the drier after passing through the screen. Each bin shall be provided with an overflow pipe to prevent any backing up of material into other bins.

xi. The plant shall be provided with asphaltic control unit by weighing to obtain the proper amount of asphaltic material in the mix within the tolerance specified for the job-mix.

xii. The batch mixer shall be an approved twin pugmill type and capable of producing a continuous uniform mixture within the job-mix tolerances.

The mixer capacity shall not be less than 1000 kilogram batch.

xiii. An armoured thermometer reading from 50 degree C to 200 degree C shall be fixed in the asphaltic feed line at a suitable location near the discharge valve at the mixer unit.

xiv. The plant shall be further equipped with an electric pyrometer, or other approved thermometric instrument so placed at the discharge chute of the drier as to register automatically or indicate the temperature of the heated aggregate.

xv. The plant shall be equipped with a dust collector.

xvi. The plant shall be equipped with accurate positive means to govern the time of mixing and to maintain it constant. The time of mixing shall be divided into two steps, dry mixing and wet mixing. For dry mixing, the aggregate from hot bins shall be mixed for a period of 5-15 seconds. For wet mixing, the mixing time shall begin with the start of the asphalt spray after dry mixing. The wet mixing shall take about 30-45 seconds. The mixing time shall be extended if in the consideration of the Engineer the material obtained is not homogeneous.

d) Equipment for Hauling and placing

i. Trucks for hauling asphaltic mixtures shall have tight, clean, and smooth metal beds that have been sprayed with soapy water, thinned fuel oil, or lime solution to prevent the mixing from adhering to the beds (The amount of sprayed fluid shall however be kept to the practical minimum. Each load shall be covered with a canvas or other suitable material of such size as to protect the mixture from the weather). Any truck causing excessive segregation of material by its spring suspension or other contributing factors, or that shows oil leaks in detrimental amounts, or that causes undue delays, shall upon direction of the Engineer be removed from the work until such conditions are corrected.

ii. The equipment for spreading and finishing shall be mechanical, self powered pavers, capable of spreading and finishing the mixture true to the lines, grades, dimensions and cross sections.

The pavers shall be equipped with hoppers and distributing screws of the reversing type to place the mixture evenly.

The pavers shall maintain trueness of grade and confine the edges of the pavement to true lines without the use of stationary side forms. The equipment shall include blending or joint levelling devices for smoothing and adjusting longitudinal joints between lanes. The assembly shall be adjustable to give the cross-section shape prescribed and shall be so designed and operated as to place the thickness or weight per square metre of material required.

Pavers shall be equipped with activated screeds and devices for heating the screeds to the temperature required for the laying of the mixture without pulling or marring.

The term "screed" includes any cutting, crowing, or other practical action that is effective in producing a finished surface of the evenness and texture specified, without tearing, shoving, or gouging.

If, during construction, it is found that the spreading and finishing equipment in operation leaves in the pavement surface tracks or indented areas or other objectionable irregularities, the use of such equipment shall be discontinued and other satisfactory spreading and finishing shall be provided by the Contractor forthwith.

e) Preparation and transport of mix

Bituminous macadam mix shall be prepared in a hot-mix plant either owned by the Contractor or it may be taken from an approved hot mix plant before supply of mix for the work, consent for the use of the mix shall be taken from the Engineer. The hot-mix plant should be of adequate capacity of batch mix type with the features as described under Subsection 6.7.3 or otherwise approved by Engineer unless some work specific features are required and capable of yielding a mix of proper and uniform quality with thoroughly coated aggregates. The plant shall meet the overall requirements through stringent quality control practices.

The mineral aggregates shall be dried and heated to a temperature between 150 degree C and 163 degree C

The contractor shall submit for consent the exact temperature to the Engineer. Surfaces of aggregates shall be clean and free of carbon and unburnt fuel oil. The aggregates, immediately after heating, shall be screened into three or more fractions and conveyed into separate bins ready for combining and mixing with asphaltic material.

The dried mineral aggregates prepared as prescribed above, shall be combined in the plant in the amount of each fraction of aggregate required to meet the job-mix formula for the particular mixture. The proper amount of asphaltic material shall be distributed over the mineral aggregate and the whole thoroughly mixed for a period of at least 30 seconds, or longer if necessary to produce a homogeneous mixture in which all particles of the mineral aggregates are coated uniformly. The total mixing time shall be regulated by a suitable locking means.

The mixture shall when emptied from the mixer be at a temperature between 150degree C and 163degree C even for tolerances.

The mixture shall be transported from the mixing plant to the point of use in vehicles conforming to the requirements of Subsection 6.7.3 unless otherwise approved by the Engineer.

f) Application of the Pre-mix

The application of the mix shall proceed immediately after application of tack coat. The mix shall be spread immediately by means of self-propelled mechanical paver with suitable screeds capable of spreading, tamping, and finishing the mix true to lines, levels, dimensions and cross-sections specified. Any bare or insufficiently filled areas shall be re-treated by the mechanical spreader or covered by hand as necessary to give uniform and complete coverage. Any aggregate spread in excess of the agreed rate shall be scattered and evenly distributed on the road or otherwise removed and stockpiled.

The temperature of the mix at the time of laying shall be in the range of 120 or 160degree C.

g) Rolling

After the spreading of the mix, the rolling shall be done by road roller of suitable type and capacity. Rolling shall start as soon as possible after the material has been spread and it shall be completed within limited time frame, and to meet this, the Contractor shall deploy a set of rollers. Rolling shall be done with care to avoid unduly roughening of the pavement surface. It shall commence at the edges and progress towards the centre longitudinally except that on super-elevated and unidirectional cambered portions, it shall progress from the lower to the upper edge parallel to the centre line of the pavement.

The speed of the rollers shall not exceed 5 kilometre per hour for steel wheeled rollers and 7 kilometre per hour for pneumatic tired rollers and shall be at all times slow enough to avoid displacement of the hot mixture. Any displacements occurring as a result of reversing the direction of the roller or from any other cause shall at once be corrected with rakes and fresh mixture where required. Care shall be exercised in rolling not to displace the line and grade of the edges.

Rolling shall progress continuously as may be necessary to obtain uniform compaction while the mixture is in a workable condition and until all roller marks are eliminated.

Heavy equipment or rollers shall not be permitted to stand on the finished surface until it has thoroughly cooled or set.

Any petroleum products dropped or spilled from the vehicles or equipment employed by the Contractor upon any portion of the pavement under construction is cause for the removal and replacement of the contaminated pavement by the Contractor.

When the roller has passed over the whole area once, any high spots or depressions which become apparent shall be corrected by removing or adding premixed material. Rolling shall then be continued until the entire surface has been rolled to 95 % of the average laboratory density, and there is no crushing of aggregates. and all roller marks are eliminated. In each pass of the roller, preceding track shall be overlapped uniformly by at least 1/3rd width. The roller wheels shall be kept damp to prevent premix from adhering to the wheels and being picked up. In no case shall fuel/ lubricating oil be used for this purpose.

Along kerbs, man-holes etc., and at any other locations where proper consolidation by rollers is not practicable, alternative means such as steel rammers shall simultaneously be used to secure adequate consolidation.

6.6.4 Surface Control

a) Surface Regularity
Maximum permissible undulation in longitudinal profile with 3m straight edge shall be as 12mm.

Maximum permissible variation from specified cross profile under camber template shall be as 8mm.

Surface evenness requirements in respect of both longitudinal and cross profiles should be simultaneously satisfied.

Tests for conformity with the specified crown and grade shall be made immediately after initial compaction, and variations shall be corrected by removing or adding materials as may be necessary. Rolling shall then be continued as specified. After final rolling, the smoothness of the course shall be checked again and any irregularity of the surface exceeding the permissible limits corrected as agreed by the Engineer's Representative, including removal and replacement.

b) Surface Finish
The bituminous macadam shall be covered with either the next pavement course or wearing course, as the case may be, without any delay. If there is to be any delay, the course shall be covered with the seal coat. The seal coat in such cases shall be considered incidental to the work and shall not be paid separately.

6.7 PPE-MIX CARPET

6.7.1 Description

This work consists of applying a tack coat on the prepared base followed immediately by spreading aggregates pre-coated with specified binder to camber and consolidated. The consolidated thickness of this type of treatment shall be 2 cm or 2.5 cm as specified.

Premix carpet shall not be laid during rainy weather or when the base course is damp or wet or, when the atmospheric temperature in the shade is not more than 16^0 C.

6.7.2 Materials

a) Binder
Binder shall be bitumen paving asphalt grade VG-10/VG-30 of suitable grade meeting the requirements of the work and other environmental conditions. This shall be conforming to the requirements of IS : 73.

b) Coarse aggregates
Coarse aggregates consist of crushed stones and shall be clean, strong, durable, and free from organic or other deleterious materials. The aggregates shall be hydrophobic and of low porosity.
The aggregates shall meet the requirements given in Table 6.7.1 except that the water absorption shall be limited to 1 per cent. The Stone Polishing Value as measured by BS : 812-(Part-114) shall not be less than 55.

c) Proportioning of Materials
They shall comprise of a mix of stone chipping 13.2mm size (passing 22.4 mm sieve and retained on 11.2 mm size) and 11.2 mm size (passing 13.2 mm sieve and retained on 5.6 mm sieve.) The contractor shall propose material proportions to the Engineer for his consent.

6.7.3 Construction Methods

a) Tack Coat
This shall be applied as per Subsection 6.5.

b) Preparation and transport of Premix
The binder shall be heated to a temperature appropriate to the grade of bitumen in boilers of suitable design avoiding local overheating and ensuring a continuous supply.
The aggregates shall be dry and suitably pre-heated to the required temperature before they are placed in a mixer. After about 15 seconds of dry mixing, the heated binder shall be distributed over the aggregates at the rate specified. Mixing shall be continuous and thorough to ensure a homogeneous mixture in which all particles are coated uniformly and the discharge temperature shall be within the specified range.
The mixing of binder with chippings shall be continued until the chippings are thoroughly coated with binder. The mix shall be discharged and immediately transported from mixer to the point of use in suitable vehicles or wheel barrows. The vehicles employed for transport shall be clean and the mix being transported

should be covered in transit and protected from any kind of damage.

c) Spreading and Rolling
Immediately after the application of tack coat, premixed material shall be spread by means of mechanical paver finisher truly to lines, levels, dimensions and cross section as specified. The areas not covered by the mechanical means shall be treated with manual means for which the Engineer has given his consent.

d) Rolling
This shall be carried out as per Subsection 6.6.3

6.8 BITUMINOUS CONCRETE

6.8.1 Description

This work shall consist of a surfacing of single-layer bituminous concrete of specified thickness on previously prepared bituminous surface to the lines, grades, dimensions and cross section as shown on Drawings. It shall be 25mm/40mm thick as required by Engineer.

6.8.2 Materials

a) Bitumen
The bitumen shall be paving bitumen of suitable penetration grade within the range S 35 to S 90 or A 90 to IS: 73. The actual grade of bitumen to be used shall be appropriate to the requirements of the work and environmental conditions.

b) Coarse aggregates
The aggregates shall satisfy the physical requirements given in Table 6.7.1. Flakiness index shall not exceed 30% and water absorbed not more than 1%

c) Fine aggregates
Fine aggregates shall be the fraction passing 2.36 mm sieve and retained on 75 micron sieve, consisting of crushed run screenings, natural sand or a mixture of both. These shall be clean, hard, durable, uncoated, dry and free from any injurious, soft or flaky pieces and organic or other deleterious substances.

d) Filler
Filter shall consist of finely divided mineral matter such as rock dust, hydrated lime or cement. The filter shall be graded within following limits:

IS Sieve	Per cent passing by weight
600 micron	100
300 micron	95 – 100
75 micron	85 – 100

The filter shall be free from organic impurities and have a Plasticity Index not greater than 4. The Plasticity Index requirement shall not apply if filter is cement or lime. When coarse aggregate is gravel, 2 per cent of mass of total aggregate of Portland cement or hydrated lime shall be added and percentage of fine aggregate reduced accordingly. Cement or lime is not required when the gravel is lime stone.

e) Aggregate gradation

Mineral aggregates, including filler shall be so graded or combined as to conform to gradings set forth in Table 6.8.1 below.

Table 6.8.1

Sieve Designation	**Per cent by weight passing through sieve for**		
	25mm thick Grade 1	**25-40mm thick Grade 2**	**>40mm thick Grade 1**
26.5mm	--	--	100
22.4mm	--	100	75-100
13.2mm	100	80-100	--
11.2mm	90-100	75-95	50-85
5.6mm	60-80	55-75	20-40
2.8mm	40-55	40-55	5-20
710micron	20-30	20-30	--
300micron	15-25	15-25	--
180micron	10-20	10-20	--
90micron	5-11	5-11	0-5

6.8.3 Mix Design

a) Requirement of Mix

Apart from conformity with grading and quality requirements of individual ingredients, the mix shall also meet the requirements set forth in Table 6.8.2.

Table 6.8.2

Requirements of Bituminous Concrete Mix

S.NO	Description	Requirements
1.	Marshall stability (ASTM Designation: D-1559) determined on Marshall specimens compacted by 75 compaction blows on each end	820 Kg (1800 pounds)
2.	Marshall flow (mm)	Minimum 2-4
3.	Per cent air voids in mix	3-5
4.	Per cent voids in mineral aggregate (VMA)	Minimum 11-13
5.	Percent voids in mineral aggregates filled by bitumen (VFB)	65-75
6.	Binder content, per cent by weight of mix	Minimum 4.5
7.	Water sensitivity (ASTM : D-1075) loss of Stability on immersion in water at 60 deg. C	Minimum 75% Retained strength
	Swell Test (Asphalt Instt. MS-2, No. 2)	Maximum 1.5%

b) Binder content
Binder content shall be so determined as to achieve the requirements of the mix set forth in Table 6.8.2. Marshall method for arriving at binder content shall be adopted.

c) Job Mix Formula
Before starting work the Contractor shall submit to the Engineer for his consent. The job mix formula for the mixture shall fix a single percentage of aggregate passing each required sieve size, a single percentage of asphalt to be added to the aggregate, and a single temperature at which the mixture is to be delivered on the road, all of which shall fall within the ranges of the composition and the temperature limits. The formula shall give the following details:

I. Source and location of all materials

II. Proportions of all materials as described under :

III. Binder- as percentage by weight of total mix Coarse aggregate/Fine aggregate/ Mineral Filler- as percentage by weight of total aggregate including Mineral Filler

IV. A single definite percentage passing each sieve for the mixed aggregate (Vide Table 6.8.1)

v. The results of test as per specifications obtained by the contractor

vi. Test results of physical characteristics of aggregates to be used

vii. Mixing temperature and compacting temperature

d) Application of job-mix formula and Allowable Tolerances
The approved job mix formula shall remain effective unless and until modified. Each day as many samples of the materials and mixtures shall be taken and tested considers necessary for checking the required uniformity of the mixture. All mixture furnished shall conform to the job-mix formula within the range of tolerances set in forth in Table 6.8.3.

Table 6.8.3

Permissible variations from the job-mix formula

S. No	Description of Ingredients	Permissible Variation by Weight of Total mix in Percentage
1	Aggregate passing 13.2mm sieve and larger	± 8
2	Aggregate passing 9.5mm sieve and 4.75mm sieve	± 7
3	Aggregate passing 2.36mm sieve & 1.18mm sieve	± 6
4	Aggregate passing 600 micron sieve & 300 micron sieve	± 5
5	Aggregate passing 150 micron sieve	± 4
6	Aggregate passing 75 micron sieve	± 3
7	Binder	± 0.3
8	Mixing Temperature (Centigrade)	± 10

When unsatisfactory results or changed conditions make it necessary, a new job mix shall be submitted to the Engineer.
Should a change in a material be encountered or should a change in a source of material be made, a new job mix formula shall be submitted before the mixture containing the new material is delivered.

6.8.4 Construction Methods

a) Weather Limitation
The control over the weather conditions shall be as described under Subsection 6.5.3 above.

b) Progress of Work
No work shall be performed when there is insufficient hauling, spreading or finishing equipment, or labour to ensure progress at a rate not less than 75% of the capacity of the mixing plant.

c) Preparation of Existing Surface
The surface on which the mix is to be laid shall be swept thoroughly and cleaned of all loose dirt and other objectionable material using mechanical broom immediately before start of work. In portions where mechanical means cannot reach, the surface shall be prepared, shaped and conditioned to specified levels, grade and cross-fall (camber).

d) Preparation of Mix
A Hot-mix plant of adequate capacity and capable of producing a proper and uniform quality mix shall be used for preparing the mix. The plant may be either a weigh batch type or volumetric proportioning continuous or drum mix type. The plant shall have co-ordinated set of essential units capable of producing uniform mix as per the job-mix formula. The temperature of the binder at the time of mixing shall be in the range of 150 to 163 degree C and of aggregates in the range of 155 to 163 degree C, provided also that at no time shall the difference in temperature between the aggregates and binder exceed 14 degree C. The Contractor shall submit the exact temperatures and total mixing time for the consent of the Engineer. Mixing shall be thorough to ensure that a homogeneous mixture is obtained in which all particle of mineral aggregates are coated uniformly.

e) Transportation and Delivery of Mix.
The mix shall be transported from the mixing plant to the point of use in suitable tipper vehicles. The vehicles employed for the transport shall be clean and be covered in transit.

f) Spreading and Finishing
The mix transported from the hot mix plant to the site and shall be spread by means of a self- propelled mechanical paver with suitable screeds capable of spreading, tamping and finishing the mix to specified grade, elevation, and cross-section. However, in restricted locations and narrow widths, where available equipment cannot be operated, other suitable means shall be employed subject to the consent of the Engineer. The mixture shall be laid upon an approved surface and only when weather conditions are considered suitable. The

temperature of the mix, at the time of laying, shall be in the range of 120 degree C to 160 degree C.

The prime coat and tack coat to be applied shall be as per Subsections 6.4 and 6.5 respectively.

Spreading, finishing and compacting of the mix shall be carried out during daylight hours only, unless satisfactory illumination is provided by the Contractor.

g) Compaction of Mixture

Immediately after spreading of mix by paver, it shall be thoroughly and uniformly compacted by rolling with a set of self-propelled rollers moving at a speed not more than 5 km per hour, immediately following close to the paver. Generally with each paver, two steel wheeled tandem rollers and one pneumatic tired roller will be required. The initial or breakdown rolling shall be with 8 to 10 ton static weight smooth three wheeled steel roller and finish rolling with 6 to 8 ton tandem roller. The breakdown rolling shall preferably be followed by an intermediate rolling with a smooth wheel pneumatic roller of 10 to 25 ton having a tire pressure of 7kg/sqcm moving with a speed not more than 7 km per hour and shall be at all times slow enough to avoid displacement of the hot mixture. Means shall be provided for checking and adjusting the tire pressure on the job at all times. All compaction operations, i.e., breakdown rolling can be accomplished by using vibratory roller of 8 to 10 ton static weight. During initial or breakdown rolling and finished rolling, the vibratory shall be switched off. The joints and edges shall be rolled with a 8 to 10 ton three wheeled static roller.

No delays in rolling the paved surface shall be tolerated, the breakdown roller must be right up to the paver at all times and the intermediate pneumatic roller right up to the breakdown roller. The compaction of the asphaltic concrete shall be controlled by temperature as follows:

Roller	Temperature
Breakdown	120˚C - 135˚C
Pneumatic	95˚C - 115˚C
Finishing	< 65˚C

Rolling procedure shall be as specified under Subsection 6.6.3

Rolling shall be continued till the density achieved is at least 98% of that of laboratory Marshall specimen. Rolling operations shall be completed in all respects before the temperature of the mix falls below 100 degree C.

h) Joints

Both longitudinal and lateral joints in successive courses shall be staggered so as not to be one above the other. Longitudinal joints and edges shall be

constructed true to delineating lines parallel to the centre line of the road. Longitudinal joints shall be offset by at least 150mm from those in the lower course.
Longitudinal and transverse joints shall be made in a careful manner so that well bonded and sealed joints are provided for the full depth of the course.

i) Surface regularity
Surface shall be tested for undulations in longitudinal and cross profiles with 3 m straight edge and crown template respectively. Crown template shall conform to the typical cross section.
Maximum permissible undulation in longitudinal profile with 3m straight edge shall be as 8mm.
Maximum permissible variation from specified cross profile under camber template shall be as 4mm.
Surface evenness requirements in respect of both longitudinal and cross profiles should be simultaneously satisfied.

j) Protection of the pavement from traffic
Subsection 6.1 shall apply except as stated below.
Section of the newly finished works shall be protected from traffic of any kind until the mixture
has cooled to approximately ambient air temperature and well set.

6.9 SEAL COAT

6.9.1 Description

This work shall consist of application of a seal coat for sealing the voids in a bituminous surface laid to the specified levels, grade, and cross fall. Seal coat used shall be of premix type unless otherwise approved by the Engineer.

6.9.2 Materials

a) Binder

The binder shall be bitumen of a suitable grade appropriate to the requirements of the work and other environmental conditions as directed by the Engineer and satisfying the requirements of IS : 73, 217, 454 or other cut back as applicable.

b) Aggregates

The aggregates shall be sand or grit and shall consist of clean, hard, durable, dry particles and shall be free from dust, soft or flaky/ elongated material, organic matter or other deleterious substances. The aggregates shall pass 2.36mm sieve and be retained on 180 micron sieve. The quantity used for premixing shall be 0.06 cum per 10 sq m area.

6.9.3 Construction Methods

a) Preparation of base

The seal coat shall be applied immediately after laying of bituminous course which is required to be sealed. Before application of seal coat materials, the surface shall be cleaned free of any dust or other objectionable matter.

b) Preparation and Application of Mix

Mixtures of approved type shall be employed for mixing aggregates with suitable bituminous binder.

The binder shall be heated in boilers of suitable design, to a temperature appropriate to the grade of bitumen. The aggregates shall be clean, dry and suitably heated to a temperature before the same are placed in the mixture. Mixing of binder with aggregates to specified proportions shall be continued till the latter are thoroughly coated with the former.

The mix shall be immediately transported from the mixing plant to the point of use and spread uniformly on the bituminous surface to be sealed.

c) Rolling

As soon as sufficient length has been covered with pre-mixed material, the surface shall be rolled with 8-10 ton smooth wheeled steel, suitable vibratory or other equipment.

As regards procedure for rolling it shall be as specified under Subsection 6.7.3.

d) Control of Traffic Subsection 6.1 shall apply.

6.10 C EMENT CONCRETE PAVEMENTS

6.10.1 General

This work shall consist of constructing Plain/ or Reinforced Cement Concrete Pavements as required in accordance with these Specification and in conformity with the lines, levels, grades and dimension in accordance with the design.

6.10.2 Materials

a) General

The concrete materials viz. cement, aggregates, water, steel reinforcement, admixtures shall be in accordance with Annexure OCS -1 (Concrete: Plain and Reinforced) except as specified herein.

b) Dowel and Tie bars

Dowel bars shall be plain round bars. They shall be free from burring or other deformation restricting slippage in the concrete. Before delivery to the Works, one half of the length of each dowel bar shall be painted with one coat of bituminous material.

Tie bars shall be deformed bars free from oil, dirt, loose rust and scale.

These shall conform to the requirements of IS : 432, IS : 1139 and IS : 1786 as relevant.

c) Sleeves

The sleeves for dowel bars of expansion joints shall be of plastic material. This shall be designed to cover the dowels specified by the Designer, with a closed end, and with a suitable stop to hold the end of the sleeve a distance equal to the thickness of joint filler or at least 30mm from the end of the dowel bar. These shall be of such design that they do not deflect or collapse during construction, and the arrangement of sleeves shall be in accordance with these Specifications.

d) Waterproof Membrane

Where Waterproof membrane is to be provided, it shall be an impermeable polythene plastic sheeting. Where an overlap of underlay material is necessary this shall be at least 300mm. Water shall not be allowed to pond on the membrane which shall be completely dry when the concrete is laid.

e) Jointing Materials

i. Joint Filler

The expansion joint fillers shall conform to the requirements of IS: 1838. They shall be punched to admit the dowels where called for as specified by the Designer. The filler for each joint shall be furnished in a single piece for the full depth and width required for the joint. When the use of more than one piece is authorized for a joint, the abutting ends shall be fastened closely together securely and accurately to shape by stapling or other satisfactory positive fastening.

ii. Joint Primer

Joint primer shall be fully compatible with the joint sealant and shall be applied strictly in accordance with the manufacturer's instructions.

iii. Joint Sealing Compound

The Sealing Compound of hot poured, elastomeric type shall conform to AASHTO M282 and cold applied sealant shall be in accordance with BS 5212 (Part 2).

6.10.3 Equipment and Tools

a) General

The concrete paving shall be carried out by use of mechanised method. Equipment and tools necessary for handling materials and performing the work shall have the consent of the Engineer as to design, type, capacity and mechanical, condition shall be at the site of the work before work is started. In special cases like a very short length of road to be laid at a location, other methods may be approved by Engineer.

b) Batching and Mixing Plant

This shall be of suitable type, capacity and make meeting the requirements of work.

i. Paving Equipment

The concrete shall be placed with an approved fixed form or slip form paver with independent units designed to (i) spread, (ii)consolidate, screed and float finish, (iii)texture and cure the freshly placed concrete in one complete pass of the machine in such a manner that a minimum of hand finishing will be necessary and so as to provide a dense and homogeneous pavement in conformity with the plans and Specifications.

Vibrators for full width vibration of concrete paving slabs may be either the surface pan type or the internal type. They may be attached to the spread finisher. They shall not come in contact with the joint, sub base or side forms.

The frequency of the surface vibrators shall not be less than 3500 impulses per minute and for the internal type not less than 5000 impulses per minute. The variable vibration setting shall be provided in the machine.

At least two spare vibrators and one generating unit shall be on hand in case of any breakdown of the vibrating equipment being used.

ii. Concrete Saw for joint cutting

The mechanical saw for cutting concrete shall be adequately powered to cut rapidly with a water-cooled diamond edge saw blade to the depth required. A water tank with flexible hoses and pump shall be made available in this activity on priority basis. The Contractor shall have at least one standby saw in good working condition.

iii. Forms

Straight side forms shall be metal forms having a thickness of at least 5mm and have a depth equal to the prescribed edge thickness of the pavement slab. Curved forms shall be of the radius called for as specified by the Designer and acceptable flexible forms shall be installed with that radius. Built-up forms with horizontal joints shall not be used. Forms shall be free from kinks, bend or wraps. Forms shall not deflect more than 6 mm when tested as a simple beam with a span of three metres under a load equal to that which the finishers or other construction equipment will exert on them. The top of the form shall not vary from a three metre straight edge by more than 3mm at any point and the side by more than 6mm at any point. The forms shall contain provision for locking together tightly the ends of abutting from sections and for secure setting.

iv. Curing Compounds

The curing compounds shall have a water retention efficiency index of 90% in accordance with BS 7542.

6.10.4 Construction Methods

a) Preparation of Sub-base

The sub-base, which shall generally be of water-bound macadam (WBM) conforming to Subsection 6.3.3. The sub base shall be wetted adequately or provided with a water proof membrane so that it dose not absorb any water from the concrete to be laid over it. Concrete shall not be placed on any portion of the sub-base until the consent of the Engineer is given.

b) Setting Forms

The sub-base under the forms shall be compacted and cut to grade so that forms, when set to the position are within + 3mm of a straight line formed by the top of the forms. If the sub-base is found to be below the required grade at the form line, the grade line shall be lifted by placing lean concrete mix 1:4:8 beneath the form and setting the form when it is set. Imperfections and variations above grade shall be corrected by tamping or cutting to the degree required.

The alignment and grade elevations of the forms shall be checked and the necessary corrections made by the Contractor immediately before and after placing the concrete. When any form has been disturbed or any roadbed has become unstable, the form shall be reset and rechecked.

On final setting of the forms, these shall be checked for at least half the length of pavement to be concreted in a particular day before concreting commences on that day. While concreting long lengths, the setting up of forms to the exact grade and alignment shall be in advance of the concreting operation by at least 60 m.

Forms shall be cleaned and oiled prior to the placing of concrete. The forms shall be removed not earlier than 24 hours after the concrete has been laid.

c) Preparation of Concrete

i. Trial Mix / Mix Design Subsection 6.2.1 shall be followed Minimum grade of concrete to be used is M25.

ii. Batching, Mixing and Transporting Materials Subsection 6.2.4 shall apply. The Ready-Mixed Concrete (RMC) shall conform to Subsection Annexure OCS-1.

d) Placing Concrete

Concrete shall be placed only on a prepared sub-base as specified in Subsection 6.3.3. No concrete shall be placed around structures until they have been brought to the required grade and alignment nor until expansion joint material has been placed around them.

The concrete shall be spread, compacted and finished by a mechanical paver and in accordance with Subsection 6.10.3. The mixing and placing of concrete shall progress only at such a rate as to permit proper finishing, protecting and curing of the pavement.

The truck mixers, truck agitators and other approved hauling equipment shall be equipped with means for discharge of concrete into the hopper of the paver without segregation of the materials. In all cases, the temperature of the concrete shall be measured at the point of discharge from the delivery vehicle.

The acceptance criteria regarding level, thickness, surface regularity, texture, finish, strength of concrete and all other quality control measures for hand laid concrete shall be the same as in the case of machine laid work.

The concrete shall be thoroughly consolidated against and along the faces of all forms by means of vibrators inserted in the concrete. Vibrators shall not be permitted to come in contact with a joint assembly, the sub-base or a side form. In no case shall the vibrator be operated longer than 30 seconds in any location. The vibrator shall be inserted in the concrete and worked along the full length and both sides of a joint.

Concrete shall be deposited as near to expansion and contraction joints as possible without disturbing them, but shall not be dumped from the discharge bucket on to a joint assembly.

Except at construction joints, concrete shall be shovelled against both sides of the joint simultaneously, maintaining equal pressure on both sides. It shall be deposited to a height of approximately 5 cm more than the depth of the joint, and shall be vibrated so that all honeycombing and voids are prevented. The vibrator shall be inserted in the concrete and worked along the full length and both sides of the joints.

e) Initial strike-off and Placement of Reinforcement

Where the concrete is laid in two layers, the bottom layer of concrete shall be struck off for the full width between longitudinal construction joint true to crown at the required distance below the finished surface elevation, for placement of reinforcement or for placement of a top layer of the required thickness.

The striking-off shall be accomplished by use of the finishing machine, unless some other approved device is allowed. The reinforcement shall be placed as called for by the Designer and pouring of concrete over it shall only be allowed after placement of reinforcement is proper in all respects and approved by the Engineer.

f) Joints

i) General

Joints shall comply with the design approved for the construction.

A strip of the preformed expansion joint filler shall be placed around each structure which extends into or through the pavement before concrete is placed.

ii) Transverse Expansion Joints

These shall be formed at the design spacings. The material for a transverse joint shall be assembled at the roadbed, and placed into position as a unit.

i) Transverse Contraction Joints

Transverse Contraction joints shall consist of planes of weakness created by forming or cutting grooves in the surface of the pavement. Transverse contraction joints shall also include load transfer dowel-bars where these are specified by the Designer.

The contraction joints shall be cut as soon as the concrete has undergone initial hardening and is hard enough to take up the load of joint sawing machine without causing damage to the slab. Grooves shall be at right angles to the centreline of the pavement and shall be true to line, subject to a tolerance of 5 mm in the width of the slab.

Any procedure for sawing joints that results in premature and uncontrolled cracking shall be revised immediately by adjusting the sequence of cutting the joints or the time interval involved between the placing of the concrete and cutting of the joints.

Load transfer assemblies for transverse contraction joints shall consist of dowel bars without sleeves and an approved auxiliary spacing and supporting element.

The assembly shall be placed into position so that the dowels are parallel to the centreline and shall be staked into position in such a way as to hold the assembly securely in position throughout construction.

ii) Longitudinal Joints

Longitudinal joints shall be constructed in conformity with the design. Planes of weakness shall be created by forming or cutting grooves in the surface of the pavement in accordance with the applicable provisions of this Section.

When adjacent lanes of pavement are constructed separately, steel side forms shall be used which will form a keyway along the construction joint. The bars may be bent at angles against the form of the first lane constructed and straightened into final position before the concrete of the adjacent lane is poured.

iii) Transverse Construction Joint

Transverse construction joints shall be placed whenever concreting is completed after a day's work or is suspended for more than duration permissible for continuous pouring of concrete.

Joints shall be formed by placing installing bars or suitable bulkhead material so that a vertical face with approved key is formed or shall be butt joints formed with suitable material so that a vertical face is formed with no key. No tie bars shall be necessary when key joints are formed but dowel bars of the same dimensions and at the same spacing as for contraction joints shall be necessary at all butt joints.

g) Finishing

i. Machine Finishing

As soon as the concrete has been placed, it shall be struck off and screeded by an approved finishing machine or tools to the grades and cross sections specified by the Designer and to a level slightly above grade so that when properly consolidated and finished the surface of the pavement will be at the exact level and grade. The machine or tool shall go over each area of pavement as many times and at such intervals as necessary to give the proper compaction and to leave a surface of uniform texture, true to grade and cross section.

Excessive operation over a given area shall be avoided. The tops of the forms shall be kept clean by an effective device attached to the machine and the travel of the machine on the forms shall be maintained true without lift, wobble or other variation tending to effect the precision finish.

After concrete has been placed on both sides of the joint and struck off, the installing bar or channel cap shall be slowly and carefully withdrawn, the concrete shall be carefully spaded and additional freshly mixed concrete worked into any depression left by the removal of the installing bar.

A diagonal finishing machine shall be used if available.

ii. Hand Finishing

A portable screed shall be provided for use. The screed shall be at least 60 cm longer than the width of the slab to be struck off and consolidated. It shall be of approved shape, sufficiently rigid to retain its shape and constructed either of metal or of other material shod with metal. (If necessary, a second screed shall be provided for striking off the bottom layer of concrete).

The screed shall then be placed on the forms and slip along them, without lifting, in a combined longitudinal and transverse shearing motion moving always in the direction in which the work is progressing. If necessary this shall be repeated until the surface is of uniform texture, true to grade and contour, and free from porous areas.

h) Edging at Forms and Joints

After the concrete's initial set, the edges of the pavement along each side of each slab, and on each side of transverse expansion joints, planes of weakness except when sawed transverse construction joints, and emergency construction joints shall be worked with an approved tool and rounded to a radius of 5 mm. A well defined and continuous radius shall be produced and a smooth, dense mortar finish obtained. The surface of the slab shall not be unduly disturbed by tilting of the tool during use.

All joints shall be tested with a straight edge before the concrete has set, and correction shall be made if one side of the joint is higher than the other or if they are higher or lower than the adjacent slabs.

i) Surface Texture

The surface of the carriage-way shall be textured by wire brushing in a direction at right angles to the longitudinal axis of the carriage-way. The pavement shall be given this broomed texturing as soon as surplus water has risen to the surface.

The wire brushes shall be either mechanically operated or manual methods may be allowed depending upon the type of paver being used on the Work. In either case the wire broom shall be not less than 450 mm wide with two rows of spring steel. At least two brooms in working order shall be on the site at all times.

The surface texturing shall be completed before the concrete is in such condition that the surface is torn or unduly roughened by the brooming. The broomed surface shall be free from rough areas, porous areas, irregularities, or depressions.

j) Surface Requirements

After the concrete has hardened sufficiently, the surface shall be given a further test for tureens, using an approved 3 m straight edge laid on the surface. Any portion of the surface, when tested in the longitudinal direction, which shows a variation or departure from the testing edge of more than 3.5mm but not exceeding 7mm shall be marked and immediately ground down with an approved grinding tool until the variation does not exceed 3.5mm.

Whenever the variation or departure from the testing edge is more than 7.0mm the pavement shall be removed and replaced. Such removal shall be of the full depth and width of the slab and at least 3m long.

k) Curing

Immediately after the surface texturing, the surface and sides of the slab shall be cured by approved curing method for not less than 7 days. During this period measures shall be taken to prevent the loss of moisture.

The concrete shall not be left exposed between stages of curing.

The surface shall be inspected regularly to ascertain the earliest time at which it is able to withstand the spreading of moisture retaining material. This shall be by ponding of water or spreading and wetting either two layers of burlap or two mats of cotton / jute or a layer of sand or other approved highly absorbent material. Whatever material is used it shall be kept continuously moist for not less than 7 days and to a degree which will ensure that 100% humidity is maintained adjacent to the concrete surface. A membrane curing compound meeting the requirements of BS 7542 may be used subject to the consent of the Engineer.

Concrete surfaces which are subjected to heavy rainfall within three hours after the curing compound has been applied shall be resprayed by the method and the coverage specified above.

Concrete surfaces to which membrane curing compounds have been applied shall be adequately protected for the duration of the entire curing period from the pedestrian and vehicular traffic, except as required for joint sawing operations and surfaces tests, and from only other cause which will disrupt the continuity of the membrane. The curing membrane so formed shall be maintained intact for a period of not less than 14 days. The entire surface shall be protected from the effects of solar radiation and in addition by the use of frames covered with material with heat and light reflecting properties.

Concrete liable to be affected by running water shall be adequately protected from the damage during the setting period.

l) Removing Forms

Forms shall be removed only after stipulated period and carefully so as to avoid damage to the pavement.

m) Protection of Pavement

The Contractor shall erect and maintain suitable barricades and shall employ watchmen to exclude public traffic and that of his employees and agents from the newly constructed pavement until opened for use. These barriers shall be arranged as not to interfere with public traffic on any lane intended to be kept open and necessary signs and lights shall be maintained by the Contractor clearly indicating any lanes open to the public.

Where any stipulated public traffic lane is contiguous to the slab or lane being placed, the Contractor shall provide, erect, and subsequently remove a substantial temporary guard fence along the prescribed dividing line, which shall be maintained there and protected by signages until the slab is opened to traffic. The Contractor's plan of operation shall be such as to obviate any need for encroachment on the public traffic lane or lanes under use.

The same shall be approved by the local competent authority. Any part of the pavement damaged by traffic or other cause prior to its final acceptance shall be repaired or replaced by the Contractor.

n) Sealing Joints

Before the pavement is opened to traffic, and as soon after the curing period as is feasible, all joints both longitudinal and transverse, shall be filled with the material approved for use as seal.

Both primer and sealing compound shall be treated and applied strictly in accordance with the manufacturer's specifications/ instruction and by use of approved equipment.

The sealing material shall be poured into each joint opening as directed by the Engineer. The pouring shall be done in such a manner that the material will not be spilled on the exposed surfaces of the concrete. Any excess material on the surface of the concrete pavement shall be removed immediately and the pavement surface cleaned.

Chapter 7. ITEMS INCLUDED IN SCHEDULE-B

7.1 Sub-Schedule B1, B2, B5, B6, B8, B9, B10, B11 & B13

These Schedules include items of work based on North Western Railways Unified Standard Schedule of Rates (NWR USSOR)-2019 and Non-Schedule (NS) items.

The scope of work, specifications, method of measurement and payment for items based on NWR USSOR-2019 shall be governed by NWR USSOR and Indian Railway Unified Standard Specifications (Formation works, Bridges and P.way Works) – 2019 and for NS items shall be as detailed in Sub-Clause 7.3 below.

7.2 Sub-Schedule B12

Thess Schedules include items of work based on Delhi Schedule of Rates (DSR), 2021 and Non-Schedule (NS) items.

The scope of work, specifications, method of measurement and payment for items included in Schedule B12 shall be governed by DSR 2021 and CPWD Specifications - 2019 and for NS items shall be as detailed in Sub-Clause 7.3 below.

7.3 Non-Schedule (NS) items

7.3.1 NS Item No.1: Reinforced Cement Concrete M35

Supplying and laying in position M-35 RCC as per approved design mix with admixtures and manufactured in fully automatic batching plant and transported to site of work in transit mixer for all lifts & leads, having continuous agitated mixer, pumping concrete from transit mixer to site of laying, compacting, finishing & curing, with all labour, material, tools, plants, machinery and equipment, taxes, cess etc., as a complete job ,but excluding supplying & fixing form work (centering & shuttering), in accordance with the specification and drawings.

Notes: –

(i) Cost of cement is included in the above item.

(ii) Cost of Reinforcement steel is not included in the above item and will be paid separately under relevant item of Sub-Schedule B2.

(iii) Cost of supplying & fixing form work (centering & shuttering) is not included in the above item (except pile cap & open foundation) and will be paid separately under relevant item of Sub-Schedule B11.

I. Method Statement

The Contractor shall submit Method Statement for carrying out the work of bridges to the Engineer for approval. The work shall be carried out strictly in accordance with the approved Method Statement, the Specification and the

Drawings. RCC work shall comply with the provisions of Annexure OCS -1 & 2 of Section VII-6: Employer's requirements-OCS-Civil & BLT.

II. Method of Measurement

Measurement for payment of this item shall be the quantity of RCC worked out/measured in cum from the Drawings. Payment will be made at the Unit Price per cubic meter entered in the Priced Bill of Quantities**.**

7.3.2 NS Item No.2: Bored cast in-situ Piling

Boring 1200 mm diameter piles using Hydraulic Rig in all kinds of strata including boulder studded soil, underground structure like channel, sewer manholes, old foundation or any other obstruction, irrespective of sub-soil water level in all conditions whether dry or under water, shoe and temporary casing pipe, if required, with contractor plant, machinery & equipment for pile boring, use of bentonite slurry including all operations, cleaning of bore holes, supplying and laying in-situ with tremie pipe M-35 RCC in piles as per approved design mix with admixtures and manufactured in fully automatic batching plant and transported to site of work in transit mixer for all lifts & leads, having continuous agitated mixer, pumping concrete from transit mixer to site of laying including supplying & fixing form work (centering & shuttering), compacting, finishing, curing, chipping off pile top to remove laitance concrete above cut off level, removal and disposal of surplus excavated earth/debris/muck outside ROW including all lead, lift, ascends, descends, loading, unloading handling, re-handling, crossing of stream, nallahs, railway track, level crossing etc. with all labour, material, tools, plants, machinery and equipment, taxes, cess etc. as a complete job in accordance with the Specification and the Drawings.

Notes:

i. Cost of cement is included in the above item.
ii. Cost of Reinforcement steel is not included in the above item and will be paid separately under relevant item of Sub-Schedule B2.
iii. Cost of temporary casing pipe is included in the above item. However, the cost of permanent casing pipe is not included in this item and shall be paid separately under relevant item of Sub-Schedule B13, if required and approved by the Engineer.

I. Method Statement

The Contractor shall submit Method Statement for carrying out the work of piling. The work shall be carried out strictly in accordance with the approved Method Statement, Manual on the design and construction of Well and Pile foundations, Sub-clause 3.5.3 to 3.5.9 of Section VII-6: Employer's requirements-OCS-Civil & BLT and Annexure OCS-1 & 2 of Section VII-6: Employer's requirements-OCS-Civil & BLT and the Drawings.

II. Method of Measurement

The method of measurement for payment of piles shall be the length of pile in running metres from founding level to bottom of pile cap as established at the Site by the Engineer. Payment will be made at the Unit Price per running metre, entered in the Priced Bill of Quantities**.**

7.3.3 NS Item No. 3: Protection work using Precast CC blocks

Casting, supplying and laying of Pre-cast CC blocks of size 25x25 x20cm. or of required size as directed by the Engineer for protective works at bridges & banks like pitching, flooring, etc. using M20 design concrete mix with 20mm aggregate size including Contractor's shuttering, leading to bridge site from casting depot, including dressing and levelling of surface, providing gravel backing, laying & jointing blocks with cement mortar 1:3 with Contractor's labour and as directed by Engineer-in-charge (All labour and material including cement by contractor).

Notes:

i. Cost of cement is included in the item

ii. Payment for gravel backing will be paid under. NS item No. -06 of Sub-Schedule B11.

iii. 60% Payment shall be made after casting of pre-cast concrete blocks and bringing them at work site. The balance 40% will be made on completion of laying and finishing.

iv. Measurement is based on quantity calculation of blocks used only (no. of blocks x volume of one block).

I. Method Statement

The Contractor shall submit Method Statement for, supplying and laying of precast concrete blocks for protective works at bridges to the Engineer for approval. The work shall be carried out strictly in accordance with the approved Method Statement and Tender drawings (GC-HRIDC-SK-GEN-015) given in Section VII-8: Tender Drawings and Documents, Part-2 Employer's Requirements.

II. Material

The work shall consist of precast cement concrete blocks in M-20 grade of size 25 cm x 25 cm x 20 cm in a casting yard. The Contractor shall establish a casting yard for manufacture of precast cement concrete blocks. The casting yard shall have facilities for casting, compaction by mechanical vibration, curing and loading of cement concrete block into trucks/tractor trollies. Concrete shall conform to Annexure OCS -1 of Section VII-6: Employer's requirements-OCS-Civil & BLT.

III. Execution

a) Before laying the pitching, the sides of banks shall be trimmed to profile and compacted by vibratory roller to the required slope and profiles marked by means of line and pegs at intervals of 3 metres to ensure regular straight work and a uniform slope throughout. Depressions shall be filled and thoroughly compacted.

b) A layer of 150 mm thick well graded gravel/ stone aggregate shall be laid over prepared earth slope, watered and compacted.

c) Over the compacted gravel/stone aggregate layer, a RCC grid frame of size 1750 mm x 1750 mm of M-35 grade concrete shall be laid. After these grids have attained sufficient strength pre-cast CC block shall be placed inside the grids. The joints of CC blocks shall be sealed with cement mortar 1:3.

d) Toe wall shall invariably be provided at the location of pitching. The pitching shall proceed from toe wall towards the top. Payment of toe wall shall be made separately under relevant items of Schedule 'B'.

IV. Method of Measurement

Measurement shall be in cubic meter based on quantity calculation of only the blocks used (i.e. number of blocks x volume of one block). Payment of RCC used in grid frame shall be done under Item No. NS-1 of Sub-Schedule B3**.**

7.3.4 NS Item No. 4: Earthwork in Railway Embankment

Earthwork in embankment for 32.5t axle load and as per RDSO specification No. RDSO/2020/ GE:004 September 2020 "Comprehensive Guidelines and Specification for Railway Formation" with Contractor's own earth from borrow areas including all lead, lift, ascent, descent, royalty, taxes, cess, compensation, crossing of nallahs /stream and other obstructions including mechanical compaction in layers with watering, handling, re-handling, dressing of banks to the final profile with all labour, material, tools, plant, machinery and equipment, taxes, cess etc. as a complete job in accordance with the specification and drawings.

Note: 10% of payment shall be withheld till the slopes are dressed to the required profile and compacted mechanically with vibratory slope rollers as per RDSO guidelines.

I. Method Statement

The Contractor shall submit Method Statement for carrying out earthwork in embankment to the Engineer for approval.

II. Execution

Earthwork in embankment shall be carried as per Clause 3 of Section VII-5: Employer's requirements-ODS-Civil & BLT and Chapter 2 of Section VII-6: Employer's Requirements-OCS-Civil & BLT

III. Method of Measurement

Measurement for payment for earthwork in embankment shall be in-situ volume as measured in cubic meter (cum) from the levels recorded prior to any filling work and the lines and grades shown on the Drawings or established at the Site by the Engineer. Payment shall be made at the Unit Price per cubic metre, entered in the Priced Bill of Quantities. 10% payment shall be withheld till the slopes are dressed to the required profile and compacted mechanically with vibratory slope rollers as per RDSO guidelines.

7.3.5 NS Item No. 5: Blanketing material

Supplying and laying blanketing material produced through mechanical means using crushers and pug mill for 32.5 T axle load as per RDSO specification No. RDSO/2020/GE:004 September 2020 "Comprehensive Guidelines and Specification for Railway Formation" over the top of subgrade including all lead, lift, ascent, descent, royalty, taxes, cess, crossing of nallahs /stream and other obstructions including mechanical compaction in layers not exceeding 200 mm thick with vibratory rollers, watering, handling, re-handling and dressing of formation to the final profile with all labour, material, tools, plants, machinery and equipment, taxes, cess, etc. as a complete job in accordance with the specification and drawings.

Note: 10% of payment shall be withheld till the slopes are dressed to the required profile and compacted mechanically with vibratory rollers as per RDSO guidelines.

I. Method Statement

The Contractor shall submit Method Statement for providing blanketing to the Engineer for approval.

II. Execution

i. After conducting necessary tests and field trials the Contractor shall get the blanket material approved from the Engineer.

ii. The work of blanketing shall be carried out in accordance with RDSO specification No. RDSO/2020/GE:004 September 2020 "Comprehensive Guidelines and Specification for Railway Formation".

III. Method of Measurement

Measurement for payment of blanketing shall be as per the cross section shown in the Drawings or established at the Site by the Engineer. Payment will be made at the Unit

Price per cubic metre, entered in the Priced Bill of Quantities. 10% payment shall be withheld till the slopes are dressed to the required profile and compacted mechanically with vibratory slope rollers as per RDSO guidelines.

7.3.6 NS Item No. 6: Gravel Base Layer Below Pre-Cast CC Block

Supplying and laying of 150mm thick well graded stones aggregate/gravel as base layer over the embankment slopes with manual dressing, watering & compaction including the cost of supply of all material, labour, lead, lift, tools, plants, crossing of tracks etc. complete as per approved drawings and technical specifications.

I. Method Statement

The contractor shall submit method statement for laying of stone aggregate/gravel layer to the Engineer for approval.

II. Material

Stone aggregate/gravel for base layer shall be hard & well graded. Maximum particle size shall be limited up to 40 mm and fines (particle <75micron) shall be limited upto 5%.

III. Execution

Stone aggregate/gravel shall be laid in uniform layer over levelled and compacted embankment slopes. Base layer shall be watered and compacted manually before laying of CC blocks.

IV. Method of Measurement

Measurement shall be in cubic meter based on the area and thickness of layer.

7.3.7 NS Item No.7: Boulder Backing

Providing Boulder Backing behind wing wall, return wall, retaining wall with hand packed boulders & cobbles not less than 15cm in any direction & not less than 15kg (except smaller boulders required for filling voids) including all lead, lift, labour & other incidental charges as complete work in all respect. Cost of boulder/cobbles is included in this item.

I. Method Statement

The Contractor shall submit Method Statement for carrying out the work to the Engineer for approval. The work shall be carried out strictly in accordance with the approved Method Statement.

II. Method of Measurement

Measurement for payment of this item shall be the quantity of boulder backing worked out/measured in cum from the Drawings/site. Payment will be made at the Unit Price per cubic meter entered in the Priced Bill of Quantities.

7.3.8 NS Item No.8: 75 mm dia PVC Weep Holes

Providing and fixing of 75mm dia PVC pipe for weep holes in abutments, Wing Wall, Return Wall, Face wall, retaining wall etc. at suitable intervals as directed by the Engineer-.

I. Method Statement.

The method statement for providing and fixing of weep holes shall be submitted by the Contractor to the Engineer for approval. The pipes for weep holes shall be UPVC pipe, Type 'A' conforming to IS:13592

II. Execution

Pipe for weep holes shall be placed at the specified locations and spacing in abutment, return walls and retaining walls etc. as shown in the Drawings.

III. Method of Measurement

Measurement for payment for weep holes shall be in running metres as shown in the Drawings.

7.3.9 NS Item No.9: Precast RCC Drain with Cover

Manufacturing, transportation (including loading & unloading) and installation in position (including joining and grouting) M-35 or higher grade precast reinforced cement concrete U-shaped drain with cover as per the directions of the Engineer. Precast reinforced U-shaped drain shall be factory-made, and steam cured in a controlled environment with inserts for handling/transportation. Dimensional tolerances shall be as per IS: 6408 (part 2) for PC Class 6.

Notes: -

1. This item includes cost of all the materials, labour, machinery, tools & plant etc. complete required for manufacture of precast segments except Steel Reinforcement which shall be paid separately under relevant item of Sub-Schedule B2.
2. Excavation of soil for foundation shall be paid separately under item (USSOR item No. 022010) of Sub-Schedule B11.
3. Before placing drain/duct segments, 20 mm thick stiff 1:3 cement mortar bedding layer shall be laid over a levelling course of 50 mm thick of M20 concrete. Payment for M20 concrete shall be made under relevant item (USSOR-2019 item 022040)

of Sub-Schedule B11 and for mortar under relevant item (DSR Item no. 3.8) of Sub-Schedule B12.

4. 60% of the rate shall be paid on receipt of the precast drain/duct segments at site and the balance of 40% will be paid on fixing the same in position in satisfactory condition.

I. Method Statement

The Contractor shall submit detailed design & drawings and Method Statement for carrying out the work to the Engineer for approval. The work shall be carried out strictly in accordance with the approved Method Statement and the Drawings. RCC work shall comply with the provisions of Annexure OCS -1 & 2 of Section VII-6: Employer's requirements-OCS-Civil & BLT. Special care shall be taken in lifting and transportation of precast segments to avoid impact and damage.

II. Method of Measurement

Measurement for payment of this item shall be the quantity of concrete in precast segment worked out/measured in cum from the Drawings. Payment will be made at the Unit Price per cubic meter entered in the Priced Bill of Quantities.

7.3.10 NS Item No.10: Precast RCC Facia Panels of RE Wall

Designing, Providing and erection of specified grade precast RCC Facia Panel of thickness 180 mm made with M-35 Grade Concrete Batching plant, Transit Mixer, Concrete Pump and Vibrator for retaining earth with all element and accessories including reinforcing element complete as per approval drawing and Section 3100 of MORT&H specification including all material labour machinery etc. (Scope of work including designing, getting approval, casting in yad, curing, storing, Transporting, lifting, placing in position, erection with all necessaries fasteners etc complete). The cost of cement & steel are include in this item & no separate payment shall be paid whatsoever. The rate also include cost for excavation, foundation, reinforcing element, fasteners, drainage layer, drain pipe, coping beam and other accessories for which nothing extra shall be paid.

Mode of Payment:

1- Casting of RE Panel: 60%
2- Erection & fixing: 35 %
3- Completion in all respects: 5%

I. Method Statement

The Contractor shall submit detailed design & drawings and Method Statement for carrying out the work to the Engineer for approval. The work shall comply with the provisions of Section 3100 of MORTH Specifications for Road and Bridge Works. Geogrid shall be used as reinforcing element. The work shall be carried out strictly in accordance with the approved Method Statement and the Drawings. RCC work shall comply with the provisions of Annexure OCS -1 & 2 of Section VII-6: Employer's requirements-OCS-Civil & BLT. Special care shall be taken in lifting and transportation of precast segments to avoid impact and damage.

II. Method of Measurement

Measurement for payment of this item shall be the area of precast facia panels worked out/measured in Sqm from the Site/Drawings. Payment will be made at the Unit Price per Square meter entered in the Priced Bill of Quantities.

7.3.11 NS Item No.11: Back Fill in RE Wall

Providing Placing & Compacting to desired density approved backfill material in layers as per approved methodology including testing of reinforced fill portion in approaches between reinforced soil (RS) wall panels as per approved drawing as per Section 3103 of MORT&H Specification. The soil should be predominantly coarse grained, not more than 10 % of particles should pass 75 micron sieve. The item shall be measured and paid for the finished volume of backfill and sub-grade placed in position excluding the volume of filter media at base and behind the RE Wall.

I. Method Statement

The Contractor shall submit Method Statement for carrying out the work to the Engineer for approval. The work shall comply with the provisions of Section 3100 of MORTH Specifications for Road and Bridge Works. Geogrid shall be used as reinforcing element. The work shall be carried out strictly in accordance with the approved Method Statement and the Drawings.

II. Method of Measurement

Measurement for payment of this item shall be the quantity of back fill worked out/measured in cum from the Drawings/site. Payment will be made at the Unit Price per cubic meter entered in the Priced Bill of Quantities.

7.3.12 NS Item No.12: RCC Crash Barrier

Providing & constructing of RCC Crash Barrier of M35 at the edge of road , approaches to bridge structures and medians, constructed with specified grade of concrete using batching plant , transit mixer, concrete pump and vibrator with 450 mm long at expansion joint filled with premolded asphalt filler board, keyed to the structure on which it is built and installed as per design and dimension in the approved drawing and at location directed by the engineer, all as specified as per Section 809 of MORT&H Specification including all material labour, scaffolding etc.

I. Method Statement

The Contractor shall submit Method Statement for carrying out the work to the Engineer for approval. The work shall be carried out strictly in accordance with the approved Method Statement and the Drawings. RCC work shall comply with the provisions of Annexure OCS -1 & 2 of Section VII-6: Employer's requirements-OCS-Civil & BLT.

II. Method of Measurement

Measurement for payment of this item shall be the quantity of concrete in crash barrier worked out/measured in cum from the Drawings/site. Payment will be made at the Unit Price per cubic meter entered in the Priced Bill of Quantities.

7.3.13 NS Item No.13: Earthwork in Filling

Earthwork in filling with contractor's own earth of approved quality from borrow areas including all lead, lift, ascent, descent, royalty, taxes, cess, compensation, crossing of nallahs /stream and other obstructions including mechanical compaction in layers with watering to 95% of MDD (as per IS 2720 part 8), handling, re-handling, dressing to the final profile with all labour, material, tools, plant, machinery and equipment, taxes, cess etc. as a complete job in accordance with the specification and drawings.

I. Method Statement

This item will be used for earthwork in filling for other than Railway embankment. The Contractor shall submit Method Statement for carrying out the work to the Engineer for approval. The work shall be carried out strictly in accordance with the approved Method Statement.

II. Method of Measurement

Measurement for payment for earthwork in filling will be the in-situ volume as measured in cubic meter (cum) from the levels recorded prior to any filling work and the lines and grades shown on the Drawings or established at the Site by the Engineer. Payment will be made at the Unit Price per cubic metre, entered in the Priced Bill of Quantities. 10% payment shall be withheld till the slopes are dressed to the required profile and compacted mechanically with vibratory rollers

7.3.14 NS Item No.14: Supply and laying of MS Pipe

Supply and laying of Mild Steel pipe conforming to IS: 3589 of outer dia 323.9 mm & plate thickness 5.6 mm in railway formation as per approved Drawings.

(i) Method Statement

The Contractor shall submit Method Statement for carrying out the work to the Engineer for approval. The work shall comply to provisions of Sub-Clause 3.3.5 Section VII-5: Employer's requirements-ODS-Civil & BLT and Sub-Clause 2.2 Section VII-6: Employer's requirements-OCS-Civil & BLT.

(ii) Method of Measurement

Measurement for payment of this item shall be the length of pipe measured in running meter. Payment will be made at the Unit Price per running meter entered in the Priced Bill of Quantities.

7.3.15 NS Item No.15: Pathway on Open Web Girder & Composite Girder

Supplying, fabrication and fixing pathway on Open Web Girder & Composite girder bridges with hollow steel, rolled and chequered plate including welding / bolting, priming painting with one coat of ready mix Zinc Chromate primer conforming to IS: 104 with DFTof 25-30 microns, followed by one coat of Zinc Chrome red oxide conforming to IS: 2074 with DFTof 25 with all material, labour, T&P and material as a complete job as per RDSO drawing No. CBS 0045 & CBS 0046

I. Method Statement

The Contractor shall submit Method Statement for carrying out the work of pathway on OWG and composite girder bridges to the Engineer for approval. The work shall be carried out strictly in accordance with the approved Method Statement, the Specifications and the Drawings. The work shall comply with the provisions of Annexure OCS-3 of Section VII-6: Employer's Requirements-OCS-Civil & BLT. Hollow steel sections shall conform to IS: 4923, steel tube sections to IS: 1148, chequered plate to IS:3502 and rolled sections to IS:2062.

II. Method of Measurement

Measurement for payment of this item shall be the weight of metal in the fabricated structure worked out/computed on the basis of nominal weight of materials and exact cut size of the member used in the structure as per drawing in MT. No additional payment shall be made for welds, bolt & nuts etc. Payment will be made at the Unit Price per MT entered in the Priced Bill of Quantities.

7.3.16 NS Item No.16: MS angle expansion Joint

Supplying and fixing M.S. Angles 100 mm x 100 mm x 10mm size conforming to IS:2062 in expansion joint of Composite girder bridges including provision of 10mm dia dowel bar & 12mm dia anchor bolts at 150 mm centre to centre, and 250mm wide GI plate over the top of angles as per relevant RDSO standard drawing with all material, labour, T&P as a complete job.

I. Method Statement

The Contractor shall submit Method Statement for carrying out the work of expansion joint in composite bridge girders to the Engineer for approval. The work shall be carried out strictly in accordance with the approved Method Statement, the Specifications and the Drawings. The work shall comply with the provisions of Annexure OCS-3 of Section VII-6: Employer's Requirements-OCS-Civil & BLT. Mild steel bolt and nuts shall conform to IS: 226 & IS: 1148 but shall have minimum tensile strength of 44 Kg/sqm and minimum percentage elongation of 14.

II. Method of Measurement

Measurement for payment of this item shall be the length of the expansion joint across the track measured/worked out in meter as per the Drawings. Payment will be made at the Unit Price per meter entered in the Priced Bill of Quantities.

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7.3.17 NS Item No. 17: H- beam sleeper

Supplying, fabricating, transportation and fixing galvanized H-Beam sleepers as per RDSO drawing RDSO/B/1636/4/R & RDSO/B/1636/5 with latest alteration and specifications thereto complete with all fittings and fixtures including the cost of all steel sections, all fittings and fixtures ,elastomeric pad, galvanized bolts, nuts, washer, split pin, fish plates 1m and 0.6m long along with fish bolts and nuts for 60Kg running rail and 52Kg guard rail respectively, track fittings and fastenings (Zero Toe Load Fastening) for 60 kg running rail and 52 Kg guard rail as per RDSO drg -RDSO/T-8759 to RDSO/T8765. labour, lead, lift, plants and equipment including galvanized work of full steel components complete in all respects as per approved drawing and technical specifications & as per direction of Engineer on Open Web Girder (OWG) bridges. The rate is also inclusive of the cost of supply of approved quality of epoxy/adhesive and fixing of elastomeric pads with different components of steel sleepers & girder in accordance with approved drawings. The steel to be supplied by the contractor for fabrication of steel H-Beam sleepers shall conform to IS-2062-2006, Grade B0 only. The rate is also inclusive of inspection charges of components of sleepers including all fixtures & fastening, galvanization etc. from the reputed laboratory/organization. Elastomeric pad plate and other track fittings shall be procured from RDSO approved source.

Notes: Payment under this item shall be made in following manner;

i. 75% of the rate shall be paid after fabrication, galvanization and transportation of H beam sleepers to the site and submission of material test certificate of manufacturer and inspection certificate of the agency nominated by the Engineer.

ii. 15% of the rate shall be paid after supply of fittings to the site and submission of inspection certificate of the agency nominated by the Engineer.

iii. iii. 10% of the rate will be paid after fixing H Beam sleepers to the girder in satisfactory manner.

iv. In case fixing is not required, then balance payment will be released on handing over of the sleepers after making recovery @ Rs.850/- per sleeper.

I. Method Statement

The Contractor shall submit Method Statement for fabrication and inspection/testing of steel-H beam sleeper and its fittings/fixtures to the Engineer for approval.

II. Execution

i. Steel used for fabrication of H-beam sleepers shall be of grade E-250 B0 quality as mentioned in para 8.2 of IRS B 1-2001.

ii. H-beam sleepers shall be fabricated as per RDSO drg. RDSO/B-1636/4/R & RDSO B-1636/5 & RDSO specification No. BS: 45 and other relevant specifications.

iii. Tie angle on H-beam sleepers can be dispensed with.

iv. All track fittings shall be procured from RDSO approved source. H- beam sleeper and fittings shall be inspected and passed by agency approved by the Engineer at the fabricator's/ manufacturer's works before supply.

III. Measurement

Measurement of H-beam sleepers shall be done in number. Payment under this item shall be made in following manner.

i. 75% of the rate shall be paid after fabrication, galvanization and transportation of H beam sleepers to the site and submission of material test certificate of manufacturer and inspection certificate of the agency nominated by Engineer.

ii. 15% of the rate shall be paid after supply of fittings to the site and submission of inspection certificate of the agency nominated by Engineer.

iii. 10% of the rate will be paid after fixing H Beam sleepers to the girder in satisfactory manner. In case fixing is not required, then balance payment will be released on handing over of the sleepers after making recovery @ Rs.850/- per sleeper.

7.3.18 NS Item No. 18: Stainless Steel Railing

Providing and fixing stainless steel (Grade 304) railing made of hollow tubes, channels, plates etc., including welding, grinding, buffing, polishing and making curvature (wherever required) and fitting the same with necessary stainless steel nuts and bolts complete, including fixing the railing with necessary accessories & stainless steel dash fasteners , stainless steel bolts etc., of required size, on the top of the floor or the side of waist slab with suitable arrangement as per approval of the Engineer, (for payment purpose only weight of stainless steel members shall be considered excluding fixing accessories such as nuts, bolts, fasteners etc.)

I. Method Statement

The Contractor shall submit Method Statement for fixing of stainless steel (Grade 304) for railing in staircase, balconies, pedestrian subway, Enquiry/Reservation counters to the Engineer for approval. The work shall be carried out strictly in accordance with the approved Method statement and the Drawings.

II. Material

The stainless steel (304 grade) shall conform to IS 6911: 2017. Fabrication of railing shall be done as shown in the Drawings. Fabrication of all stainless-steel sections should be done only with tools dedicated to stainless steel materials. Tooling and work surfaces must be thoroughly cleaned before use.

Following items shall be ensured:

i. Removal of all moisture by blowing with dry air or heating with a torch.
ii. Elimination of organic contaminates like oil, paints, anti-spatter compounds, grease, pencil marks, cutting compounds, adhesive from protective paper, soap used for leak testing etc.
iii. Plasma cutter to be used for cutting stainless steel.
iv. Zinc contamination to be avoided.
v. Brushes or tools previously used on galvanized steel not to be used.

III. Fixing

The railing shall be fixed with necessary accessories and stainless-steel dash fasteners & stainless-steel bolts etc. of required size, on the top of the floor or the side of waist slab with suitable arrangement as per approval of the Engineer.

IV. Method of Measurement

Only weight of stainless-steel members shall be considered in kg for the purpose of measurement. Fixing accessories such as nuts, bolts, fasteners etc. shall be deemed to be included in this item and shall not be paid separately. The rate shall include the cost of materials and labour involved in all the operations described above. Nothing extra shall be paid for fixing arrangements i.e. drilling, providing nuts & bolts etc

7.3.19 NS Item No.19: Bed Plate

Supply, fabrication and erection of bed plate of approved sizes as per relevant RDSO drawing No. RDSO/B-11751/4R2, B-11753/5R1, B-11754/3R2 with upto date corrections, in exact position over bed block on pier/abutments by giving full and even bearing, setting them on the layer of free flow non-shrinkable grouting compound, scrapping or chipping of bed block, if required, fabrication and fixing of HD bolts of suitable sizes along with nuts, washers etc., grouting of holes by epoxy mortar after fixing HD bolts with all labour, material, T & P as a complete job.

NS 19 A - More than 12.2 m and Up to 18.3 m clear span.

I. Method Statement

The Contractor shall submit Method Statement for carrying out the work to the Engineer for approval. The work shall be carried out strictly in accordance with the approved Method Statement, the Specifications and the Drawings. The work shall comply with the provisions of Annexure OCS-3 of Section VII-6: Employer's Requirements-OCS-Civil & BLT.

II. Method of Measurement

Measurement for payment of this item shall be the weight of metal in the fabricated structure worked out/computed on the basis of the drawing in Kilogram. No additional payment shall be made for bolt & nuts etc and no deductions shall be made for holes. Payment will be made at the Unit Price per kg entered in the Priced Bill of Quantities. Payment will be made at the Unit Price per unit entered in the Priced Bill of Quantities.

7.3.20 Item No.20: Metallic Guided bearing

Supply and fixing of Metallic Guided Bearing in position true to line and level as per RDSO drawing No. RDSO/B-11754/3R2 and IRC:83 pt. III-2018 including supply & grouting of anchor bolts with approved non-shrinking epoxy grout with all material, labour, T&P as a complete job.

I. Method Statement

The Contractor shall submit Method Statement for carrying out the work to the Engineer for approval. The work shall be carried out strictly in accordance with the approved Method Statement, the Specifications and the Drawings.

II. Method of Measurement

Measurement for payment of this item shall be in number. Payment will be made at the Unit Price per unit entered in the Priced Bill of Quantities.

7.3.21 NS Item No.21: Ballastless Track (BLT) On Bridges

Construction of ballast less track (BLT) on bridges in straight/curve including linking of track with 60 Kg rails in LWR, supply and fixing of rail fittings/ fastening, Construction of derailment guard , as per approved Design & Drawing. The item includes supply and leading of all material, labour, tools & plants including welding of track in LWR, destressing, drainage arrangement as per the approved drawing complete in all respect. Nothing extra shall be paid.

Note:-

(1) 60 Kg 350 R Rails shall be paid under item no NS-25 of this Sub-Schedule.

(i) Method Statement

The Contractor shall submit Method Statement for carrying out the work of bridges to the Engineer for approval. The work shall be carried out strictly in accordance with the approved Method Statement, the Specifications and the Drawings. Ballastless track work shall comply with the provisions of Clause 8 of Section VII-5: Employer's requirements-ODS-Civil & BLT and Chapter 8 & **Annexure OCS -1 & 2** of Section VII-6: Employer's requirements-OCS-Civil & BLT.

(ii) Method of Measurement

Measurement for payment of this item shall be the length of BLT worked out/measured in running meter for each track separately. Payment will be made at the Unit Price per running meter entered in the Priced Bill of Quantities.

7.3.22 NS Item No.22: Transition of Ballastless Track (BLT) To Ballasted Track On Bridge Approaches

Construction of Transition system of ballastless track to ballasted track on bridge approach including linking of track with 60 Kg rails in LWR including, supply and fixing of rail fittings/ fastening, Construction of derailment guard as per approved Design & Drawings. The item includes supply and leading of all material, labour and tools & plants, welding of track in LWR, destressing, drainage arrangement as per the approved drawing complete in all respect. Nothing extra shall be paid.

Note:-

60 Kg 350 R Rails shall be paid under item no NS-25 of this Sub-Schedule.

(i) Method Statement

The Contractor shall submit Method Statement for carrying out the work of transition system of ballastless track to ballasted track on bridge approaches to the Engineer for approval. The work shall be carried out strictly in accordance with the approved Method Statement, the Specifications and the Drawings. Ballastless track work shall comply with the provisions of Sub-Clause 4.2 of Section VII-5: Employer's Requirements-ODS-Civil & BLT and Sub-Clause 7.3.17 & Annexure OCS -1 & 2 of Section VII-6: Employer's Requirements-OCS-Civil & BLT.

(ii) Method of Measurement

Measurement for payment of this item shall be the number of transitions of Ballastless track to Ballasted track for each bridge approach for one track. Payment will be made at the Unit Price per transition entered in the Priced Bill of Quantities.

7.3.23 Item No. 23: Linking of Track on H- beam sleeper

Linking of track on H- beam sleepers on Open Web Girder (OWG) bridges with 60 Kg running rail and 52 kg guard rail with track fittings/fastenings including leading of Running and guard rails from bridge approach and fixing of running rails & guard rails, bending of guard rails, notching, drilling of holes, cutting of rails etc., as directed and making track structure fit for normal speed. (Rails will be supplied by the Employer free of cost)

Note:-

(1) 60 Kg 350 R rails and 60 Kg Class 'IV' rails for guard rail shall be paid under for running rail item no NS-25 and item no NS-26 respectively.

I. Method Statement

The Contractor shall submit Method Statement for linking of track to the Engineer for approval.

II. Execution

i. Running rail and guard rail shall be fixed on H- beam sleeper as per assembly drawings (No. RDSO/T-8759 to RDSO/T-8765 with latest alterations/corrections) and provisions of IRPWM.

ii. Holes in the flange of guard rail shall be drilled after fixing the sleeper and running rail in position.

iii. Track shall be fit for normal speed and tolerances shall be as per permissible limits specified in IRPWM.

III. Measurement

Measurement for payment of linking of track shall be done in running track meter.

7.3.24 NS Item No.24: Supply of Special PSC Wide Base Sleeper For Bridge Approaches

Supplying at site of work including leading, loading, unloading and stacking of special PSC wide base sleepers for bridge approaches with provision of guard rails as per RDSO Drawing No. T-8673 to T-8680 for 60 Kg Rail.

(i) Method Statement

The Contractor shall submit Method Statement for carrying out the work to the Engineer for approval. The sleepers shall be procured from RDSO approved source/plant. Before dispatch sleepers shall be inspected & passed by the concerned railway authority in whose jurisdiction the plant is located or by any other agency nominated by the Employer/Engineer. Sleepers shall invariably be handled mechanically to avoid damage.

(ii) Method of Measurement

Measurement for payment of this item shall be the sets of bridge approach sleeper for one side approach of one track. Payment will be made at the Unit Price per set entered in the Priced Bill of Quantities.

7.3.25 NS Item No.25: Supply of 60 Kg, R350 Class 'A' Rails

Supplying, Transporting of Rail 60 kg, Class 'A', R350 rails of 13/26 meter length as per IRS:T-12/2009 Specifications with latest amendments issued by RDSO.

(i) Method Statement

The Contractor shall submit Method Statement for carrying out the work to the Engineer for approval. The rails shall be procured from RDSO approved source/plant. Supply of rails shall comply with the provisions of Clause 8 of Section VII-5: Employer's requirements-ODS-Civil & BLT. Before dispatch rails shall be inspected & passed by the M/s RITES or any other agency nominated by the Employer/Engineer.

(ii) Method of Measurement

Measurement for payment of this item shall be the length of rail measured in running meter. Payment will be made at the Unit Price per running meter entered in the Priced Bill of Quantities.

7.3.26 NS Item No.26: Supply of 60 Kg Class 'IU' Rails

Supplying, Transporting of Rail 60 kg Class 'IU' as per IRS: T-12/2009 Specifications with latest amendments issued by RDSO.

(i) Method Statement

The Contractor shall submit Method Statement for carrying out the work to the Engineer for approval. The rails shall be procured from RDSO approved source/plant. Supply of rails shall comply with the provisions of Clause 8 of Section VII-5: Employer's requirements-ODS-Civil & BLT. Before dispatch rails shall be inspected & passed by the M/s RITES or any other agency nominated by the Employer/Engineer.

(ii) Method of Measurement

Measurement for payment of this item shall be the length of rail measured in running meter. Payment will be made at the Unit Price per running meter entered in the Priced Bill of Quantities.

Chapter 8. BALLASTLESS TRACK

8.1 GENERAL

a) BLT on bridges has to be laid ~~over the tunnel invert concrete base~~.

b) The opposite electrical continuity between rail bases shall be checked by means of a low resistance continuity apparatus (10V-100 amp) in presence of the Engineer.

c) Detailed specification for RCC to be used in construction shall be as per **Annexure OCS-1** & **Annexure OCS-2.**

8.2 BALLASTLESS TRACK INSTALLATION

8.2.1 GENERAL

i. The track gauge throughout shall be 1673 mm (nominal) measured between the running edge gauge point of each rail and normal to the Centre line of the track 14 mm below top of rail.

ii. All main line track shall be laid with 1:20 inward rail slope.

8.2.2 RAIL JOINTING

i. All rail joints throughout the main lines glued insulated joints, switch expansion joints etc. shall be welded.

ii. The welding of nominal rail lengths into long welded rail panels for main lines shall be done with Mobile Flash butt welding machine approved by RDSO. Wherever the Mobile Flash Butt welding is practically not possible the Alumino-thermit welding can be done in accordance with RDSO specification.

8.2.3 RAIL EXPANSION JOINTS

i. Particular attention shall be given to ensure that rail expansion joints are assembled and installed in accordance with the Drawings and correctly located with relation to the type of Rail Expansion joint and the direction of traffic.

ii. Immediately prior to completion of a section, all sliding surfaces of rail expansion joint shall be cleaned and greased.

8.2.4 RAIL TEMPERATURE

Rail temperatures shall be measured using appropriate dial type magnetic thermometers placed on the web of the rail on the shaded side. A minimum number of thermometers required to be used per rail for measuring average rail temperature of a segment of track shall have the prior approval of Engineer.

8.2.5 CLEANING OF TRACK

The track from structure (including the rail surface) as installed shall be thoroughly cleaned to an acceptable standard as approval by the Engineer immediately after installation and as required thereafter maintaining the standard until the arrangement of service trails so as to provide adequate levels of electric insulation and rail surface quality for correct performance of train control and signaling equipment under prevailing climate and environment conditions.

8.2.6 RAIL INSULATION

The track as installed shall be thoroughly cleaned immediately after insulation. This shall be necessary to provide adequate levels of electrical insulation for the correct performance of the signaling and traction equipment under the prevailing climatic and environment condition.

8.2.7 CUTTING OF RAILS

i. Rails shall only be cut by using abrasive rail cutting machines. The proposed method and equipment for the cutting of rails shall have the prior approval of the Engineer.

ii. Rails required to be cut shall be cold sawn square and vertical across the rail. A deviation from square or vertical of more than 0.5mm measured about the rail head, shall not be permitted. All burrs shall be removed from the rail ends.

iii. Quality of cutting shall be such as to ensure tolerances specified in Alumino-thermit welding manual.

8.2.8 STAGES OF REQUEST FOR INSPECTION DURING CONSTRUCTION OF SLAB TRACK.

A. The ballastless track system consists of:

i. Support structure done as a part of bridge civil works

ii. Reinforced concrete slab track

iii. Rail fastening system (design and drawing shall be submitted by the bidder/contractor for approval).

"Request for inspection" shall be submitted to the Engineer, Complete with all necessary information to allow assessment, after the following activities and approval must be received prior to the commencement of any follow-on activity.

a) Acceptance of support structure including specified surface treatment

b) Acceptance of the slab track reinforcement

c) Acceptance of temporary/false works shuttering, jigs, fixtures and supporting arrangements

d) Acceptance of the track for concreting

e) Acceptance of the track for the movement of construction of plant equipments and machinery

f) Acceptance of the track for in-situ welding / cess welding.

g) Acceptance of the track for destressing

B. All third party (RDSO/RITES/Any other nominated agency) inspection charges, if any, for Ballastless Track system shall be paid by the Employer.

8.2.9 REINFORCED CONCRETE SLAB TRACK

a) The ballastless tracks shall be laid with reinforced concrete slab track on supporting structures.

b) The ballastless track shall be constructed by Top down method of construction. The laying tolerance for various parameters for the installed Ballastless track shall be strictly achieved in accordance with the relevant clauses in these specifications. For achieving these tolerances the tenderer may propose the method/scheme of construction of ballastless track for review before start of work. However, the sole responsibility of achieving the stipulated track laying tolerances lies with the Contractor.

c) The Contractor shall be responsible to calculate the height of the slab track at each location to maintain the desired rail level as shown in the relevant drawings and submit the same for the approval of the Engineer. The reinforced concrete slab track shall be laid on support slab duly making the provision for cant and vertical curves.

d) Suitable construction joints shall be provided in the slab track as per approved Design & Drawing. Location of the joints shall be in conformity with the location of other joints in the bridge super structure.

e) The handling and transport arrangement of rails shall ensure no damage to the rails.

f) Resilient pads placed under the metal base plates shall be coated with silicon or any suitable product, on their underside and lateral side, to stop them adhering to the slab track concrete, as approved by Engineer.

g) During the concreting phase, the track fastening device, the running rails and the expansion joints templates shall be protected by movable covers against possible splattering of concrete.

h) Conduits required for crossing of signaling wires shall have to be provided before concreting as directed by the Engineer.

i) Immediately after concreting of slab track the assembly consisting of the rails and the plinth segments shall be covered by wet cloths to prevent damage due to rise in temperature.

j) These cloths shall be damped constantly for 8 hours from the time of pouring the concrete.

k) The rail fastening between the metal base plates and running rails base shall then be removed to authorize differential movement in the longitudinal direction between the rails and structures.

l) Twenty-four (24) hours after pouring of the slab track concrete, the formwork shall be removed.

m) The concreted surfaces of the slab track below the base plates shall be smooth, devoid of any inclusions, roughness cracks and without showing any aggregate at the surface.

n) Temporary rails shall not be used for constructions, slab track shall be constructed using the permanent rail to be finally fastened.

8.3 TEST FOR RAIL FASTENING SYSTEM COMPONENTS

The following tests are required to be conducted for fastening system-

a) Pull out strength test of anchor bolts.

b) Longitudinal creep resistance test of rail seat assembly.

c) Fatigue test of tension clamp.

d) Fatigue test of helical spring.

e) Stiffness test (static & dynamic) of elastic base plate pad & the ratio of dynamic to static stiffness at various frequencies.

f) Fatigue tests of assembly as a whole. These tests shall cover as minimum heat generated in pads in terms of temperature, records of gauge, rotation of rail head, slippage of rail foot, and lateral & vertical movement of base plate and vertical deflection of rail head.

g) Installation procedure tests.

8.4 RAIL INSULATION TO EARTH TEST

a) All track work shall be subjected to a rail insulation to earth test. The track shall have a minimum rail to earth value of 40 Ω/km of single track for ballastless tracks.

b) The rail to earth test shall be undertaken after the track has been completed and cleaned but before it is finally formed into a continuously welded system and before all the bonding is installed.

c) Junctions shall be isolated and tested prior to their final connection into the track.

d) The test shall be undertaken on rail lengths up to maximum lengths of 1000 m. The tracks shall not be finally formed into a continuous length, nor shall the junctions be joined to the adjacent tracks, until the rail insulation to earth tests have been undertaken and approved.

8.5 BALLASTLESS TRACK BASE RESISTANCE TESTS

a) A ballastless track base resistance test shall be undertaken on all track lengths over 50 meters as a check of the leakage of current through the track base and rail fastening system from one rail to the other.

b) The ballastless track base resistance test shall be undertaken after the track has been complete and cleaned but before it is finally formed into a continuous length and all the bonds are attached.

c) The testing procedure and the minimum resistance shall comply with the requirements proposed by the engineer.

8.6 RAIL INCLINATION INSPECTION

a) Both rails of all ballastless running line tracks shall be checked, at maximum 10m intervals, for inclination using an approved equipment/method in the presence of the engineer.

b) Should any reading show the inclination to be outside the specification limits every alternate fastening assembly shall be further checked either side of the non-compliant reading until compliant readings are consistently obtained.

8.7 RAIL WELDING:

a) The main line track shall be welded into LWR/CWR using mobile flash butt welding machine approved by RDSO. Wherever the mobile flash butt welding is practically not possible the Alumino-thermit SKV process welding shall be done with the approval of the Engineer through agencies approved by RDSO and as per provision of manual for fusion welding of rails by the Alumino-thermit process supply of portion must be and procurement is from sources approved by RDSO.

b) Welding shall be supervised by trained welding supervisor and carried out by trained welder having competency certificate from RDSO/Lucknow in his possession.

c) The preparation of rail ends to be ensured before welding.

d) The Contractor shall arrange for test welds and their testing done as per manual.

e) The welds shall be finished to final profile by grinding and the finished weld shall be within the specified tolerance.

f) Each joint shall have distinctive marks as per details in the manual.

g) Weld collar shall be painted against corrosion as per specification given in manual.

h) All the recorded welds shall meet the acceptance tests including ultra-sonic test.

i) Rail joints welded by the Contractor shall be guaranteed against failure for a period of 2 years from date of starting of rail traffic. Any such welded joint which fails within guarantee, the joints shall be rewelded free of cost.

j) In case of failure of sample test joint, the period of guarantee for 100 joints represented by the sample joint shall be extended for a further period of 1 year. In case of failure of joints exhibiting sign of failure by cracking within extended period of guarantee, the joints shall be rewelded free of cost.

k) When one bad joint is required to be replaced by two new joints, the entire cost of both the joints shall be borne by the Contractor.

l) Drilling of holes in the 60kg rails is strictly not permitted.

8.8 DESTRESSING OF CWR:

a) Destressing must be done as per provisions of Indian Railway Permanent Way Manual.

b) Destressing of rails shall not be undertaken until it has been demonstrated to Engineer's satisfaction that the track has been completed to the specified standard specifications and the method of working for destressing of the relevant track has been approved by the Engineer.

c) Destressing must be done in accordance with temperature conditions stated in the Railway Manual.

d) The stress free temperature condition of LWR shall be achieved naturally or artificially by the use of hydraulic rail tensors as approved by the Engineer.

8.9 CONSTRUCTION PROCESS

Tenderers are advised to visit local sites location as specified in tender to get familiar with typical local environment like drainage system, rainfall etc.

Procedure of construction process of BLT should be mentioned in details suitable to local site conditions. Clearly demonstrating how it can be constructed & installed within a reasonable time frame.

8.10 MAINTENANCE AND PERFORMANCE MONITORING

a) The Defects Notification Period (DNP) will be for 3 years from the date opening of traffic.

b) After Construction of Ballastless track, HRIDC will monitor the performance jointly with the Contractor on quarterly basis & for 3 years. The performance monitoring will be based broadly upon following parameters:

c) Efficacy of fastening: Fastening system should be able to maintain track geometry (gauge, cross level, loose fitting etc.) at all times within track tolerances during service without any components breakage, excessive wear & tear.

d) Track tolerances to be maintained at the time of construction & during trial/services should be as per Section VII-5 Outline Design Specification (ODS) - Civil.

e) Any track settlement which impairs the functionality of ballastless track.

f) Any visible crack of width more than 0.1 mm in concrete/RCC portion of slab which impairs the functionality of ballastless track.

g) Efficacy of drainage system e.g. the slope and drains constructed should function properly during Monsoon period.

h) Any special observation.

The decision of HRIDC about performance of the ballastless track after monitoring period shall be final.

Annexure OCS-1

PLAIN AND REINFORCED CEMENT CONCRETE

1 MATERIALS

a. Before bringing to the site, all materials for concrete shall be approved by the Engineer. All approved samples shall be deposited in the office of the Engineer before placing orders for the materials with suppliers. The materials brought on to the works shall conform in every respect to their approved samples.

b. Fresh samples shall be deposited with Engineer whenever type or source of any material changes. The contractor shall check fresh consignment of materials as it is brought on to the works to ensure that they conform to the specifications and/or approved samples.

c. The Engineer shall have the option to have any of the materials tested to find whether they are in accordance with specifications at the contractor's expense. All bills vouchers and test certificates which in the opinion of the Engineer are necessary to convince him as to the quality of materials or their suitability shall be produced for his inspection when required.

d. If fly ash is used in concrete, the contractor shall demonstrate the quality control procedure including source of fly ash, its properties, handling as per the relevant IS & international codes etc. and shall use in slabs and walls only after "no objection" to the same has been obtained from the Engineer.

e. Any materials which have not been found to conform to the specifications and not approved by the Engineer shall be rejected forthwith and shall be removed from the site by the contractor at his own cost within the time stipulated by the Engineer. The Engineer shall have the powers to cause the contractors to purchase and use materials from any particular source, as may in his opinion be necessary for the proper execution of work.

f. Contractor shall also ensure that all constituents of exposed concrete shall be taken from same sources to achieve a uniform colour and texture.

g. Approved list of Manufacturer's/Suppliers is given in Section VII- 8:Tender Drawings and Documents. In case the Contractor desired to procure the material from any other supplier, it shall be got approved by the Engineer.

2 Cement

2.1. Product and Materials for Cement

a. Cement to be used in the works shall conform to 53-grade OPC (IS 269:2015) or blended cement such as Portland Pozzolana Cement (IS 1489:2015) or Portland Slag Cement (IS 455:2015).

b. The Contractor shall submit to the Engineer the Manufacturer's Certificate to affirm that the cement complies with the relevant standards.

c. Samples of the proposed cement shall be taken and forwarded to an independent laboratory for analysis before the source is approved.

d. Prior to ordering cement, the Contractor shall submit details of the proposed supplier or manufacturer and information on the proposed methods of transport, storage and certification for the Engineer's approval and show that the quantity and quality required can be attained and maintained throughout the construction period. In exposed concrete elements, the cement used in the concrete for entire element shall preferably be from a single manufacturer to ensure uniform colour.

e. Subsequent to obtaining the Engineer's approval, the Contractor shall not change the agreed arrangements without the prior approval from the Engineer. Each delivery of cement shall be accompanied by a certificate which shall be submitted to the Engineer immediately after the delivery showing the place of manufacture and the results of standard tests carried out by the manufacturer.

2.2. Testing for Cement

a. Samples shall be tested from every batch of cement delivered on site or once for every 1000 bags whichever is more frequent. The sampling from bulker shall be increased as decided by the Engineer.

b. Samples shall be taken immediately on receipt of cement at site. The methods and procedures for sampling shall be in accordance with IS: 3535.

c. Tests shall be carried out as per IS4031 for physical analysis as fineness, initial and final setting time and compressive strength and results approved by the Engineer before use. The contractor shall provide complete facilities at site for carrying out the following tests:

   i. Setting time by vicat's apparatus as per IS:5513 and IS:4031.

   ii. Compressive strength of cement as per IS: 4031, IS:650, IS:10080.

d. The Engineer may require any other form of sampling and tests including chemical analysis. Total chloride content in cement and total sulphur content calculated shall in no case exceed the requirements of Table 2 of IS 269. In case the cement supplied is of doubtful quality, tests shall be done in accordance with IS 4032. The costs of such additional tests shall be borne by the Contractor.

3 Aggregates

3.1 General

Aggregates shall conform to the provisions specified in IS 383:2016. The contractor shall submit to the Engineer certificates of grading and compliance for all consignments of aggregate. In addition, at site from time to time, the contractor shall allow for carrying out tests and for supplying test records to the Engineer. Prior to commencing any concrete work, the Contractor shall obtain the Engineer's approval of the proposed types and sources of aggregate.

For fair faced concrete, the contractor shall ensure that aggregates are free from iron pyrites and impurities, which may cause discoloration. Aggregates shall be stored on paved areas in different compartments according to their nominal size.

Sampling of aggregates shall be as per IS 2430.

3.2 Fine Aggregates (Sand)

a. The grading of the sand shall conform to IS:2386(Part1). The grading of fine aggregate shall be within the grading zones I, II, III. Sand, if found too coarse, shall be suitably blended with finer sand obtained from approved sources to obtain the desired grading. The provision of two types of sand, their separate stacking and their mixing in the specified proportions shall be at the Contractor's own cost.

b. The sand shall not contain silt, shale, clay and other weak particles for more than a total of 3% by weight. In case of sand containing excess silt, clay and chlorides, the sand shall be washed in screw type mechanical washers in potable water to remove the same. The screening and washing of sand shall be completed at least one day before using it in concrete. The washed sand shall be stored on a sloping platform while ensuring that contamination is avoided.

c. Water absorption shall be less than 3% by weight (ASTM C 117)

d. The sand shall be screened on a 4.75 mm size screen to eliminate oversized particles. The Contractor shall carry out the following tests at Site and ensure that the appropriate provisions of Indian or other standards, as may be applicable, are complied with:

i. Proportion of clay, silt and fine dust by sedimentation method as per IS 383:2016 and IS 2386 (Part II)

ii. Moisture content in fine aggregate as per IS 2386(Part III)

iii. Water absorption shall be worked out as per IS 2386(Part III)

iv. Bulk Density or bulkage as per IS 2386(Part III)

v. Grading of fine aggregate asper IS 383:2016 and IS 2386(Part I)

3.3 Coarse Aggregates

a. All coarse aggregate shall conform to IS: 383 and tests for conformity shall be carried out as per IS: 2386, Parts I to VIII.

b. The maximum size of coarse aggregate shall be such that the concrete can be placed without difficulty so as to surround all reinforcement thoroughly and fill the corners of formwork. The grading of coarse aggregate shall be such that not more than 5% shall be larger than the maximum size and not more than 10% shall be smaller than the smallest size. Between these sizes the coarse aggregate shall be well graded. Unless otherwise permitted by the Engineer the nominal maximum size shall not exceed 20 mm.

c. Water absorption shall be less than 3% by weight (ASTM C 117)

d. Coarse aggregates used for the Works shall be crushed stone conforming to IS 383, obtained from approved sources by the Engineer. Only quarries having jaw crushers with choke feeding arrangements producing aggregates of nearly cubical shape shall be applied.

e. Coarse aggregate containing flat or flaky pieces or mica shall be rejected.

f. The Contractor shall carry out the following tests at site and ensure that the appropriate provisions of following Indian standards as may be applicable are complied with:

i. Moisture content in coarse aggregate asper IS 2386(Part III)

ii. Water absorption shall be worked out as per IS 2386(Part III)

iii. Bulk density and voids asper IS 2386(Part III)

iv. Grading of coarse aggregate as per IS 383:2016 and IS 2386(Part I)

4 Water

Water used in the works shall be potable water and free from deleterious materials. Water used for mixing and curing concrete as well as for cooling and/or washing aggregate shall be fresh and clean free from injurious amounts of oil, salts, acids, alkali, sugar other chemicals and organic matter. Mixing and curing with seawater shall not be permitted.

Water shall be from the source approved by the Engineer and shall be in accordance with IRS: CBC(Cl.4.3), IS: 456 (Cl. 5.4) and/or BS 3148.

Water samples from the intended source of supply shall be taken for analysis before any concrete work commences, and at regular intervals throughout the duration of the Works, as approved by the Engineer. Whenever the source of water changes, the water shall be tested for its chemical and other properties or impurities to ascertain its suitability for use in concrete, subject to the approval of the Engineer. No water shall be used until tested and found satisfactory. Cost of all such tests shall be borne by the Contractor.

5 Chloride Content

The chloride content of aggregates shall be within the recommended limits stated in IS: 383 or BS 882 and the chloride content of the concrete mix shall be within the recommended limit of IS: 456 or BS 8110. Chloride levels shall be determined daily in accordance with the methods described in BS 812.

6 Alkali-Silica Reactivity

If aggregates contain any materials which are reactive with alkalis in any of the constituents of the concrete, or in water which will be in contact with the finished work, then the Contractor shall take samples of these materials every week. The Contractor shall ensure that the concrete mix complies with the requirements of this Specification regarding "Minimising risk of alkali-silica reaction in concrete". The results of the Contractor's weekly monitoring tests shall be submitted in writing to the Engineer-in-charge.

7 Sulphate Content

The total acid soluble sulphate content of the concrete mix, expressed as SO3, shall not exceed the recommended limit in IS: 456 or BS 8110.

8 Reinforcement Steel

The Contractor shall refer to Annexure - C of these Technical Specifications.

9 Binding Wire

GI wires of 1.6mm diameter shall be used for binding of reinforcements. It shall conform to the provisions laid down in IS 280.

10 Concrete Admixtures

a. Admixtures shall conform to the provision laid down in IRS: CBC (Cl. 4.4).

b. Concrete admixtures are proprietary items of the manufacturer and shall be obtained only from established manufacturers with proven track record, quality assurance and full- fledged laboratory facilities for the manufacture and testing of concrete. Naphthalene or melamine-based admixtures that are approved by the Engineer only shall be used in the Works. The admixture shall be non-air entraining type. The Contractor shall provide the following information concerning each admixture after obtaining the same from the manufacturer:

    i. Normal dosage and detrimental effects, if any, of under dosage and over dosage.

    ii. The chemical names of the main ingredients in the admixtures.

iii. The chloride content, if any, expressed as a percentage by weight of the admixture.

iv. Values of dry material content, ash content and relative density of the admixture which can be used for uniformity tests.

v. Whether or not the admixture leads to the entrainment of air when used as per the manufacturer's recommended dosage, and if so, to what extent.

vi. Where two or more admixtures are proposed to be used in any one mix, confirmation of their compatibility.

vii. Whether or not there would be an increase in risk of corrosion of the reinforcement or other embodiments as a result of using the admixture.

viii. Retardation achieved in initial setting time.

c. Physical and chemical requirements of admixtures shall conform to IS 9103. In addition, the following conditions shall be satisfied:

i. Plasticizers and superplasticizers shall meet the requirements indicated for "Water reducing Admixture".

ii. The air content of freshly mixed concrete, in accordance with the pressure method given in IS 1199, shall not be more than 1% higher than that of the corresponding control mix.

iii. There shall be no chloride content in admixture when tested in accordance with IS 6925.

iv. Uniformity tests on the admixtures are essential to compare qualitatively the composition of different samples taken from batch to batch or from the same batch at different times.

v. All tests relating to the concrete admixtures shall be conducted periodically at an independent laboratory and compared with the data given by the manufacturer.

vi. While qualifying the admixture, the infrared spectrograph plot shall be given. Each batch of the supply shall be tested for IR spectrograph and prove the consistency of supply.

11 Minimising the Risk of Alkali-Silica Reaction (ASR) in Concrete

a) Precautions against ASR in Concrete

Concrete mixes for use in the Permanent Works shall comply with one of the Subsections (b), (c) or (d). The Contractor shall notify the Engineer of his proposals for complying with this requirement.

b) The cementitious material shall have a reactive alkali content not exceeding a maximum value of 0.6% by mass when defined and tested in accordance with Subsections 3.3.1 ((e) to (k) inclusive).

To combat the ASR, Microsilica shall be used in minimum 5% cement and shall not exceed 10% by the wt of cement in order to bind free alkalis early in plastic concrete and to reduce the permeability of concrete to prevent the moisture and external alkalis penetration.

OR

c) The total mass of reactive alkali in the concrete mix shall not exceed 3.0 kg/m^3 of concrete when defined, tested and calculated in accordance with Subsections 3.3.1 ((e) to (k) inclusive) and 3.3.1 ((l) to (o) inclusive).

OR

d) The aggregate shall be classed as non-reactive in accordance with the definition in Subsection (n).

e) Cementitious Material (Hydraulic and Latent Hydraulic Binders):

f) The term alkali refers to the alkali metals sodium and potassium expressed as their oxides. The reactive alkali content of Portland cements shall be defined as the percentage by mass of equivalent sodium oxide (Na_2O) calculated from:- % equivalent Na_2O = % acid soluble Na_2O + 0.658 x (% acid soluble K_2O)

g) The method used in determining the acid soluble alkali content of the materials shall be in accordance with BS 4550: Part 2: Subsection 16.2.

h) The Contractor shall make available the certified average acid soluble alkali content of Portland cement on a weekly basis.

i) The Contractor shall give immediate notice of any change which may increase the certified average acid soluble alkali content above the level used in the mix design for the concrete. A revised mix design for any concrete which would be affected by the increased alkali content shall be submitted for consent with notification of the change.

j) Minimising the Risk by Using Cementitious material Containing less than 0.6% Reactive Alkali

The requirements of Subsection (b) will be met by Subsection (k) provided that the contribution of alkalis from other sources does not exceed 0.2 kg/m3 (see Subsections and (u)). Where alkalis exceed 0.2 kg/m3 the requirements of Subsections (l) to (o) shall apply.

k) The cementitious material shall be Portland cement complying with Indian Standard and shall have additionally a certified maximum acid soluble alkali content not exceeding 0.6%.

l) The Contractor shall provide on request weekly certificates which name the source of the cement and confirm compliance with the Specification.

Minimising the Risk by Limiting the Reactive Alkali content of the concrete to 3.0 kg/m3. The requirements of Subsection (c) will be met provided that Subsections (m), (n) and are satisfied.

m) The reactive alkali content of the concrete contributed by the Portland cement to the concrete shall be calculated from:

Portland cement

$$A = \frac{C \times \frac{a}{100}}{}\,,$$

Where,

A = reactive alkali content of the concrete to the nearest 0.1 (kg/m3) C = target mean Portland cement content of the concrete (kg/m3)

a = certified average acid soluble alkali content of the Portland cement (%).

n) Where reactive alkalis in excess of 0.2kg/m^3 are contributed to the concrete from sources other than the cementitious material the limit of 3.0 kg/m^3 from the cementitious material shall be reduced by the total amount so contributed.

The reactive alkali contributed by sodium chloride contamination of aggregates shall be calculated from:

$$H = 0.76x\,\frac{(NFxMF)+(NCxMC)}{100}\ (kg/m3)$$

Where H = equivalent alkali contribution made to the concrete by the sodium chloride

NF = chloride ion content of the fine aggregate as a percentage by mass of dry aggregates and measured according to BS 812: Part 4

MF = fine aggregate content (kg/m3)

NC = chloride ion content of the coarse aggregate as a percentage by mass of dry aggregate and measured according to BS 812: Part 4: 1976 (now in draft as Part 117)

MC = coarse aggregate content (kg/m3).

The factor 0.76 is obtained from a consideration of the composition of sea water.

The chloride ion content of aggregate sources containing 0.01% of chloride ion by mass or more shall be determined weekly in accordance with BS 812 or another approved method. When the chloride ion level is less than 0.01% it shall be regarded as nil.

o) The Contractor shall provide certificates on request confirming compliance with the Specification and stating:

i. The target mean cementitious material content of the concrete.

ii. The names of the works manufacturing the cement.

iii. A weekly report of the cement alkali determinations in accordance with Subsection (f).

iv. The certified average acid soluble alkali content of the Portland cement.

p) Minimising the Risk by Using Selected Aggregates

Fine and coarse aggregate material shall comply with the requirements of IS:383 (and/or AASHTO Standard Specifications M6 and M80 respectively) to be taken out to conform to 512(2).

q) Water

r) Water for use in the manufacture of concrete shall be obtained from a public utility undertaking supply or from a source approved by Engineer and shall be of potable quality, and comply with the requirement of IS:456 and or BS 3148

s) Where a potable mains supply is not available the Contractor shall obtain confirmation of the quality and reliability of the proposed source from the appropriate water authority and shall thereafter seek consent from the Engineer to use the proposed source.

t) Water other than from a public utility undertaking supply shall be sampled at a frequency to be determined by the Engineer and tested in accordance with the relevant provisions of IS:3025 or BS 3148. The sodium oxide and potassium oxide content shall be declared and expressed as equivalent Na_2O and shall be taken into account when calculating the total reactive alkali content of the concrete mix.

u) Admixtures and Pigments

Admixtures and pigments shall comply with the requirements of IS 9103 and IS:6925 or BS 5075 and BS 1014. The manufacturer's declared equivalent acid soluble alkali content and the dosage rate of any admixture or pigment to be incorporated shall be included with details of all concrete mixes submitted for consent.

v) The alkali content of admixtures shall be taken into account when determining the total equivalent alkali content of the concrete mix.

w) Micro silica (silica fume) shall be used in 5% by the weight of cement and shall not exceed 15% by the weight of cement.

12 Storage of Materials

12.1 General

a. Handling and storage of all material shall be as per IS 4082.

b. All materials shall be stored at proper places to prevent their deterioration or intrusion by foreign matter and to ensure their satisfactory quality and fitness for the work. The storage space shall also permit easy inspection, removal and restoring of the materials. All such materials even though stored in approved storage places, will be subjected to acceptance test prior to their immediate use.

c. The procedures to be adopted for transportation and storage of the materials shall obtain prior approval from the Engineer.

12.2 Cement

a. Cement shall be transported, handled and stored on the site in such a manner as to avoid deterioration or contamination. Cement shall be stored above ground level in perfectly dry and watertight sheds and shall be stacked not more than eight bags high. Wherever bulk storage containers are used, it shall be ensured that their capacity is adequate to cater to the requirement at Site and they are cleaned at least once every 3 months. Cement older than 3 months from the date of manufacture shall not be used.

b. Each consignment shall be stored separately so that it may be readily identified and inspected, and cement shall be used in the sequence in which it is delivered at Site. Any consignment or part of a consignment of cement which had deteriorated of any sort during storage, shall not be used in the Works and shall be removed from the Site by the Contractor, without adding any costs to the Employer.

c. The Contractor shall prepare and maintain proper records on site regarding delivery, handling, storage and use of cement. These records shall be available for inspection by the Engineer at all times.

d. The Contractor shall make a monthly return to the Engineer on the date corresponding to the interim certificate date, showing the quantities of cement received and issued during the month and in stock at the end of the month.

12.3 Aggregates

a. Storage areas for aggregates have to be covered, protected against any kind of contamination, avoid the possibility of mix among aggregates and protected also against any water inflow. The floor of the storage for aggregates has to be in concrete and has to be drained. Storage areas for different size of aggregates have to be independent to avoid any possibility of mix.

b. During rainy and cold weather periods, the aggregates shall be stored undercover for at least 48 hours before being used and kept sufficiently dry.

c. The stockpiling of the processed aggregate and drawl there from shall be such as to ensure that the variation in the free moisture in the aggregate during anyone shift of working, does not exceed 1 percent.

d. The coarse aggregates shall, be stored as per the procedure of relevant IS: codes.

e. Care shall be taken in screening and stocking of the coarse aggregates so as to avoid intermixture of different gauge materials and inclusion of any foreign materials.

f. The stockpiles shall be built up in horizontal or gently sloping layers.

g. Trucks and bulldozers shall be kept off the stockpiles to prevent breakage and impairing the cleanliness of aggregate.

h. A hard base shall be provided to prevent contamination from underlying materials in storage areas in continuous use.

i. Overlap of different sizes of materials shall be prevented with suitable walls or by ample distance between storage piles.

j. Arrangement shall be made to store natural and manufactured sand in a way that shall protect it from being contaminated with dust, organic matter or other deleterious substances.

13 Design Mix Concrete

13.1 General

a. For all items of concrete, only design mix shall be used. Prior to the commencement of construction, the Contractor shall design the mix and submit the proportions of materials, including admixtures to be used to the Engineer for obtaining approval. Suitable water reducing admixtures or super-plasticizing admixtures shall be used for achieving desired workability and strength of the concrete only after obtaining prior approval from the Engineer. No extra payment shall be made for such admixtures.

b. Mix design shall conform to the provisions under IRS: CBC (Cl. 5.5 and 8.7) and IS 10262.

c. Drying shrinkage of concrete shall be 0.03% or less. Drying shrinkage of concrete shall be tested in accordance with IS 1199.

d. When non-bleeding high flow concrete is used, it shall be confirmed that no bleeding occurs under Concrete Bleeding Test specified in IS 9103. The Contractor shall submit the test results to the Engineer prior to the commencement of concrete works for obtaining approval.

e. Mix design, once approved, must not be altered without obtaining prior approval of the Engineer. However, if the Contractor anticipates any change in quality and/or change in source of future supply of materials than that used for earlier mix design, the Contractor shall inform the Engineer well in advance and bring fresh samples sufficiently in advance, to carry out fresh trial mixes.

f. The total chloride content of all constituents of concrete in mix shall be limited to 0.43 kg/m3 for reinforced concrete works and prestressed concrete works as per IS:14959.

13.2 Workability of Concrete

a. The mix shall have the consistency which allows proper placement and consolidation in the required position. It shall be ensured that uniform consistency is maintained.

b. Workability of concrete shall conform to the provisions of IRS: CBC(Cl.5.3).

13.3 Durability of Concrete

a. Maximum water cement ratio for design mix shall conform to IRS: CBC(Clause5.4.3) as follows:

Plain Concrete	**Reinforced Concrete**
0.45	0.40

b. Minimum grade of concrete shall conform to IRS: CBC(Clause5.4.4) as follows:

Plain Concrete	**Reinforced Concrete**
M-20	M-35

c. Maximum and minimum permissible cementitious material shall conform to IRS: CBC (Clause5.4.5) as follows:

Minimum(kg/cum)		**Max**
Plain Concrete	**Reinforced Concrete**	
250	350	500

13.4 Trial Mixes

a. The Contractor is entirely responsible for the design of the concrete mixes. However, the design shall have approval from the Engineer. At least 8 weeks before commencing any concreting in the Works, the Contractor shall make trial mixes using samples of coarse aggregates, sand, water, super plasticiser and cement, typical of those to be used in the Works, and which have been tested in an approved laboratory. A clean dry mixer shall be used, and the first batch shall be discarded.

b. The mix shall be designed to produce the grade of concrete having the required workability, durability and a characteristic strength not less than appropriate value given in IRS: CBC (CL. 5.1, 5.3 & 5.4). Trial mixes shall be prepared under full-scale site conditions and tested in accordance with IS 10262.

c. Whenever there is a significant change in the quality of any of the ingredients for concrete, the Engineer, at his discretion, may order the carrying out of fresh trial mixes. All costs for trial mixes and tests shall be borne by the Contractor's and held to be included in the rates quoted in the priced Bill of Quantities.

d. Before commencing the Works, the Contractor shall submit full details of the preliminary trial mixes and tests to the Engineer for approval.

13.5 Size of Coarse Aggregate

The nominal size of coarse aggregates for concrete shall be as per the Drawings. The proportions of the various individual size of aggregates shall be so adjusted that the grading produces densest mix and the grading curve corresponds to the maximum nominal size adopted for the concrete mix.

13.6 Mixing Concrete

13.6.1 General

a. Production and control of concrete shall conform to IRS: CBC(Cl.5.6).

b. Concrete shall be mixed in an automatic batching and mixing plant as per this Technical Specifications. Hand mixing shall not be permitted. The mixer or the plant shall be at an approved location that shall be selected considering the properties of the mixes and the transportation arrangements available with the Contractor. The mixer or the plant shall be approved by the Engineer. Unless permitted by the Engineer, all concrete shall be produced in computerised automatic weigh batching plant having printing facilities to printout records of each batch and installed at the Site.

c. Mixingshallbecontinuedtillmaterialsareuniformlydistributedandauniform colour of the entire mass is obtained, and each individual particle of the coarse aggregate shows complete coating of mortar containing its proportionate amount of cement.

d. Mixers which have been out of use for more than 30 minutes shall be thoroughly cleaned before putting in a new batch. Unless otherwise agreed by the Engineer, the first batch of concrete from the mixer shall contain only two thirds of the normal quantity of coarse aggregate for cleaning purpose only, and the same shall not be used for concreting purpose. Mixing plant shall be thoroughly cleaned before changing from one type of mix to another.

13.6.2 Batching on site

a. Batching of concrete shall conform to the provision of IRS: CBC (Cl. 5.6.2) and IS 4925.

b. All weighing and measuring equipment shall be tested and calibrated as per IS 4926.The results of these tests and calibration shall be submitted to the Engineer.

c. Addition of water to compensate for slump loss shall not be resorted to nor shall the design maximum water content and maximum water-cement ratio be exceeded. If permitted by the Engineer, additional dose of retarder shall be used to compensate the loss of slump at the Contractor's cost. Re-tempering water shall not be allowed to be added to mixed batches to obtain desired slump.

13.6.3 Ready Mixed Concrete

The Contractor can use RMC, if approved by the Engineer. The source batching plant of RMC shall not change during the course of work. If RMC is used, it shall conform to the provisions laid down in IRS: CBC (CL. 5.7). The batching plant shall have consent to establish and consent to operate permit from Pollution Control Authority. The batching plant shall be operated by trained staff. The batching plant shall have suitable motorable road and a traffic plan to ensure free and safe passage of all vehicles. Waste water and sludge from batching plant shall be at the designated points.

a. Transporting, Placing and Compaction of Concrete

Transporting, placing, compacting and curing of concrete shall be in accordance with IRS: CBC(Cl.8), IS 456 and IS 5892.

i. Transporting

- The method of transporting and placing concrete shall have approval from the Engineer. Transportation of concrete shall conform to IRS: CBC (Cl. 8.1, 5.7), if not in contravention to the following provisions.
- The mix shall be transported by agitating transit mixers, buckets, pumps etc. or asper approval by the Engineer, without causing segregation and loss of cement slurry and without altering its desired properties with respect to water content, water cement ratio, slump, air content, cohesion and homogeneity.
- 1m^3 of each mix shall be supplied to Site before it is required in the Works to enable the Contractor to carry out workability tests. Under no circumstances shall extra water be added to the concrete after the original mixing is completed.

ii. Pumping

- Pumping of concrete shall conform to IRS: CBC (Cl.8.9), if not in contravention to the following provisions.
- The type of concrete pump, the diameter of transporting pipe, the route of piping etc. shall be determined considering the pumpability of the concrete to obtain the required quality of concrete after pumping.
- The type and the number of concrete pumps shall be determined in consideration of the pumping pressure, the discharge amount, the pumping rate per hour, the environmental conditions of construction site etc.
- Prior to pumping design mix concrete, pumping of mortar with the same proportion as of design mix concrete shall be done to prevent loss of mortar in pump due to adherence.
- The mortar pumped prior to the concrete pumping shall not discharge into the formwork.

iii. Placing

a) Placing General

- Placing of concrete shall conform to the provisions laid down in IRS: CBC(Cl.8.2).
- Prior to concreting, detailed planning on the placing system, the arrangement and the number of pumping cars, the position of the inlet for concrete pump, lighting equipment and arrangements for power supply, the sequence and rate of placing, time interval between concrete lifts etc. shall be specified in the Method Statement and the same shall be submitted to the Engineer for approval. Due allowance shall be made to secure enough clear spacing of reinforcement bars which enables concrete to flow through the spaces between reinforcement bars.
- Concrete shall be transported by means which prevent contamination (by dust, rain etc.) segregation or loss of ingredients, and shall be transported and placed without delay.
- Concrete shall be placed directly in its final position without segregation or displacement of the reinforcement, embedded items and formwork. Concrete shall not be placed in water, except as specified. Concrete shall not be dropped through a height greater than 1.5 metres.
- All formwork shall be thoroughly cleaned to remove debris etc. before concreting. In addition, the Engineer shall inspect that there is no debris etc. in the formwork before concrete is cast. It shall be examined that there

is no abnormality in the formwork and falsework before and during concreting.

- No concrete shall be placed in any part of the structure until approval of the Engineer has been obtained. If concreting did not commence within 24 hours of issuance of approval, then it shall be obtained again from the Engineer. Concreting then shall proceed continuously over the area between the construction joints.
- Except where otherwise agreed by the Engineer, concrete shall be deposited in horizontal layers to a compacted depth of not more than 300 mm.
- Concrete when delivered in the works shall be maintained at a temperature of not more than 35°C as far as possible.
- Clear spacing between reinforcements shall be secured adequately and lighting equipment shall be arranged adequately in order to visually check the position of inlet of the concrete pump and the filling situation of the concrete during concreting works. In addition, suitable measures shall be taken so that the reinforcement bars do not move and clear cover to the reinforcement bars does not change.
- The clear cover shall be uniform and as per the Drawings. Concrete cover blocks used shall be of the same concrete mix as the member and shall contain the binding wire to secure it to the reinforcement. All ends of binding wire shall be carefully turned inside so that they do not project out of concrete cover. Reinforcement bars shall be adequately secured by chairs/ties/hangers so that it maintains its position during casting and vibrating concrete. Ends of the wires used to tie bars shall be bent into the member.
- In case of concreting the horizontal member immediately after the concreting of vertical member is finished, the horizontal member shall be cast after any settlement of concrete of the vertical member ceases in order to prevent settling cracks.
- If bleeding water is present on the surface of concrete during concreting, the bleeding water shall be removed before the following concrete is placed.
- The Contractor shall ensure that the place where concreting is to be done shall be free of water.

b) Extent of Pours

For piers and pier heads, portal columns the concreting is to be carried out in single stage i.e. in first stage concreting will be from kicker to just below pier head bottom and second stage of concreting will be pier head including shear key and cross girder (in station zone stages as given in drawings for all heights by using tremie/ pumps at the rate not more than 1.5m / hr or as approved by the Engineer.

Floors, roofs and ground slabs shall be placed in a sequence of pours to the approval of the Designer and the consent of the Engineer.

If the use of slip-forms or paving trains is permitted, these limits may be revised. The sequence of pours shall be arranged to minimise thermal and shrinkage strains.

c) Placing Equipment

Concrete shall generally be placed without segregation by pumping or bottom-opening skips. If chutes are used their slopes shall not cause segregation and spouts or baffles shall be provided.

d) Time for Placing

Concrete and mortar must be placed and compacted within 30 minutes of water being added to the mix or otherwise included via damp aggregates, unless admixtures are in use. Partially-set concrete shall not be used in the Works.

e) Continuity of Placing

Placing in each section of work shall be continuous between construction joints. The Contractor shall make provision for standby equipment. If the placing of concrete is delayed due to breakdown then the Contractor shall erect vertical stop-ends and form a construction joint or remove the concrete already placed and restart after repair of the breakdown, as directed.

f) Placing in Inclement Weather

Placing shall not take place in the open during storms or heavy rains. If such conditions are likely to occur the Contractor shall provide protection for the materials, plant and formwork so that work may proceed. If strong winds are prevalent protection from driving rain and dust shall be provided.

g) Placing in High Temperature and Low Temperature

The temperature of concrete shall not exceed 32^{o} nor below $5^{o}C$ or the temperature stated in the table of Mixes whichever is the lower at the time of placing concrete. Also the maximum concrete temperature after placing shall not exceed temperature 50oC or 30oC above the concrete temperature at the time of placing whichever is the lower.

"Concrete in hot countries" published by FIP congress at New Delhi 1986 shall be complied with. The procedures the Contractor wishes to employ shall be subject to the Engineer consent

The Contractor shall supply suitable maximum/minimum thermometers and record the shade and sun temperatures at locations where concrete is being placed. Recommendations for cold weather concrete can be had from IS: 7861 (Part 2).

h) Placing at Night

If consent has been given for placing at night or in dark interiors, adequate lighting shall be provided where mixing, transportation and placing are in progress.

i) Placing Under Water

Underwater concrete shall be placed with minimum disturbance of the water. Running water and wave wash shall be controlled. The specified concrete grade shall be used and the mix design shall provide for good flowing ability.

Tremie pipes, bottom-dump skips or other approved placing equipment shall be used. Segregation shall be avoided.

Placing shall be commenced in approved sections and continued to completion.

The tremie pipe shall be buried in the concrete for at least 1.5m and the pipe must not be emptied until the pour is complete. If a bottom-dump skip is used, the contents shall be covered by canvas or similar before lowering into the water. The doors shall be opened when the skip is resting on the bottom with no tension in the support cable, and the skip shall be lifted gradually so that the concrete flows out steadily.

j) Preparation Before Placing

Before placing concrete for reinforced work on the ground, the formation shall be compacted as specified and a screed of blinding concrete shall be applied to form a surface for construction.

Before placing concrete on or against rock, masonry, brickwork or old concrete, loose material shall be removed and the surface washed down; water seepage shall be stopped or channelled away from the work.

iv. Compaction

1. Compaction of concrete shall conform to the provisions laid down in IRS: CBC (Cl.8.3).

   - Additional vibrators in serviceable condition shall be kept at site so that they can be used in the event of breakdowns. Concrete shall be compacted before setting commences and shall not be subsequently disturbed.

2. Internal (needle) and surface (screed board) vibrators of approved make shall be used for compaction of concrete. Internal vibrators shall be inserted in an orderly manner. The distance between insertions shall be 500 mm or less. The vibrator shall be made to operate at a regular pattern of spacing. The effective radii of action will overlap approximately half a radius to ensure complete compaction.

3. Internal vibrators shall be used for compaction of concrete in foundations, columns, buttresses arch section, slabs etc, and if required surface vibrators shall also be used. Depending on the thickness of layer to be compacted, 25 mm, 40 mm, 60 mm and 75 mm dia internal vibrators will be used. The concrete shall be compacted by use of appropriate diameter vibrator by holding the vibrator in position until:

   a) Air bubbles cease to come to surface.

   b) Resumption of steady frequency of vibrator after the initial short period of drop in the frequency, when the vibrator is first inserted.

      - The vibration shall be done till the tone of the vibrated concrete becomes uniform. To achieve an even and dense surface free of aggregate pockets, vibration shall be supplemented by tamping or rodding by hand in the corners of forms and along the form surfaces while the concrete is plastic.

   c) Flattened, glistening surface, with coarse aggregates particles blended into it appears on the surface.

   d) Use of curing compounds may be permitted with specific approval of Engineer.

4. After the compaction is completed, the vibrator should be withdrawn slowly from the concrete so that concrete can flow in to the space previously occupied by the vibrator. To avoid segregation during

vibration the vibrator shall not be dragged through the concrete nor used to spread the concrete. The vibrator shall be made to penetrate, into the layer of fresh concrete below if any for a depth of about 150mm. The vibrator shall be made to operate at a regular pattern of spacing. The effective radii of action will overlap approximately half a radius to ensure complete compaction.

a) To secure even and dense surfaces free from aggregate pockets, vibration shall be supplemented by tamping or rodding by hand in the corners of forms and along the form surfaces while the concrete is plastic.

b) A sufficient number of spare vibrators shall be kept readily accessible to the place of deposition of concrete to assure adequate vibration in case of breakdown of those in use.

c) Form vibrators whenever used shall be clamped to the sides of formwork and shall not be fixed more than 450 mm above the base of the new formwork and concrete shall be filled not higher than 230mm above the vibrator. The formwork must be made specially strong and watertight where this type of vibrator is used.

d) Care must be taken to guard against over vibration especially where the workability of the concrete mix is high since this will encourage segregation of the concrete.

e) Plain concrete in foundations shall be placed in direct contact with the bottom of the excavation, the concrete being deposited in such a manner as not to be mixed with the earth. Plain concrete also shall be vibrated to achieve full compaction.

5. Construction Joints

a. Construction joints shall be avoided as far as possible and in no case the locations of such joints shall be changed or increased from those shown in the drawings, unless otherwise approved by the Engineer.

b. Where provision of construction joint is unavoidable, the location, direction and construction method of construction joint shall be determined in consideration of the structural strength, durability and appearance of the structure. Concreting shall be carried out continuously upto the construction joints. Construction joints shall conform to the provisions laid down in IRS: CBC (Cl. 8.5 and Annexure - B). The Contractor shall submit Method Statement on the construction joints which shall be subject to the consent of the Engineer prior to concreting works.

c. The location of the construction joints and their arrangement, procedure for surface preparation of construction joint and sequence of concreting shall be subject to the consent of the Engineer. Construction joints shall be located at locations where the shear force is minimum. The joints shall be provided in a direction perpendicular to the member axis. Sequencing of concrete placement shall be organized in such a way that cold joints are totally eliminated. Properly designed reinforcement shall be provided prior to casting of the next lift for transfer of full tensile stress across the joints.

6. Expansion, Contraction and Movement Joints

Expansion, contraction and other movement joints shall be incorporated in the works as shown on the Drawings.

Where shown on the Drawings approved, expansion joint fillers shall be supplied and installed. Filler material shall be stored flat on a dry surface adequately protected from rain or moisture in such a way that the material does not deteriorate. Filler material which has been damaged or has started to deteriorate shall not be incorporated in the works.

Movement joints shall be sealed with an approved sealant applied in strict accordance with the manufacturer's instructions to the dimensions shown on the Drawings. The surface of the concrete to which the sealant is to adhere shall be straight and cleaned of all filler material, dirt, oil, grease and other matter. The sealant shall be applied by methods recommended by the manufacturer so that the sealant is brought flush to the surface of structure and a smooth surface is achieved. Excess material and spillage shall be properly cleaned off and removed.

Dowel bars shall be installed and cast in across the movement joint where shown on the Drawings. The bars shall be straight with clean cut ends of the diameters and lengths as

shown on the Drawings or in the Schedules. Cutting and cleaning of the dowel bars shall comply with the requirements of this Specification.

The bars shall be firmly supported in the positions shown on the Drawings so that they remain accurately parallel and are not displaced during the casting of the concrete in the first part of the structure. After the concrete has hardened and the formwork removed, the projecting ends shall be cleaned of all concrete spillage and painted with two coats of an approved bituminous paint and caps shall be fitted to the free ends of the bars. Dowel bar end caps shall be of cardboard or other material, of correct diameter for the dowel bar and of sufficient length to allow the specified movement of the two adjacent concrete structures. They shall be manufactured expressly for this purpose by an approved manufacturer.

The Contractor shall take care to protect the projecting ends of dowel bars from bending or other damage prior to concreting the succeeding bay. The bituminous paint shall be applied as soon as practicable, but end caps shall not be fitted until immediately prior to the succeeding concreting operations.

7. Bolts, Inserts and Openings

All fixing blocks, brackets, built in bolts, holes, chases, etc., shall be accurately set out and formed and carefully sealed prior to the concrete being placed. No cutting away of concrete for any of these items shall be done without the permission of the Engineer-in- Charge.

Bolts and other inserts to be cast into the concrete shall be securely fixed to the formwork in such a way that they are not displaced during the concreting operations, and that there is no loss of materials from the wet concrete through holes in the formwork.

Unless shown otherwise on the Drawings or the Engineer has given consent, reinforcement shall be locally moved so that the minimum specified cover is maintained at the locations of inserts, holes, chases, etc.

Temporary plugs shall be removed and the threads of cast in bolts shall be proved to be free and shall be greased before handing over any part of the Works. Construction joints in all concrete work shall be made as directed by the Engineer. Where vertical joints are required, these shall be shuttered as directed and not allowed to take the natural slope of the concrete.

8. Concreting under Special Conditions

Concreting under special conditions shall conform to the provisions laid down in IRS: CBC.

13.7 Concreting in Extreme Weather Conditions

Concreting in extreme weather conditions shall conform to the provisions laid down in IRS: CBC (Cl. 8.6.1).

13.8 Concreting under Water

a. Concreting underwater and seawater shall conform to the provisions laid down in IRS: CBC (Cl. 8.6.2 and Cl. 8.6.3), where not contravening to the following provisions.

b. When it is necessary to deposit concrete under water, the methods, equipment, materials and proportions of mix to be used shall obtain approval of the Engineer, prior to the commencement of any work.

c. Concrete shall not be placed in water having a temperature below 5°C. The temperature of the concrete, when deposited, shall neither be less than 16 °C nor more than 35°C.

d. All underwater concreting shall be carried out by tremie method as described in IRS: CBC (CL.8.6.2) only, using tremie of appropriate diameter. The number and spacing of the tremie shall be worked out to ensure proper concreting. The tremie concreting when started shall continue without interruption for the full height of the member being concreted. The concrete production and placement equipment shall be adequate to enable the underwater concrete to be completed uninterrupted within the stipulated time. Necessary standby equipment shall be available for emergency situation.

e. In case of withdrawal of tremie out of the concrete either accidentally or to remove a choke in the tremie with the approval of the Engineer, the tremie shall be reintroduced in the following manner to prevent impregnation of laitance or scum lying on top of the concrete deposited in the bore. The tremie shall be gently lowered on to the old concrete with very little penetration initially. A vermiculite plug shall be introduced in the tremie. Fresh concrete of slump between 150 mm and 175 mm shall be filled in the tremie which will push the plug forward and will emerge out of the tremie displacing the laitance or scum. The tremie shall be pushed further in steps making fresh concrete sweep away the laitance or scum in its way. When tremie is buried in for about 0.60m to1.0 m, concreting may be resumed.

f. In case of concreting through tremie or such pipes which are subsequently withdrawn, the concrete shall be placed in adequate quantity to ensure that during withdrawal of the tube, a sufficient head of concrete is maintained to prevent the inflow of soil and water or bentonite slurry.

g. No concrete shall be allowed to come in contact with seawater within 72 hours of casting.

13.9 Concreting under Aggressive Soils and Water

Concreting under aggressive soils and water shall conform to the provisions laid down in IRS: CBC (Cl. 8.6.4).

14. Curing of Concrete

14.1 General

a. Concreting operations shall not commence until adequate arrangements for curing of concrete have been made by the Contractor. Curing and protection of concrete shall commence after the concrete has set hard enough, to with stand stresses due to curing work and does not get damaged, in order to protect it from the following:

   i. Premature drying out, particularly by solar radiation and wind.

   ii. High internal thermal gradients.

   iii. Leaching out by rain and flowing water.

   iv. Rapid cooling during the first few days after placing.

   v. Low temperature.

   vi. Vibration and impact which may disrupt the concrete and interfere with its bond to there reinforcement.

   b. Where members are of considerable size and length, with high cement content, accelerated curing methods may be applied, as approved by the Engineer.

14.2 Curing Procedure

a. In order to ensure the required quality of concrete in terms of parametres such as strength, durability and permeability, concrete shall be cured adequately, being kept at a temperature and humidity necessary to be hardened within a certain period of time after concreting, in order not to be affected by harmful effects such as low or high temperature, rapid temperature change, drying, loading and impact loading.

b. Curing of concrete shall conform to the provisions laid down in IRS: CBC (Cl.8.4). Approved curing compounds shall be used in lieu of moist curing, with the approval of the Engineer, particularly for all vertical faces and inaccessible areas, conforming to IRS: CBC (CL. 8.4.2).

14.3 Finishing

Finishing shall conform to the provisions laid down in IRS: CBC (Cl. 6.2.4), if not in contravention to the following provisions:

a. Immediately after removal of forms, exposed bars or bolt, if any, shall be cut inside the concrete member to a depth of at least 50 mm below the surface of the concrete and the resulting holes shall be filled with cement mortar of dry pack consistency.

b. All construction and expansion joints in the completed work shall be left carefully tooled and free of any mortar and concrete. Expansion joint filler shall be left exposed for its full length with clean and true edges.

c. The finished surfaces of concrete after removal of form work shall be such that no touching up is required. All finsca used by form joints, if any, shall be ground using electric sur face grinder.

d. Immediate Lyon removal of forms, before any defects are rectified, the concrete work shall be examined by the Engineer.

   i. Exposed concrete surfaces shall be smooth and even, originally as stripped, without any finishing or rendering. The Contractor shall exercise special care and supervision of formwork and concreting to ensure that the cast members are made true to their sizes, shapes and positions. The work that has sagged or contains honeycombing to an extent which is detrimental to structural safety or architectural appearance shall be rejected. Honeycombed parts of the concrete, including other surface defects in the concrete, shall be removed by the Contractor as per the methods which do not affect the strength of adjoining concrete and as per approval of the Engineer. In the final finish, no honeycombing is allowed.

   ii. Part of defective concrete thus removed shall be recast using fresh concrete of same grade, as approved by the Engineer without any additional cost. For that purpose, the Contractor shall prepare a comprehensive work procedure and obtain approval of the Engineer. No additional payment shall be made for repair of the concrete. The Contractor shall ensure that no air bubbles are formed on the exposed surface. Concrete pouring sequence, vibration methodology etc. shall be planned to ensure that air bubbles are not formed. All materials, sizes and layouts of formwork including the locations for their joints shall have approval from the Engineer prior to the commencement of the works.

   iii. After the finishing works, cracks which occurred in the surface of concrete until the concrete starts to set shall be removed by refinishing or tamping.

e. The top face of a slab intended to be surfaced with other material shall be left with a spaded finish.

f. Chemical surface retarders, if approved by the Engineer, shall be used to produce an exposed aggregate finish, provided the Contractor demonstrates that the durability of the concrete surface is not reduced.

15. Inspection, Tests and Standards of Acceptance

a. The Contractor shall submit test certificates from the manufacturer or supplier of materials along with each batch of material(s) delivered to site.

b. The Contractor shall set up a field laboratory with necessary equipment for testing of all materials & finished products to be used in the construction. The laboratory must have riffle divider of adequate capacity as approved by the Engineer for preparation of lab sample for sieve analysis of aggregates.

c. The test in go falls the materials shall be carried out by the Contractor at the field laboratory or from the laboratory approved by the Engineer and in the presence of the Engineer. The Contractor shall make all the necessary arrangements and bear the entire cost for the same.

d. Tests which cannot be carried out in the field laboratory shall be done at the Contractor's cost at any recognized laboratory or testing establishments having NABL certification and duly approved by the Engineer.

e. If materials are brought from abroad, the cost of sampling or testing, whether in India or abroad, shall be borne by the Contractor. The Contractor shall provide and maintain on site, until the works are completed, at all times the equipment and staff required for carrying out these tests.

16. Quality Control of Concrete

a. The Contractor shall carry out the following tests for concrete, at the site of placing, and ensure that they comply with appropriate provisions of Indian and/or other standards, as may be applicable:

   i. Slump test for concrete: The frequency of slump test shall be as follows:

   ii. Case 1: If the site of placing is at the same area as the concrete plant installed, then it shall be conducted once in every hour, as per IS1199(Cl. 5.0) and IS7320.

   iii. Case2: Other than Case1, it shall be conducted once in each delivery of transit mixer, asper IS 1199 (CL. 5.0) and IS 7320.

   iv. Tolerance for slump shall conform to IS4926(Cl.6.2.1).

   v. Compressive and Flexural strength of concrete: Sampling, Strength tests and Acceptance criteria of concrete shall conform to IRS: CBC (Cl. 8.7) according to the type of concrete grade.

   vi. Chloride ion content test: It shall be conducted as per IS:15949 once a week. Chloride ion content shall be0.43kg/m3 or less.

   vii. Relative Density and pH value of plasticizer (if used): The test shall conform to IS9103(Cl.7.1, Cl.10.0, Annexure-E) and the tolerances shall be as specified in IS9103(Cl. 9.0, Table-2).

   viii. Temperature of concrete shall be verified once in each slump test.

ix. The concrete shall be verified for permeability and the test procedure along with tolerances shall conform to IRS: CBC (Cl. 5.4.2, Appendix - G). The frequency of test shall depend up on the change in design mix or change in source of material used in the work. However, the Engineer shall select random batches of concrete for examination at his discretion, and any time during concreting. Sampling shall generally be done at the point of discharge from the mixer and at placing point. The concrete shall pass the permeability test if it is properly compacted and the water penetration depth in the broken core is less than 25mm.

b. It is the complete responsibility of the Contractor to redesign the concrete mixes as per the standard methods that have been approved and to produce there in forced concrete conforming to the specifications. The Contractor shall have competent staff to carry out this work.

c. After the completion of the quality control checks of concrete, the Contractor shall immediately report the test results to the Engineer by submitting quality control records of the concrete.

17. Inspection of Concrete

a. Inspection shall be carried out by the Contractor, after the removal of form work. Also, additional inspection shall be carried out if instructed by the Engineer.

b. Inspection shall be carried out as per approval of the Engineer for the Method Statement, incorporating the test procedures specified in Table below:

Table: Inspection of Concrete Surface Condition

<table>
<tr><th>Measurement Items</th><th>Inspection Method</th><th>Place to be Inspected</th></tr>
<tr><td>Presence or absence of honey combing, cold joint, discoloration, and cracking</td><td>Visual inspection at point-blank range</td><td>All parts</td></tr>
<tr><td>Presence or absence of cavity, float, and cracking</td><td>Hammering Inspection</td><td rowspan="2">As per approved Method Statement, and as directed by the Engineer</td></tr>
<tr><td>Clear cover to the outermost reinforcement</td><td>Non-destructive test using a probe</td></tr>
</table>

c. Additional non-destructive tests (NDT) on the hardened concrete in the structure as a whole or any finished part of the structure where necessary, or directed by the Engineer, shall be carried out as laid down in IRS: CBC (CL. 18.3).

d. The Contractor shall report the inspection results along with the location to the Engineer immediately after the inspection. The forms generated from the probes during the inspection shall be attached to the records.

e. If defects such as deleterious cracking, spalling, deformation and finishing defects or damages caused by the Contractor are noticed from the results of the inspection, no repair work shall be commenced without prior permission taken from the Engineer.

f. Counter measures against the defects shall be subject to approval of the Engineer. In this case, "repair work" refers to all actions which make alterations to the surface of concrete after the removal of formwork (including plastering etc.). If repair work is required, the Contract or shall submit Method Statement on the repair work and shall obtain approval of the Engineer for the same, prior to the commencement of repair work. During the repair work, the Contractor shall record about the work, and shall report to the Engineer on the results of the work immediately after the repair work has finished.

g. If cracks develop in concrete construction, which in the opinion of the Engineer may be detrimental to the strength of the construction, the Contractor, at his own cost, shall dismantle the construction, carry away the debris, replace the construction and carry out all consequential work thereto.

h. If any cracks develop in the concrete construction, which in the opinion of the Engineer, are not detrimental to the stability of the construction, the Engineer shall decide whether such cracks are required to be grouted. The Contractor shall grout such cracks as decided by the Engineer with polymer cement grout of approved quality at his own risk and cost.

i. External crack width shall be restricted to 0.2mm or less on all concrete structures, unless otherwise specified in the Drawings/Design.

ADDITIONAL TESTS FOR CONCRETE:

As frequently as the Engineer may require, additional testing shall be carried out for concreting in addition to mandatory test specified in CPWD specifications 1996/2002 / relevant IS Code / MOST/MORTH Specifications.

18. Non-Destructive tests for concrete

1. Ultrasonic pulse velocity test

2. Rebound hammer test

In order to determine the following properties of concrete, non-destructive tests for concrete (ultra-sonic pulse velocity test and rebound hammer test) in accordance with IS 13311(Part 1 and Part 2) shall be carried out.

i. the homogeneity of concrete

ii. the presence of cracks, voids and other imperfections

iii. changes in the structure of the concrete which may occur with time

iv. the quality of the concrete in relation to the standard requirements

v. the quality of one element of concrete in relation to the another, and

vi. the values of dynamic elastic modulus of the concrete

In view of the limitations of each method of the non destructive testing of the concrete, it is essential that the results of tests obtained by one method should be complemented by other tests and each method should be adopted very carefully.

19. Permeability test for Concrete:

The concrete will be verified for permeability by the following procedure and shall confirm to IS: 3085-1965 – „Permeability of Cement Mortar & Concrete", Section 1717.7.5 of MOST Specification and DIN 1048.

a) The Engineer shall select random batches of concrete for examination at his discretion and sampling will generally be done at the point of discharge from the mixer and at placing point.

b) From the batches thus selected two concrete cylinders shall be made in accordance DIN 1048.

c) All cylinders shall be made, cured, stored, transported and tested in accordance with clause 1717.7.5 of MOST Specifications. The tests shall be carried out in a laboratory approved by the Engineer.

d) At least two cylinders shall be made on each day"s concreting until 60 cylinders have been made for each grade of concrete. The cylinders will be tested as per the procedure, given in Clause (e) next.

e) Test Procedure:

The permeability of concrete will be verified by the following procedure:

i. Prepare a cylindrical test specimen 150 mm dia and 160mm high.

ii. After 28 days of curing, test specimen will be fitted in a machine such that the specimen can be placed in water under pressure up to 7 bars. The typical machine shall be similar to one shown in Appendix 1700/II of MOST.

iii. At first a pressure of one bar is applied for 48 hours, followed by 3 bars for 24 hours and 7 bars for next 24 hours.

iv. After the passage of the above period, the specimen is taken out and split in the middle by compression applied on two round bars on opposite sides above and below.

v. The water penetration in the broken core is measured with scale and the depth of penetration assessed in mm (max permissible limit 25 mm).

f) Acceptability Criteria:

The concrete shall pass the permeability test if it is properly compacted and is not considered permeable when tested as per DIN, and the water penetration in the broken core is less than 25mm.

No extra payment shall be made for this test and cost of the same will be included in his rate for concrete work.

20. Chlorides in Concrete

The levels of equivalent acid-soluble chlorides as NaCl (Cl x 1.65 = NaCl) in the constituents of concrete as stated elsewhere are indicative and are subject to the over-riding limits for the mixes.

The total estimated content as a percentage by weight of the cement in the mix shall not exceed the following limits: -

(a) For reinforced concrete

0.5% if made with Ordinary Portland Cement (OPC)

0.1% if made with Sulphate Resistant Portland Cement (SRPC)

(b) For mass concrete

1.0% if made with OPC

0.2% if made with SRPC

The Contractor shall test the constituents of the concrete to establish these contents as provided for elsewhere in this Specification.

In addition, regular tests to BS 1881: Part 6 for chloride content shall be made on the hardened concrete. The following values are acceptable: -

(i) For reinforced concrete made with OPC

95% of the test results less than 0.40% NaCl by weight of cement and no result greater than 0.50% NaCl by weight of cement.

(ii) For reinforced concrete made with SRPC

95% of the test results less than 0.1% NaCl by weight of cement and no result greater than 0.14% NaCl by weight of cement.

(iii) For mass concrete made with OPC

95% of the test results less than 1.0% NaCl by weight of cement, and no result greater than 1.30% NaCl by weight of cement.

(iv) For mass concrete made with SRPC

95% of the test results less than 0.2% NaCl by weight of cement and no result greater than 0.25% NaCl by weight of cement.

In the event that the SRPC used contains a proportion by weight of tri-calcium aluminate which approaches 4 - 8%, then consent may be sought for an appropriate adjustment of the relevant chloride content limits.

21. Sulphates in Concrete

The level of acid-soluble sulphates (SO_3) in the mix shall be no greater than: Coarse aggregate 0.4% by weight

Fine aggregate 0.4% by weight

Water500 mg/l

The total estimated sulphate content (SO_3) of the mix including that present in the cement shall not exceed 3.7% by weight of cement in the mix.

In addition, regular tests to BS 1881: Part 6 shall be made on the hardened concrete to determine the total sulphate content, which shall not exceed 4% by weight of cement in the mix.

Permissible Level of Chloride and Sulphates

The permissible level of chlorides and sulphates quoted in the above Subsections shall not be considered as mean values for the whole of the Works, but shall apply to any concrete.

Concrete for water-retaining structures shall in addition be as per IS: 3370.

22. CRACKS:

If cracks, which in the opinion of the Engineer may be detrimental to the strength of the construction, develop in concrete construction, the Contractor at his own expense shall test the structure as specified in "Loading Tests" of these Specifications.

If under such test loads the cracks develop further, the Contractor shall dismantle the construction, carry away the debris, replace the construction and carry out all consequential work thereto.

If any cracks develop in the concrete construction, which in the opinion of the Engineer- in-Charge, are not detrimental to the stability of the construction, the Contractor at his own expense shall grout the cracks with neat cement grout or with other composition as directed by Engineer-in-Charge and also at his own expense and risk shall make good to the satisfaction of the Engineer all other works such as plaster, moulding, surface finish, which in the opinion of the Engineer have suffered damage either in appearance or stability owing to such cracks. The Engineer's decision as to the extent of the liability of the Contractor in the above matter shall be final and binding.

External crack width shall be as per IRS: CBC with latest addendums.

23. DEFECTIVE CONCRETE:

Should any concrete be found honeycombed or in any way defective, such concrete shall be cut out partially or wholly by the Contractor and made good at his own expense. If Engineer feels that repaired structure will not be having same strength or shape or uniformity with other exposed surface as original desired structure / original structure, the same shall be rejected by Engineer and required to be dismantled and disposed by contractor at his own cost as instructed by Engineer-in-Charge. Decision of the Engineer shall be final and binding in this regard.

24. EXPOSED FACES, HOLES AND FIXTURES:

On no account shall concrete surfaces be patched or covered up or damaged concrete rectified or replaced until the Engineer or his representative has inspected the works and issued written instructions for rectification. Failure to observe this procedure will render that portion of the works liable to rejection.

Holes for foundation or other bolts or for any other purposes shall be moulded, and steel angles, holdfasts or other fixtures shall be embedded, according to the drawing or as instructed by the Engineer.

25. FINISHES:

Unless otherwise instructed the face of exposed concrete placed against formwork shall be rubbed down immediately on removal of the formwork to remove irregularities. The face of concrete for which formwork is not provided other than slabs shall be smoothed with a float to give a finish equal to that of the rubbed down face, where formwork is provided. The top face of a slab which is not intended to be covered with other materials shall be leveled and floated to a smooth finish at the levels or falls shown on the drawings or as directed. The floating shall be done so as not to bring an excess of mortar to the surface of the concrete. The top face of a slab intended to be surfaced with other material shall be left with a spaded finish. Faces of concrete intended to be plastered shall be roughened by approved means to form key.

26. CONCRETE FOR FLOORING ON GRADE:

Concrete for flooring on grade shall be placed in alternate bays not exceeding more than 4m x 6m or as specified in the drawings including forming the joints or adjacent bays. The stiff mix shall be thoroughly vibrated and finished to receive the floor finish.

27. GROUTING OF BASE PLATES & BOLT HOLES:

a) **Mixing :**

Dry grout should be mixed in a mechanical mixer: the conventional 200/400-litre capacity concrete mixer can be used to mix four bags of dry grout; alternatively, paddle type mortar mixers can be used. The quantity of grout to be mixed at one time should not exceed that amount which can be placed in approximately 10 to 15 minutes.

b) **Batching :**

Batching of grout by fraction of a bag is not allowed. The quantity of mixing water should be the minimum commensurate with workability, compaction, and filling of the grout in all corners and crevices. Mixing should be done for a minimum of three minutes to obtain a fluid grout of uniform consistency.

c) **Cleaning and preparation of the surface :**

The base concrete should be clean and strong, and its surface should be properly hacked; all dust should be removed suction or compressed air. The surface should be thoroughly wetted with water for several hours. Before the grout is poured, all free water should be removed and the flat surfaces coated with a thin cement slurry.

d) **Restraint :**

Heavy back-up blocks of timber or concrete should be fixed on all sided of the base plate to prevent escape of the grout, when poured through the openings provided in the base plate. Adequate restraint must be ensured on all the sides for a period of 7 days to obtain effective expansion and shrinkage compensation.

e) **Curing :**

The grout should not dry out where external restraint is provided in the form of form- work, the top opening and all stray openings should be covered with wet sack for at least 7 days.

f) **Placing and Compaction :**

The grout should be placed quickly and continuously either through the holes in the base plates or from one side only to ensure complete filling without entrapment of air. Grout should be properly spread and compacted by rodding. Excessive vibration should be avoided.

Below the bed plates the grout should be compacted using long pieces of doubled-over flexible steel strapping or chains. The forward and backward movement of the strap or chain will assist in the flow of the grout into place. Steps must be taken to keep the grout in full contact with the underside of the bedplate until the grout sets; maintaining a small head of fresh grout in the forms.

g) **Shrinkage Compensated Grout:**

Shrinkage compensated grout or non-shrinkable grout of Associated Cement Companies Limited or any other approved manufacturer (Fosroc, Roff, Sikka) should be used. The batching shall be as per the manufacturer's specifications, other procedures being as above.

28. Tolerance

Tolerances for the finished concrete structures shall be as specified in the Contract.

29. Mass Concrete

a) Any concrete having minimum dimension of more than 1 m shall be considered mass concrete.

b) In mass concrete core temperature shall not exceed 75^0C and differential temperature between core and surface of concrete shall not exceed 20^0C.

c) For each grade of mass concrete mock up trial shall be carried out of size 2m x 2m x thickness of mass concrete. Mock up trial shall use thermocouples to measure concrete temperature both near surface and at the core. Thermocouples shall be located centrally along the length and width of the mock up. Thermocouple shall be rigidly suspended so that they do not move out of position during casting. The Contractor shall monitor and document the conformance of the trial with the maximum allowable temperature requirement as given above. Result shall be automatically locked at the minimum of hourly intervals and logging shall continue for at least 72 hours or until the core reached ambient temperature, which ever is longer.

d) The scheme of mock up trial shall be submitted by the Contractor to the Engineer for approval. If there is change in brand/ factory of cement, mock up trial will be required again.

e) The Contractor shall carry out temperature monitoring of core temperature and surface temperature of 1st structure of mass concrete to confirm the results of mock up trial.

f) Ply shuttering will be preferred. However, if steel plate shuttering is used, insulation will be provided with thermocol.

g) No water curing should be carried out for 07 days. Concrete top surface shall be covered with plastic sheets after initial setting of concrete and insulation of plastic sheets by thermocol after final setting of concrete. Vertical shuttering shall remain intact till 07 days or as per directions of the Engineer.

h) Detailed report shall be submitted by the Contractor to the Engineer after mock up and 1st structure casting.

i) The contractor shall submit pour plan to the Engineer for approval for each structure of mass concreting. The pour plan shall include pour sequence, infrastructure required (RMC plant, TM, Concrete pump, placing boom), logistic plan, manpower (duties and responsibilities), lab equipment. Mass concrete shall preferably use PPC to reduce core temperature. Concrete placement temperature shall be decided by the results of mock trial and the same shall be followed.

30. Precast Concrete

30.1 Manufacture Off-Site

a. Casting of members shall not begin until a NONO has been given by the Engineer to the shop drawings, required computation and method of manufacture.

b. When the drawings and method of manufacture have been noticed, no changes shall be made without NONO from the Engineer

c. The Contract or shall in form the Engineer in advance of the date of commencement of manufacture and casting of each type of member.

d. Concrete reinforcement and work man ship shall be asper IS: 456.

e. A copy of all cube test results for the precast concrete works shall be sent to the Engineer as soon as these are available.

f. No members to which the tests relate shall be dispatched to the Site until the tests have been satisfactorily completed and noticed by the Engineer.

30.2 Forms

The design and fabrication of the forms and false work as well as their construction shall be the responsibility of the Contractor. Forms shall be inspected prior to authorizing casting operations. Details shown on the Drawings shall be built into the forms. Worn, damaged, or otherwise unacceptable forms shall be repaired be forecasting of any member is authorized. The forms may be made either of steel or of plywood. If the Contractor elects to use plywood forms, it shall be high quality plywood, 19mm minimum thickness marine grade subject to NONO from the Engineer. Forms shall be structurally adequate to support the members within permissible tolerances. Forms shall be coated with a noticed form-release agent prior to use. Anchor devices may be cast into the concrete for later use in supporting forms provided the arrangement has Notice from the Engineer. Bottom/base should be true level without offsets and kinks of designed supports and shutterings over required PCC base with proper drainage arrangement for proper working and curing.

30.3 Curing

a) Steam curing with approved methodology can be adopted if required, for precast components subject to the approval of Engineer-in-Charge. No extra payment will be made for adopting steam curing. Before concrete products are subjected to any accelerated method of curing, the cement to be used shall be tested in accordance with accepted standards (relevant IS codes) especially for soundness, setting time and suitability for steam curing. In the case of elements manufactured by accelerated curing methods, concrete admixtures to reduce the water content may be allowed to be as permitted by applicable codes of practice subject to the approval of the Engineer-in- Charge. The normal aeration agents used to increase the workability of concrete shall not be allowed. The steam curing of concrete products shall take place under hoods, under chambers or in tunnels. Use of insulated tarpaulin may be permitted. The steam shall have a uniform quality throughout the length of the member. The precast elements shall be stacked with sufficient clearance between each other and the bounding enclosure, so as to allow proper circulation of steam. The surrounding walls, the top cover and the floor of steam curing chamber or tunnel or hood shall be so designed as not to allow more than 1 kcal/m2/h/ deg C. The inside face of the steam curing chamber, tunnel or hood shall have a damp-proof layer to maintain the humidity of steam. Moreover, proper slope shall be given to the floor and the roof to allow the condensed water to be easily drained away. At first, when steam is let into the curing chambers, the air inside shall be allowed to go out through openings provided in the hoods or side walls which shall be closed soon after moist steam is seen jetting out. Preferably, steam should be let in at the top of the chamber through perforated pipelines to allow uniform entry of steam throughout the chamber. In no case shall steam impinge directly on concrete products. The fresh concrete in the moulds shall be allowed to get the initial set before allowing the concrete to come into contact with steam. The regular heating up of fresh concrete product from 20 °C to 35 °C shall start only after a waiting period ranging from 2 to 5 hours depending on the setting time of cement used. The second stage in steam curing process shall be to heat up the concrete elements, moulds and the surroundings in the chamber. The air-space around the member shall be heated up to a temperature maximum to 70°C at a gradual rate, not faster than 10° per hour. This process shall continue 1 1/2 to 2 1/2 hours depending upon the outside temperature. The third stage of steam curing shall be to maintain the uniform temperature and pressure for a duration depending upon thickness of the section. This may vary from 3 to 5 1/2 hours. The fourth stage of steam curing shall be the gradual cooling down of concrete products and surroundings in the chamber and normalization of the pressure to bring it at par with the outside air. The maximum cooling rate, which is dependent on the thickness of the member, shall not exceed 30° per hour. In all these cases, the difference between the temperature of the concrete product and the outside temperature shall not be more than 60°C for concrete up to M 30 and 75°C for concrete greater than M 45. In the case of light weight concrete, the difference in temperature shall not be more than 60°C for concrete less than M 25. For concrete greater than M 50, the temperature differences may go up to 75°C. After the steam curing is completed, the elements shall be further water cured for about 3 to 7 days.

The curing shall be carried out as per approved Method Statement.

30.4 Storage

When members are stored, they shall be firmly supported only at the points specified.

a. The accumulation of trapped water and deleterious matter in the units shall be prevented.

b. Care shall be taken to avoid rust staining and efflorescence.

c. The area intended for the storage of pre-cast units should be surfaced in such a way that no unequal settlement can occur.

d. To prevent deformation of slender units, they should be provided with supports at fairly close intervals and should also be safeguarded against tilting. Lifting and hand ling positions should conform to the Engineer's directions and drawings. In addition, location and orientation marks shall be put on the members, as and where necessary.

30.5 Handling and Transport

a. Members shall be lifted or supported only at points specified or otherwise given a NONO from the Engineer and shall be handled and placed without impact.

b. The Contractor shall define the method of lifting, the type of equipment and transport to be used, and the minimum age of the members to be handled and shall submit to obtain approval from the Engineer.

30.6 Protection

At all stages of construction, pre-cast concrete units and other concrete associated there with shall be properly protected to prevent damage to permanently exposed concrete surfaces, specially arises and decorative features.

31. Falsework and Formwork

31.1 General

Falsework and formwork shall conform to the provisions laid down in IRS: CBC (CL. 6.1 to6.4) and IRC: 87, if not in contravention to the following provisions.

a. Falsework shall be designed in consideration of appropriate raising (camber) against sinking and deformation due to the weight of the concrete during construction and after completion. Furthermore, the Contractor shall submit the plan of the camber to the Engineer prior to the commencement of works for obtaining approval.

b. Ties shall not be welded to the reinforcement bars. Clear cover to the end of the ties shall not be less than 25mm. Filling of tie locations after removal of form work shall be carried out with dry pack cement mortar.

c. The form work shall be of steel plates of proper thickness to give good finish.

31.2 Design of Formwork

a. The Contractor shall submit the design and drawing of complete formwork (i.e. the forms as well as their supports) to the Engineer, before any erection work commences. If proprietary system of formwork is used, the Contractor shall furnish detailed information to the Engineer. However, the Contractor shall be entirely responsible for the adequacy and safety for formwork.

b. The foundation of all supports shall be designed to suit the bearing capacity of soil to support the designed loads without settlement.

c. The Contractor shall prepare detailed shop drawing showing the arrangement of form work for structural members including shoring system, horizontal and diagonal bracing system, details of foundation etc. The sizes of individual members shall be as per the design calculations.

31.3 Finishing of Formwork

a. Finishing shall conform to IRS: CBC (Cl.6.2.4 and Cl.6.2.5).

b. Formwork shall be made to produce a finished concrete true to shape, line, levels and dimensions.

c. Chamfers shall be provided at all angles of the formwork to avoid sharp corners. The chamfers, bevelled edges and mouldings shall be made in the form work itself, conforming to the Drawings.

31.4 Cleaning and Treatment of Forms

Cleaning and treatment of forms shall conform to IRS: CBC(Cl.6.3).

31.5 Specialized Formwork

a. Specialized form work shall conform to the provisions laid down in IRC:87(Cl.10).

b. Specialized formwork may be required in the case of slip formwork, underwater concreting etc. Such specialized formwork shall be designed and detailed by competent agencies and a set of complete working drawings and installation instructions shall be supplied to the Engineer. The site personnel shall be trained in the erection and dismantling as well as operation of such specialized formwork. If proprietary equipment is used, the supplier shall supply drawings, details, installation instructions, etc. in the form of manuals along with the formwork. Where specialized formwork is used, close coordination with the design of permanent structure is necessary.

c. For slip form, the rate of slipping the formwork shall be designed for each individual case considering various parametres including the grade of concrete, concrete strength, concrete temperature, ambient temperature and concreted mixtures.

d. In order to verify the time and sequence of striking or removal of specialized formwork, routine field tests for the consistency of concrete and strength development are mandatory and shall be carried out before adoption.

31.6 Inspection of Formwork

a. The Contractor shall inspect the formwork and shall submit inspection results by "Formwork Assembly Inspection Record" prior to concreting works.

"Formwork Assembly Inspection Record" describes the results of verification of inspection results of the formwork with design documents in which the shape and dimensions of the formwork, clear cover to the outermost reinforcement, effective height etc. are verified. The proposed form of "Formwork Assembly Inspection Record" shall be submitted by the Contractor for approval of the Engineer.

b. Concreting shall not be allowed unless approved for the formwork by the Engineer.

31.7 Stripping and Removal of Formwork

a. Stripping time shall conform to the provisions laid down in IRS: CBC(Cl.6.4).

b. The scheme for removal of formwork (i.e., de-shuttering and decentring) shall be planned in advance and submitted to the Engineer for scrutiny and approval. No form work or any part there of shall be removed without prior approval of the Engineer.

c. The formwork shall be removed in such a manner that does not cause any damage to concrete. Centring shall be gradually and uniformly lowered in such a manner that it permits the concrete to take stresses due to its own weight uniformly and gradually to avoid any shock or vibration.

d. Where the rear ere- entrant angles in the concrete sections, the formwork shall be removed at these sections as soon as possible after the concrete has set to avoid cracking due to shrinkage of concrete.

31.8 Reuse of Forms

The Contractor shall not be permitted reuse of timber facing formwork brought new on the works for more than 5 times for exposed concrete formwork and 8 times for ordinary formwork.5 or 8 uses shall be permitted only if forms are properly cared for, stored and repaired after each use. Use of different quality boards or the use of old and new boards in the same form work shall not be allowed. If any other type of special or proprietary form work is used, the number of times they can be used shall begiven a NONO from the Engineer.

Annexure OCS 2

REINFORCEMENT STEEL

1 General

a) High strength deformed steel bars for concrete reinforcement used in the works shall be Fe 500D TMT, conforming to IS 1786 and manufactured by SAIL/TATA STEEL /JSW STEEL/RINL/*JSPL* . No rerolled steel shall be used. The Contractor shall produce copy of original challan or voucher as a proof of having purchased the steel reinforcement from manufacturers or their authorized distributors having approval of the Engineer. Reinforcement steel shall be stored as per IS 4082.

b) Any steel specified for reinforcement shall conform in every respect to the latest relevant Indian Standard Specifications and shall be of tested quality under the ISI Certification Scheme.

c) All reinforcement work shall be executed in conformity with the drawings supplied and instructions given by the Engineer and shall generally be carried out in accordance with the relevant Indian Standard Specifications IS: 2502- Bending and Fixing of Bars for Concrete Reinforcement.

d) No work shall be commenced without the Engineer's approval for reinforcement bar bending schedule. The reinforcement bars shall be bent to conform to the dimensions and shape shown in the Drawings in a manner that will not damage the parent material. Bars shall be bent cold. Any reinforcement, which is bent, shall not be re-bent. However, when it is unavoidable to re-bend the reinforcement, the same shall have approval from the Engineer.

e) Placement of reinforcement shall conform to the provisions laid down in IRS: CBC (Cl. 7.1.3). Cover and spacing of steel shall be uniform and as specified in the specifications and as shown in the Drawings.

f) Uncoated reinforcement steel shall be protected from rusting or chloride contamination. Reinforcements shall be free of rust, mortar, loose mill scale, grease, oil or paint.

g) Procurement of reinforcement steel shall be so phased by the Contractor that the storage period before its actual use in the works is limited to the bare minimum as directed by the Engineer.

h) Steel shall be stored in a rebar yard having proper workflow or a hard surface i.e.100 mm thick concrete over compacted base so that the surface of the rebar yard is not damaged during handling of bars. The yard should enable easy and efficient handling of the reinforcement bar for various stages i.e; receipt of material, cutting and bending stacking and dispatch to site.

2 Inspection and Testing

a) Manufacturer's test certificate shall be submitted for each lot of supply brought at the Site by the Contractor. Physical tests shall conform to IS1387, IS1599, IS1608 and IS1786. Independent test on quality of steel from each lot shall be carried out as per IRS: CBC (Cl.4.5.2).

b) The frequency of tests on reinforcement consignments delivered at site from one manufacturer should be as per IS 1786:2008 (Cl. 11.1).

c) Specimens required for three tensile tests for each of the different size of bar for each consignment delivered shall be sampled and tested by the Contractor before use at Site. Test results shall be duly supported by graph with respect to stress and strain. If first test of three test samples does not give the specified results, two additional tests shall be carried out. Both retests shall conform to the requirements as specified in IS 1786. The steel shall be rejected otherwise.

d) Reinforcement steel shall be inspected prior to the commencement of works and assembly on Site. Defective, brittle, excessively rusted or burnt bar shall be discarded. Cracked ends of bars shall be cut out. All reinforcement steel shall be free of loose small scales, rust and coats of paint, oil, mud etc.

e) The Contractor shall inspect the reinforcement works and submit inspection results by "Reinforcement Assembly Inspection Record". "Reinforcement Assembly Inspection Record" describes the results of verification of inspection results of the reinforcement work with the Drawing in which the diameter, number and length of the reinforcements, position of splices and joints, position and interval of the bent reinforcement bar, type and disposition of cover blocks are verified. The form of "Reinforcement Assembly Inspection Record" shall be proposed by the Contractor for approval of the Engineer.

f) The Contractor shall obtain approval of the Engineer for reinforcement work prior to the commencement of concrete work.

3 Tolerances and Criteria

a) Unless otherwise specified by the engineer, reinforcement shall be placed within the following tolerances:

i. For overall depth 200 mm or less : ±10mm

ii. For overall depth more than 200mm : ±15mm

The cover shall, in no case, be reduced by more than one third of specified cover or 5mm whichever is less.

4 Lapping and Joints

a) Lapped Splices: No splicing of bars shall be permitted without prior approval of the Engineer. Lengths of splice, wherever required, shall be as indicated on the drawings and approved by the Engineer. Lapped splices shall be staggered and located at points along the span where shear stresses are low.

b) Mechanical Joints: Mechanical coupler shall be used for jointing of reinforcement bars of diameter 25 mm and above. Mechanical coupler shall conform to laid down specification given in Clause 6 below.

c) Welded Joints : Not permitted

5 Coupler Specifications

a) Introduction

Only cold-forged, parallel threaded mechanical coupler system shall be used. All mechanical couplers shall be of Type 2 (or Class H as specified in IS-16172) and should be simple to install and which can be confirmed by quick visual inspection to have been correctly installed and to have achieved the required full strength connection. Any other types of mechanical coupler systems are not permitted.

The couplers shall be of standard parallel thread type. Ends of the reinforcement bars, which are to be joined, shall be enlarged by cold forging, threaded in such a way that root thread diameter is not lesser than the parent bar to be joined. The coupler shall be of TYPE – II and qualified/Certified as per UK CARES, IS code 16172:2014, ACI 318, ASME, Section III, and Div.2, Caltrans.

Couplers shall be installed strictly in accordance with the manufacturer's recommendations. Couplers shall be located away from high stress zones in the various structural elements and shall be staggered and shall conform to provision of IRS: CBC

All the couplers shall be manufactured in a factory which is ISO 9001:2008 (or higher revision) certified for "Manufacturing of Mechanical Steel Rebar Couplers & Accessories" and also be certified for "Site Management of Threading & Processing of Rebar including Sales and Distribution". All the couplers shall undergo quality checks on uniformity of threads, dimensional accuracy etc. Each coupler shall be clearly stamped indicating batch number and diameter. This number shall be traceable to the original cast. The relevant material mill certificate shall be submitted with supply of a particular lot. The certificate shall give salient material properties. The coupler manufacturer shall operate at least an ISO 9000 approved quality assurance programme or equivalent for the manufacture of couplers.

b). Threading of ends of the reinforcing bars:

The threading activity shall preferably be done at Site. The various stages involved in threading are as given below:

i. **Cutting (Rebar End Preparation):**

The ends of reinforcement bars shall be cut by mechanical means to get a perfect plane surface perpendicular to the axis of the bar.

ii. **Cold forging & threading:**

After cutting the ends of the bar shall be enlarged by cold forging such that the area of cross section after threading shall not be less than the area of cross section of the parent bar. The length of cold forging shall be adequate for proposed thread length as per manufacturer's design. Threading shall be done on threading machine. The threads shall be square parallel type to suit the couplers. The thread length and depth shall be as per manufacturer's design. After threading is completed, the threaded length of the bars shall be protected by providing plastic end caps before taking the bars out of the shop.

a) **Quality control in making of threads:**

Double forging of bars is not permitted. In case of improper cold forging the forged of the bar shall be square cut and fresh cold forging shall be undertaken. 100% threading at threaded rebars shall be checked with 'go' and 'no go' gauges for the correctness of the thread profile on the rebar. A proper record for same shall be maintained at site.

b) **Qualification tests**

The coupler shall be qualified as per IS code 16172:2014, ACI 318, ASME - Section III, and Div.2, Caltrans and must have conducted & qualified for the following tests:

i. **Static tensile test**

Mechanical connections shall be tested for all reinforcing rebar sizes. For each rebar size, a minimum of three connections (3 joints + 1 Parent bar) in each load direction shall be tested in accordance with ASTM A370 test method to meet code requirement. A tensile test on an unsliced specimen from the same bar used for the spliced specimens shall be performed to establish actual tensile strength. The tensile strength of an individual splice system shall not be less than the 125% of the specified minimum yield strength (fy of rebar) of the spliced bar.

ii. **Cyclic tension and compression test**

Mechanical connections shall be tested in all reinforcing rebar sizes. For each rebar size, a minimum of three connections shall be tested for cyclic tension & compression test. Each specimen shall withstand cycles of stress variation of the specified minimum yield strength of the reinforcing bar. The test should be carried out as per the table mentioned below:

Loading Stages and Cycles per stage for cyclic load test

Stage	Tension	Compression	Cycles
1	0.95 fy	0.5 fy	20cycles
2	2 εy	0.5 fy	4cycles
3	5 εy	0.5 fy	4cycles

Note:

fy is specified yield strength of the reinforcing bar.

εy is the strength of reinforcing bar at actual yield stress

iii. **Cyclic tensile test**

Mechanical connections shall be tested in all reinforcing rebar sizes. For each rebar size, a minimum of three connections shall be tested for low cyclic tensile test. Each specimen shall withstand 100 cycles of stress variation from 5% to 90% of the specified minimum yield strength (fy) of the reinforcing bar. One cycle is defined as an increase from the lower load to the higher load & return.

iv. **Low cycle fatigue test (for 10,000 cycles)**

Fatigue test shall be conducted on splice sample from +173 Mpa to -173 Mpa for 10,000 cycles. A sine wave form @ 0.5 Hz shall be followed for bar dia 36 mm & above and 0.35 Hz shall be followed for bar dia less than 36 mm. Test shall be conducted confirming to IS 16172:2014 & Caltrans specifications. Past certificates for low cycle fatigue test shall be accepted. However these should not be more than 3 years old.

v. **High cycle fatigue test (for 2,000,000 cycles)**

In high cycle fatigue test, the test specimen is subjected to an axial tensile load which varies cyclically according to the sinusoidal wave form of constant frequency in the elastic range, as accordance with IS-16172. Past certificates for high cycle fatigue test shall be accepted. However these should not be more than 3 years old.

vi. **Slip test**

Slip Test Shall be performed on each diameter coupler specimen as per ASTM A 370 section 10. Test shall be conducted conforming to IS 16172:2014 & Caltrans specifications. Total slip shall not exceed the max value of 0.1 mm.

vii. **Proof loading test**

Every cold-forged, threaded bar end shall undergo a proof load test prior to leaving system supplier's workshop. Every threaded bar must be subjected to proof load testing to a minimum test loading of 75% of the characteristic strength (theoretical fy). The system supplier shall essentially install a proof load tester equipment within its threading workshop premises and ensure to test each and every threaded bar. A positive indication shall be marked on the rebar to indicate that this operation has been carried out.

Note: All three steps involved in the preparation of mechanical joints i.e end cutting of reinforcement, cold forging and threading shall be performed by the coupler manufacturer at site/supplier's workshop. Alternatively, these three steps can also be carried out at site by the Contractor in which case all required machinery shall be procured from the manufacturer and work carried out under the guidance of manufacturer. The manufacturer shall supervise complete operation at site in the initial stage. The manufacturer shall train staff of the Contractor in all activities. However, the manufacturer shall oversee the quality of threading activities through periodical audits and shall give guarantee for the overall quality of preparation of mechanical joints. Contractor shall submit the test certificates of joint strength of samples for static tensile test carried out at NABL approved lab duly certified by the manufacturer.

6 INSTALLATION OF COUPLERS IN THE FIELD:

The installation of couplers in the field, for joining reinforcing bars shall be undertaken by trained manpower and as per manufacturer's instructions. Threads of both the couplers and the bars shall be thoroughly cleaned just before installation. Where couplers are cast-in the concrete, but connection is not to be completed immediately, the couplers shall be internally greased and plastic capped to a protection detail acceptable to the engineer. This cap shall be removed only when next bar is to be attached, then the same to be cleaned before joining the next bar.

The contractor shall arrange for a suitably qualified manufacturer's representative experienced in mechanically connecting reinforcement to be present at site before the start of work for initial training of personnel, and also to demonstrate the equipment and techniques as necessary. The threading workshop is to be fully supervised by the manufacturer's representative.

The contractor shall submit to the Engineer, for his approval a method statement duly approved by the manufacturer for mechanically connecting the reinforcement and for the installation and verification in the field. All activities of manufacture of mechanical joint i.e. cutting, forging and threading shall be carried out under the overall guidance of the manufacturer at the rebar yard with necessary machines and equipment supplied by the manufacturer. The Contractor shall also submit certificate for satisfactory performance of the mechanical joint from the manufacturer for all the coupled bars. This shall take into account any special requirements for horizontal, vertical and inclined couplers and shall include a rectification procedure, if the connection is incorrectly made. It shall also cover the correct methodology for handling of tools and equipment for mechanical connection on site. The following information shall also be included:

1. Requirements for cleanliness
2. Equipment for threading bars
3. Method of locking the connections on both rebars
4. Method of verification of final rebars alignment and coupler integrity

Each coupler shall be visually examined prior to use to ensure the absence of rust and of any foreign material on the inside surface. All completed couplers shall be inspected and verified in accordance with the approved QAP. The Contractor shall ensure the acceptance of the Engineer for a procedure for documenting the inspection of the couplers. The contractor shall retain inspection records and shall submit copies to the Engineer-in-Charge within 7 days. The Couplers that do not meet the acceptance shall be completely removed and the bars re-connected as required.

7 BAR BENDING AND BAR BENDING SCHEDULE:

All bars will be carefully and accurately bent by approved means in accordance with IS: 2502, and relevant drawings. It shall be ensured that depth of crank is correct as per the bar cutting and bending schedule and bent bars are not straightened for use in any manner that will injure the material.

Prior to starting bar bending work, the Contractor shall prepare bar bending schedule from the structural drawings supplied to him and get the same approved by Engineer. Any discrepancies and inaccuracies found by the Contractor in the drawings shall be immediately reported to the Engineer whose interpretation and decision there to, shall be accepted.

8 SPACING, SUPPORTING AND CLEANING:

a) All reinforcement shall be placed and maintained in the positions shown on the drawings to be prepared by contractor.

b) The Contractor shall provide approved types of supports for maintaining the bars in position and ensuring required spacing and correct cover of concrete to the reinforcement as specified on the drawings. Cover blocks of required shape and size, Chairs and spacer bars shall be used to ensure accurate positioning of reinforcement. Spacers or chairs should be placed at a maximum spacing of 1m and closer spacing sometime be necessary. Cover blocks of approved proprietary should be pre-packaged free flowing mortars (Conbextra HF of Fosroc or equivalent). Cover blocks of concrete (not sand cement mortar) should be of the same strength as that of the surrounding concrete and properly compacted and vibrated on a vibrating table. They shall be cured for a minimum period of 14days before they are used in the works. The cost of cover block shall be deemed to have been included in the rates.

Cover blocks shall be firmly placed at appropriate intervals to maintain specified concrete cover to the reinforcement. The number of cover blocks to be provided shall generally be about 4 pieces per m2 for the bottom surface of the member and about 2-4 pieces per m2 for the side surface of the member. Cover blocks shall be made of concrete or mortar having quality equal to or higher than that of the parent concrete.

c) Bars must be cleaned, before concreting commences, of all scale, rust or partially set concrete which may have been deposited there during placing of previous lift of concrete. On no account shall the bars be oiled or painted nor shall mould oil used on the formwork be allowed to come in contact with the bars. Cement wash to bars will not be permitted.

d) Only Fe500D TMT bars complying to IS:1786 shall be provided.

e) 1.6mm dia. G.I. wire shall be used for binding reinforcement.

Annexure OCS-3

FABRICATION AND ERECTION OF STEEL BRIDGE GIRDER

1. General

Fabrication of all Steel Bridge Girders shall be performed within the plants and by fabricators having the experience, knowledge, trained manpower, quality controls, equipment and other facilities required to produce the steel work to desired quality. The plants where fabrication works are proposed to be performed shall be duly approved by RDSO for fabrication of OWG. The tenderer shall submit complete details of the plants along with his tender for the approval of the Engineer. Inspection and passing of fabricated elements/girder shall be done by the RDSO/Employer as per codal provisions and specifications.

Fabrication and erection of steel girder bridges shall be in accordance with IRS fabrication specifications (B1).

2. Material

a. Steel: Mild steel for welded/riveted bridge girders subjected to railway loading shall conform to IS: 2062, Quality "B0" Grade Designation E250, fully killed and with normalizing/ normalizing rolling/ controlled rolling. Plates less than 12mm thick need not be with normalizing/ normalizing rolling/ controlled rolling.

b. In case Rolled Steel Standard Sections conforming to IS:2062 Quality "B0" are not available in market, Engineer may permit use of steel conforming to IS:2062 Quality "BR" / "A" on case to case basis.

c. Steel shall have smooth and uniform finish and shall be free from rolling defects such as cracks, flaws, seams, laps, imperfect edges etc. and other defects such as loose mill scale, rust, pitting, or other defects affecting its strength and durability.

d. High Strength Friction Grip (HSFG) bolt assembly including Direct Tension Indicator (DTI)washers shall conform to EN: 14399 series.

e. All the steel sections used in the fabrication must have mill test certificate clearly indicating the specification to which the steel conforms and whether steel is killed and normalized.

f. The materials, on receipt, shall be carefully unloaded, examined for defects, checked, sorted, and stacked securely on a level bed, out of danger from flood or tide and out of contact with water or ground moisture. They will be supported on timber or concrete plinths so that they do not touch the ground.

3. Fabrication of steel work

a. The records of fabrication shall be maintained in the registers as per the formats given in the Appendix I of IRS: B1-2001.

b. The greatest accuracy shall be observed in the design, fabrication, and erection of every part of the work to ensure that all parts will fit accurately together on erection. Components of all the spans shall be fully interchangeable. Same jigs and assembly fixtures duly approved shall be used. The tolerances in manufacture shall be in accordance with as shown in Appendix II of IRS: B1-2001.

c. There should be level, finished concrete floor of sufficient dimensions in the fabrication yard, on which the fabricator will precisely set out the outline of the structure (to full scale) as per drawings for the purpose of preparing templates. Only steel tapes shall be used for all measurements, and they will be held tight and level on the floor while measuring or marking.

d. Steel tapes used for marking out the work shall be calibrated at a temperature of 20° C.

e. The templates throughout the work shall be of steel bushed.

i. Flattening and straightening

All steel materials, plates, bars and rolled sections shall have straight edges, flat surfaces and be free from twist. If necessary, they shall be cold straightened or flattened by pressure before being worked or assembled unless they are required to be of curvilinear form.

ii. Cutting of Steel

Cutting of steel for fabrication may be done by shearing, sawing, or by gas using mechanically controlled torch/torches. All flame cut edges shall be ground to obtain reasonably clean square and true edges. Plasma-arc cutting method may also be employed. This process offers less heat input causing less distortion.

iii. Making of Holes

Marking and drilling of holes in members shall preferably be done with the use of templates/jigs. All bolt holes in members built up by welding shall be drilled after welding.

Holes for turned bolts, should be 1mm under drilled in shop and should be reamed at site to suit the diameter of turned bolt. Jigs shall be periodically checked for tolerances from master plates.

iv. Welding

Welded construction work shall be carried out generally in accordance with the provisions of Indian Railway Standard Welded Bridge Code and subject to further specifications as given below:

i. All welds shall be done by submerged arc welding process in shop. Site welding should not be undertaken except in special circumstances with the approval of the Engineer. Site welding should be confined to connections having low stresses, secondary members, bracings etc.

ii. Suitable jigs and fixtures shall be used to avoid distortion during welding. Components which are mass fabricated in the shop should be proved in master templates.

iii. Class and size of electrode for welding shall conform to IRS Specification M-28. For fabrication of steel bridge girder following class of electrode shall be used-

Class of Electrode as per IRS Specification No. M.28.66	**Type of work to be welded**	**I.S. Specification No.**	**Code (as per IS:815- 66)**
Class B2 (Moderately high ductility)	For welding of mild steel to IS:2062-1962 (Fusion welding quality) or equivalent, for service conditions where the weldment is rigid and subjected to relatively high dynamic stresses	814-63	M 110 to M 997-H, J, K or P.

Brand and make of electrode on approved list of M&C wing of RDSO should be used.

i. No welding operator shall be employed on the work until he has, in the presence of the Engineer, passed the appropriate tests laid down in relevant codes.

ii. All main butt welds shall have complete penetration and shall comply with the requirements of IRS Welded Bridge Code. They shall be made between prepared fusion faces. Where possible they shall be welded from both sides. The ends of the welds shall have full throat thickness. This shall be obtained on all main welds by the use of extension pieces adequately secured on either side of the main plates. Additional metal remaining after the removal of the extension pieces shall be removed by machining, or by other approved means and the ends and surfaces of the welds shall be smoothly finished.

iii. In the fabrication of built-up assemblies all butt welds in the component parts shall be complete before the final assembly.

iv. A record of butt welds shall be kept to enable it to be identified with the welders responsible for the work but material shall not be marked by hard stamping for this purpose.

The welding techniques and sequence, quality, size of electrodes, voltage and current required shall be as prescribed by manufacturers of the material and welding equipment. The Contractor shall submit full details of welding procedure in proforma given at Appendix V of IRS: B1-2001 for approval of the Engineer.

v. Welding of Stud Shear Connectors:

i. The welding of stud shear connectors shall be done by "DRAWN ARC STUD WELDING WITH CERAMIC FERRULE" technique. The shear stud and ceramic ferrules shall conform to type SD1/UF as per BS EN ISO 13918-2008.

ii. The stud and the surface to which studs are welded shall be free from scale, moisture, rust and other foreign material. The stud base shall not be painted, galvanized or cadmium plated prior to welding. Welding shall not be carried out when temperature is below 10 degrees Celsius or surface is wet or during periods of strong winds unless the work and the welder are adequately protected. The welds shall be visually free from cracks and shall be capable of developing at least the nominal ultimate strength of studs. The procedural trial for welding the stud shall be carried out when specified by the Engineer.

iii. Testing of Stud Shear Connectors:

(A) Appearance Test

1) The weld to a shear stud connector should form a complete collar around the shank and free from cracks, excessive splashes of weld material, free from injurious laps, fins, seams, twist, bends or other injurious defects.

2) Weld material should have a 'steel blue' appearance.

(B) Test to check the fixing of shear studs

1) Ring Test: Involves striking the side of the head of stud with a 2 kg hammer. A ringing tone achieved after striking indicates good fusion whereas dull tone indicates a lack of fusion (BS 5400-6) All studs shall be checked by Ring test.

2) Bend Test: Test requires the head of a stud to be displaced laterally by approximate 25% of its height using 6kg hammer.

* The weld should then be checked for sign of cracking or lack of fusion.

* Stud should not be bent as back as this is likely to damage the weld.

* The testing rate should be 1 in 50 (BS 5400-6).

vi. Making of Joints

i. Joints shall normally be made by filling not less than 50 per cent of holes with service bolts and barrel drifts in the ratio 4:1. Only barrel drifts shall be used in erection. Drifts may be used for drawing light members in position; but their use on heavy members shall be restricted to securing them in their correct position. Any error in the shop fabrication or deformation resulting from handling and transportation which prevents proper assembling and fitting up of parts shall be reported immediately to the Engineer. No reaming shall be undertaken without the written authority of the Engineer.

ii. The erection of OWG shall be done in accordance with Appendix III of IRS: B1-2001. However, if the Contractor desires to adopt any other method of erection, they shall submit the scheme and obtain the approval of the Engineer. It shall be ensured that when in position, the girder has the camber as per drawing.

vii. High Strength Friction Grip (HSFG) bolting assembly

The HSFG bolting assembly shall conform to EN 14399 Series (High strength structural bolting assemblies for preloading):

- EN 14399-1:2015- General requirements.
- EN 14399-2:2015- Suitability for preloading.
- EN 14399-3:2015- System HR- Hexagonal bolt and nut assemblies.
- EN 14399-5:2015- Plain washers.
- EN 14399-6:2015- Plain chamfered washers.
- EN 14399-9:2009- Direct Tension Indicator for bolt and nut assembly.

HSFG bolting assemblies are very sensitive to differences in manufacture and lubrication. Therefore, complete HSFG bolting assembly (i.e. bolt, nut, washers & DTI) including galvanizing shall be procured from single manufacturer. Use of Direct Tension Indicator (DTI) washers shall be mandatory in the HSFG bolting assemblies.

Grade and size of bolts shall be as per the Drawings. The surface preparation, tightening procedures and other details for HSFG bolts shall be as per RDSO standard Drawing No. RDSO/B-11760/R1.

Table: Composition of high strength structural bolting assembly and its component marking

<table>
<tr><td colspan="2">Type of bolting assembly</td><td colspan="2">System HR</td></tr>
<tr><td colspan="2">General requirements</td><td colspan="2">EN 14399-1</td></tr>
<tr><td colspan="2">Suitability for preloading</td><td colspan="2">EN 14399--2 and, if any, additional testing specified in the product standard</td></tr>
<tr><td colspan="2">Bolt & Nut</td><td colspan="2">EN 14399-3</td></tr>
<tr><td rowspan="2">Marking</td><td>Bolt</td><td>HR8.8</td><td>HR10.9</td></tr>
<tr><td>Nut</td><td>HR8 or HR10</td><td>HR10</td></tr>
<tr><td colspan="2">Washers</td><td colspan="2">EN 14399-5[a] or EN 14399-6</td></tr>
<tr><td colspan="2">Marking</td><td colspan="2">H or HR[b]</td></tr>
<tr><td colspan="2">Direct tension indicator and nut face washer or bolt face washer</td><td colspan="2">EN 14399-9</td></tr>
<tr><td rowspan="3">Marking</td><td>Direct Tension Indicator</td><td>H8</td><td>H10</td></tr>
<tr><td>Nut Face Washer</td><td colspan="2">HN</td></tr>
<tr><td>Bolt Face Washer</td><td colspan="2">HB</td></tr>
<tr><td colspan="4">[a] EN 14399–5 can only be used under the nut.
[b] At the choice of the manufacturer.</td></tr>
</table>

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 the outer face of the nut to the end of bolt

b) at least four full threads (in addition to the thread run out) shall remain clear between the bearing surface of the nut and unthreaded part of the shank.

Holes for HSFG bolts- The holes shall be made by drilling only. The actual diameter of hole shall be 1.5 mm more than the bolt diameter for less than 25mm diameter bolts and 2mm more than nominal diameters of HSFG bolts for diameters 25mm and above.

Surface preparation of steel interface before providing HSFG bolts–Wherever property class 8.8 bolts are used these should be hot dip galvanized as per ISO: 10684(latest version). Property class 10.9 bolts should not be hot dip galvanized since this may cause hydrogen embrittlement. So these bolts should be coated with zinc flakes as per ISO: 10683 (latest version). However, depending on the site conditions, locations of these bolts in the structure and corrosion proneness, use of zinc flake spray coating as per ISO: 10683(latest version) can be adopted even for property class 8.8 bolts as well.

Installation of HSFG bolting assembly- Installation /tightening of preloaded bolting assemblies shall be carried out as per clause 8.3 & 8.5 of EN 1090-2 and clause 5.2 of EN 14399-9. The following steps shall be followed for tightening of bolts:

i. The holes shall be brought in alignment by using drifts etc. such that bolt threads are not damaged/enlarged during insertion of bolts.

ii. The members being joined shall be held in position by insertion of few HSFG bolts (tightened to first stage only i.e. snug tight condition).

iii. After the alignment/geometry of members is verified to be correct as per drawings, balance bolts shall be inserted and tightened upto first stage of tightening. The drifts inserted as above shall also be replaced by HSFG bolts one by one.

iv. After first stage of tightening, the joint shall be checked to see if the plies are in close contact and clearances are not exceeded.

v. Second stage tightening shall be done with torque wrench. Bolts shall be tightened until indentation on the DTI indicate full tightening. In order to minimize loosening of already tight bolts, tightening in both the stages shall be done starting from the stiffest part to free edges.

vi. 100% bolts shall be checked for proper tightening using feeler gauge of 0.4/0.25 mm.

vii. Fully tensioned bolt, opened for any reason whatsoever, shall be rejected and removed from the site of work along with washers, nut and DTI.

4. Bearing and Expansion Gear

All bearings and expansion gears shall be procured from a reputed and experienced manufacturer qualified to undertake precision fabrication of this type and shall be approved by the Engineer.

5. Trial Shop erection

Trial shop erection shall be done in accordance with Cl.614 of IRBM.

6. Field erection

Field erection shall be done in accordance with Cl.616 of IRBM.

7. Erection in contractor's Works

The whole of the work shall be completely interchangeable. First span (of each type) shall be temporarily erected complete at the Contractor's Works for inspection by the Inspecting Officer to test the accuracy of the templates. Further spans or part span assemblies built from parts selected at random by the Inspecting Officer shall be erected from time to time to check the accuracy of the work as the Inspecting Officer may require.

8. Launching

Before taking up launching, the Contractor shall prepare and submit launching scheme along with design and methodology of launching including details of equipment proposed to be used for the approval of the Engineer.

a) Rail Flyovers (RFO)

After approval of the Engineer, launching scheme shall be got approved from Chief Bridge Engineer/Northern Railway. CRS application shall be prepared by the Contractor and submitted to the Commissioner of Railway Safety (CRS) through the Engineer, HRIDC and CBE/NR. Work of launching shall be started only after receipt of sanction of CRS.

b) Road Under Bridges

After approval of the Engineer, launching scheme shall be got approved from concerned road authorities. Work of launching shall be started only after receipt of approval of concerned road authority.

During erection of plate/composite steel girder by crane special care shall be taken to support the girder by wooden blocks & temporary bracing to ensure stability against toppling till permanent bracings are provided."

9. Track work for OWG:

Track work for open web girder bridge on H-beam sleepers shall be done as per IRPWM, relevant RDSO drawings and codal provisions.

10. Camber

In order to eliminate secondary stresses in a span under loaded condition, the nominal length (i.e. the lengths which will give no camber) of member shall be increased or decreased by the amount shown on the camber diagram supplied by the Employer. Frequent checks shall be made of the camber of girders during erection and care taken to see that the camber as per drawing is obtained when the girder is completely assembled. When span is supported on ends and intermediate supports are removed the dead load camber shall be recorded and entered in bridge register. This will provide the reference to compare the camber checked during technical inspection to ascertain the loss of camber.

11. Test certificates & testing

All materials for the work shall pass Mechanical test, Charpy test, Chemical Analysis, etc. prescribed by the relevant IS specifications or such other equivalent specifications.

For all materials including HSFG bolts, the contractor shall furnish copies of test certificates from the manufacturers including proof sheets, mill test certificates, etc. showing that the materials have been tested in accordance with the requirements of various specifications and codal provisions.

If any further testing of materials is required by Engineer in respect of these and other items, it shall be arranged for by the contractor at a reputed laboratory/National test house as approved by Engineer. For this, nothing extra shall be payable.

Even satisfactory outcome of such tests or analysis shall in no way limit, dilute or interfere with the absolute right of the Engineer to reject the whole or part of such materials supplied, which in the judgement of the inspecting authority does not comply with the conditions of the contract. The decision of the Engineer in this regard shall be final, binding and conclusive for all purposes.

The Engineer shall be empowered, at his/her discretion to make or have made under the supervision, any of the tests specified in the specifications mentioned herein in addition to such other tests as he/she may consider necessary, at any time up to the completion of the contract and to such an extent as he/she may think necessary to determine the quality of all materials used therein. In doing so, he/she shall be at liberty under any reasonable procedure, he/she may think fit to select, identify, have cut-off and take possession of test pieces from the material either before, during or after its being worked up into the finished product.

The Engineer shall also be empowered to call for a duly authenticated series of mechanical tests to be obtained from the maker for this materials used in the work and to accept the same in lieu of other tests to the extent he/she deems fit. The Contractor shall supply the material for the test pieces and shall also prepare the test pieces necessary.

The test shall be carried out by the Contractor, for which Contractor shall provide all facilities including supply of labour and plant. Engineer may at his/her discretion direct the Contractor to despatch such tests pieces as he/she may require to the National Test House or elsewhere as he/she may think fit for such testing purposes. The Engineer may at his/her discretion, check test results obtained at Contractor's work by independent tests at National Test House.

The Engineer shall at all times be empowered to examine and check the working of the Contractor's plant before and after using it. Should the Contractor's plant be found, in the Engineer's opinion, unreliable, he/she is empowered to cancel any tests already carried out in this contract and have these tests carried out at any National Test House or elsewhere, as he/she may think fit.

12. Fabrication drawings

The contractor shall prepare detailed shop drawings including drawing office dispatch lists (DODL's) on the basis of design drawings supplied by Engineer in such size and in such details as may be specified by Engineer. The shop drawings shall be submitted to Engineer in triplicate.

No work of fabrication will be started without such approval being obtained. Contractor has to arrange the proof checking of the working fabrication drawings from the nominated Institution / Consultant. The cost will be borne by the contractor.

13. Painting

a. Fabricated steel work shall not be painted over except to the extent specified in para (b) until it has been inspected and passed by the Engineer or his representative and any defect, pointed out by him has been rectified.

b. All surfaces which shall be in permanent contact and any others which will not be accessible for painting later on shall be cleaned thoroughly and given one coat of Zinc Chrome Red Oxide Priming to IS 2074 or other approved composition in the prescribed number of coats immediately prior to assembly.

c. Steel girders (including all components) shall be provided with protective coating by metalizing with sprayed aluminum as given in the Appendix-VII of IRS: B1-2001, followed by painting as per painting schedule given below-

i. One coat of etch primer to IS:5666

ii. One coat of zinc chrome primer 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.

iii. Two coats of aluminum paint to IS: 2339 brushing or spraying as required. One coat shall be applied before the fabricated steel work leaves the shop. 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.

14. All third Party (RDSO/RITES/Any other nominated agency) Inspections charges for Open Web Girders and Composite Girders etc. shall be paid by the Employer."

Annexure OCS-4

PRESTRESSING

1 GENERAL

The work shall be carried out in accordance with the drawing and these specifications or as approved by the Engineer.

Concrete and un-tensioned steel for the construction of prestressed concrete members shall conform to the requirements of respective sections so far as the requirements of these Sections apply and are not specifically modified by requirements set forth herein.

Contractor shall ensure that different components of prestressing such as jacks, bearing plates, wedges, anchorages, strands, and HDPE ducts etc. are compatible to each other and the same shall be exchanged in between all the suppliers to ensure the same.

2 MATERIALS

a. Sheathing

i. The sheathing ducts shall be of the spiral corrugated type. Unless otherwise specified, the material shall be Cold Rolled Cold Annealed (CRCA) Mild Steel conforming to IS: 513 intended for mechanical treatment and surface refining but not for quench hardening or tempering.

ii. The material shall normally be bright finished. However, where specified, as in case of use in aggressive environment, galvanized or lead-coated mild steel strips shall be used. The thickness of sheathing shall be as shown on the drawing, but shall nevertheless not be less than 0.3mm, 0.4mm and 0.5mm for sheathing ducts having internal diameter of 50mm, 75mm and 90 mm respectively. For larger diameter of ducts, thickness of sheathing shall be based on recommendations of prestressing system supplier or as directed by the Engineer.

iii. For major projects, the sheathing ducts should preferably be manufactured at the project site utilising appropriate machines. With such an arrangement, long lengths of sheathing ducts may be used with consequent reduction in the number of joints and couplers. Where sheathing duct joints are unavoidable, such joints shall be made slurry tight by the use of corrugated threaded sleeve couplers which may be tightly screwed onto the outer side of the sheathing ducts.

iv. The length of the coupler should not be less than 150mm but should be increased upto 200mm wherever practicable. The joints between the ends of the coupler and the duct shall be sealed with adhesive sealing tape to prevent penetration of cement slurry during concreting. The couplers of adjacent ducts should be staggered wherever practicable. As far as possible, couplers should not be located in curved zones. The corrugated sleeve couplers are being conveniently manufactured using the sheath making machine with the next higher size of die set.

v. The internal diameter of the sheathing duct shall be in accordance with the recommendations of the system manufacturer and shall be about three times the area of the tendons. In case of 6T13, 12T13 and 19T13 sizes of tendons comprising 12/13mm dia strands, the inner diameter of the sheathing shall not be less than 50mm, 75mm and 90mm respectively or those shown in the drawing, whichever is greater.

b. Anchorages

i. Anchorages shall be procured from authorized manufacturers only. Anchorages shall conform to BS 4447. Test certificates from a laboratory fully equipped to carry out the tests shall be furnished to the Engineer. Such test certificates shall not be more than 12 months old at the time of making the proposal for adoption of a particular system for the project.

ii. No damaged anchorages shall be used. Steel parts shall be protected from corrosion at all times. Threaded parts shall be protected by greased wrappings and tapped holes shall be protected by suitable plugs until used. The anchorage components shall be kept free from mortar and loose rust and any other deleterious coating.

iii. Swages of prestressing strand and button heads of prestressing wire, where provided shall develop a strength of at least 95 per cent of the specified breaking load of the strand or wire as the case may be. Where swaging / button-heading is envisaged, the Contractor shall furnish details of his methodology and obtain approval of the Engineer, prior to his taking up the work.

c. Prestressing Steel

i. 12.7mm nominal dia stress relieved low relaxation high tensile steel strand (CLASS-II) conforming to IS: 14268 with ultimate tensile strength 1861 N/mm2 shall be used. Various test as recommended in IS: 14268 shall be conducted before transporting the lot to site. Apart from 1000 hrs relaxation test conducted by manufacturer, at least two such tests are required to be conducted by independent agency in the beginning of project.

d. Prestressing strands/Wires storage

i. All high tensile steel for prestressing work shall be stored about 30cm above the ground in a suitably covered and closed space to protect it from dampness. It shall also be invariably wrapped in gunny cloth or tar paper or any other suitable materials, as per approval of Engineer. Even if it is to be stored in an area at the site for short time during transit it shall be suitably covered. Protection during storage and repacking or application of washable protective coating to the H.T. steel shall be given by the contractor at no extra cost if the packing of H. T. Strand/wire during unloading and storage / handling in the stores gets damaged.

ii. Stock piling of H. T. Steel on the work site shall not be allowed any time, especially before and during the monsoon.

iii. The Engineer or his authorized representative shall always have an easy access to the store-yard for inspecting the H. T. Wire/strands/Bars and satisfying themselves regarding the condition thereof. Any modifications regarding storage suggested by the Engineer shall scrupulously be followed by the contractor. During monsoon days, H.T wires/strands shall be kept in reasonable airtight store, if required by the Engineer, at no extra cost.

e. Testing of Prestressing steel and Anchorages

i. All materials specified for testing shall be furnished free of cost and shall be delivered in time for tests to be made well in advance of anticipated time of use.

ii. All wire, strand or bars to be shipped to the site shall be assigned a lot number and tagged for identification purposes. Anchorage assemblies to be shipped shall be like-wise identified.

iii. All samples submitted shall be representative of the lot to be furnished and in the case of wire or strand, shall be taken from the same master roll. The Contractor shall furnish samples of at least 5.0m length selected from each lot for testing. Also, two anchorage assemblies, complete with distribution plates of each size or types to be used, shall be furnished along with short lengths of strands as required.

3 WORKMANSHIP

a. **Cleaning**

i. Tendons shall be free from loose rust, oil, grease, tar, paint, mud or any other deleterious substance.

ii. Cleaning of the steel may be carried out by immersion in suitable solvent solutions, wire brushing or passing through a pressure box containing carborandum powder. However, the tendons shall not be brought to a polished condition.

b. **Straightening**

i. High tensile steel wire and strand shall be supplied in coils of sufficiently large diameter such that tendons shall retain their physical properties and shall be straight as it unwinds from the coil. Tendons of any type that are damaged, kinked or bent shall not be used.

ii. The packing of prestressing wire / strand shall be removed only just prior to making of cable for placement. Suitable stands shall be provided to facilitate uncoiling of wires / strands without damage to steel. Care shall be taken to avoid the possibility of steel coming into contact with the ground.

c. **Positioning**

i. Post-Tensioning

Prestressing tendons shall be accurately located and maintained in position, both vertically and horizontally, as per drawings.

Tendons shall be so arranged that they have a smooth profile without sudden bends or kinks.

The location of prestressed cables shall be such as to facilitate easy placement and vibration of concrete in between the tendons.

Sheathing shall be placed in correct position and profile by providing suitable ladders and spacers. Such ladders may be provided at intervals of approximately 1.0 m. Sheathing shall be tied rigidly with such ladders/spacer bars so that they do not get disturbed during concreting.

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.

- Each anchorage device shall be set square to the line of action of the corresponding prestressing tendon and shall be positioned securely to prevent movement during concreting.
- The anchorage devices shall be cleaned to the satisfaction of the Engineer prior to the placing of concrete. After concreting, any mortar or concrete which adheres to bearing or wedging surfaces shall be removed immediately.

d. **Cutting**

i. Cutting and trimming of wires or strands shall be done by suitable mechanical or flame cutters. When a flame cutter is used, care shall be taken to ensure that the flame does not come in contract with other stressed steel. The location of flame cutting of wire or strand shall be kept beyond 75mm of where the tendon will be gripped by the anchorage or jacks.

ii. In post-tensioning the ends of prestressing steel projecting beyond the anchorages, shall be cut after the grout has set.

e. **Protection of Prestressing steel**

i. Prestressing steel shall be continuously protected against corrosion, until grouted. The corrosion protector shall have no deleterious effect on the steel or concrete or on the bond strength of steel to concrete. Grouting shall conform to these specifications or as directed by the Engineer or specified in Contract Specifications.

f. **Sheathing Joints and Couplings**

i. Joints in sheathing shall, if so, instructed be sealed with a heat shrink tape.

ii. Special attention should be paid to its junction at the anchorage. It should tightly fit on the trumpet end of anchorage and the junction should be sealed, preferably, with heat shrink tape.

iii. The heat shrink tape is supplied in the form of bandage rolls which can be used for all diameters of sheathing ducts. The bandage is coated on the underside with a heat sensitive adhesive so that after heating the bandage material shrinks on the sheathing duct and ensures formation of a leak-proof joint. The heating is affected by means of a soft gas flame.

iv. The sheathing and all joints shall be watertight. Any temporary opening in the sheathing shall be satisfactorily plugged and all joints between sheathing and any other part of the prestressing system shall be effectively sealed to prevent entry of mortar, dust, water or other deleterious matter. Sheathing shall be neatly fitted at joints without internal projection or reduction of diameter.

v. Enlarged portions of the sheathing at couplings or anchorages shall be of sufficient length to provide for the extension of the tendons.

g. **Grout Vents**

i. Grout vents of atleast 20mm diameter shall be provided at both ends of the sheathing and at all valleys and crests along its length. Additional vents with plugs shall also be provided along the length of sheathing such that the spacings of consecutive vents do not exceed 20m. Each of the grout vents shall be provided with a plug or similar device capable of withstanding a pressure of 1.0MPa without the loss of water, air pressure or grout.

h. **Anchorages**

i. All bearing surfaces of the anchorages shall be cleaned prior to concreting and tensioning. Anchor cones, blocks and plates shall be securely positioned and maintained during concreting such that the centre line of the duct passes axially through the anchorage assembly.

ii. The anchorages shall be recessed from the concrete surface as per drawings.

iii. After the prestressing operations are completed and prestressing strands are cut, the surface shall be painted with two coats of epoxy of suitable formulation having a dry film thickness of 80 microns per coat and entire recess shall be filled with concrete or non-shrink/pre-packaged mortar or epoxy concrete.

i. **Handling and Storage**

i. Care shall be taken to avoid mechanically damaging, work-hardening or heating prestressing tendons while handling. All prestressing tendons shall be stored clear of the ground and protected from the weather, from splashes from any other materials, and from splashes from the cutting operation of an oxy-acetylene torch, or arc-welding processes in the vicinity.

ii. In no circumstances shall prestressing tendons after manufacture be subjected to any welding operation, or 'on-site' heat treatment or metallic coating such as galvanizing. This does not preclude cutting as specified.

iii. All wires, strands or bars stressed in one operation shall be taken, where possible, from the same parcel. Each cable shall be tagged with its number from which the coil numbers of the steel used can be identified. Cables shall not be kinked or twisted. Individual wires and strands for which extensions are to be measured shall be readily identifiable at each end of the member. No strand that has become unraveled shall be used.

j. **Supervision**

i. All prestressing and grouting operations shall be undertaken by trained personnel only. A representative of supplier of the prestressing system shall be present during all tensioning and grouting operations and shall ensure, monitor and certify their correctness.

4 Tensioning Equipment

All tensioning equipment shall be procured from authorized manufacturers only and be approved by the Engineer prior to use. Where hydraulic jacks are used, they shall be power driven unless otherwise approved by the Engineer. The tensioning equipment shall satisfy the following requirements:

a. The means of attachments of the prestressing steel to the jack or any other tensioning apparatus shall be safe and secure.

b. Where two or more wires / strands constitute a tendon, a single multiple stressing jack shall be used which is capable of tensioning simultaneously all the wires / strands of the tendon. Suitable facilities for handling and attaching the multi-pull jack to the tendons shall be provided.

c. The tensioning equipment shall be such that it can apply controlled total force gradually on the concrete without inducing dangerous secondary stresses in steel, anchorage or concrete; and

d. Means shall be provided for direct measurement of the force by use of dynamometres or pressure gauges fitted in the hydraulic system itself to determine the pressure in the jacks. Facilities shall also be provided for the linear measurement of the extension of prestressing steel to the nearest mm and of any slip of the gripping devices at transfer.

e. Any indication in the loss of strength in tendons during the tensioning operation shall be brought to the attention of the Engineer. Any corrective measures which may be required in procedures and/or material shall be approved by the Engineer.

f. When friction must be reduced, water soluble oil may be used subject to the approval of the Engineer. This oil may be flushed from the duct as soon as possible after stressing is completed by use of water pressure. These ducts shall be flushed again just prior to the grouting operations. Each time the ducts are flushed, they shall be immediately blown dry with oil-free air.

5 Testing by the Contractor

For the purpose of accurately determining the tendon elongations while stressing, the Contractor shall bench test two samples of each size and type of strand tendon to determine the modulus of elasticity prior to stressing the initial tendon. The bench should be at least 6metres long, with concrete anchorage blocks having a constant area end section of at least four times that of the anchorage assembly area. The tendon shall be straight and centered on the cross-sectional area of the bench. The test procedure shall consist of stressing the tendon at an anchor assembly with the dead end consisting of a load cell. The test specimen shall be tensioned to 80 percent of ultimate in 10 increments. For each increment, the gauge pressure, elongation and load cell force shall be recorded. The data shall be furnished to the Engineer. The theoretical elongations shown on the post-tensioning working drawings shall be re-evaluated by the Contractor using the results of the tests and corrected as necessary. Revisions to the theoretical elongations shall be submitted to the Engineer for approval.

Apparatus and methods used to perform the tests shall be proposed by the Contractor and be subject to the approval of the Engineer. After the initial testing, five more tests shall be performed. These tests shall be spaced evenly throughout the duration of the Contract.

a. Post Tensioning Procedure

i. Tensioning force shall be applied in gradual and steady steps and carried out in such a manner that the applied tensions and elongations can be measured at all times. The sequence of stressing applied tensions and elongations shall be in accordance with the approved drawing or as directed by the Engineer.

ii. It shall be ensured that in no case, the load is applied to the concrete before it attains the strength specified on the drawing or as stipulated by the prestressing system supplier, whichever is more.

iii. After prestressing steel has been anchored, the force exerted by the tensioning equipment shall be decreased gradually and steadily so as to avoid shock to the prestressing steel or anchorage.

iv. The tensioning force applied to any tendon shall be determined by direct reading of the pressure gauges or dynamo metres and by comparison of the measured elongation with the calculated elongation. The calculated elongation shall be invariably adjusted with respect to the modulus of elasticity of steel for the particular lot as given by the manufacturer.

v. The difference between calculated and observed tension and elongation during prestressing operations shall be regulated.

vi. **Grouting of Prestressed Tendons:** Grouting shall conform to provisions in **Annexure D** of "IRS Concrete Bridge Code: 1997". A record of grouting operations shall be maintained in a format given by Engineer.

6 Safety Precautions during Tensioning

These are applicable for both pre-tensioning and post tensioning operations.

a. Care shall be taken during tensioning to ensure the safety of all persons in the vicinity.

b. Jacks shall be secured in such a manner that they will be held in position, should they lose their grip on the tendons.

c. No person shall be allowed to stand behind the jacks or close to the line of the tendons while tensioning is in progress.

d. The operations of the jacks and the measurement of the elongation and associated operations shall be carried out in such a manner and from such a position that the safety of all concerned is ensured.

e. A safety barrier shall be provided at both ends to prevent any tendon, which might become loose from recoiling unchecked.

f. During actual tensioning operation, warning sign shall be displayed at both ends of the tendon. No person will stand behind in line with jacks while tendon / wire are being stressed.

g. After prestressing, concrete shall neither be drilled nor any portion cut nor chipped away nor disturbed, without express approval of the Engineer.

h. No welding shall be permitted on or near tendons nor shall any heat be applied to tendons. Any tendon which has been affected by welding, weld spatter or heat shall be rejected.

7 Transportation and Storage of Units

a. Precast girders or elements shall be transported in an upright position. 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.

b. When members are to be stacked, they shall be firmly supported at such bearing positions as will ensure that the stresses induced in them are always less than the permissible design stresses. Further, inclined side supports shall be provided at the ends and along the length of a precast girder to prevent lateral movements or instability.

c. Care shall be taken during storage, hoisting and handling of the precast units to prevent their cracking or being otherwise damaged. Units worked or damaged by improper storing or handling or transport shall be replaced by the Contractor at his expense.

8 Tolerances

a. Permissible tolerances for positional deviation of prestressing tendons shall be limited to the following:

   i. Variation from the specified horizontal profile: 5 mm
   ii. Variation from the specified vertical profile: 5 mm
   iii. Variation from the specified position in member: 5 mm

Section VII: Employer's Requirements

Section VII-7A: General Electrical Services

C O N T E N T S

CHAPTER-1 – INTRODUCTION AND OBJECTIVE

1.1 INTRODUCTION

(1) Haryana Rail Infrastructure Development Corporation Limited (HRIDC) was Incorporated on 22nd August,2017 as a Joint Venture between Government of Haryana and Ministry of Railways with equity Participation of 51% and 49% respectively. The Haryana Orbital Rail Corridor (HORC) is the project of HRIDC, from Prithla (near Palwal station of Indian Railways) to New Harsana Kalan (near Sonipat station of Indian Railways).

(2) Haryana Orbital Rail Corridor (HORC)route will be Broad Gauge, Double Line, with High Rise Electrification at 2x25 kV, AC, approximately 145 RKM and 315 TKM from Prithla to New Harsana Kalan including connectivity to Indian Railway (IR) and Dedicated Freight Corridor Corporation of India Limited (DFCCIL) stations. There are twin Tunnels from 24.850 km to 29.580 km and both tunnels interconnected at 27.215 km with one vertical shaft. The viaduct is from 20.942 km to 24.843 km.

(3) There are 17 New Stations namely Prithla, Silani, Sohna IMT, Dhulawat, Chandla Dungerwas, Panchgaon, Manesar, New Patli, Badsa, Deverkhana, Badli, Mandothi, New Asaudah, Jasaur Kheri, Kharkhoda, Tarakpur and New Harsana Kalan and details are as under:

SN	Station	Chainage (km)
1	Prithla (crossing)	0.00
2	Silani (halt)	10.40
3	Sohna IMT (crossing)	19.01
4	Dhulawat (crossing)	32.77
5	Chandla Dungerwas (halt)	42.60
6	Panchgaon (halt)	46.29
7	Manesar (junction)	51.89
8	New Patli (junction)	58.00
9	Badsa (junction)	64.75
10	Deverkhana (halt)	71.14
11	Badli (crossing)	76.83
12	Mandothi (junction)	90.45
13	New Asaudah (halt)	94.03
14	Jasaur Kheri (halt)	100.22
15	Kharkhoda (crossing)	108.72
16	Tarakpur (crossing)	114.20
17	New Harsana Kalan (crossing)	125.13

In addition to above 17 stations, There are 3 stations i.e Sultanpur and Asaudah and Patli of Indian Railway where HORC connectivity shall be made.

(4) The present works are from Prithla to IMT Sohna and there are 3 stations in the section namely Prithla, Silani and IMT Sohna. But works can be executed anywhere in the section from Prithla to New Harsana Kalan, as per directions of the Engineer.

(5) The objective of the Specifications is to minimize maintenance cost by design and selection of Maintenance friendly System which have high Availability, low Life Cycle Cost (LCC), higher Meantime between Failure (MTBF) and minimum Maintenance Time to Restore(MTTR).

(6) The objective of the specifications is to minimize energy usage. The requirement is to reduce energy consumption by employing the energy efficient system design and product specification.

(7) The Works shall be designed and executed to achieve an aesthetic character and provide a feeling of design commonality throughout the project.

1.2 SCOPE OF WORK

The broad scope of work, relating to works are given below and shall be for the purpose of general guidance only and is not exhaustive. For complete appreciation of the scope, the specification, drawings and other relevant document, mentioned in the Tender documents shall be referred to. The indicative items of work are as under:

(1) Electrification of Prithla, Silani and IMT Sohna Station, Yard areas and S&T buildings with allied facilities and complete power supply arrangement as per Standard Railway Practice and guidelines issued by Railway Board/ RDSO/ CPWD specification etc.

(2) Supply, Installation, testing and commissioning of 11 kV/0.44 kV, 1x250 kVA Compact Substation (CSS) with Dry type transformer (250 kVA) with earthing and all safety equipment with complete power supply arrangement at Prithla and IMT Sohna stations.

(3) Supply, Installation, testing and commissioning of silent type DG Set of 125 kVA capacity (emission CPCB 4-plus norm) including AMF, APFC Panel of 100kVAR & LT Panel) including earthing system and all safety equipment with complete power supply arrangement at IMT Sohna station.

(4) Supply, Installation, Testing and Commissioning of High Mast Towers (20 meter) with luminaires, with complete cabling arrangement to meet standard lux level at Prithla, Silani and IMT Sohna stations as per specifications and guidelines issued be RDSO/ Railway Board.

(5) Supply, Installation, Testing and Commissioning of 11 meter high decorative poles with luminaires, with complete cabling arrangement Prithla, Silani and IMT Sohna stations to meet standard lux level as per specifications and guideline issued by RDSO/ Railway Board.

(6) Supply, Installation, Testing and Commissioning of Colour Light Signalling (CLS) Panel with cabling arrangement of suitable size and rating at each station as per RDSO specifications.

(7) Supply, installation, Testing and Commissioning of Single sided and Double-sided LED signage board with pictogram/ symbol at each stations as per specification.

(8) The space for (13 Passenger, 1000 Kg) lift and Escalators at IMT Sohna station shall be kept. If needed, the lifts and escalators can be provided in future.

(9) Provision of LT panel for distribution of LT supply for lighting (indoor and outdoor), fans, air conditioners, yard lighting, FOB/ Sub Way Lighting, Signalling and Telecom Load, SCADA RTU load, Lift load, submersible pump load, Power supply for operation of OHE motorised isolator/ Interrupter etc. Twenty percent (20%) spare capacity shall be kept in LT panel for future loads.

(10) Supply and laying of Conduits Fire Resistant PVC or GI and all conduits shall be concealed. No surface conduit shall be allowed and if surface conduit is essential then it shall be with GI pipe only and with the approval of Engineer.

(11) Provision of conduits, wiring, lights (indoor and outdoor) , fans and power sockets etc. in all stations, S&T installations at station, pump houses and other service buildings. The wiring shall be with copper wires and cables.

(12) Provision of conduits, wiring, lights, fans, air-conditioners and power sockets etc. at S&T installations i.e Relay Huts (RH) at both ends of Prithla and IMT Sohna stations.

(13) Provision of lights, fans, exhaust fans in all buildings and provision of lights in subways, platforms, passenger shelters etc.

(14) Earthing of all equipment's and systems.

(15) Lightning protection of all buildings.

(16) Supply, installation, testing and commissioning of LT copper cables. The cable shall be laid under ground, under platform, under floor, below tracks etc and cable route markers shall be provided as per specifications and drawings. These cables shall feed 20 m high mast flood light towers, 11 m high decorative poles, platform lighting, S&T loads at both ends of platform etc. The maximum voltage drop from source to load point shall not exceed 5%.

(17) Supply, installation, testing and commissioning of HT cables with all safety norms.

(18) Supply, installation, testing and commissioning of submersible and mono-block pumpsets.

(19) Supply, installation, testing and commissioning of UPS.

(20) All Nuts, bolts, Studs, washers, Pins etc. shall be of GI or stainless steel. All earthing strips shall be of GI except Copper strips for copper earthing.

(21) Provision of water cooler, RO system etc. at stations.

(22) Provision of conduits, wiring, lights, fans, air-conditioners and power sockets etc. in S&T installations i.e Auto Signalling System buildings (Auto Location Hut: ALH) - 7 nos. enroute from Prithla to IMT Sohna.

(23) Both sides of the viaduct shall be provided illumination and minimum lux level shall be 10. The 240 V AC, power supply for LED lights shall be taken from substation at IMT Sohna and substation at shaft of the tunnel. The feeding zone of each substation shall be approximately equal.

(24) Miscellaneous items e.g. shock treatment charts, sectioning layouts, safety rubber mats, equipment number plates, first aid boxes, indication boards and danger notice plates, fire buckets, etc.

(25) All equipment testing (type test, routine tests and factory acceptance tests etc), system acceptance tests, integrated testing and commissioning of all equipments.

(26) Interface with other Contractors to ensure timely completion of the Works.

(27) Provision of all the construction drawings, documents, and as-built drawings required to supply, install, testing and commissioning of the above works and all other installations, as required. Operation & Maintenance Manuals, training manual and other related Documentation.

(28) Provide maintenance supervision support during Defect Notification Period.

(29) The above works can be executed anywhere in the section from Prithla to New Harsana Kalan, as per directions of the Engineer.

(30) The arrangement of 11kV, 3-phase or 440 volt, 3-phase AC supply, from Power Supply Authority (PSA) substation to HORC point at H-Pole in HORC premises shall be arranged by HRIDC and all coordination with PSA including necessary payments to PSA shall be made by HRIDC.

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CHAPTER 2 - DESIGN AND PERFORMANCE REQUIREMENTS

2.1 General

1 The design, supply, installation, testing and commissioning of General Services work including Power supply system etc. shall meet the design and performance requirements within the design environments specified in this Particular Specifications.

2 Design Environment

Adequate Margin shall be built in Design, particularly to take care of Climate Conditions/Operating Environment. Wherever, the equipment installed in open at the surface level or inside service buildings at surface level, the same shall be designed for working in the existing tropical conditions and the ambient temperature and humidity levels pertaining to HORC Project area. All ferrous components and fittings shall be hot-dip galvanized. All Nuts, bolts, Studs, washers, Pins etc. shall be of GI or stainless steel. All earthing strips shall be of GI except Copper strips for copper earthing.

2.2 Basic Design Philosophy and Requirements

2.2.1 Proven Design

(a) The Contractor shall develop the design based on specification and on proven and reliable Engineering Practices. The design details shall be submitted with technical data and calculations to the Engineer for review.The Design shall include complete Single Line Diagram (SLD) indicating Local, DG set and Auxiliary Transformer LT supply.

(b) The Contractor shall submit drawings in such a form as the Engineer will require them for approval, copies as required of all drawings, diagrams, and details of all equipment in part or in whole. Any review shall be done by the Engineer on receipt of drawings in hard copy. The drawings shall be submitted in soft copy also along with submissions. The Contractor shall make drawings available to the Engineer at all reasonable times. Wiring diagrams and other drawings as the Engineer deems shall not be finally settled until satisfactory installation and testing has been made, this shall be approved in principle.

(c) The Contractor shall submit a schematic block diagram of the equipment showing the functional requirements of this specification. The Contractor shall submit a schedule including details of numbering, categories and drawing registers / indexes for the production, submission, and approval during the period of the contract of drawings and of any information, required for the Engineer in connection with the design of the contract works.

(d) This schedule shall be suited to the requirements of manufacture, delivery and installation of the contract works to meet the requirements of the contract and shall allow reasonable time (approx. 8 weeks) for study and approval by the Engineer of all drawings, calculations and graphics submitted (and as necessary, resubmitted) by the Contractor.

(e) No approval by the Engineer of any drawing shall relieve the Contractor of any of his obligations of liabilities under the contract or of his responsibility for ensuring that the work is satisfactory done and that all operational requirements shall be met.

(f) The Contractor shall provide final drawings without undue delay, and in any case within twelve weeks of the award of the contract, these drawings shall include dimensions, capacity of equipments and complete power supply arrangement with all associated items of each station.Incomplete submission of documents and Drawings shall not be considered as submission by contactor.

2.2.2 The design philosophy shall meet the following criteria:

a) Application of state-of-the-art Technology
b) Service proven design
c) Design life 30 years (However, the individual equipment shall have different design life).
d) Minimum life cycle cost
e) Low maintenance cost
f) Use of interchangeable, modular components
g) Extensive and prominent labelling of parts, cables, and wires
h) High reliability
i) Low energy loss
j) System safety
k) Adequate redundancy in system
l) Fire and smoke protection
m) Use of fire-retardant materials and fire survivals cables
n) Environment friendly
o) Adherence to operational performance requirements
p) Maximum utilization of indigenous materials and skills, subject to quality conformity.

Adequate margin shall be built into the design particularly to take care of the higher ambient temperatures, dusty conditions, and high seasonal humidity, etc. prevailing in HORC Project area.

2.2.3 SERVICE LIFE

All equipment, cables and wiring shall be designed, manufactured and installed so as to secure a service life as shown below:

Main switchboards	30 Years
Transformers	30 Years
Sub-main switchboards	30 Years
Cables	30 Years
Fire alarm main panel	30 Years
Luminaires	20 Years
Tray, trunking and supports	30 Years
Lightning protection	30 Years
Sub-assemblies and components	30 Years
Earth Mat	30 years
All other equipment	minimum 20 Years

2.2.4 Name Plates and Identification

All parts of the installation, which are of relevance for its operation and maintenance, shall be provided with nameplates, tags or other markers/ arrows, especially in enclosed areas, such as ceiling, shafts, and other places accessible for maintenance service.

2.2.5 Corrosion Protection

All ferrous components and fittings shall be hot-dip galvanized. The minimum coating of zinc shall be 1000 gm/m^2 as per RDSO's specifications no. ETI/OHE/13 (4/84 or latest), until and unless specifically mentioned in the specifications.

2.2.6 Acoustic Criteria

Noise emanating from the equipment / service installations shall be within the permissible limit prescribed in the relevant international standards for each of the equipment. In addition, Central Pollution Control Board of India laid down guidelines shall prevail.

2.2.7 Colour Coding

Colour for power cables, bus bars shall be as follows:

Phase R	:	Red
Phase Y	:	Yellow
Phase B	:	Blue
Neutral	:	Black
Ground	:	Green or Green-Yellow Strip

Large wires and cables shall be colour coded with tapes as specific colour. Colour coding for Junction boxes shall be as follow:

Normal power	:	Orange
Essential power	:	Yellow
Telephone system	:	Green
Fire Alarm System	:	Red
Control System	:	Blue

2.3 EARTHING

(1) The Contractor shall prepare an Earthing and Bonding Plan which shall include service buildings, sub-station, LT/HT Panels, High mast towers, light poles, feeder pillars, DG set pumpsets etc. This shall be submitted to the Engineer for approval. The Contractor shall take all measures as the system will be in the proximity of 2x25 kV OHE system. Earthing system shall be designed to ensure personnel safety and protection of persons and installations against damage.

(2) The earthing of sub-station, LT/HT panels, DG set and high mast towers (with 2 independent earth electrodes) shall be done with Copper cladded Steel Earth Electrode of 4-meter length, 19 mm with Exothermically welded busbar with 50 kg Earth Enhancement Compound in each pit. The pit and covers shall be made up of M-25 grade RCC concrete. The connection between equipment and earth electrode shall be made with 40x6 mm GI flat. The earth resistance of sub- station shall be less than 1 ohm.

(3) The earthing of light poles, ACO panel, Distribution Board in S&T Relay Hut at both ends of station and ALH etc., shall be done with single Copper cladded Steel Earth Rod of 4-meter length, 19 mm with Exothermically welded busbar buried 500 mm below the ground. Necessary protection shall be provided to avoid damage and rusting of the earthing system. The connection between equipment and earth electrode shall be

made with 40x6 mm GI flat. The earthing of light poles at platform shall be done on alternate poles. The metallic armour of the cable (incoming and outgoing) shall be connected to each light pole of platform.

(4) The earthing of H-pole of discom (with 2 earth electrodes) shall be done with Copper cladded Steel Earth Rod of 4-meter length, 19 mm with Exothermically welded busbar for connection with 40x6 mm GI flat. The connection between equipment and earth electrode shall be made with 40x6 mm GI flat. RCC chamber with cover (with M-25 grade concrete) shall be provided.

(5) Building Lightning Protection earthing: Protection of building against lightning shall be done in accordance with IS: 2309-2005 as applicable and shall include the provision of a parallel path lighting system complete with air terminal conductors, ground terminals, interconnecting conductors & other fittings required for the complete system. Lightning protection system shall meet the requirements of the National Building Code of India-2005. All two storey buildings shall be provided with lightning protection earthing. GI flat 40x6 mm size shall be laid on all parapet wall top and flat shall be welded to make it one piece and properly secured with GI or non-corrosive fasteners on parapet. The parapet top GI flat shall be connected to two independent copper cladded Steel Earth Electrode of 4-meter length, 19 mm with Exothermically welded busbar for connection through 40x6 mm GI flat. RCC chamber with cover (with M-25 grade concrete) shall be provided.

(6) The 4 m, 19 mm dia steel earth electrode shall have minimum 250 micron copper cladding. The earth clamp exothermically welded on the top of earth electrode shall be 50x6 mm GI flat 300 mm long with 2 holes of 10 mm dia on either side of the earth electrode centre as per the indicative drawing. All nuts, locknuts, bolts, washers etc shall be of stainless steel or GI. All bolts shall be with washers and locknuts.

(7) The earth resistance of compact sub-station body and neutral earthing shall be less than 1 ohm and of LT/HT panel, DG set and high mast towers shall be less than 2 ohms. The resistance of all other earth systems shall be less than 5 ohms. Value of each earth (in black paint) shall be measured and marked on G.I plate size 150x100x3mm painted with yellow enamel paint shall be fixed near the earth, and following information shall be indicated (i) Earth No. (ii) Individual value of earth (iii) Date of testing. Earth resistance at each electrode shall be measured jointly by the Contractor and the Engineer. Complete work shall be as per IS-3043. Normally an earth electrode shall not be located closer than 1.5m from any building. The separation between two earth electrode shall not be less than 2m.

2.4 Climate Conditions:

The traction power system shall be fully operable and maintainable in the following climatic and atmospheric conditions:

Ambient air temperature	(-)5℃ degrees to +50℃
Average ambient temperature for one year	35℃
Maximum solar gain of metallic object under the sun	1kW/sqm.
Maximum relative humidity	100%

Annual Rainfall	Dry Arid regions and also heavy monsoon Affecting regions with rainfall ranging from 1750mm to 6250mm.
Maximum number of thunderstorms days per annum	85
Maximum number of dust storm Days per annum	35
Number of rainy days per annum	120
Basic wind pressure	50m/sec as per wind map based on IS–875.
Creepage distance for (i) Extreme pollution condition (ii) Polluted conditions	As per IEC60815–2008 (31 mm/kV minimum)
Horizontal Seismic Zone	Refer IS 1893 Part1 for earthquake mapping
Creepage distance of Insulators	Minimum nominal creepage distance of insulators shall be 31mm/kV

2.5 CODES & STANDARDS

(1) Equipment, material, and systems/sub-systems shall be designed, manufactured and tested in accordance with the latest issue of approved and recognized codes and standards defined and proposed by the Contractor and approved for the Work. All standards, codes and manuals with correction slips issued up to 28 days prior to last date of Bid submission shall be applicable for this bid. Any other applicable code, circular, instruction of UIC shall be referred with the approval of the Engineer.

(2) References to standards or to material and equipment of a particular manufacturer in these contract documents shall be regarded as followed by the words or equivalent.

(3) The Contractor shall supply to the Engineer, two original full editions of the publications/ technical standards including codes, standards, manuals and other documents that Contractor proposes to use or used for the work. These publications shall be for the sole use of the Engineer and Employer and shall become the property of the Employer.

(4) The Contractor shall ensure that items of equipment and their components are standardized wherever possible throughout the Works where similar requirements and functions exist.

(5) The Contractor shall submit design to the Engineer for review and no objection. The proposed standards used shall also be referred with the design listed in the Employer's Requirements. The Contractor may propose an alternative equivalent international standard during the design stage but the acceptance of the alternative standard shall be subject to review by the Engineer.

(6) In case of any conflict or inconsistency between the provision of the codes/ standards as mentioned above and provisions contained in these specifications, the provisions mentioned in these specifications shall prevail. However, the approval of the Engineer shall be obtained to follow the relevant codes/ specifications. The decision of the Engineer shall be final.

2.6 AS-BUILT DRAWINGS

(1) Preparation of the As-built drawings shall be part of these specifications. As-built drawings shall be Final Design Drawings of the project showing the actual work done. The Contractor shall provide the as-built drawings in one original and one reproducible negative produced from the original, with the names of the signature authorities of the Engineer and the Contractor. After they are signed for approval, prints shall be taken from the signed original of each drawing. Also, two nos. Hard Disk Drive (1 TB) of all as-built drawings shall be supplied to the Engineer. Together with the as-built drawings, the Contractor shall provide reduced size (e.g., A3 size) booklets of the as-built drawings as per the Employer's Requirements.

(2) All details, dimensions, texts, etc., on the reduced size drawings shall be clearly recognizable and readable. The Contractor shall complete and obtain the Engineer's approval on the as-built drawings and make the final submission of the as-built drawings together with the A3 size booklets latest within three months following the date of the Certificate of Completion. All costs associated with the provisions mentioned above shall be deemed to be included in the contract price.

(3) As-built drawings shall cover in general (but not limited to):

a) For mechanical equipment:

i. Construction drawings,
ii. Instruction drawings,
iii. Functional block diagrams with set-point range of process parameters depicted thereon.

b) For electrical installation:

i. Installation drawings with circuit numbers and exact type-assignation of all installed equipment,
ii. Distribution diagrams with circuit numbers,
iii. Fault analysis and protection co-ordination settings the of protection system,
iv. Power consumption,
v. Precise type numbering
vi. Earthing systems

c) For distribution panels:

i. Construction drawings,
ii. Circuit drawings as operating diagrams,
iii. Additional current flow-charts where required,
iv. Accurate lists of any installed equipment with precise description of this equipment,
v. Adjustment tolerances of circuit-breakers, switches, etc.

d) For equipment:

i. Construction drawings,
ii. Circuit diagrams,
iii. Functional block diagrams with set-point range of process

iv. parameters depicted thereon,

v. List of quantities with detailed break-down of the bill of materials comprising the equipment.

e) For cabling:

i. Diagrams with dimensions, type of cables and power requirements with regular cross- section area and measured cable values shall be used for these diagrams. Cable route plan.

2.7 SYSTEM REQUIREMENTS:

1 Conformity with Governing Specifications and other Statutory Requirements: -

The work shall be carried out in accordance with the following governing specifications and other statutory rules:

i. Indian Electricity Act 2003 with latest amendment

ii. CEA Regulations, 2010

iii. Regulations laid down by Chief Electrical Inspector to the Government.

iv. Regulations laid down by EIG Indian Railways.

v. National Building Code

vi. Rules and Regulations prescribed by local authorities as applicable.

vii. Relevant, Indian Standards, IEC Standards, CENELEC, British Standards and other National/ International standards as applicable.

viii. The Contractor shall furnish information asked for by a statutory body (e.g., Government of India, Ministry of Railways, Commissioner of Railway Safety, Government of Haryana etc.) in particular format as directed by Engineer. Any documents, studies, test reports, compliances required for getting safety clearances from any authority shall be submitted by the Contractor.

2.8 ABBREVIATIONS AND ACRONYMS

Abbreviation	Description
AC	Alternating Current
ACTM	AC Traction Manual
AHRI	Airconditioning, Heating and Refrigeration Institute
AMF	Automatic Main Failure
ANSI	American National Standards Institute
APFC	Automatic Power Factor Correction
ARI	Airconditioning and Refrigeration Institute
ASM	Assistant Station Master
AuxXer	Auxiliary Transformers
AT	Auto Transformer
ALARP	As Low as Reasonably Practicable

BS	British Standards
BIS	Bureau of Indian Standards
BTS	Base Transceiver Station
CAD	Computer Aided Design
CENELEC	European Committee for ElectroTechnical Standards
CEA	Central Electricity Authority
CFM	Cubic Feet per Minute
CHC	Chief Controller
CIP	Co-ordinated Installation Plan
CLS	Colour Light Signaling
COP	Coefficient Of Performance
CP	Contract Package
CPCB	Central Pollution Control Board
CPWD	Centre Public Works Department
CPM	Critical Path Method
CRCA	Cold Rolled Close Annealed Steel
CRS	Commissioner for Railway Safety
CSD	Combined Service Drawings
CSS	Compact Sub Station
CST	Civil, Structure and Track
CV	Curriculum-Vitae
DC	Direct Current
DG	Diesel Generator
DDF	Digital Distribution Frame
DB	Dry Bulb
dB	Decibel
DCN	Design Change Notice
DFC	Dedicated Freight Corridor
DFCC	Dedicated Freight Corridor Corporation
DFCCIL	Dedicated Freight Corridor Corporation of India Limited
DIN	Deutsche Industrie Normen
DL	Double Line
DNP	Defect Notification Period
DPR	Detailed Project Report
DT	Down Time
DTN	Data Transmission Network
DVT	Design Verification Table
DVV	Design Verification and Validation
E&M	Electrical and Mechanical
EDFC	Eastern Dedicated Freight Corridor

EIG	Electrical Inspector to the Government of India
EI	Electronic Interlocking
EMC	Electro Magnetic Compatibility
EMI	Electro Magnetic Interference
EMP	Environmental Management Plan
EN	Euro Norm
ERP	Enterprise Resource Planning
Excl.	Excluding
FAT	Factory Acceptance Test
FCN	Field Change Notice
FDT	Firetrace Detection Tubing
FIU	Field Interface Unit
FM Steel	Ferritic Martensitic steel
FMEA	Fault Mode and Effects Analysis
FMECA	Failure Modes Effect and Criticality Analysis
FRCAS	Failure Recording and Corrective Action System
FRLS	Flame Retardant, Low Smoke Low Halogen
FTA	Fault Tree Analysis
GE	Geotechnical Engineering
GI	Galvanized Iron
GSM-R	Global System for Mobile Communication–Railway
GWR	Gate Working Rules
G&SR	General and Subsidiary Rules
GAD	General Arrangement Drawing
GCC	General Conditions of Contract
GS	General Specification
HRIDC	Haryana Rail Infrastructure Development Corporation Limited
HORC	Haryana Orbital Rail Corridor
HT	High Tension
HTML	Hyper Text Markup Language
HAZOP	Hazard and Operability Studies
HF	High Frequency
HDD	Hard Disc Drive
HDPE	High Density Poly Ethylene
Hz	Hertz
ID	Identification
ICD	Interface Co-ordination Document
IEEE	Institute of Electrical and Electronics Engineers
IEC	International Electro–technical Commission
IHA	Interface Hazard Analysis

IMT	Industrial Model Township
IMD	Integrated Maintenance Depot
IMSD	Integrated Maintenance Sub-Depot
IMP	Interface Management Plan
INR	Indian Rupees
IPS	Integrated Power Supply
IR	Indian Railway
IRS	Indian Railway Standards
IRSEM	Indian Railway Signal Engineering Manual
IS	Indian Standard
ISO	International Standards Organization
IT	Information Technology
Km/KM	KiloMeter
KMPH	Kilo Meter Per Hour
KV	Kilo Volt
KVAR	Kilo-Volt-Amperes Reactive power
KVA	Kilo Volt Ampere
LED	Light Emitting Diode
LILO	Loop In Loop Out
LT	Low Tension
LC	Level Crossing
LCC	Life Cycle cost
LRU	Line Replaceable Unit
LIU	Line Interface Unit
LPM	Litre per minute
M&P	Machines and Plants
MACLS	Multiple Aspect Colour Light signaling
MCB	Miniature Circuit Breaker
MCIL	Maintainability Critical Items List
MDF	Main Distribution Frame
MDO	Manually operated Draw Out
MDT	Mean Down Time
MTBSAF	Mean Time Between Service Affecting Failure
MMD	Maximum Moving Dimensions
MMI	Man Machine Interface
MOR	Ministry of Railway
MPR	Monthly Progress Report
MTBF	Mean Time Between Failure
MTTR	Mean Time To Repair
MTTR	Mean Time To Restore

NABL	National Accreditation Board for Laboratories
NDT	Non Destructive Test
NMCP	Noise Monitoring and Control Plan
NOC	No Objection Certificate
NOO	Notice of Objection
NONO	Notice of No Objection
O&M	Operation and Maintenance
O&SHA	Operating and Support Hazard Analysis
OCC	Operations Control Centre
OD	Outer Diameter
ODBC	Open Data Base Connectivity
ODF	Optional Distribution Frame
OEM	Original Equipment Manufacturer
OFC	Optic Fiber Cable
OHE	Over Head Equipment
OHTL	Over Head Transmission Lines
OPM	Other Preventive Measures
NEMA	National Electrical Manufacturers Association
PBX	Private Branch Exchange
PC	Personal Computer
PHA	Preliminary Hazard Analysis
PMIS	Project Management Information System
PS	Particular Specifications
PVC	Poly Vinyl Chloride
QA	Quality Assurance
RAM	Reliability, Availability & Maintainability
RAMS	Reliability, Availability, Maintainability and Safety
RAP	Resettlement Action Plan
RBD	Reliability Block Diagram
RCIL	Reliability Critical Item List
RDSO	Research, Design and Standards Organization
RDT	Reliability Demonstration Testing
RE	Railway Electrification
RKM	Running Kilo meter
ROB	Road Over Bridge
RO	Reverse Osmosis
ROW	Right of Way
RTU	Remote Terminal Unit
RUB	Rail Under Bridge
SAT	System Acceptance Test

SCIL	Safety Critical Items List
SCADA	Supervisory Control and Data Acquisition
SDFU	Switch Disconnector Fuse Unit
SER	Signaling Equipment Room
SHE	Safety, Health and Environment
SIL	Safety Integrity Level
SLD	Single Line Diagram
SM	Station Master
SMACNA	Sheet Metal and Air-Conditioniong Contractor's National Association
SOD	Schedule of Dimensions
SOGP	Schedule of Guaranteed Parameters
SP	Sectioning & Paralleling Post
SSP	Sub-Sectioning Post
SPM	Suspended Particulate Matter
SRS	System Requirement Specification
SRR	Submission Response Request
SSHA	Sub-system Hazard Analysis
S&T	Signaling &Telecommunication
SWR	Station Working Rules
TB	Tera Byte
TDC	Transverse Duct Connection
TEFC	Totally Enclosed, Fan-Cooled
TER	Telecommunication Equipment Room
TKM	Track Kilo meter
T&P	Tools & Plants
TMS	Train Management System
TOT	Transfer of Technology
TPC	Traction Power Controller
TPN	Triple Pole and Neutral
TR	Ton of Refrigeration
TSS	Traction Sub-Station
UIC	International Union of Railways
UPS	Uninterruptible Power Supply
VAT	Value Added Tax
VDU	Video Display Unit
VRLA	Valve Regulated Lead Acid
VHF	Very High Frequency
WB	Wet Bulb
WGS	World Geodetic System
XLPE	Cross Linked Polyethylene

2.9 DOCUMENT SUBMISSION PROCEDURE

i. For each stage of submittal, the Contractor shall prepare a Submission Response Request (SRR) carrying the date of submission, the submission reference number as defined above, the submission title, the stage of submission (e.g. Inception Report, Simulation Report (if any), Detailed Design, etc.), and the signature of the Contractor's Representative:

ii. The Documents and Drawings shall be submitted under the signatures of Designer and Project Manager of The Contractors to establish proper issue & Control of the documents. The authority will not be delegated below the rank of Project Manager.

iii. The submission shall be accompanied with a checklist duly signed (with name) by the Preparer and Checker of the Drawing/ document.

iv. The submission shall be accompanied with Exception Statement on Deviations, if any to the Specifications.

v. Each Document / drawings shall be signed by the Preparer (who has prepared the Document/drawing), the Designer (who has checked the document/ drawing) for conformance to specifications, and the issuers (who has verified the document for the purpose, and issued after Careful examination) to demonstrate that document have gone through the process of quality assurance.

vi. The Contractor shall refer the indicative tender drawings while making submissions.

vii. All the documents, drawings and Designs shall be submitted with the endorsement thereon the Documents as under:

   a) Certificate of the Contractor to the effect that "the submission is prepared, checked and issued by the qualified engineers of the Contractor and has been properly reviewed by the Contractor, according to the Contractor's Project Quality Assurance Plan", thereby confirming its completeness, accuracy, adequacy and validity and conformance to the satisfactory, safe and reliable performance,

   b) Compliance with all relevant clauses of the Employer's Requirements;

   c) Conformance to all interface requirements;

   d) Certifying that it is based on auditable and proven or verified calculations or design criteria;

   e) Has taken account of all requirements for approval by statutory bodies or similar organizations, and that where required, such approvals have been granted.

viii. The Contractor shall submit hard copies of all drawings, data of the documents and copy of transmittal along with a soft copy transfer electronically in the agreed format. Contractor will share the softcopies as advance information. However, the reviews will only be made on hard copies and shall be preserved in hard copies with endorsed signed copy. The work shall be executed based on the latest hardcopies of the drawings and documents.

ix. Errors, omissions, ambiguities, inconsistencies, inadequacies and other defects shall be rectified by the Contractor at his own cost and the acceptance by the Engineer of the Manufacture and Construction Documents shall not amount to any waiver and shall not relieve the Contractor of his obligations under the Contract.

x. After receipt of "Notice of No Objection" from the Engineer, the Contractor shall submit six (6) hard copies (and softcopy) of the Design and / or Drawings for the use of the Engineer.

2.10 ENGINEERING REVIEW COORDINATION

2.10.1 Throughout the Design Stage, the Contractor (along with Designer) shall attend monthly design review meetings with the Engineer. At these Engineer's review meetings, the Contractor shall present information, drawings and other documents to the Engineer in respect of all submissions Program to occur during the following four week period. The Contractor's presentations shall be in sufficient depth to enable the Engineer to obtain a clear understanding of the Contractor's proposals and to discuss the methodology and process used in reaching the proposed design solutions. Unless otherwise directed by the Engineer, all meetings shall be convened in Engineer's Office or Contractor's Main Office or at the Site Office or at any other location as decided by the Engineer.

2.10.2 The Contractor shall comply all of the Engineer's observations and any agreed actions resulting from the Engineer's review meeting and shall address each of these fully before submission of the respective documents for formal review.

2.11. ENGINEER'S REVIEW

i. The Engineer will complete his review of the submission within 28-days, and communicate review comments in writing or on marked up drawings/documents.

ii. Within two weeks of the receipt of the Engineer's comments the Contractor shall resubmit the submittals/ documents needing resubmission.

iii. Where the comments are minor, the same may be clarified by calculations, part prints, etc. as acceptable to the Engineer and included in the Contractor's next submission.

iv. Should the Engineer considers the submission to be unacceptable, the Contractor shall revise and re-submit the entire submission within two weeks, unless otherwise agreed with the Engineer.

2.12 ENGINEER'S RESPONSE

1) The Engineer will respond in one of the following three ways:

   a. Notice of No Objection

   b. Notice of Objection

   c. Notice of No Objection with Comments

2) Definition of Engineer's response:

   a. "Notice of No Objection": if following his review of the submission, the Engineer has not discovered any non-compliance with the Contract, the Engineer will issue to the Contractor a formal "Notice of No Objection" (NONO). A NONO from the Engineer, irrespective of with or without comments does not in any way imply the Engineer's consent of the submission nor does it remove any responsibility from the Contractor for complying with the Contract. Issue of a NONO from the Engineer entitles the Contractor to proceed to the next stage of the Programed work.

b. "Notice of Objection: if following his review of the submission, the Engineer discovers major non-compliance, discrepancies or omissions etc. that in his opinion are of a critical nature, the Engineer will issue a "Notice of Objection"(NOO). The Contractor shall revise and reissue the submission addressing the Engineer's comments. Following the issue of a NOO by the Engineer, the Contractor is not entitled to proceed to the next Programed stage on the path in the relevant network as previously approved by the Engineer until all of the Engineer's comments have been fully addressed and a NONO is issued.

c. "Notice of No Objection" (With Comments)": if following his review of the submission, the Engineer discovers discrepancies or omissions etc. that in his opinion are not of a critical nature, the Engineer may issue a "Notice of No Objection with Comments" (NONOC). The Contractor shall respond to the comments, agreed and incorporated prior to inclusion in the "Construction Package" Following the issue of a NONOC by the Engineer, the Contractor is entitled to proceed to the next stage of the Programed work subject to the inclusion of amendments necessary to address the comments.

3 (a) Should it be found at any time after notification of consent / "Notice of No Objection" / "Notice of No objection with Comments" (as the case may be) that the relevant drawings or documents do not comply with the Contract or do not agree with drawings or documents in relation to which the Engineer has previously notified his consent / "Notice of No Objection" / "Notice of No objection with Comments" (as the case may be), the Contractor shall, at his own expense, make such alterations or additions as, in the opinion of the Engineer, are necessary to remedy such non-compliance or non-agreement and shall submit all such varied or amended drawings or documents for the consent of the Engineer.

(b) No examination by the Engineer of the drawings and / or documents submitted by the Contractor, nor any consent / "Notice of No Objection" / "Notice of No objection with Comments" (as the case may be) of the Engineer in relation to the same, with or without amendment, shall absolve the Contractor from any of his obligations under the Contract or any liability for or arising from such drawings or documents.

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CHAPTER 3–EXPLANATARY NOTES FOR INDICATIVE BOOK OF QUANTITIES (BOQ) ITEMS

3.1 EXPLANATORY NOTES FOR BOQ ITEMS:

The explanatory notes to the BOQ are as under and shall be read in conjunction with tender drawings, specifications and Employer's Requirements.

S.No.	Description for BOQ Items
1 CONDUITS, WIRING, PLUGS, FAN AND DISTRIBUTION BOARDS	
1.1	**Point Wiring By 3x2.5 sqmm Copper Cable (With Modular Switches & Socket) in Conduits:** Supply of material and wiring of Light point/ Fan point/ Exhaust-Fan point. Wiring shall be done by 3x2.5 sqmm multi stranded copper flexible FRLS PVC insulated ISI marked 1100 volts grade cable, confirming to IS: 694-1990. Concealed conduit shall be laid with FRLS PVC pipe or GI pipe minimum 25 mm dia (as required). Surface conduits shall not be laid and if required, shall be done with GI pipe only with the help of GI clamps/ rawal plugs etc. as required as per site requirement. Wherever required, the flexible metallic conduits shall be provided to complete the circuit. The zinc coating on GI conduits shall be as per IS-4736. One-way piano type modular switch 6A shall be provided on phase cable. Plugs and Sockets shall conform to IS-1293 and switches to IS-3854. The entire GI box shall have modular plate for switches and 6A modular plugs with required modular design groove cutting for installation of switches/ sockets etc. The wiring shall be done in such a way that minimum conduit pipes run inside the room as far as possible. The size of copper cable used for earthing purpose shall not be less than the size of cable used for wiring and cable shall be ISI marked confirming to relevant IS code, specifications. The Contractor shall be responsible for proper plastering and distempering/ fixing of tiles to restore the original finish of wall such that it matches with original surface and colour of wall on which conduit pipe has been laid. There should be no loose connections in the wiring circuit. Joints in cables are not allowed. Any discrepancy occurred in engineering work during the wiring should be restored in the original condition by the Contractor, at his own cost. All metallic parts, fittings etc. shall be connected to the earth cable. Contractor shall make necessary interface with Civil Contractor during laying of conduits and shall handover conduiting drawing to Civil Contractor in advance.
1.2	**Supply of Material and Provision of 3x2.5 Sqmm Copper Cable Sub-Mains in Conduits**: Supply of material and wiring of sub-main with single core insulated, multi-stranded 2x2.5 sqmm FRLS PVC copper cable in FRLS PVC/ GI conduit ISI mark & 2.5 sqmm FRLS PVC insulated copper cable multi-

	stranded for earthing. Concealed conduit shall be laid with FRLS PVC pipe or GI pipe minimum 25 mm dia (as required). Surface conduits shall not be laid and if required, shall be done with GI pipe only with the help of GI clamps/ rawal plugs etc. as required as per site requirement. Wherever required, the flexible metallic conduits shall be provided to complete the circuit. Cable shall be ISI marked confirming to IS: 694-1990 specifications and make of reference list. The sub wiring shall be done in such a way that minimum conduit pipes run inside the room as far as possible. The size of copper cable used for earthing purpose shall not be less than the size of cable used for phase wiring. The Contractor shall be responsible for proper plastering and distempering/ fixing of tiles to restore the original finish of wall such that it matches with original surface and colour of wall on which conduit pipe has been laid. There should be no loose connections in the wiring circuit. Joints in cables are not allowed. Any discrepancy occurred in engineering work during the wiring should be restored in the original condition by the Contractor, at his own cost. All metallic parts, fittings etc. shall be connected to the earth cable.
1.3	**Supply of Material and Provision of 3x6 Sqmm Copper Cable Sub-Mains in Conduits**: Supply of material and wiring of sub-main with single core insulated, multi-stranded 2x6 sqmm FRLS PVC copper cable in FRLS PVC/ GI conduit ISI mark & 6 sqmm FRLS PVC insulated copper cable multi-stranded for earthing. Concealed conduit shall be laid with FRLS PVC pipe or GI pipe minimum 25 mm dia (as required). Surface conduits shall not be laid and if required, shall be done with GI pipe only with the help of GI clamps, plugs etc. as required as per site requirement. Wherever required, the flexible metallic conduits shall be provided to complete the circuit. Cable shall be ISI marked confirming to IS: 694-1990 specifications and make of reference list. The sub wiring shall be done in such a way that minimum conduit pipes run inside the room as far as possible. The size of copper cable used for earthing purpose shall not be less than the size of cable used for phase wiring. The Contractor shall be responsible for proper plastering and distempering/ fixing of tiles to restore the original finish of wall such that it matches with original surface and colour of wall on which conduit pipe has been laid. There should be no loose connections in the wiring circuit. Joints in cables are not allowed. Any discrepancy occurred in engineering work during the wiring should be restored in the original condition by the Contractor, at his own cost. All metallic parts, fittings etc. shall be connected to the earth cable.
1.4	**Supply and Installation of 6A Modular Switch Socket:**

	Supply and installation of 6A plug, 5-pin 240V modular type switch socket of standard size on existing board and connection with 2.5 sqmm FRLS PVC copper cable. A switch for controlling power supply of plug shall be connected in phase cable and earth cable size shall be same size of wiring to flow maximum fault current.
1.5	**Supply and Installation of 16A Modular Power Switch Socket**: Supply and installation of modular type 16A plug, 6-pin power socket 240V and switch modular type with GI or powder coated metal box concealed in wall and connection with 6sqmm FRLS PVC copper cable. A switch for controlling power supply of plug shall be connect in phase cable and earth cable size shall be same size of wiring to flow maximum fault current.
1.6	**Supply and Installation of 02 Module Plate GI Box**: Supply and installation of 2 module modular plates powder coated for installation of switches and sheet metal box of thickness 2 mm (minimum), good quality concealed fixing of GI box confirming to IS 14772 (2000). GI box should be of standard size.
1.7	**Supply and Installation of 04 Module Plate GI Box**: Supply and installation of 4 module modular plates powder coated for installation of switches and sheet metal box of thickness 2 mm (minimum), good quality concealed fixing of GI box confirming to IS 14772 (2000). GI box should be of standard size.
1.8	**Supply and Installation of 08 Module Plate GI Box**: Supply and installation of 8 module modular plates powder coated for installation of switches and sheet metal box of thickness 2 mm (minimum), good quality concealed fixing of GI box confirming to IS 14772 (2000). GI box should be of standard size.
1.9	**Supply and Installation of 12 Module Plate GI Box**: Supply and installation of 12 module modular plates powder coated for installation of switches and sheet metal box of thickness 2 mm (minimum), good quality concealed fixing of GI box confirming to IS 14772 (2000). GI box should be of standard size.
1.10	**Supply, Installation, Testing and Commissioning (SITC) of 1200 mm Sweep Ceiling Fan with Fan Regulator:** Supply, installation, testing and commissioning of all materials of 240V A.C. 1200 mm sweep ceiling fan having 3 blades, double ball bearing, copper wound motor, suitably sized down rod, canopies and capacitor etc. complete with all accessories including fixing phenolic laminated sheet cover on the fan box, FR PVC insulated multi-stranded three core copper conductor cabling and connecting with earthing system etc. Fan should have ISI mark and as per IS-374 and 5-star energy rating issued by BEE. The modular type electronic fan regulator shall be 5 step type on existing board and connection as per requirement.

1.11	**Supply, Installation, Testing and Commissioning (SITC) Of 300 mm Sweep Exhaust Fan:** Supply, installation, testing and commissioning of exhaust fan 300 mm sweep (having reinforced insulation and metal blade) with louver shutter heavy duty (ISI marked, as per IS-2312), 5-star energy rating issued by BEE and making hole in wall including repairing the same properly with cement-sand (1:4) or M-25 grade concrete and connection complete in all respect, installation of suitable fire-resistant framing etc. The price also covers supply and installation of suitable clamps/ brackets & cost of all materials including cost of FR PVC insulated multi stranded single core copper conductor wiring, earthing connection etc. for fixing above.
1.12	**Supply, Installation, Testing and Commissioning of Double Door, MCB TPN 440V, 8 Module Distribution Boards (DB)**: Supply, installation, testing and commissioning of minimum 1.6 mm thick CRCA power coated (7 tank process) Double Door with MCB TPN 440V, 8 modules 4 row Distribution Board, with neutral and earth link and minimum IP42 ingress protection. The DB shall be with one no. four pole MCB 40A, one no. four pole RCCB 40A 30 mA and twenty four nos. SP MCB 40/32/25/16/10/6 A 'C' series conforming to IS-2675. All MCB should be of 'C 'series with breaking capacity not less than 10 kA. MCB, RCCB and DB should be of same make. The distribution board shall be fixed in such a fashion that its door flushed with the wall on which it is fixed. Circuit breakers shall be conforming to IS/IEC-60898-1.
1.13	**Supply, Installation, Testing and Commissioning of Double Door, MCB SP, 12 Way Distribution Board (DB):** Supply, installation, testing and commissioning of minimum 1.6 mm thick CRCA power coated (7 tank process) Double Door MCB SP 12 way DB, neutral and earth link and minimum IP42 ingress protection, with one no. DP MCB 40A, one no. DP RCCB 40A, 30 mA and eight nos. SP MCB 32/25/16/10/6 A 'C' series. All MCB should be of 'C' series with breaking capacity not less than 10 kA. MCB, RCCB and DB shall be of same make. The distribution board shall be fixed in such a fashion that its door flushed with the wall on which it is fixed.
1.14	**Supply, Installation, Testing and Commissioning of Change Over Distribution Board:** Supply, installation, testing and commissioning of minimum1.6 mm thick CRCA power coated (7 tank process) box of size 610 x 450 x 190 mm approximate change over distribution board with minimum IP42 ingress protection. The distribution board shall be indoor type dust vermin proof knock out/ glands plates as applicable shall be provided in the box for incoming and outgoing cables. Earth terminals shall be provided. Danger notice shall be provided at appropriate place. The complete internal wiring for each phase selector is to be done with copper cable of size 10 sqmm. It shall comprise of following items: - • 01 no. 100 A TPN MCCB as incomer • 01 no. 63 A SPN MCCB as outgoing.

	• 04 nos. integrated LED pilot lamp (3 incoming+1 outgoing) 01 no. 63A selector switch (phase selector switch) without OFF Three pole three ways (Three phase incoming & only one phase outgoing).
1.15	**Supply, Installation, Testing and Commissioning of MCCB 200A (4 Pole, 36 kA):** Supply, installation, testing and commissioning of four Pole Moulded case circuit breaker (MCCB) of 200A, 36 kA with adjustable thermal, fix magnetic release complete. MCCB is to be provided in minimum 1.6 mm thick CRCA power coated enclosure at location as per the site requirement.
1.16	**Supply, Installation, Testing and Commissioning of Double Door, 63A MCB SP 8 Way Distribution Board:** Supply, installation, testing and commissioning of minimum 1.6 mm thick CRCA power coated Double Door MCB SP 8 way DB, neutral and earth link and minimum IP42 ingress protection, with one no. DP MCB 63A, one no. DP RCCB 63A, 30 mA and eight nos. SP MCB 32 A 'C' series (for feed from ACO Panel). All MCB should be of 'C' series with breaking capacity not less than 10 kA. MCB, RCCB and DB shall be of same make. The distribution board shall be fixed in such a fashion that its door flushed with the wall on which it is fixed.
1.17	**Supply and Installation of Junction Box Size 390(H)x305(B)x170(D) mm:** Supply and installation of junction box size 390(H)x305(B)x170(D) mm comprising stainless steel material with 1.6 mm thick sheet having power coating with 7 tank processes with rubber gasket, padlock arrangement, zinc passivated earth bolt, etc. with terminals suitable for 440V/240V supply requirement. All busbars and terminals in the junction box shall be of copper material with 4 nos. copper bus bar capacity 200A, 250mm long suitable for 440V supply requirement. The box shall be fixed robustly with clamps at pole/ wall as per requirement. All the material should be of good quality.
1.18	**Supply, Installation, Testing and Commissioning of Control and Distribution Panel for Colour Light Signalling (CLS) for 10/ 25/ 50 kVA AT supply:** Supply, installation, testing and commissioning of automatic changeover panel complete as per RDSO specification No. TI/SPC/PSI/CLS/0020 (12/02) with A&C slips No. 1 to 4 or latest, connections as required. The Make of panel shall be on the approved list of manufacturers issued by RDSO/ Lucknow.
1.19	**Supply and Installation of Metal Clad Plug Socket 20A, Single Phase with 32A MCB:** Supply and installation of metal clad plug socket 20A single phase with 32A MCB SP 10kA, C series including installation and sheet metal enclosure box with one 20A plug top (Ray roll type) to be supplied with board.
1.20	**Supply and Installation of Metal Clad Plug Socket 16A, Single Phase with 20A MCB:** Supply and installation of metal clad plug socket 16A single phase

	with 20A MCB SP 10kA, C series including installation and sheet metal enclosure box with one 16A plug top (Ray roll type) to be supplied with board.
1.21	**Supply, installation, testing and commissioning of 20 mm dia GI Conduit:** Supply, installation, testing and commissioning of 20 mm dia GI Conduit concealed/surface including all junction boxes (2 way, 3 way, 4 way as required), bends etc. conforming to IS-9537.
1.22	**Supply, installation, testing and commissioning of 25 mm dia GI Conduit:** Supply, installation, testing and commissioning of 25 mm dia GI Conduit concealed/ surface including all junction boxes (2 way, 3 way, 4 way as required), bends etc. conforming to IS-9537.
1.23	Design and Drawing of conduits, wiring, panels, distribution board, as built drawings, survey, calculation etc. for item no. 1.1 to 1.22.
2 LT & HT CABLES AND LAYING	
2.1	**Supply of 2 Core x 10 sqmm Copper Cable:** Supply of 1.1 KV grade 2 Core x 10 Sqmm LT XLPE insulated, FRLS, armoured copper conductor cable, end terminations with suitable crimping sockets/ lugs, gland, testing and meggering etc. as per required technical specifications & confirming to IS: 7098, IS: 8130 and IEC-60502-1 standards with latest amendment.
2.2	**Supply of 2 Core x 16 sqmm Copper Cable:** Supply of 1.1 KV grade 2 Core x 16 Sqmm LT XLPE insulated, FRLS, armoured copper conductor cable, end terminations with suitable crimping sockets/ lugs, gland, testing and meggering etc. as per required technical specifications & confirming to IS: 7098, IS: 8130 and IEC-60502-1 standards with latest amendment.
2.3	**Supply of 2 Core x 35 sqmm Copper Cable:** Supply of 1.1 KV grade 2 Core x 35 Sqmm LT XLPE insulated, FRLS, armoured copper conductor cable, end terminations with suitable crimping sockets/ lugs, glands, testing and meggering etc. as per required technical specifications & confirming to IS: 7098, IS: 8130 and IEC-60502-1 standards with latest amendment.
2.4	**Supply of 2 Core x 70 sqmm Copper Cable:** Supply of 1.1 KV grade, 2 Core x 70 Sqmm LT XLPE insulated, FRLS, armored copper conductor cable, end terminations with suitable crimping sockets/ lugs, glands, testing and meggering etc. as per required technical specifications & confirming to IS: 7098, IS: 8130 and IEC-60502-1 standards with latest amendment.
2.5	**Supply of 2 Core x 95 sqmm Copper Cable:** Supply of 1.1 KV grade, 2 Core x 95 Sqmm LT XLPE insulated, FRLS, armored copper conductor cable, end terminations with suitable crimping sockets/ lugs, glands, testing and meggering etc. as per required technical specifications & confirming to IS: 7098, IS: 8130 and IEC-60502-1 standards with latest amendment.

2.6	**Supply of 4 Core x 120 sqmm Copper Cable:** Supply of 1.1 KV grade 4 Core x 120 Sqmm LT XLPE insulated, FRLS, armoured copper conductor cable, end terminations with suitable crimping sockets/ lugs, glands, testing and meggering etc. as per required technical specifications & confirming to IS: 7098, IS: 8130 and IEC-60502-1 standards with latest amendment.
2.7	**Supply of 4 Core x 240 sqmm Copper Cable:** Supply of 1.1 KV grade 4 Core x 240 Sqmm LT XLPE insulated, FRLS, armoured copper conductor cable, end terminations with suitable crimping sockets/ lugs, glands, testing and meggering etc. as per required technical specifications & confirming to IS: 7098, IS: 8130 and IEC-60502-1 standards with latest amendment.
2.8	**Supply, Installation, Testing and Commissioning of LT Heat Shrinkable Straight Through Joint:** Supply, installation, testing and commissioning of LT heat shrinkable straight through joint (conforming to IS-1255) with required accessories complete in all respect suitable for XLPE 1.1 kV and above rating cables as per site requirement.
2.9	**Supply of 3 Core x 120 sqmm 11 kV Copper Cable:** Supply of 3 Core x 120 Sqmm 11 kV XLPE insulated, armoured, Copper conductor Cable conforming to IS: 7098 (Part 2)/ 2011 or latest.
2.10	**Supply and Installation of End Termination Kit for 3 core 70 to 185 Sqmm, 11 kV Copper Cable:** Supply and installation of outdoor type, heat shrinkable, end termination kit suitable for 3 core 11 kV 70 to 185 Sqmm XLPE insulated, armoured Copper conductor cable and making termination connections with overhead conductor, testing and commissioning etc. The material shall conform to IS-1255.
2.11	**Laying of LT/ HT Cables (All Size) In Air/ Pipe/ Cable Tray/ Trench etc.:** Laying and commissioning of LT/ HT XLPE insulated armoured sheathed copper cable underground/ under the road/ under the track along with pole/ wall/ trench/ air in already laid pipe. Before and after laying cable, the IR value should be checked. While laying the cable, care should be taken that no tree roots/ water logging area come on the way of cable, as it may damage the outside insulation of cable. Armoring at both ends of the cable should be earthed. At termination point of cable suitable lugs and brass glands of suitable size and good quality shall be provided. The Contractor shall restore the original condition of the Roads/ platform/ concrete flooring after laying of cable. Bending radius of the cable shall not be less than 16 times of dia. of the cable. Wherever the cable emerges out of the ground at least two loops of sufficient radius should be laid. Installation of cable along with wall/ pole/ roof top/ underneath sheds wherever required shall be done with support of G.I. Saddles/ clamp of proper size and GI Pipe as required. Breaking of floor/ wall/ road and other civil structures and repairing up to original condition, shall be done by the

	Contractor, and no extra cost shall be paid for it. Permission for crossing any road/ track if required shall be arranged by the Contractor in coordination with Engineer, and all the expenditures shall be borne by the Contractor. All the instruments required for insulation testing, high voltage testing shall be arranged by the Contractor at his own cost. The cable shall be transported by the Contractor through his own means from major electrical depot to required site of work. Before transportation of the cable it shall be tested at site to ascertain the serviceability of the cable by the Contractor. The work shall conform to IS-1255.
2.12	**Excavation and Refilling of Trench of Size 500 mm Wide and depth up to 1200 mm (as per design) for cables:** Excavation and refilling of Trench of size 500 mm wide and depth up to 1200 mm (as per design with the approval of the Engineer) in all kinds of soil for laying of HDPE/ GI pipe for underground cables crossing. Contractor shall clear all metallic parts & stones etc. in trench. After laying of pipe, the trench should be refilled with same soil, ramming and restore to original position. After cable/ pipe laying Contractor shall clear all site debris. The excess earth and debris etc. shall be disposed off upto a distance of 2km at suitable place by the Contractor.
2.13	**Laying Of Cable Under the Road/ Railway Track, Recessing in Platform/ Wall laid in GI pipe:** Laying of underground cable under the Road/ Railway Track, recessing in platform/ wall along with Railway Track in laid in GI pipe as required for LT/ HT XLPE insulated armoured, copper conductor cable including making chase & plastering after laying of cable/ digging of cable trench, sand cushioning, protective covering with bricks of compressive strength class designation 10 (minimum). All cable connection shall be made with proper size of crimping socket/ glands by the Contractor at his own cost and labour.
2.14	**Supply and Laying of HDPE Pipe (90 mm outside dia)**: Supply and laying of HDPE pipe in already excavated trench under floor, platform, road, ground, air etc. as per site requirement size 90 mm outside dia wall thickness 4.3 mm to 5.0 mm, PN-4 conforming to IS 4984:1995 or latest as per site requirement (including laying of 63 mm outside dia HDPE pipe for making connection to 90 mm outside dia HDPE pipe and reducer wherever required). Pipe should be laid in trench such that it shall be possible to withdraw the cables for repair or replacement without disturbing the work. The pipes shall be laid with a gradient to facilitate drainage of water. Accessories related with laying of HDPE pipe like fitting, bends joints/ coupler junction, flange end cap etc. as per site requirement shall be provided by Contractor and the payment of 90 mm outside dia HDPE pipe shall include all these items as required.
2.15	**Supply and Laying of HDPE Pipe (90 mm outside dia) at platform along with pit and cover**: Supply and laying of HDPE Pipe (90 mm outside dia) at platform

	along with pit and cover at every 40m as per design in already excavated trench at platform as per site requirement. The HDPE pipe size shall be 90 mm outside dia, wall thickness 4.3 mm to 5.0 mm, PN-4 conforming to IS 4984:1995 or latest. Pipe should be laid in trench such that it shall be possible to withdraw the cables for repair or replacement without disturbing the work. The pipes shall be laid with a gradient to facilitate drainage of water. Accessories related with laying of HDPE pipe like fitting, bends joints/ coupler junction, flange end cap etc. as per site requirement shall be provided by Contractor and the payment of 90 mm outside dia HDPE pipe shall include all these items as required. The pit shall be with bricks having inside dimensions 400x400 mm with 400 mm depth and M-25 RCC cover thickness shall be 75mm and pit cover shall cover the entire brick work. The top layer of cover shall flush with platform level as per design.
2.16	**Supply and Laying of HDPE Pipe (125 mm outside dia)**: Supply and laying of HDPE pipe in already excavated trench underfloor, platform, road, ground, air etc. as per site requirement, size 125 mm outside dia wall thickness 6 mm to 6.8 mm, PN-4 conforming to IS 4984:1995 or latest. Pipe shall be laid in trench such that It shall be possible to withdraw the cables for repair or replacement without disturbing the work. The pipes shall be laid with a gradient to facilitate drainage of water. Accessories related with laying of HDPE pipe like fitting, bends joints/ coupler junction, flange end cap etc. as per site requirement shall be provided by Contractor and payment of HDPE pipe shall include all these items as required.
2.17	**Supply and Laying of HDPE Pipe (160 mm outside dia):** Supply and laying of HDPE pipe in already excavated trench under floor, platform, road, ground, air etc. with technical specification of 160 mm dia (OD), wall thickness between 7.7 mm to 8.6 mm, PN-4 with confirming to IS: 4984/1995 of latest. Pipe shall be laid in trench such that possible to withdraw the cable for repair or replacement. The pipes shall be laid with a gradient to facilitate drainage of water. Accessories related with laying of HDPE pipe like fitting, bends joints/ coupler junction, reducer, flange end cap etc. as per site requirement shall be provided by Contractor and payment of HDPE pipe shall include all these items as required.
2.18	**Supply and Laying of GI Pipe (nominal bore 125 mm):** Supply and laying of 125 mm dia GI Pipe medium class as per IS 1239 under road/ Railway track. The GI pipe shall be fixed with pole/ wall/ structure etc. by GI flat/clamps of suitable size & GI nut-bolt-washer etc. In the case of GI pipe is laid in road/ permanent floor/ other civil structures etc, and require any dismantling then repairing up to original condition shall be done by the Contractor. The pipes shall be laid with a gradient to facilitate drainage of water and shall be laid right angle to the track. Accessories related with laying of HDPE pipe like fitting, bends joints/ coupler junction, reducer, flange end cap etc. as per site requirement shall be provided by Contractor and payment of GI pipe shall include all these items as required.

2.19	**Supply and Installation of Cable Route Marker:** Supply and installation of Cable Route marker along straight runs of the cables at locations approved by the Engineer and generally at intervals not exceeding 100 meters. Wherever, the cable route is changing or it is entering a fixed installation, route marker shall be provided. Route marker shall also be provided at joints of cable. The item price includes labour & cost of all materials including cost of cable route markers. The route marker shall be 150mm dia, 6mm thick GI plate welded with GI angle of size 40x25x5mm and lower part of angle shall be embedded (end slightly bent) in 150x150x150mm M-15 cube which shall be buried 200 mm below the ground as per drawing. The plate shall be painted in yellow paint and on one face of plate HRIDC shall be painted in black paint and on other side voltage level (240V/440V/11000V) as applicable shall be marked. Drawing of cable route marker shall get approved from Engineer before installation.
2.20	**Drilling of horizontal bore below Railway track by pushing method for laying of HDPE/GI pipe:** Drilling of horizontal bore by pushing method (trenchless technology) in all types of soil/ rock for laying of HDPE/GI pipe dia up to 250mm by pushing method. Horizontal boring shall be done at minimum 1.5 metre below or as per site requirement from ground level at Road/ canal/ bridges/ Railway track portion but in case, where bank is high then boring should be such that outer side and under track HDPE/ GI pipes are in same alignment. All work shall be done without disturbing the Road/ canal/ bridges/ Railway track taking all necessary safety precautions related to Road/ canal/ bridges/ track and movement of Road transport and trains.
2.21	Design and Drawing of cable layout, trench layout, route markers, cable and pipe schedule, as built drawings, survey, calculation etc. for item no. 2.1 to 2.20.
3 LIGHTING, STREET LIGHT POLE AND HIGH MAST	
3.1	**Provision of 22 Watt LED Tube Light:** Supply, installation, testing & commissioning of surface mounted Energy efficient LED tubular lamp with fitting and its driver and Luminaries (22 watt), of CRCA steel sheet enclosure, IP-20 for indoor application, operating voltage (140-270) V, minimum 2000 lumens, complete with all accessories of approved make etc. The item price also includes labour & cost of all materials including cost of FRLS PVC insulated multi stranded single core copper conductor cable, earthing connection etc. The price also covers supply and installation of suitable clamps/ brackets etc. to fix light fittings under FOB/ Poles/ roofs/ walls/ sheds etc. The material shall conform to IS-2418, IS-3528, IS-5077, IS-10322, IS-16101, IS-16102, IS-16103, IS-16106, IS-16107 and other specifications as applicable.
3.2	**Provision of 40 Watt LED Street Light Fitting:** Supply, installation, testing & commissioning of Energy efficient 40 Watt LED with street light fitting with pressure die cast aluminium housing with driver & suitable fixing arrangement, IP-65 for outdoor application, operating voltage (140-270) V, System efficacy more than

	100 lumen/W, complete with all accessories of approved make etc. The item price also includes labour & cost of all materials including cost of FRLS PVC insulated multi-stranded single core copper conductor cable, earthing connection etc.
3.3	**Provision of 120 Watt LED Street Light Fitting:** Supply, installation, testing & commissioning of Energy efficient 120 Watt LED with street light fitting with pressure die cast aluminium housing with driver & suitable fixing arrangement, IP-65 for outdoor application, operating voltage (140-270) V, System efficacy more than 100 lumen/W, complete with all accessories of approved make etc. The item price also includes labour & cost of all materials including cost of FRLS PVC insulated multi-stranded single core copper conductor cable, earthing connection etc.
3.4	**Provision of Rechargeable Batten Type 240 Watt Emergency Light:** Supply, installation, testing & commissioning of rechargeable batten type Emergency light, 240 watt (60 LEDs 4 watts) with Two-hour minimum backup. The battery life shall be minimum 4 years. The luminaire shall provided rated lumen within 5 second after switching on. The material shall conform to IS-9583.
3.5	**Provision of Outdoor LED Type Flood Light Luminaries (200 Watt):** Supply, installation, testing & commissioning of 200 watt pre wired LED Flood light fitting with 200 watt LED Type Flood Light Luminaries complete conforming to BAJAJ Cat. No. BARFEG-200W LED or equivalent with IP- 65 protection with LEDs and driver and all accessories. The Contractor shall make necessary fixing/ suspension arrangement for LED fitting. **Specification of LED fitting:** The LED lamps, driver & luminaries shall be suitable for outdoor lighting/ facade lighting and other installations. **Technical requirements of LED Flood light fitting:** (i) LED efficacy shall be 120 lumen/ watt for luminaire system wattage. (ii) LED used should be of Surface Mounted Diode (SMD) type only. (iii) L70 Reported Life span of LEDs used in the luminaries shall be greater than 50,000 hrs. at the soldering point temperature of 85°C. (iv) Color temperature of the proposed white color LED shall be 5700 K (minimum). (v) Color Rendering Index (CRI): Greater than 65. **Technical requirements of Driver:** (i) Efficiency of driver: power output rating > 100 W = 90% (ii) Power factor of complete fitting: 0.90. (iii) Input Operating Voltage: 140V to 270 V. (iv) Short circuit protection: Compliant

	(v) Open load protection: Compliant (vi) Driver Surge Protection standard: (a) 3 kV Min (b) 10 kV for lighting prone location (External to driver circuit). (vii) Total Harmonic Distortion (THD): Less than 20% at full load. (viii) Tc (Maximum Driver case temperature) must be declared on the data sheet. (ix) Isolated driver should be used. **Technical requirements of Luminaire:** (i) Shall submit the LM-79 and/or IS: 16106 test report. The manufacturer shall submit accreditation that the luminaire submitted for LM-79 testing was equipped with the LED Driver now being offered by the Contractor. (ii) Cover type: Toughened glass or UV stabilized polycarbonate cover. The material shall conform to IS-3528, IS-10322, IS-16101, IS-16106, IS-16107 and other specifications as applicable.
3.6	**Supply, installation, testing and commissioning of 11 meter high cast iron decorative street light pole**: Supply, installation, testing and commissioning of 11 meter high cast iron decorative platform/street light pole with single/double arm model with all accessories i.e. GI pipe, clamps, nuts, bolts etc. along with outdoor type junction box with 5A MCB complete as required with anti corrosive treatment and suitable for 50m/s wind speed. Galvanized base plate of 220 x 220x 12 mm (as per IS 2062) and GI bolt size M20 X 600mm X 4 nos. (as minimum) in position including excavation of pit and filling the same with M-25 grade concrete with two curved 63mm dia HDPE pipe embedded in foundation for cable loop-in-loop-out including supply of material as required or recommended by pole manufacturer. The allied accessories such as cross arms bakelite sheet with SP MCB (6A, C series) and stud terminals, clamping, etc. are included. Single arm (and double arm as per requirement) of 500 to 1500 mm length are to be provided as per the site requirement with the approval of Engineer. The bakelite sheet with MCB & stud terminals shall be provided in the base compartment of the poles. All the connecting terminals shall be properly tightened and crimped in order to avoid any loose connection. Earthing of pole shall be done in proper manner under the designated item of earthing. Prior approval of foundation and pole/arm drawing shall be obtained from Engineer. The item shall also include LED light fitting accessories i.e. GI pipe, clamps, nuts, bolts etc. The outdoor type junction box (IP65 protection) shall have loop-in loop-out arrangement for feeding cable and with 5A MCB to control pole light fittings. The cable connections shall be with proper thimbling arrangement. GI pipe shall be medium class conforming to IS 1239 and size of GI pipe shall be as per LED fitting. The Contractor shall design the spacing between two poles based on lux level calculations. The platform lights shall be controlled by Assistant Station Master

	(ASM) and suitable control shall be provided by the Contractor. This is in addition to the Modular Digital Timers for control of platform lights (the cost of Timer shall be paid under relevant Timer material item). Contractor shall prepare complete drawing of decorative street/platform light pole, single/double arm, its foundation, accessories, control from ASM chamber etc. as required and obtain approval of the Engineer.
3.7	**Supply, Installation, Testing and Commissioning of (OFF Delay) Modular Digital Timers:** Supply, installation, testing and commissioning of modular digital timer for automatic operation of platform, circulating area, street light etc. complete with required power contactor, digital timer, wiring, MCB etc. suitable for outdoor as required in minimum 1.6 mm CRCA powder coated enclosure of suitable size. The timer shall be programmable to any time (ON/OFF) in 24 hours. The timer shall switch ON lights at preset time and shall switch OFF also at preset time. The life of timer shall not be less than 10 years. The manufacturer's certificate regarding life shall be submitted. Contractor shall submit drawing and obtain approval of Engineer.
3.8	**Supply, Installation, Testing and Commissioning of 20 Meter High Mast:** **Structure:** The 20 meter high mast, shall be of continuously tapered, polygonal cross section minimum 20 sided, presenting a good and pleasing appearance (as per manufacture design) and shall be based on proven in-tension design conforming to relevant standards to give an assured performance and reliable service. The mast shall be designed as per IS-875 (Part 3) and Technical Report 7 (TR 7) of the Institution of Lighting Engineers. **Construction:** The Mast shall be fabricated from special steel plates, to BSEN-10025 cut and folded to form polygonal section and shall be telescopically jointed and fillet welded. The welding shall be in accordance with BS: 5135. The mast section shall have one longitudinal seam weld and no circumferential weld as per section. The Mast shall be delivered in minimum sections as per design without any circumferential welding at site, which shall be joined together by slip-stressed-fit method. The jointing shall be with stressing equipment, thus forming the sleeve joint. No site welding or bolted joint shall be accepted. The overlap distance shall have full penetration of longitudinal welds. The overlap distance shall be 1.5 times the diameter at penetration. The base plate of the mast shall be at least 25mm thick. A door opening of minimum 950mm x 225mm shall be provided at the base of each Mast. For metal protection of the Mast, the entire fabricated Mast shall be hot dip galvanized internally and externally, having minimum average thickness of 75 microns suitable for wind velocity of 50m/s as per IS 875 Part-3.

	The mast sections shall be galvanized by single dipping method. Sections galvanized by double/ multiple dipping methods shall not be accepted. The Contractor may propose heavier sections also. **Foundation: -** The Contractor shall see the site closely and minutely with regard to the nature of the soil, average depth of decomposed garbage and debris at proposed site, mast location and the other site conditions before working out the type of foundation and specification for the proposed High Mast. The Contractor shall be responsible for the design of the foundation and safe installation of the High Mast in mechanically and structurally safe working condition for the design life of the Mast. The load bearing (safe) capacity of the soil shall be carried out by the Contractor to decide the type of foundation. The holding down GI bolts shall be 16 Nos. of high tensile strength (EN – 19 grades) and shall be supplied complete with GI anchor plate of 6 mm thick for casting into the foundation. The precision made steel template with tube holes shall be provided to ensure correct vertically and horizontally of bolt alignment. The casting shall be with M-25 grade RCC concrete with safe soil bearing cap at site as 10 T/m^2 at 3 meter depth. Foundation shall bear the wind pressure minimum 200 kg/m^2 and earthquake of Haryana region. Prior approval of foundation drawing shall be obtained from the Engineer. **Door Opening: -** An adequate door opening shall be provided at the base of the mast and the opening shall be such that it permits clear access to equipment's like winches, cables, plugs and sockets etc. and also facilitate easy removal of the winch. The door opening shall be complete with a close fitting, vandal resistant, weatherproof door, provided with a heavy-duty double internal lock with special paddle key. The door opening shall be carefully designed and reinforced with welded steel section; so that the mast section at the base shall be unaffected and undue buckling of the cut portion is prevented. Size of door opening shall be minimum 950 x 225 mm to avoid buckling of the mast section under heavy wind condition. **Dynamic Loading For Mast: -** The Mast structure shall be designed for an assumed maximum reaction arising from the maximum wind speed (50m/s) likely to be exceeded only once in 50 years (180 km per hour) and is measured at height of 10M above ground level. The design life of the Mast shall be 30 years. Wind excited oscillations shall be damped by the method of construction and adequate allowance is made for the related stresses. The offered High Mast shall be a tested design. **Fabrication: -** A fabricated lantern carriage shall be provided for installation and holding the flood light fittings and control gearboxes. The lantern carriage shall be of special design and shall be of steel tube construction, the tubes acting as conduits for wires, with holes fully protected by grommets. The lantern carriage shall be so designed and

	fabricated to hold the required number of flood light fittings and the control gearboxes also have a perfect self-balance. The lantern carriage shall be fabricated in two halves and joined by bolted flanges with stainless steel bolts and nylon type stainless steel nuts to enable easy installation or removal from the erected mast. The inner lining of the carriage shall be provided with protective PVC arrangement, so that no damage is caused to the surface of the mast during the raising and lowering operation of the carriage. The entire lantern carriage shall be hot dip galvanized after fabrication. **Raising And Lowering Mechanism: -** For the installation and maintenance of the luminaries and lamps, it shall be necessary to lower and raise the lantern carriage assembly. To enable this, a suitable winch arrangement shall be provided, with the winch fixed at the base of the mast and the specially designed head frame assembly at the top. **Winch: -** The winch shall be of completely self-sustaining type, without the need for brake shoe, springs or clutches. Each driving spindle of the winch shall be positively locked when not in use, by gravity activated pawls. Individual drum also should be operated for fine adjustment of lantern carriage. The capacity, operating speed, safe working load, recommended lubrication and serial number of the winch shall be clearly marked on each winch. The gear ratio of the winch shall be 53:1. However, the minimum working load shall be not less than 750 kg. The winch shall be self-lubricating type by means of an oil bath and the oil shall be readily available grades of reputed producers. The winch drums shall be grooved to ensure perfect seat for stable and tidy rope lay, with no chances of rope slippage. The rope termination in the winch shall be such that distortion or twisting is eliminated and at least 5 to 6 turns of rope remains on the drum even when the lantern carriage is fully lowered and rested on the rest pads. It should be possible to operate the winch manually by a suitable handle and/or by an integral power tool. Operation of the winch with manual handle shall be independent of the power tool. Winches with manually operation through the power tools shaft shall not be accepted. Individual drum operation of the winch shall be possible. A Double drum winch shall have 2 drums and two worm gears independent in operation for increased safety. It shall be possible to remove the double drum after dismantling, through the door opening provided at the base of the mast. Also, a winch gearbox for simultaneous and reversible operation of the double drum winch shall be provided as part of the Contract. The winch shall be type tested in presence of a reputed institution and the test certificates shall be furnished before supply of materials. A test certificates shall be furnished by the Contractor from the original equipment manufacturer, for each winch in support of the maximum load operated by the winch.

	Head Frame: - The head frame which is to be designed as a capping unit of the mast, shall be of welded steel construction, galvanized both internally and externally after assembly. The top pulley shall be of appropriate diameter, large enough to accommodate the stainless steel wire ropes and the multi-core electrical cable. The pulley block shall be made of non-corrodible material, and shall be of die-cast Aluminium Alloy (LM-6). Pulley made of synthetic materials such as plastic or PVC is not acceptable. Self-lubricating bearings and stainless steel shaft shall be provided to facilitate smooth and maintenance free operation for a long period. The pulley assembly shall be fully protected by a canopy galvanized internally and externally. Close fitting guides and sleeves shall be provided to ensure that the ropes and cables do not dislodged from their respective positions in the grooves. The head frame shall be provided with guides and stops with PVC buffer for docking the lantern carriage. **Stainless Steel Wire Ropes: -** The suspension system shall essentially be without any intermediate joint and shall consist of only non-corrodible stainless steel of minimum AISI 316 grade. The stainless steel wire ropes shall be of 7/19 (7 strands including 19 wires each), the central core of stainless steel material. The overall diameter of the rope shall not be less than 8mm. The breaking load of each rope shall not be less than 2350 kg giving a factor of safety of not less than 5 for the system at full load as per the TR-7. The end constructions of rope to the winch drum shall be fitted with talurit. The thimbles shall be secured on ropes by compression splices. Three continuous lengths of stainless steel wire ropes shall be used in the system and no intermediate joints are acceptable in view of the required safety. No intermediate joints/ terminations, either bolted or else, shall be provided on the wire ropes between winch and lantern carriage. **Power Tool For The Winch: -** A suitable high powered, electrically driven, internally mounted power tool, with manual override shall be supplied for the raising and lowering of the lantern carriage for maintenance purposes. The speed for the power tool shall be to suit the system. The power tool shall be single speed. Provided with motor of the required rating. The power tool shall be supplied complete with a suitable control switch so that the operation of the mast can be done at a safe distance. The capacity and speed of the electric motor used in the power tool shall be suitable for the lifting of the design load installed on the lantern carriage. The power tool mounting shall be so designed that it shall be not only self-supporting but also aligns the power tool perfectly with respect to the winch spindle during the operations. Also, a handle for the manual operation of the winches in case of problems with the electrically operated tool, shall be provided and shall incorporate a torque limiting device. There shall be a separate torque-limiting device to protect the wire

	ropes from over stretching. It shall be mechanical with suitable load adjusting device. The torque limiter shall trip the load when it exceeds the adjusted limits. There shall be suitable provision for warning the operator once the load is tripped off. The torque limiter is a requirement as per the relevant standards in view of the overall safety of the system. Each mast shall have its own power tool motor. **Electrical System, Cable and Cable Connections: -** A suitable terminal box shall be provided as part of the contract at the base compartment of the high mast for terminating the incoming cable. The electrical connections from the bottom to the top shall be made by special trailing cable. The cable shall be EPR (Ethylene Propylene Rubber) insulated and PCP (Polychloroprene) sheathed to get flexibility and endurance. Size of the copper cable shall be minimum 5 core 2.5 Sqmm of reputed make. At the top there shall be weatherproof (GI or 7 tank powder coated) junction box to terminate the trailing cable. Connections from the top junction box to the individual luminaries shall be made by using 3 core 1.5 Sqmm flexible PVC copper cables of reputed make. The system shall have in-built facilities for testing the luminaries while in lowered position. Also, suitable provision shall be made at the base compartment of the mast to facilitate the operation of internally mounted, electrically operated power tool for raising and lowering of the lantern carriage assembly. The trailing cables of the lantern carriage rings shall be terminated by means of specially designed, metal clad, multi-pin plug and socket provided in the base compartment to enable easy disconnection when required. **Incoming Power Cable:** 4x2.5 Sqmm copper conductor armored cable for motor supply shall be provided from High mast control panel to the base compartment of the high mast. Cable shall be taken to the base compartment of the high mast through the provision made with 63mm dia HDPE pipe embedded in foundation. Power cable of suitable size up to the feeder pillar from supply point shall be laid by the Contractor. All copper cables required are included in the cost of the tender. **Lightning Arrestor:** One number heavy duty hot dip galvanized lighting spike rod shall be provided for each mast. The lightning spike rod shall be minimum 1.2 meter in length and shall be provided at the centre of the head frame. It shall be bolted solidly to the head frame to get a direct conducting path to the earth through the mast. **Aviation Obstruction Lights:** Aviation lighting arrangement shall be made on the top of high mast system and two nos. light fittings shall be fitted on each high mast complete with wiring. The fittings shall be of Bajaj reference BJAOL-I or similar Philips/ Crompton make. **Earthing Terminals:** Suitable earth terminal using 12 mm diameter stainless steel bolts shall be provided at a convenient location on the base of the mast for

lightening and electrical earthing of the mast.

High Mast Control Panel:

Each mast shall be provided with a control panel fabricated out of 14 SWG CRCA sheet (GI or 7 tank powder coated). It is to be mounted on a raised plate from above ground level. Construction endures suitability for outdoor use.

Basic components inside the control panel shall consist of the following: -

- 1X63 A TPN MCB for incoming supply
- 3X32 A SPN MCB for outgoing (50% lighting, 100% lighting, motor)
- Automatic Astronomical Timer with contactor of suitable capacity for control of lighting.
- 1 no. multi plug socket 16A for Auxiliary power supply.
- 2 nos. of contactors for forward and reverse operation of winch motor.

Control Panel shall be connected with the help of a cable to the remote control switch for raising and lowering of the lantern carriage. The power feed cable should be flexible, sheathed copper type and shall be connected between the control panel and the junction box on the lantern carriage. The control panel shall be suitable for outside use weatherproof.

Technical Data for High Mast and Components:

A. High Mast Structures:

i) Height of Mast : 20 Meter

ii) Material of construction: High tensile steel as per BSEN 10025

iii) Thickness (in mm)

Section	Thickness (20 Meter)
Top	3 mm
Middle	4 mm
Bottom	5 mm

iv) Cross section of mast : In polygon minimum 20 sides or as per design

v) No. of section of Masts : 3

vi) Base and top diameters : 150mm (minimum) at Top 560mm (minimum) as per design of manufacture for 20m

vii) Type of joints : Telescopic stress fit (slip over joint system) with no circumferential weld

viii) Thickness of galvanization : Minimum 75 Microns as per BSEN ISO 1461

ix) Size of opening of door at base : Not less than 950mm x 225mm

x) Length of overlap minimum : 1.5 times the diameter at penetration

B. Dynamic Loading:

i) Max. Wind speed : 50m/s
ii) Height forms the ground level : 10 Meter for measurement of wind Velocity
iii) Factor of safety for wind loads : More than 1.25
iv) Factor of safety for material : More than 1.15 (as per TR No.7)
v) Factor of safety of Tower : More than 1.5

C. Lantern Carriage:

i) Material of construction : G.I (Hot dip galvanized)
ii) Buffer arrangement between Carriage & mast. : PVC sleeves

D. Winch:

i) No. of winch per mast : One (Double drum)

E. Method Of Operation: : MANUAL/ ELECTRICAL

i) Lubrication : Self-lubricating permanent oil bath
ii) Safe Working Load (SWL) of the winch : 750 Kg
iii) Breaking system : In built
iv) Gear ratio : 53:1

F. Power Tool:

i) Power supply : 240 Volts, 50 C/S, AC supply
ii) Speed of power tool : 1.2 meter/ min
iii) Number of speeds : Single speed
iv) Reversible/ non-reversible : Reversible
v) Remote control switch
a) Type : Push Button.
b) Length of control cable : 5 Meter copper.

G. Foundation:

i) Type of foundation : Open raft shallow M-25 grade RCC type
ii) Size of foundation : As per site conditions considered and as per design
iii) Considered wind speed/ pressure : 200 Kg/ SqM
iv) Design safety factor considered : 2.5 (minimum)

H. Stainless Steel Wire Rope:

i) Grade : AISI 316 or better Grade
ii) Nos. of ropes : Not less than 2 continuous ropes
iii) Construction : 7/19
iv) Center core material : Stainless steel wire.

	v) Breaking load capacity : 2350 Kg vi) Factor of safety : not less than 5 per rope as per TR-7 **I. Torque Limitor:** a) Lifting capacity : Up to 700 Kg b) Adjustable/ Non- Adjustable : Adjustable **J. High Mast Enclosure:** Each mast shall be completely enclosed from all sides with GI panels of dimensions 1200mmx1200mm (with GI Wire Mesh 25mmx25mmx5mm) with 50x6 mm GI stiffners and wire mesh shall be enclosed in GI angles 50x50x6mm. The enclosure shall have proper entrance supported with 75x75x8 mm GI angles and 50x6 mm GI flats as required with locking arrangement etc. This enclosure shall be embedded in M-25 grade concrete work as per site requirement and approved by the Engineer.
3.9	Design and Drawing of high masts, platform/street poles, digital timer, foundation, lighting lux calculations, earthing, calculation, survey, as built drawings etc. for item no. 3.1 to 3.8.
4 ELECTRICAL EQUIPMENTS (PUMPS, AIR-CONDITIONERS, UPS, WATER COOLER ETC.)	
4.1	**Supply of Submersible Pump Set of 7.5 kW:** Supply of submersible energy efficient pump set of 7.5 kW (3 star & above rated), 20 Stages, Head Range: 15 Metre or above, 15000 LPH or above, 440 V, 3-phase, AC complete with all accessories as per site requirement. The material shall conform to IS-8034, IS-9283 or as applicable.
4.2	**Supply, Installation, Testing and Commissioning of Automatic Control Panel For 7.5 kW Three- Phase Submersible Pump:** Supply, installation, testing and commissioning of automatic control panel with star-delta starter for 7.5 kW three-phase submersible pump voltage 380 – 440 volt, 3-phase, AC, 50Hz, IP protection IP-52. The panel box shall be stainless steel or CRCA powder coated. The cables shall be copper including connections and providing cable from main board to control panel and connection for Water Level Controller (WLC) in bore well. Necessary switchgear including protection, meters, selector switch, pushbuttons etc. as required for successful operation of submersible pump shall be provided. The approval of Engineer shall be obtained.
4.3	**Installation, Testing and Commissioning of Submersible Pump Set of 7.5 kW:** Installation, testing and commissioning of submersible pump set of 7.5 kW with G.I. pipe, nuts, bolts, washer & rubber packing and copper flat cable. Interface shall be made with Civil agencies who shall be making the bore hole.
4.4	**Supply, installation, testing and commissioning of Mono-Block Pump 1.5 kW Complete with All Accessories:** Supply, installation, testing and commissioning of single stage Mono-block open well submersible pump set with control panel rating 1.5 kW, Head range-26 meter and above, suction and delivery size shall be 50X40mm, Discharge (LPM):180 or above at 26-meter head, IP-55 protection, suitable for 240V, single phase, 50Hz, AC supply.

4.5	**Supply and Installation of G.I. Pipe 50 mm nominal dia Medium Class With Flanges and Sockets**: Supply and installation of delivery GI pipe B class 50mm dia as per IS-1239: Part-1 or latest for bore well/ open well with flanges/ sockets/ bends etc. as per IS-1239:Part-2 as required as per site conditions in 6 meter lengths or as per requirement.
4.6	**Supply and Installation G.I. Pipe Fitting Bends, Sockets, Flanges, Delivery Valve, Non-Return Valve:** Supply and installation G.I. pipe fittings, bends, sockets, flanges, delivery valve and non-return valve and supporting clamps in set; all complete**.** The material shall conform to IS-1239:Part-2, IS-5312, IS-6392, IS-5290, IS-13095, IS-14846 etc. as applicable
4.7	**Supply, Installation, Testing, Commissioning Of 3 Core, 10 Sqmm Copper Flat Cable:** Supply, Installation, Testing, Commissioning of flat submersible cable copper, 3C x 10 sqmm for pump set ISI mark as per IS 694 Part-I latest**.**
4.8	**Supply of Mono Block Pump 3.75 kW:** Supply, installation and connecting of Three phase, monoblock Horizontal/ sump pump, 3.75 kW, 20-25 meters Head, discharge 15000 LPH complete with all accessories. IP-55 protection, suitable for 240V, single phase, 50Hz, AC supply.
4.9	**Supply, Installation, Testing and Commissioning of Automatic Control Panel with DOL Starter for 3.75 kW Three-Phase Pump:** Supply, installation, testing and commissioning of automatic control panel with with DOL starter for 3.75 kW pump, voltage 240V, 1-phase, AC, 50Hz, IP protection IP-52. The panel box shall be stainless steel or CRCA powder coated. The cables shall be copper including connections and providing cable from main board to control panel. Necessary switchgear including protection, meters, selector switch, pushbuttons etc. as required for successful operation of pump shall be provided. The approval of Engineer shall be obtained.
4.10	**Installation, Testing and Commissioning of 3.75 kW Mono Block Pump Set:** Installation, testing and commissioning of horizontal type 3.75 kW mono block pump complete with DOL starter and provide with all required accessories i.e. nut-bolts, clamps, valve etc. All supports shall be correctly aligned before connecting and masonry work if required shall be done by the Contractor. Piping work from sump to overhead tank with all required accessories like GI pipe, bend, copper cable, coupling etc. shall be done by Contractor. Interface shall be made with Civil agencies who shall be making the tank. The drawing of the system with piping etc shall be approved by the Engineer.
4.11	**Supply, Installation, Testing and Commissioning of 32A DP MCB:** Supply, installation, testing and commissioning of Double Pole MCB of 32A, 10 kA C series is to be provided in the metal enclosure powder coated as per the site requirement and at locations as per the

	instruction of the site Engineer. The material shall conform to IS-2147, IS-8623, IS/IEC-60898 Part-1 etc as applicable.
4.12	**Supply, Installation, Testing and Commissioning of Heavy Duty 5 Star, 1.5 Ton Split Inverter Type Air Conditioner:** Supply, installation, testing and commissioning of 1.5 Ton heavy duty, 5-star inverter type Split air conditioner suitable for 240V, single-phase, 50Hz, AC supply. Suitable size GI nuts, bolts, fasteners, copper pipe with insulation, drain pipe & petty hardware shall be provided to complete the work in all respect along with the required refrigerant & maintain the pressure with Eco-friendly refrigerant. Necessary hole in wall, concrete etc as required shall be made for pipe laying and the surface shall be restored to original finish. All fixtures etc for installation of indoor unit and outdoor unit shall be provided. The outdoor unit shall rest on floor or wall or roof as per site requirement and heavy duty support fixtures shall be provided as required. The 3 core copper cable of suitable size from power point to indoor and outdoor unit shall be provided by the Contractor. The material shall conform to IS-694, IS-996, IS-10617, IS-10773, IS-11338 etc as applicable.
4.13	**Supply, Installation, Testing and Commissioning of Heavy Duty 5 Star, 2 Ton Split Inverter Type Air Conditioner:** Supply, installation, testing and commissioning of 2 Ton heavy duty, 5-star inverter type Split air conditioner suitable for 240V, single-phase, 50Hz, AC supply. Suitable size GI nuts, bolts, fasteners, copper pipe with insulation, drain pipe & petty hardware shall be provided to complete the work in all respect along with the required refrigerant & maintain the pressure with Eco-friendly refrigerant. Necessary hole in wall, concrete etc as required shall be made for pipe laying and the surface shall be restored to original finish. All fixtures etc for installation of indoor unit and outdoor unit shall be provided. The outdoor unit shall rest on floor or wall or roof as per site requirement and heavy duty support fixtures shall be provided as required. The 3 core copper cable of suitable size from power point to indoor and outdoor unit shall be provided by the Contractor. The material shall conform to IS-694, IS-996, IS-10617, IS-10773, IS-11338 etc as applicable.
4.14	**Supply, Installation, Testing and Commissioning of 2 KVA, 240 Volt, AC, Pure Sine Wave Online UPS cum Inverter:** Supply, installation, testing and commissioning of 2 kVA pure sine wave, online UPS cum inverter. The input supply shall be 240 Volt (range 170 volt to 265 volt), AC, and inverter full load output voltage shall be 230(+/-10%) volt. The unit shall consist of intelligent battery charging mechanism with adaptive battery charging with 150 AH tubular battery of voltage 12 volt (2 Nos.) suitable for heavy duty application with minimum two hours capacity. All features i.e meters, switches, overload and underload indications, input/output indications, charging current, battery voltage etc. shall be provided. The material shall conform to relevant IS specifications.
4.15	**Supply, Installation, Testing and Commissioning of Water Cooler (150 Litre):**

	Supply, installation, testing and commissioning of self-contained drinking water cooler 150 litre capacity (cooling capacity 150 litres per hour) [conforming to IS-1475 (part-1)], ISI marked, minimum 3-star rated, suitable for operation on 240 volt +/- 10%, 50Hz, AC supply system. The unit shall be complete with all connected standard fittings, accessories etc. and 5 KVA, wall mounted, I.C. controlled electronic auto-voltage corrector conforming to relevant IS (latest version), suitable for operation on single phase 180 to 260 volts, 50Hz incoming AC supply and output 200 to 240 volts A.C. supply. All the indicating instruments, switches etc complete with time delay relay, voltmeter, instant start provision with push button switch etc. shall be provided. Necessary arrangement for provision of earthing of the unit shall be provided.
4.16	**Supply, Installation, Testing and Commissioning of 5 star rated storage geyser 25 litre capacity:** Supply, installation, testing and commissioning of 5-star rated storage geyser 25 litre capacity suitable for 240V, single-phase AC supply. All the required GI nuts, bolts, fasteners, petty hardware, connecting pipe assemblies, supply ON, Supply OFF indications etc shall be provided. Geyser shall be ISI/ BIS marked with 5-star rating. All safety provisions against bursting, overload trip etc shall be provided. After installation, repairing of the civil work up to the original position shall be done.
4.17	Design and Drawing of pumps, control panels, AC, water coolers, geyser, UPS, survey, calculation, as built drawings etc. for item no. 4.1 to 4.16.
5. SUBSTATION 11kV/ 0.44 KV, HT PANEL, LT PANEL, DG SET AND EARTHING	
5.1	**Supply, Installation, Testing and Commissioning Of 11kV/0.44kV, 1x250 kVA, Compact Substation (CSS):** Supply, installation, testing and commissioning of Compact Sub-Station (CSS) (11/0.440 kV) consisting of 11 kV, 630A Load break switch, 11kV Compact VCB panel (1 isolator + 1 outgoing ACB with air insulated BUS PT metering module) with DRY type Transformer (250 kVA) Capacity and LT Switchgear with all HT & LT inter- connections, accessories, fittings & auxiliary equipment inside GI enclosure. CSS shall include (1) 11 kV, 630 Amp load break switch; (2) 11 KV Compact VCB , 11 kV, 630 Amp; (3) 11 kV, 630 Amp off load break switch; (4) LT panel; (5) APFC panel 100 kVAR, MPP (metalized polypropylene capacitor) type heavy duty; (6) CT/ PT for Metering system; (7) all HT and LT cable with proper termination arrangement of suitable size and length; (8) suitable H-pole arrangement with GO/DO (gang operated/drop out) switch (if required). Provision of earthing as per requirement and supply & installation of all safety items required for 11/0.44 kV substation as per rules. Schematic Diagram of substation and Transformer Data, computer printed and suitably laminated, shall be provided. The material shall conform to detailed specification and drawings mentioned in the tender document.
5.2	**Supply, Installation, Testing and Commissioning of Indoor Type 250A LT Panel:** Supply, installation, testing and commissioning of minimum 1.6 mm

	CRCA sheet steel fabricated, cubicle, powder coated as per standard 7 tank process having outdoor type LT panel distribution board, having suitable IP54 protection, floor mounted front operated, mounted on GI base channel of suitable size, with top/ bottom removable cable gland plate as required, earth bus, hinged and lockable doors, dust and vermin proof, complete with all inter connections, small wiring by minimum 2.5 sq. mm copper FRLS cables. The panel shall consist of (1) 2 nos. incoming 250A, 4 pole, MCCBs with microprocessor release having integral overload, short circuit, earth fault and neutral protection and breaking capacity 60 KA (Ices=100%Icu). (2) outgoing 4x125A, 4x100A and 6x63A, 4 poles, MCCBs with adjustable overload and adjustable short trip unit and breaking capacity 36KA (Ics=100%Icu). The panel shall be provided with over voltage protection with suitable relay. The copper bus bars shall be insulated by heat shrinkable sleeves. The copper earth bus shall also be provided for suitable length and capacity for earthing purpose. The instrument shall be of flush type ammeter, voltmeter, and selector switches with CTs, feeder name and danger board. General arrangement and wiring diagram along with panel dimensions shall be supplied by the Contractor for approval of Engineer before fabrication of panel. Special tools shall be supplied with the panel. Danger notice plate shall be placed on the front. All metal structures shall be 7 tank process powder coated. The final finishing shall be smooth and attractive. Caution boards of anodised aluminium or stainless steel plate in English/ Hindi shall be provided. Schematic Diagram of LT Panel, computer printed and suitably laminated shall be provided. The foundation of panel and trenching (with M-25 concrete) with GI/ CC/ Stone cover work shall be provided. Circuit identification by means of engraved on poly propylene sheet as per design approved by Engineer shall be provided. The panel shall be fixed on GI Channel of 100x50x6mm size with lifting hooks also. The earthing arrangement terminals (2 nos.) shall be made in the panel. The material shall conform to IS/IEC-60947 part-2 ; IS/IEC-60898 Part-1 and other relevant specifications.
5.3	**Supply, Installation, Testing and Commissioning of Indoor Type 160A LT Panel:** Supply, installation, testing and commissioning of minimum 1.6 mm CRCA sheet steel fabricated, cubicle, powder coated as per standard 7 tank process having outdoor type LT panel distribution board, having suitable IP54 protection, floor mounted front operated, mounted on GI base channel of suitable size, with top/ bottom removable cable gland plate as required, earth bus, hinged and lockable doors, dust and vermin proof, complete with all inter connections, small wiring by minimum 2.5 sq. mm copper FRLS cables. The panel shall consist of (1) 2 nos. incoming 160A, 4 pole, MCCBs with microprocessor release having integral overload, short circuit, earth fault and neutral protection and breaking capacity 60 KA (Ices=100%Icu). (2) outgoing 2x125A, 2x100A and 3x63A with 4

	poles, MCCBs with adjustable overload and adjustable short trip unit and breaking capacity 36KA (Ics=100%Icu). The panel shall be provided with over voltage protection with suitable relay. The copper bus bar shall be insulated by heat shrinkable sleeves. The copper earth bus shall also be provided for suitable length and capacity for earthing purpose. The instrument shall be of flush type ammeter, voltmeter, and selector switches with CTs, feeder name and danger board. Schematic Diagram of LT Panel, computer printed and suitably laminated shall be provided. General arrangement and wiring diagram along with panel dimensions shall be supplied by the Contractor for approval of Engineer before fabrication of panel. Special tools shall be supplied with the panel. Danger notice plate shall be placed on the front. All metal structures shall be 7 tank process powder coated. The final finishing shall be smooth and attractive. Caution board of anodised aluminium or stainless steel plate in English/ Hindi shall be provided. The foundation of panel and trenching (with M-25 concrete) with GI/ CC/ Stone cover work shall be provided. Circuit identification by means of engraved on poly propylene sheet as per design approved by Engineer shall be provided. The panel shall be fixed on GI Channel of 100x50x6mm size with lifting hooks also. The earthing arrangement terminals (2 nos.) shall be made in the panel. The material shall conform to IS/IEC-60947 part-2 ; IS/IEC-60898 Part-1 and other relevant specifications.
5.4	**Supply, Installation, Testing and Commissioning of Indoor Type 160A Essential LT Panel:** Supply, installation, testing and commissioning of minimum 1.6 mm CRCA sheet steel fabricated, cubicle, powder coated as per standard 7 tank process having outdoor type essential LT panel distribution board, having suitable IP54 protection, floor mounted front operated, mounted on GI base channel of suitable size, with top/ bottom removable cable gland plate as required, earth bus, hinged and lockable doors, dust and vermin proof, complete with all inter connections, small wiring by minimum 2.5 sq. mm copper FRLS cables. This panel shall receive LT supply from AMF panel (of DG set) and shall feed to (a) ACO panel for CLS load and (b) emergency station loads. The panel shall consist of (1) 2nos. incoming 160A with 4 pole, MCCBs with changeover provision (if required) with microprocessor release having integral overload, short circuit, earth fault and neutral protection and breaking capacity 60 KA (Ices=100%Icu). (2) outgoing 2x125A, 3x100A and 4x63A with 4 poles, MCCBs with adjustable overload and adjustable short trip unit and breaking capacity 36KA (Ics=100%Icu). The panel shall be provided with over voltage protection with suitable relay. The copper bus bars shall be insulated by heat shrinkable sleeves. The copper earth bus shall also be provided for suitable length and capacity for earthing purpose. The instrument shall be of flush type ammeter, voltmeter, and selector

	switches with CTs, feeder name and danger board. Schematic Diagram of LT Panel, computer printed and suitably laminated shall be provided. General arrangement and wiring diagram along with panel dimensions shall be supplied by the Contractor for approval of Engineer before fabrication of panel. Special tools shall be supplied with the panel. Danger notice plate shall be placed on the front. All metal structures shall be 7 tank process powder coated. The final finishing shall be smooth and attractive. Caution board of anodised aluminium or stainless steel plate in English/ Hindi shall be provided. The foundation of panel and trenching (with M-25 concrete) with GI/ CC/ Stone cover work shall be provided. Circuit identification by means of engraved on poly propylene sheet as per design approved by Engineer shall be provided. The panel shall be fixed on GI Channel of 100x50x6mm size with lifting hooks also. The earthing arrangement terminals (2 nos.) shall be made in the panel. The material shall conform to IS/IEC-60947 part-2 ; IS/IEC-60898 Part-1 and other relevant specifications.
5.5	**Supply and Installation of 3 mm Thick Rubber Mat:** Supply and Installation of (ISI marked) Rubber mat with thickness 3 mm as per IS: 15652 (2006).
5.6	**Supply, Installation, Testing and Commissioning of 125 kVA Capacity, Radiator Cooled Silent DG Set:** Supply, installation, testing and commissioning of 125 kVA DG set (440 volt, 3-phase, AC, 50 Hz, unity power factor) suitable emergency operation at full load with acoustic enclosure, AMF panel and all other accessories, construction of plinth with materials as per OEM recommendations and approved drawing, first filling of lubricating oil, supply of High Speed Diesel oil required for testing, commissioning at site etc. The Diesel Engine at 75% rating shall produce alternator output of 125kVA at unity power factor. DG set shall be complete with radiator cooled heat exchanger, turbo charged, battery starting, 1500 rpm, diesel engine, 110% engine over speed set etc. conforming to BS-5514, ISO-3046, SAE J1349, IS-10000 and as applicable. Copper wound alternator (insulation H class) with suitable rating as per manufacturer, salient pole, synchronous, 440V, 3-phase, 50 Hz, short circuit ratio not less than 0.5, brushless exciter, air cooled, star connection with isolated neutral terminals, fast acting solid state voltage regulator, anti-condensation heater etc. conforming to IS-1271, IS-2253, IS-4722, IS-4728, IS-4889, IS-6362, IS-7132, IS-7306, IS-7816, IS-12065, IS-12075, IS-12802, IS-13364, IS-13118, IEC-60034 and as applicable. DG set shall include battery set, anti-vibration pads, fuel tank (400 litre capacity) and all other accessories/ equipment's/ protective devices, copper fuel pipe etc. The battery of 12V DC with 180AH capacity along with suitable battery charger and 2 core, 70 sqmm copper XLPE insulated cable between battery and starter shall be provided. AMF control panel fabricated with CRCA, 1.6 mm sheet, 7 tank process powder coated and comprising of incoming 4 pole, 400 Amps ACB (MDO) for DG Set, copper bus-bars, 4 pole, heavy duty contactors, multifunction panel meter for display of current

	and voltage on phases and lines, power factor, frequency, KWH, MD etc., LED indications lights including connections with single core 1.1 kV grade LT XLPE insulated copper conductor control cable between LT panel, AMF panel and alternator for auto and manual operation etc. DG set shall be provided with minimum protection of over-current relay, under voltage protection, under frequency protection, reverse power protection, field failure relay, single element over voltage relay with timer, PT fuse failure relay, over speed protection and any other protection required for proper functioning of DG set. Noise level shall be less than 75-dBA averages or as per latest CPCB norms whichever is less. The emission pollution level shall be as CPCB 4-Plus norm. Suitable exhaust with insulation and supports shall be provided. Foundation shall be with RCC M-25 grade (minimum). The material shall conform to CPWD specification Part-VII: DG sets (2013) and all the relevant and applicable IS/ IEC standards. All documents and design shall be submitted to Engineer for approval.
5.7	**Supply, Installation, Testing and Commissioning of Feeder Pillar:** Supply, installation, testing and commissioning of feeder pillar minimum size 900x600x300 mm fabricated from 1.6 mm thick CRCA sheet powder coated with 7 tank process suitable for outdoor installation with IP-54 protection , powder coated complete enclosed type dust and vermin proof, with gland plate in bottom as required. The connecting incoming & outgoing cables with copper lugs and brass glands, with (i) incoming 3-phase 63 amp, 4 pole MCCB, 35 kA and (ii) outgoing 4 nos. (three phase), 40A, 4 pole, 25 kA MCCB, (iii) outgoing 6 nos, 40A, 10 kA double pole MCB (iv) copper bus-bar 200 A in bus bar Chamber (v) indication lights, complete with locking arrangement with GI angle stand 600 mm height angle size 50x50x6 mm Grouted in M-25 grade concrete. Schematic Diagram of feeder pillar supplies and cabling.
5.8	**Supply, Installing, Testing and Commissioning Earth Electrode Complete:** Supply, installation, testing and commissioning of the earthing system and earthing shall be done with 4 meter long, 19 mm dia, copper cladded steel electrode with minimum 250 micron copper cladding. RCC chamber with cover (M-25 grade concrete) along with 50 kg earth enhancing compound as per drawing shall be provided as per Employer's Requirements. Each earth electrode shall be connected with 40x6 mm GI flat with GI nuts, bolts, spring washer etc. The earth resistance shall be mentioned as per specification. The cost of 40x6mm GI flat shall be paid under the designated item.
5.9	**Supply, Installing, Testing and Commissioning Earth Electrode buried in ground complete:** Supply, installation, testing and commissioning of earth system with 4 metre long, 19 mm dia copper cladded earth electrode with minimum 250 micron copper cladding, buried 500 mm below the earth with connections complete as required. The connections shall be made with 40x6 mm GI flat with GI nuts, bolts, spring washer etc. The earth resistance shall be mentioned as per specification or as approved by the Engineer. The earth system buried in earth shall be provided anti corrosion treatment. The cost of 40x6mm GI flat shall be paid under the designated item.

5.10	**Supply and Installation of 40x5 mm Copper Strip on Surface or in Recess or in GI Pipe**: Supply and installation of all materials including cost of copper strip of size 40x5 mm on surface or recess or digging in ground/ making chase in wall/ floor or in GI pipe and making good the damages, connections including soldering/ riveting etc. as required.
5.11	**Supply and laying 40mm x 6mm GI Flat:** Supply and laying 40mm x 6mm G.I strip for earth connection on the ground, below the ground, on wall or recess etc as applicable as per site. The GI strip shall be in compliance to IS-1730 for mild steel strips /flats and IS 4826 for hot-dip galvanization coating on steel strip/flat.
5.12	**Supply and Installation of 5 mm Dia GI Wire:** Supply and installation 5 mm dia GI Wire on surface or in recess for earthing as required. The GI wire shall be in compliance to IS 280 for mild steel wire and IS 4826 for hot-dip galvanization coating on round steel wire.
5.13	**Supply, installation, testing and commissioning of CO2 Panel Flooding System for length above 6000mm -** Fire Trace Tube system for Panel with size: Panel length above 6000 mm.
5.14	**Supply, installation, testing and commissioning of CO2 Panel Flooding System for length upto 6000mm -** Fire Trace Tube system for Panel with size: Panel length up to 6000 mm.
5.15	Design and Drawing of Sub-station, panels, DG set, earthing, feeder pillar, fire trace system, as-build drawings, calculations, survey etc. for item no. 5.1 to 5.14.
6 FIRE DETECTION & ALARM SYSTEM AND FIRE FIGHTING	
6.1	**Supply and Installation of Safety Items in the Substation:** Supply and installation of First Aid Box with medicine (ISI mark) and associated materials, Shock Treatment Chart on Aluminium frame, (a) First Aid Box (ISI mark) complete with medicines – 1 set (b) Electric Shock Treatment Chart (large size) with Aluminium frame and laminated as approved – 2 nos.
6.2	**Supply and installation of Set of 04 fire buckets (10 litre) capacity** with one GI stand and GI cover of thickness minimum 2mm supported with suitable GI angles at suitable location as approved by Engineer.
6.3	**Supply and installation of Portable fire extinguisher Dry Chemical Powder** as per IS 2171, ISI marked (5 kg). Necessary installation shall be done and fixing arrangement drawing shall be approved by the Engineer.
6.4	**Supply and installation Carbon dioxide fire extinguishers** complete as required (CCOE Nagpur approved cylinders) capacity 4.5 kg ISI marked IS: 2878. Necessary installation shall be done and fixing arrangement drawing shall be approved by the Engineer.
6.5	**Supply, installation, testing and commissioning of microprocessor based 4 loop Fire Alarm Control Panel:** Supply, installation, testing and commissioning of microprocessor based 4 loop Fire Alarm Control Panel, complete as required and as per specification.

6.6	**Supply, installation, testing & commissioning of Repeater Panel:** Supply, installation, testing & commissioning of Repeater Panel complete as required and as per specification.
6.7	**Supply, installation, testing & commissioning of analogue addressable microprocessor based photo thermal multi criteria smoke cum heat detector:** Supply, installation, testing & commissioning of analogue addressable microprocessor based photo thermal multi criteria smoke cum heat detector with mounting based LED, complete as required and as per specification.
6.8	**Supply, installation, testing & commissioning of Multi Co-operative Sensing Analogue Addressable Rate of Rise Cum Fixed temperature, heat detector:** Supply, installation, testing & commissioning of Multi Co-operative Sensing Analog Addressable Rate of Rise Cum Fixed temperature, heat detector complete as required and as per specification.
6.9	**Supply, Installation, testing & commissioning of addressable Manual Glass Break station:** Supply, Installation, testing & commissioning of addressable Manual Glass Break station complete as required and as per specification.
6.10	**Supply, installation, testing & commissioning of Conventional Sounder cum strobe:** Supply, installation, testing & commissioning of Conventional Sounder cum strobe complete as required and as per specification.
6.11	**Supply, Installation, testing & commissioning of Addressable Control modules for Hooters/ Sounders/ Strobes:** Supply, Installation, testing & commissioning of Addressable Control modules for Hooters/ Sounders/ Strobes complete as required and as per specification.
6.12	**Supply, installation, testing & commissioning of addressable type Fault isolator:** Supply, installation, testing & commissioning of addressable type Fault isolator for isolating shorted, dewired and loose circuits between two successive fault isolators complete as required and as per specification.
6.13	**Supply, installation, testing & commissioning of Response Indicators:** Supply, installation, testing & commissioning of Response Indicators complete as required and as per specification.
6.14	**Supply and laying on surface/conduit 2x1.5 sq.mm 1100V grade FRLS insulated PVC sheathed copper conductor armoured cable:** Supply and laying on surface/conduits 2x1.5 sq.mm 1100V grade, FRLS insulated, PVC sheathed, copper conductor armoured cable including termination, connections and all labour and material etc. complete as required and as per specification. Wherever required, the flexible metallic conduits shall be provided to complete the circuit.
6.15	**Supply, installation, testing & commissioning of single pair PVC insulated twisted 32/0.2 mm dia copper conductor cable:** Supply, installation, testing & commissioning of single pair PVC insulated twisted 32/0.2 mm dia copper conductor cable in existing conduit for hooter complete as required.
6.16	Design and Drawing of Fire detection and alarm system, fire safety items, calculation, survey, as-built drawings etc for item no. 6.1 to 6.15.

7 VIADUCT LIGHTING	
7.1	**Provision of 22 Watt LED and Light Fitting on viaduct:** Supply, installation, testing & commissioning of Energy efficient 22 Watt LED with bulkhead light fitting on viaduct with pressure die cast aluminium housing with driver & suitable fixing arrangement, IP-67 for outdoor application, operating voltage (140-270) V AC, system efficacy more than 100 lumen/W, wattage of each LED shall be greater than 1 W and less than 3 W, complete with all accessories of approved make etc. The life of LED lamp shall be minimum 50000 hours. The light fitting shall be provided on side railings of both sides of viaduct. The item price includes labour and cost of all materials including cost of FRLS PVC insulated multi-stranded single core copper conductor cable used for connection to light fitting from the terminal or junction box etc, earthing connection etc. The bulkhead light fittings shall be provided every 15 m to 20m distance. The illumination between the mid point area of two lights shall not be less than 10 lux. The uniform lux ratio (minimum to maximum lumens) shall not be less than 1/10th across the installations on the viaduct. The Contractor shall submit dialux calculations and design for approval of the Engineer. The luminaire shall conform to IEC 60598. Provision of modular digital timer for automatic operation of viaduct LED light shall be made as per details given in Section C-3 (Item No. 6) and payment will be made in that section.
7.2	**Laying of 2 Core x 70 sqmm LT Cable In Viaduct/ Tunnel/ Air etc.:** Laying and commissioning of 2 Core x 70 Sqmm LT, XLPE insulated armoured sheathed copper cable between (a) IMT Sohna station to a point on viaduct and (b) viaduct point to substation on tunnel shaft. The point on viaduct shall be such that cable length on both sides i.e. to IMT Sohna station and tunnel shaft substation shall be equal. The cable shall be laid in viaduct/ tunnel/ air/tunnel shaft, as required. Clamping with G.I. Saddles/ clamp of proper size suitable for 2 Core x 70 Sqmm LT cable with all accessories shall be provided for the laying of cable. The fixing arrangement shall not become loose due to train vibrations. Before and after laying of cable, the IR value shall be checked. While laying the cable, care shall be taken to avoid any damage to outside insulation of cable. Armouring at both ends of the cables shall be earthed. At termination point of cable suitable lugs and brass glands of suitable size and good quality shall be provided. The Contractor shall restore the original condition of the concrete flooring/ viaduct/ tunnel after laying of cable. Bending radius of the cable shall not be less than 16 times of dia. of the cable. Wherever, the cable emerges out of the ground at least two loops of sufficient radius should be laid. Installation of cable along with wall/ pole/ viaduct/ tunnel, wherever required, shall be done with support of G.I. saddles/ clamp of proper size and GI Pipe as required. Breaking of floor/ wall/ viaduct/ tunnel and other civil structures and repairing up to original condition, shall be done by the Contractor, and no extra cost shall be paid for it. Track crossing, if required, shall be arranged by the Contractor in coordination with Engineer. All the instruments required for insulation testing, high voltage testing shall be arranged by the Contractor at his

	own cost. The cable shall be transported by the Contractor through his own means from major electrical depot to required site of work. Before transportation of the cable, it shall be tested at site to ascertain the serviceability of the cable by the Contractor. The work shall conform to IS-1255. All stainless steel/ GI Saddle Clamp of proper size shall be provided at every one metre, for support of 2 core x 70 sqmm copper cable including stainless steel scew, washer-nut-bolt, drilling etc. all complete. The clamps shall not come out or become loose due to vibrations. GI earth wire of 10 mm dia shall run from IMT Sohna station to Tunnel shaft substation along with each cable properly clamped. The earthing of cable armour shall be done at each end of the cable with proper clamps. Each junction box shall be earthed with this earth wire by suitable T-clamps as required. The viaduct railing (if railing length is more than 20m) shall be earthed with 10mm dia GI wire with suitable connectors. Necessary interface by the Contractor shall be made with the concerned civil Contractor. The price include 10 mm dia GI wire supply, laying and connection wherever required. The GI wire shall be in compliance to IS 280 for mild steel wire and IS 4826 for hot-dip galvanization coating on round steel wire. The approval of Engineer of method statement of cable laying, earthing and drawing shall be obtained before start of work.
7.3	**Laying of 2 Core x 10 Sqmm LT Cable In Viaduct/ Tunnel/ Air etc.:** Laying and commissioning of 2 Core x 10 Sqmm LT, XLPE insulated armoured sheathed copper cable between junction boxes having double pole (DP) MCB to the light fittings. The cabling arrangement shall be such that each DP MCB shall cater to supply power to 10-15 nos. of LED lights on the viaduct. The 2 Core x 10 Sqmm copper cable shall be laid in viaduct as required. Clamping with G.I. Saddles/ clamp of proper size suitable for 2 Core x 10 Sqmm LT cable with all accessories shall be provided for the laying of cable. The cable shall have loop-in loop-out in suitable size junction box (stainless steel or 7 tank process powder coating) with necessary termination at every LED light fitting. Before and after laying cable, the IR value shall be checked. While laying the cable, care shall be taken to avoid any damage to outside insulation of cable. Armouring at both ends of the cable should be earthed. At termination point of cable suitable lugs and brass glands of suitable size and good quality shall be provided. The Contractor shall restore the original condition of the concrete flooring/ viaduct after laying of cable. Bending radius of the cable shall not be less than 16 times of dia. of the cable. Installation of cable along with wall/ viaduct wherever required shall be done with support of G.I. Saddles/ clamp of proper size and GI Pipe as required. Breaking of floor/ wall/ viaduct and other civil structures and repairing up to original condition, shall be done by the Contractor, and no extra cost shall be paid for it. All the instruments required for insulation testing, high voltage testing shall be arranged by the Contractor at his own cost. The cable shall be transported by the Contractor through his own means from major electrical depot to required site of work. Before

	transportation of the cable, it shall be tested at site to ascertain the serviceability of the cable by the Contractor. The work shall conform to IS-1255. For earthing of LED light fittings, single core PVC insulated multi-stranded copper cable 6 sqmm size shall run from each junction box to all LED fitting with each 2Cx10 sqmm cable properly clamped. The earthing of each LED bulkhead light fitting shall be done and this earth cable shall terminate at junction box and shall be properly earthed with junction box. The price include PVC insulated multi-stranded 6 sqmm copper cable supply, laying and connection wherever required. The approval of Engineer of method statement of cable laying and drawing shall be obtained before start of work.
7.4	**Supply and Installation of Junction Box Size 250(H)x200(B)x105(D) mm:** Supply and installation of junction box size 250(H)x200(B)x105(D) mm comprising stainless steel material with 1.6 mm thick sheet having power coating with 7 tank processes with rubber gasket, padlock arrangement, zinc passivated earth bolt, etc. with terminals suitable for 240V supply requirement. All busbars and terminals in the junction box shall be of copper material. The junction box shall be IP 65 outdoor type for cable entry with terminals for connection of viaduct lighting. The box shall be fixed robustly with clamps at pole/ wall/ handrail as per requirement. The junction box shall be installed at every 400m on viaduct. The junction box shall enable loop-in loop-out of 2 core x 70 sqmm copper cable and shall have 2 nos. 6A, double pole MCB for supply of power to LED lights on both sides of junction box.
7.5	Design and Drawing of Viaduct lighting, cabling, earthing, calculation, survey, as-built drawings etc for item no. 7.1 to 7.4.
8 MISCELLANEOUS	
8.1	**Supply, Installation, Testing and Commissioning of 25 Litre Fully Automatic with Auto Cut-Off RO water purification system:** Wall mounted potable water purification system (Reverse Osmosis) with inbuilt storage tank (stainless steel type), minimum inlet pressure 1 kg/cm^2, Maximum inlet pressure 3.5 kg/cm^2, High pressure pump, Micron filter and also confirming to ISO 9001:2015, ISO 14001:2004, IS 10500 or latest. All the accessories required for installation of this system on wall/ structure shall be provided and after installation the wall shall be restored to the original finish by the Contractor.
8.2 & 8.3	**Supply, Installation, Testing and Commissioning of Single Sided and Double Sided LED Signage Board:** Supply, installation, testing and commissioning of LED back lit single & double sided signage boards with IP-65 CRCA housing, vinyl print on acrylic sheet which is back lit with high grade, high brightness LED modules inbuilt Switch Mode Power Supply (SMPS) driver, without battery backup. Operating voltage 80-270V AC. LED with L70 life of minimum 50,000 hours, LPM technology, including fabrication and supply of clamping arrangements. The Engineer Authorities shall decide the size, colour & content to be printed on the signage Board.

Signage Board shall be prewired with flexible copper cable and terminated in a connector from where 3-core flexible cable shall be brought out for connecting the board to ceiling rose, as per site requirement. The body of Glow sign board to be connected with earth. The pictogram and letter of desired colour and size made by translucent vinyl sheet cut through computerized machine shall be pasted on acrylic sheet. Acrylic sheet with pictogram shall be fixed on CRCA/ GI sheet powder coated box with suitable arrangement. Subject matter and pictogram can be seen in the standard book of signage available in office. The installation shall be done with GI or stainless steel nuts/ bolts/ washers etc.

LED Signage Board:- Depth of box shall be approximately 100 mm (for single sided) 140mm (for double sided) and made by 0.8 mm thick CRCA/ GI sheet with powder coated having louvers for ventilation on two sides having suitable gaskets for protection against water and vermin ingress. Louvers should be covered with wire mesh to avoid entry of insects/ lizards of suitable size as per requirement. LED light shall be provided inside the box in such way that intensity of light on both side of box (no dark spot) remains same. Individual Switch Mode Power Supply (SMPS) operated from AC source ranging from 80V to 270 Volts, 50 Hz AC, single phase shall be supplied in each board and fitted in such way that no impression is appeared outside the board. The box is to be fitted in shed with approx. size 40x40x5 mm slotted angle nut bolt etc. at a minimum clear height.

Script slogan shall be advised to the Contractor by the Site Engineer.

LED:- Clear cool white colour 5 mm LEDs of uniform intensity and luminosity shall be used for excellent Visibility. The intensity of the illumination is such that it shall be possible to read the information clearly from a distance of minimum 20 meters. NICHIA/ PHILIPS/ LUMILIDE/ AVAGO/ Seol semiconductor/ OSRAM make LED with L70 life of minimum 50,000 hours and with specified parameters as per latest data sheet of Original Equipment Manufacturer shall be used.

SMPS:- All power supply units supplied are Switch Mode Power Supply type (SMPS) operated from AC source ranging from 80V to 270 Volts, 50 Hz AC, and single phase. All the power units are tested at 50% load of maximum working capacity. Protection against transient coming in the power supply source or generated by some other source is provided. Protection against voltage fluctuations of short durations is also provided.

Signage board has following specifications:

Acrylic sheet thickness	3 mm
Dimension of LED module	295 mm x 295 mm or 600 mm x 295 mm approx.
Protection	IP-65
LED System Wattage	6 W max per square feet
LED Wattage	0.06 W per LED

Luminosity	700 mcd
LED Color	Cool White
Viewing Angle	70 Degree
Solid Angle	70 Degree
Distance between LEDs	1.5" Diagonally
No. of LEDs in each module	72 (for 295 mm x 295 mm)
Lux level inside the surface	≥3400 Lux @ 2" +/- 10%
Color Temperature	5500K/ 6500K

8.4	**Dismantling of Rail Pole, Cable Tray Pole, Overhead Line, Cable Tray Complete:** The Contractor shall cut the rail/ pole 300 mm below the ground and released material shall be handed over to store of owner (IR/ DFC etc.) or any other site as per instruction of the Engineer with own cost and transport. The site shall be properly finished. Material deposit certificate in this regard shall be handed over to the Engineer.
8.5	**Supply and Installation of GI Cable Duct 40x60 mm (wxh) Minimum 2 mm Thick:** Supply and installation of GI cable duct 40 x 60 mm (w x h) minimum 2 mm thick and fixing as per site requirement. All drilling work, suspenders, anchors bolts, angle supports, nuts, bolts etc shall be provided. The wall/floor may involve dismantling and the same shall be restored to the original finish.
8.6	**Supply and Installation of Stainless Steel Wire Mesh 25mm X 25mm (of 5 mm dia wire) Welded on GI Angle:** Supply and installation of Stainless Steel Wire Mesh 25mm x 25mm (of 5 mm dia steel wire) welded on GI angle frame 30x30x3 mm which is fixed on base GI angle frame of 50x50x6 mm and 40x6 mm GI flat in center to support the mesh. Necessary GI nuts, bolts, washers etc shall be provided. The grouting of GI angle 50x50x6 mm or as required shall be done in M-25 grade concrete.
8.7	**Supply, Installation, Testing and Commissioning of Perforated Cable Tray of Size 150x50 mm with Thickness 1.6 mm:** Supply, installation, testing and commissioning of the hot dip galvanized perforated cable trays of Size 150x50 mm with thickness 1.6 mm and their fittings shall conform to the Indian Standards or their latest amended editions or equivalent International Standard. All drilling work, suspenders, anchors bolts, angle supports, nuts, bolts etc shall be provided. The wall/floor may involve dismantling and the same shall be restored to the original finish.
8.8	**Spares:** Supply and Testing of maintenance spares. (1) Digital earth testers: Mains operation & rechargeable battery operation, 0-20-200-2000 Ohms, Short circuit current 6 mA, noise rejection 8 mA, Guard out parallel leakage resistance with a max error of 2%, IP65 rated & CAT IV rating, Safety - IEC1010-1, EMC-IEC61326-1.

	(2) Earth Leakage Detector 1000 V: Range: 0-30 mA/300 mA/30 A/300 A, 0.01 mA resolution for measuring earth leakage currents, Jaw Opening 40 mm, Analogue Bar graph Display for trending, 300 V phase to earth and 500 V phase to phase CAT III or 600 V CAT II double insulated, Safety - IEC1010-1, EMC-IEC61326-1. (3) Digital Insulation Tester 2.5 kV: 2.5 kV Insulation Tester measurement consisting of selectable measurement voltage in the 100…2500 V range with 100 V step, continuous indication of 2.5 kV insulation resistance or leakage current, automatic discharge of capacitance of tested object after the insulation resistance measurement, acoustic signalling of five-second periods to facilitate obtaining time characteristics, indication of actual test voltage during the measurement, protection against measuring live objects, two and three-lead measurement method, Continuity measurement of protective and equipotential conductors according to EN 61557-4 with the >200 mA current, Leakage current measurement, Measurement of alternating and direct voltages, Built-in rechargeable battery pack. The instruments meet the requirements of the EN 61557 standard. (4) Digital Insulation Tester 0 – 1000 V: Measures Insulation Resistance, Continuity and AC Voltage, Three rated test voltages of 250V, 500V and 1000V, IR measurement upto 2000MΩ, Robust Design: Protection class IP54, 200mA current for continuity measurement, Auto discharge of test voltage, Meets international safety standards EN 61010-1 CAT III 600V. (5) Digital Vernier Caliper: Top quality material, 150mm measuring range, Precision reading, laser reticle, Measuring Range: 0-150 millimeter, Resolution: 0.01 millimeter, Repeatability: 0.01 millimeter, Maximum measurement speed: 1m/s, Power: 1 x 1.5V LR44 cell (included), Size: 237 x 76 x 11 millimeter for caliper 40 x 15 millimeter for LCD screen. (6) Portable Diesel Generating set 3 kVA 240 V A.C.: Portable Diesel Air Cooled Generator Set, 3KVA Application, 3KVA Generator generally used for generating electricity purpose (exp: lighting, power supply-purpose and for heavy power services) in offices, Institutes etc. because of their constant voltage property. Max AC Output: 3KVA, Rated AC Output: 3kW, Rated Voltage: 240 V, AC Frequency: 50Hz, Engine Output: 3.8kW, Fuel Type: Diesel, Fuel Consumption: 750ml/hr, Starting System: Recoil and Self Start Both, Engine Type: 4-Stroke, Air Cooled, Cylinder: Single. (7) Digital Micro Meter: Range: 325-350 mm, Digital step: 0.001 mm, maximum permissible error: +/- 6 µm, accuracy: +/- 6 µm, flatness: 0.6 µm, display: LCD, character height 7.5mm, power supply: 2 batteries SR-44, measuring spindle: with spindle lock, 8mm dia, spindle pitch 0.5mm etc. (8) Digital Multi-meter: 1000V AC/DC; 10A AC/DC (with test leads and current jacks); resistance to 50 MΩ; capacitance to 10,000 µF, frequency to 100 kHz; temperature from -10 ℃ to 60 ℃, Robust, fast and accurate with manual and automatic ranging, Display Hold, Auto Hold, and Min/Max-Average recording, Backlit digital display. (9) Safety Helmet: Straps should be fitted such that minimum clearance be at least 30 mm and maximum clearance more than 80 mm. Chin strap should have minimum width of 19 mm and directly attached to shell. Nape strip should have minimum depth of 115 mm. The mass of helmet without attachments should be 400 g. (10) Tool Kit box having impact drill, 1-piece case, masonry drill bits, wood drill bits, allen keys, 10-pieces hex bits, sockets, screws, wall plugs, 7-pieces wrenches (size 8/9,10/11,12/13,14/15,16/17,18/19,21/22), 1-piece magnetic bit holder, 1-piece cutter, 1-piece hammer, 1-piece plier, 1-piece

	long nose plier, 1-piece 1/4-inch adapter and 1-piece socket etc. (11) Portable grinder Electrically operated: An electric angle grinder is a hand-operated tool that is powered by electricity and is used with several attachments for grinding, cutting and polishing. Power consumption: 660W, disc diameter: 100mm, no load speed: 12000 rpm, voltage: 220 V, weight: 1.5 kg, with power supply cord etc. (12) Portable Electric drill: Max. Drilling Diameter: 16mm, Size: 6.5-16.0mm, No-Load Speed : 330-2700 RPM, Rated Voltage : 220V, Frequency : 50 Hz, Rated Input Power : 305-1600W.
8.9	**Operation and Maintenance Manuals:** Preparation of Operations and Maintenance Manuals and supply of requisite hard bound copies and in soft copies (pdf and word format) as per Employer's requirement.
8.10	**Training to Staff:** Imparting Training to Employers/ Engineer Staff in Classroom and at Site. Preparation of Training manuals for supply to each Trainee in hard bound copy. Supply of requisite hard bound copies and in soft copies (pdf and word format) as per Employer's requirement.

Notes:

1. The make of material shall be as per Reference list.
2. The plastering shall be done with 1:4 (cement : sand ratio) and concrete grade shall be minimum M-25. The brick class designation shall be minimum 10. The painting and distempering etc shall match the original finish.
3. The specifications, wherever mentioned, shall be latest or with latest amendment. Contractor to provide specifications, if not included in the tender document, as applicable. The indicative list of Standards is given in the tender document for reference purpose for all items of BOQ.

3.2 PAYMENT

3.2.1 Payment shall be made after carrying out the work to the satisfaction of the Engineer. Item-wise payment shall be made as under:

A: Composite Items – where cost of supply and installation is combined:

(1) The cost of material and erection shall be taken in the ratio of 80%:20% of the item cost.

(2) Material cost payment (80%):
(a) 60% payment of material shall be made after supply and acceptance of material
(b) 15% payment of material shall be made after erection of material.
(c) 5% payment of material shall be made after commissioning of items of work.

(3) Erection Payment (20%):

(a) 10% payment shall be made after erection of material.
(b) 10% payment shall be made after commissioning of item of work.

B: Supply items:

(a) 80% payment of material cost shall be made after supply and acceptance of the material.
(b) 20% payment of material cost shall be made after commissioning of the work.

C: Laying/installation items:

(a) 80% payment of Laying/installation cost shall be made after completion of Laying/installation of the item.
(b) 20% payment of Laying /installation cost of shall be made after commissioning of the work.

3.2.2 Payment shall be made for the executed quantity. All wastages etc. shall be on the Contractor's account.

3.2.3 The quantities given in BOQ are indicative only and final quantities shall be as per approved drawings and quantities executed at site.

3.3 LIST OF STANDARDS

SN	IS/ IEC Code	Title
1	IS - 5	Ready mixed paints and Enamels
2	IS - 325	Three phase induction motors.
3	IS - 374	Specification for electric ceiling type fans and regulators
4	IS - 636	Non percolating flexible fire fighting delivery hose.
5	IS - 694	Polyvinyl chloride insulated unsheathed and sheathed cables/cords with rigid and flexible conductor for rated voltages up to and including 450/750 V
6	IS -732	Code of practice for electrical wiring and fitting of building.
7	IS -778	Gunmetal gate, globe and check valves for general purpose.
8	IS -780	Sluice valve for water works purpose (50 to 300 mm size).
9	IS - 875	Code of practice for design loads (other than earthquake) for buildings and structures
10	IS - 884	Specification for first aid hose reel for fire fighting.
11	IS - 900	Code of practice for installation and maintenance of induction motor.
12	IS - 901	Specification for coupling, double male and double female instantaneous pattern for fire fighting.

SN	IS/ IEC Code	Title
13	IS - 902	Specification for suction hose couplings for fire fighting purposes.
14	IS - 903	Specification for fire hose delivery coupling branch pipe, nozzles and nozzle spanner.
15	IS - 904	Specification for two-way and three-way suction collecting heads for fire fighting purposes.
16	IS - 907	Specification for suction strainers, cylindrical type for fire fighting purposes.
17	IS - 908	Specifications for hydrant, sand post type.
18	IS - 909	Specification for ground fire hydrant.
19	IS - 937	Specification for washers for water fittings for fire fighting purposes.
20	IS - 1239 Pt.1	steel tubes, tubulars and other wrought steel fittings — specification
21	IS – 1248 Pt.1	Direct acting indicating analogue electrical measuring instruments and their accessories
22	IS – 1255	Code of practice for installation and maintenance of power cables up to and including 33 kV rating
23	IS - 1293	Plugs and Sockets
24	IS - 1475	Self-contained drinking water coolers – specification
25	IS - 1514	Specification for PVC insulated (heavy duty) electric cables
26	IS - 1520	Horizontal centrifugal pumps for clear, cold, fresh water.
27	IS - 1536	Centrifugally Cast Iron Pipe.
28	IS - 1537	Vertically cast Iron Pipe.
29	IS - 1538	Cast Iron Pipe Fitting.
30	IS -1554 Pt. I	PVC insulated (heavy duty) electric cables for working voltage up to and including 1100 volts.
31	IS -1554 Pt. II	PVC insulated (heavy duty) electric cables for working voltage up to and including 11000 volts.
32	IS - 1641	Code of practices for fire safety of building (general) : General principles for fire grading and classifications.
33	IS - 1642	Code of practice for fire safety of building (general): Details of construction.
34	IS - 1643	Code of practice for fire safety of building (general) : Exposure hazard.
35	IS - 1644	Code of practice for fire safety of building (general): Exit requirements and personal hazard.
36	IS - 1646	Code of practice for fire safety of building (general) : Electrical Installation.
36A	IS-1730	Steel plates, sheets, strips and flats for structural and general engineering purposes – dimensions.

SN	IS/ IEC Code	Title
37	IS - 1822	Motor starter for voltage not exceeding 1000 volts.
38	IS – 2062	Hot rolled medium and high tensile structural steel - specification
39	IS - 2082	Stationary storage type electric water heaters - specification
40	IS - 2147	Degrees of protection provided by enclosures for low voltage switchgear and controlgear
41	IS - 2208	HRC cartridge fuse links upto 650 volts.
42	IS - 2268	electric call bells and buzzers for indoor use- specification
43	IS - 2312	Specification for propeller type ac ventilating fans
44	IS – 2418	Tubular fluorescent lamps for general lighting services
45	IS - 2516	A.C. circuit breaker for voltages not exceeding 1000 volts.
46	IS - 2592	Recommendation for methods for measurement or fluid flow be means of orifice plates and nozzles.
47	IS - 2629	Recommended practice for hot-dip galvanizing of iron and steel
48	IS - 2675	Specification for enclosed distribution fuseboards and cutouts for voltages not exceeding 1000 V ac and 1200 V dc
49	IS - 2705	Current transformers-specification
50	IS - 2871	Specification for branch pipe, universal for fire fighting.
51	IS -2930	Functional requirements for hose laying tender for fire brigade use.
52	IS - 3231	Specification for electrical relays for power system protection
53	IS - 3427	AC metal enclosed switchgear and control gear for rated voltages above 1 kV and up to and including 52 kV
54	IS – 3528	Waterproof electric lighting fitting
55	IS - 3589	Electrically welded steel pipes for water, gas and sewage.
56	IS - 3624	Burden tube pressure and vacuum gauges.
57	IS – 3646	Code of practice for interior illumination Part 1 – General requirements and recommendations for working interiors Part 2 – Schedule of illumination and glare index Part 3 – Calculations of coefficients of utilization
58	IS - 3844	Code of practice for installation and maintenance of internal fire hydrants and hose reel on premises.
59	IS - 3854	Switches for domestic and similar purposes
60	IS - 4047	Heavy duty air break switches and composite units of air break switches and fuses for voltage not exceeding 1000 volts.

SN	IS/ IEC Code	Title
61	IS - 4722	Rotating electrical machines — specification
62	IS - 4728	Terminal markings and direction of rotation for rotating electrical machinery
63	IS-4736	Specification for hot-dip zinc coatings on mild steel tubes
64	IS - 4984	High density polyethylene pipes for water supply - specification
65	IS - 5077	Specification for decorative lighting outfits
66	IS – 5135	Arc welding of carbon and carbon manganese steels
67	IS - 5290	Specification for landing valves.
68	IS - 6392	Steel pipe flanges.
69	IS – 6665	Code of practice of industrial lighting
70	IS - 7098 Pt.1	Specification for crosslinked polyethylene insulated pvc sheathed cables
71	IS – 7098 Pt.2	Crosslinked polyethylene insulated thermoplastic sheathed cables — specification
72	IS - 7637	Glossary of terms for fire fighting equipment.
73	IS - 8034	submersible pump sets — specification
74	IS - 8090	Specification for coupling, branch pipe, node, used in hose reel tubing for fire fighting.
75	IS - 8216	Inspection of lifts wire and ropes
76	IS - 8442	Specification for stand post type water monitor for fire fighting.
77	IS - 8757	Glossary of terms associated with Fire safety.
78	IS - 8828	Electrical accessories - circuit-breakers for overcurrent protection for household and similar installations
79	IS - 9283	Motors for submersible pump sets — specification
80	IS - 9537	Specification for conduits for electrical installations
81	IS – 9583	Specification for emergency lighting units
82	IS - 9668	Code of practice for provision and maintenance of water supplies and fire fighting.
83	IS - 9972	Specification for Automatic sprinkler heads.
84	IS - 9974	Specification for high pressure sodium vapour lamps
85	IS - 10001	Performance requirements for constant speed compression ignition (diesel) engines for general purposes (up to 20 kw)
86	IS - 10221	Code of practice for-coating and wrapping of under ground mild steel pipe lines.
87	IS – 10322	Luminaires Part 1 – General requirements Part 2 – Constructional requirements Part 3 – Screw and screwless terminals Part 4 – Methods of tests Part 5 (All Sections) – Particular requirements
88	IS - 11037	Specification for electronic type fan regulators

SN	IS/ IEC Code	Title
89	IS - 11101	Specification for extended branch pipe for fire brigade use.
90	IS - 11171	Dry type Power transformer
91	IS - 11260	Stabilized power supplies ac output, Part 1: Ratings and performance
92	IS - 12615	Energy efficient induction motors — three phase squirrel cage
93	IS - 12349	Fire Protection sign.
94	IS - 12585	Specification for thermoplastic hoses Textile Reinforcement for water Genset purposes.
95	IS - 12407	Graphic symbols for protection plan.
96	IS - 12640	Residual Current Operated Circuit - Breakers for Household and Similar Uses, Part 1: Circuit-Breakers Without Integral Overcurrent Protection (RCCBs) [ETD 7: Low Voltage Switchgear and Control gear]
97	IS - 13095	Butterfly valves.
98	IS - 13118	High-Voltage Alternating-Current Circuit-Breakers
99	IS - 13314	Solid state invertors run from storage batteries
100	IS - 13340	Power Capacitors of Self-healing Type for AC Power Systems having Rated Voltage up to 650 V
101	IS - 13341	Requirements for ageing test, self-healing test and destruction test on shunt capacitors of the self-healing type for ac power systems having a rated voltage up to and including 650 V
102	IS - 13364	AC generators driven by reciprocating internal combustion engines- specification
103	IS – 13573 Pt.1, Pt.2, Pt.3	Joints and terminations of polymeric cables for working voltages from 66kv up to and including 33 kv - performance requirements and type test
104	IS - 13703	Specification for low-voltage fuses for voltages not exceeding 1000 V AC or 1500 V DC
105	IS - 13779	AC static watthour meters, class 1and 2 - specification
106	IS – 13875 Pt.2	Digital measuring instruments for measurement, control, Part 2: Terms, tests, data sheet details of instruments for measuring analog quantities
107	IS – 13947 Pt.1, Pt.2, Pt.3, Pt.4, Pt.5	Specification for low-voltage switchgear and control gear
108	IS - 14220	Open well submersible pump sets — specification
109	IS -14665 Pt.2/Sec.1	Code of practice for installation, operation & maintenance of passenger lifts.
110	IS:14665 Pt.3/sec.1	Safety rules
111	IS:14665-part-5	Inspection manual
112	IS – 14772	General requirements for accessories for

SN	IS/ IEC Code	Title
		household and similar fixed Electrical installations - specification
113	IS - 15105	Design and installation of fixed automatic sprinkler fire extinguisher system - Code of practices
114	IS - 15111	Self-ballasted lamps for general lighting services
115	IS - 15652	Insulating mats for electrical purposes — specification
116	IS – 16101	General lighting — LEDs and LED modules — terms and definitions
117	IS - 16102 Pt.1, Pt.2	Self-ballasted led lamps for general lighting services
118	IS - 16103	LED modules for general lighting
119	IS – 16106	Methods of electrical and photometric measurements of solid state lighting (LED) products
120	IS – 16107	Luminaires performance
121	IEC 60502-1	Power cables with extruded insulation and their accessories for rated voltages from 1 kV up to 30 kV. Part 1: Cables for rated voltages of 1 kV and 3 kV.
122	IS/IEC-60898-1	Electrical accessories – circuit breakers for over current protection for house and similar installations.
123	BSEN 10025	Hot rolled products of structural steels
124	Technical Report 7	Technical Report 7 of Institution of Lighting Engineers - High masts

3.4 MATERIAL REFERENCE LIST

S. No.	Items	Reference Makes
1	11 kV Vacuum Circuit Breaker	GEC, Siemens, Crompton Greave, Alsthom (Areva), ABB, BHEL, L&T, Schneider or similar
2	Air Circuit Breaker (ACB)	ABB / Schneider/ L&T/ Siemens or similar
3	Compact Substation (CSS) with HT/ LT switch gear, transformer and connected accessories	ABB, Siemens, L&T, Crompton Greave, BHEL, GEC, Alsthom (Areva), Schneider, Voltamp or similar
4	MCCBs, MCBs, ELCBS/ RCCBs, RCBO, DB, TP, HRC fuse, Changing over switch, Switch Fuse Unit	ABB / Legrand/ / Schneider/ L&T/ Havells or similar
5	XLPE HT Cable 11 kV grade	Havells/ CCI/ KEC /RPG / Universal Cable / Sterlite/ Polycab or similar

S. No.	Items	Reference Makes
6	PVC/ XLPE Power Cables up to 1.1kV grade	Havells/ CCI / KEI / Finolex / RPG / Universal/ Polycab / Batra Henlay or similar
7	Instrument Voltmeter, Ammeter, PF meter	AE / Precise / IMP / Secure or similar
8	11kV Cable End Termination & Jointing kits	Raychem RPG / 3M or similar
9	Relays	ABB / Schneider/L&T or similar
10	Luminaries, LED & related Accessories	Phillips/ Crompton/ Bajaj/ GE/ Osram/ Wipro/ Surya/Syska or similar
11	PVC insulated Elect. Cables Sheathed/ unsheathed, PVC flexible LT cable, multicore, single core, Flat cable for submersible pumps	Finolex / Polycab / KEI/ Havells / Lapp/ Universal or similar
12	Current Transformer	AE / Kappa / Pragati / Precise / Hitachi / Plastofab or similar
13	On line UPS, Servo Stabilizer, Inverter, CVT	Luminous/ Microtek/ APC Schneider / Emerson Network Power / Exide/ Amaron or similar
14	Rotary Switches, Selector Switches	ABB / Kay Cee / L&T / Schneider or similar
15	Exhaust fan/ Air Circulator/ Bracket & Pedestal fans/ Ceiling fan	Crompton Greaves/ Usha/ Bajaj/ Havells/ Schneider/ Orient/ Khaitan or similar
16	High Mast Tower / Street Light pole for general purpose lighting	Bajaj/ Philips/ Crompton/ Wipro or similar
17	Electronic Energy Meter	L&T, IMP, HPL, Secure, ABB, Enercon or Similar.
18	Capacitors - PF correction for Electrical General Services	Elspec / Schneider / ABB/ Siemens or similar
19	DG Sets - Portable	Birla Yamaha/ CGL/ Shriram, Mahindra/ Honda or Similar.
20	DG set	Sudhir/ Sterling / Powerica/ Jackson/ Cummins/ Caterpiller/ Greaves Cotton or similar

S. No.	Items	Reference Makes
21	Alternator for DG set	Stamford/ Landert motoren AG / Crompton Greaves/ Kirloskar/ Bharat Bijlee or similar
22	Induction Motor	ABB/ BBL/ Crompton Greaves / Kirloskar or similar
23	LT Switchgear & control gears- Contactors & motor starters, Energy Efficient Soft Starter panel/ Earthing Switch, Single phase Preventer	GE/ Schneider/ ABB, L&T or similar
24	Pumps- Submersible	ABB/ BBL/ Crompton Greaves / KSB/ Kirloskar or similar
25	Timers- electronic solid State	ABB/ Schneider Electric / Omron or similar
26	Water Coolers	Blue Star, Kelvinator, Shriram, Voltas or Similar.
27	Electrical accessories (Piano switch, Plugs & sockets, ceiling rose, Angle holder, holders, Modular switch and socket)	Anchor / Roma/ North-West/ Schneider/ Legrand/ Havells Crabtree or similar
28	Bell Buzzer	CONA/ MAX/ Anchor/ SSK or similar
29	Electronic fan regulator/ modular Fan Regulator	Anchor/ Roma/ North-West/ Schneider/ Legrand/ Havells Crabtree or similar
30	GI/ MS Pipe	TATA/ Jindal/ Prakash/ Surya SAIL or similar
31	Lifts	OTIS/ Schindler, KONE/ Johnson or Similar
32	LEDs	NICHIA/ OSRAM/ SEOUL SEMICONDUCTOR/ PHILIPS/ LUMILEDS/ Syska or Similar
33	HDPE PIPE	Duraline/ Godavari/ Rex Polyextrusion/ Eflex or similar
34	Battery Charger for battery room	Amar Raja/ Exide/ RS Power or Similar.
35	Conduits GI/ PVC include accessories	BEC / AKG / Polypack/ Precision or similar
36	LT Panels	Rittal/ ABB/ Schneider/ Neptune/ Adlec or similar

S. No.	Items	Reference Makes
37	Glands	Comet/ Dowells/ Lapp Kabel/ Hummel or similar
38	Insulating Mats	Vardhman/ ERDI certified/ as per IS or similar
39	Lugs	Dowells/ Jainsons or similar
40	High Mast Lights	Philips/ Bajaj/ Crompton/ Wipro or similar
41	Lights and Luminaire	Philips/ Bajaj/ Crompton/ Wipro/ Surya or similar
42	Light aviation	Philips/ Bajaj/ Avaids or similar
43	MCB Distribution Boards	ABB/ Havells/ Legrand/ Schneider or similar
44	Cable Trays & Covers	Adarsh/ Indiana / Maheshwari/ BEC or similar
45	Split Air Conditioner	Voltas/ Hitachi/ Carrier/ Daikin/ Toshiba/ Blue Star/ O-General/ LG/ Samsung or similar
46	Geyser	Bajaj, Usha, Havells, Crompton or similar
47	Fire Alarm System	Honeywell/ Notifier/ Edwards/ Tyco/ Siemens/ Apollo/ Rockwell or similar
48	Portable Fire Extinguisher	Minimax/ Newage/ Safeguard/ Kanex/ Cease Fire or similar
49	Tool kit box	Bosch, Taparia, Hitachi, Stanley.

3.5 TYPICAL ILLUMINATION LEVEL AT VARIOUS LOCATIONS

SN	Location	Recommended Normal Lux Level at floor level	Type of Fitting	Indoor/Outdoor
1	Circulating Area and platform	100	LED	Outdoor
2	Entrance	200	LED	Outdoor
3	Covered Passageway Corridor Stair	150	LED	Indoor
4	Stores	200	LED	Indoor
5	Other Service Building	200	LED	Indoor
6	Public Utility Services (Toilet/Bathroom)	150	LED	Indoor
7	Equipment Room	300	LED	Indoor
8	Control Room	300	LED	Indoor
9	Staff Quarters	200	LED	Indoor
10	Streetlight	15	LED	Outdoor
11	Rest Room	150	LED	Indoor
12	Rooms	200	LED	Indoor
13	Washbasin	150	LED	Indoor
14	Substation building/ battery room/ Cable distribution Area	150	LED	Indoor
15	Sign Boards	-	LED	Outdoor
16	Level Crossing	50	LED	Outdoor
17	Switch Yard	50	LED	Outdoor
18	Depot (Technical Rooms)	300	LED	Outdoor
19	Sign, Maps, Displays	200	LED	Indoor/ Outdoor

Note: Above Lux levels may be ascertained from relevant standards as per applicability.

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CHAPTER – 4 INSTALLATION AND CONSTRUCTION

4.1 REQUIREMENTS

4.1.1 General Requirements

i. The Contractor shall comply with all Enactments in executing the Works, including but not limited to all statutory provisions on occupational health and safety.

ii. The Contractor shall co-ordinate with Other Contractors in the execution of the Works.

iii. The Contractor shall co-operate with all Relevant Authorities in the execution of the Works.

iv. The installation of all equipment shall be undertaken at all times by suitably trained and competent employees of the Contractor, to the satisfaction of the Engineer.

v. Only appropriate tools, plant, equipment, and vehicles shall be used.

vi. Installation of all equipment shall be in accordance with the Construction and Installation Plan described in the drawing/plans as approved by Engineer.

vii. Installation of all equipment shall conform to the best industry practices.

viii. Precautions shall be undertaken to ensure the safety of personnel and equipment for all installation works.

ix. The Contractor shall, prior to starting any installation and construction work, identify any possible hazards, and implement measures of eliminating and/or controlling such potential hazards, in line with safe working practices.

x. The Contractor shall ensure that all areas of work are sufficiently illuminated for the works to be undertaken and that a safe system of work is employed for all activities.

xi. The Contractor shall operate a robust system for the control of persons entering or working upon the site.

xii. The Contractor shall co-operate, always, with the Engineer and Other Contractors to ensure that the Site is protected from unauthorised admission, either wilfully or otherwise.

xiii. The Contractor shall make due provision for the safe access and egress to the Site of Works for its staff and subcontractors.

xiv. This access shall be maintained such that it is free of all hazards and is in a safe condition throughout the duration of the Works.

xv. Contractor shall submit method statement for (a) Erection of equipment, (b) Equipment testing and commissioning and (c) Performa and checklist for recording during equipment testing for review by the Engineer.

xvi. The Contractor shall set up at least one main store/ depot for receiving and storing materials & other equipment at his own cost. The Contractor shall keep the stores in safe and secure manner to avoid any damage or rust.

xvii. Contractor shall always keep at least one set of drawing approved by Engineer in hard copy at site.

4.1.2 Specific Requirements

The installation and construction work pertaining to this Contract shall include, but not be limited to the following: -

i. Finalisation of the Construction and Installation Programme provided by Contractor and duly approved by Engineer.
ii. Survey on Site and review the technical requirements shown in this Specification and the Engineer's Drawings(if any).
iii. Production of the calculation sheets and installation drawings for Site installation.
iv. Production of specific site designs and drawings based on typical designs and drawings supplied.
v. Installation in accordance with the finalised installation drawings.
vi. Co-ordination with Other Contractors.
vii. Submission of the installation reports and records.
viii. Testing and commissioning, as per finalised protocol and programme.

4.2 CONSTRUCTION AND INSTALLATION PLAN

4.2.1 The Contractor shall undertake installation work in stages as shown in the detailed installation programme. Installation, testing and commissioning of later stages shall not impact revenue operation of earlier stages. As a minimum, the detailed Construction and Installation Plan shall include but not be limited to all the activities, installation details and methods of all activities, equipment, and tools to be used for installation, safety issues, supervision, temporary land occupation needed and the vehicles to be used for installation.

4.2.2 Material Handling

To facilitate handling of equipment during installation and maintenance thereafter, the Contractor shall closely co-ordinate and interface with other Contractors. The entire material handling plan for movement of bulky items such as Transformers, Panels, DG sets, and cables etc. shall be carefully planned. Crane of adequate capacity with a jib of requisite length will be arranged by the Contractor at his own cost. A road crane for handling heavy materials at the contractor's depot for loading and unloading of material will be arranged by the Contractor and shall arrange his own crew for its operation and maintenance. All charges including pay and allowances of the crew and all running expenditure shall be borne by the Contractor.

4.3 SITE SUPERVISION/ DEPLOYMENT OF TECHNICAL STAFF: -

4.3.1 The Contractor shall set up a Site supervision system, which shall be part of the overall safety, system assurance and quality management system.

(i) The Contractor shall provide Sufficient number of experienced Engineers, Supervisors, and skilled workers to ensure progress and quality of the work at Site and in the Contractor's workshops (if any), are maintained to the satisfaction of the Engineer. The minimum number of Engineers required to be deployed is shown in table below:-

No.	Post	Minimum Eligibility	Minimum Requirements in nos.
1	Senior Engineer (Electrical) (Overall, in charge)	Graduate in Electrical Engineering with minimum 7 years experience in Electrical	1

No.	Post	Minimum Eligibility	Minimum Requirements in nos.
		General Services work or HT & LT works, airconditioning and fire detection/suppression work.	
2	Senior Designer (Electrical)	Graduate in Electrical Engineering or Electronics and Communications Engineering with minimum 7 years experience in Electrical General Services work or HT & LT works, Airconditioning and Fire Detection and Suppression work.	1
3	Field Engineer (Electrical)	Graduate in Electrical Engineering or Electronics and Communications Engineering with minimum 5 years experience in General Services work or HT & LT works, Airconditioning works. **Or** Diploma in Electrical Engineering with minimum 8 years experience in General Services work or HT & LT works.	2

(ii) The Contractor shall submit to the Engineer, not later than 60 days from the date of award of Contract, the organization chart showing following key positions, and CVs of the incumbents and the brief job descriptions. The Engineer shall issue Notice of "No-objection" or otherwise for the appointment of "key positions" within stipulated working days of such submission. The incomplete submission of CV shall not be considered as submission.

(iii) The performance of personnel shall be under observation by Engineer. In case the performance of any personnel is not up to the mark, as decided by Engineer, Contractor shall provide replacement of such personnel, with similar experience within one month.

(iv) In case the Contractor fails to employ the technical staff as aforesaid to the satisfaction of the Engineer, the recovery shall be as mentioned below per month or part thereof of default.

SN	Post	Amount to be recovered per person month or part thereof of default (Rs)

1	Senior Engineer (Electrical) (Overall Incharge)	Rs.80,000/-
2	Senior Designer (Electrical)	Rs.80,000/-
3	Field Engineer (Electrical)	Rs.50,000 /-

(v) Contractor shall abide by the provisions of Payment of Wages act & Minimum wage act.

(vi) The Contractor shall be responsible for the supervision of the concerned system installation, primary fixing system, earth mats etc.

(vii) The Contractor shall maintain a set of drawings at each system which accurately reflect the current status of field changes. The Contractor shall obtain letter of No Objection from the Engineer for any such changes. The Contractor shall prepare final drawings showing the as built configuration. These drawings shall be developed in a logical format to facilitate routine system maintenance and troubleshooting.

(viii) The Engineer reserves the right to undertake, at any time, checks on the proficiency of the Contractors staff, licensing and all associated documentation. If any of the Contractor's staff be found incompetent or unlicensed he shall be removed from the site until their Competency has been established.

4.4 WORKMANSHIP

4.4.1 All the installation shall be carried out according to the instructions shown in these specifications and Drawings (as approved). All assemblies of equipment and their components and parts shall be completely interchangeable if they are of similar type. The style and procedure of the workmanship shall be consistent throughout the Works. Unless otherwise specified, the Engineer shall decide the final colours for all paint work and other finishes to be applied to any part of the Works. All parts, which are subject to, wear or damage by dust, shall be completely enclosed in dust proof housings.

4.4.2 Installation of Cables

(1) The Contractor shall co-ordinate with the Civil Contractors wherever necessary, for the installation of cables in cable galleries, trenches, ducts, trays, risers and other locations.

(2) The cable system shall, during installation, be fully protected from mechanical damage and be generally accessible at all points for inspection along its entire route. Suitable cable markers shall be provided for covered cables upon completion of installation Should it prove necessary to cut any cable during installation, all cut ends shall be properly sealed.

(3) The maximum pulling force of any cable during installation shall not exceed the design force of cables.

(4) All cables shall be installed in the formed cable trenches, shafts, hangers, trays and brackets. The minimum recommended bending radius of the cables shall be adhered to during installation.

(5) All materials used for termination, jointing and installation of cables in confined spaces shall have flame retardant, low smoke, halogen free characteristics.

4.5 Interface Between C-5 (Elect.)/ Civil Contractor and Other Contractors

The Contractor shall carry out necessary interface with other Contractors working in the area for successful completion of works. The indicative list of interfaces as under:

S. No	Item Description	C-5 (General Electrical)/Civil Contractor	Other Contractor
1.	Auxiliary Transformer LT Supply	Shall connect Local/DG LT supply to ACO Panel.	SYS-1 Contractor shall install ACO panels and distribute LT supply to SYS -2 S&T Contractor and to SCADA and OHE motorised Isolator.
2.	Track Crossing of LT cables.	Shall lay GI pipes under the tracks for crossing the LT cable	Track Contractor shall facilitate laying of GI pipe below the track
3.	Power supply from State Electricity Authority	Shall connect 11 kV cable from H-pole of State Electricity Authorities to 11 kV Metering room and CSS.	State Electricity Authorities to facilitate connection of 11 kV cable by C-5 Contractor at H-pole.
4.	HTP, MDP, DG and SCADA connectivity	Shall facilitate to SYS-1 Contractor to connect SCADA to General Power Supply	SYS-1 Contractor shall to provide SCADA connectivity for General Power Supply.
5	Viaduct illumination	Shall interface with civil Contractor for laying of power cables and erection of junction box and light fittings.	Shall interface with SYS-1 (OHE) and SYS-2 (S&T) contractors during cable laying.

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CHAPTER – 5 TESTING AND COMMISSIONING

5.1 TESTING

(1) The testing & commissioning related to the Various General Services works shall be done in conformity with the requirements of RDSO/Railway Board Standards and standard Railway practices. Testing constitutes an essential obligation to satisfy the Railway System.

(2) These Employer's Requirements establish the overall procedure for the Contractor to follow for the Works that is related to the components manufactured off-site and supplied for installation in the Permanent Works. These requirements relate to their manufacturing, procurement, delivery, testing and installation in the system and associated activities.

(3) The Contractor shall establish procedures and controls that govern the procurement and manufacturing off-site of material/equipment/ components required for the works and supply them for construction/installation, assembling and wiring in the Permanent Works.

(4) The Contractor shall submit a comprehensive Testing Plan & Program for the project to the Engineer for his consent.

(5) Type Test shall be performed by the Contractor and shall be witnessed by Employer's Personnel and / or the Engineer.

(6) Factory Acceptance Test (FAT) including stage inspection shall be performed by the Contractor and shall be witnessed by Employer's Personnel and/ or the Engineer.

(7) Approval for witnessing Type Test shall be communicated by the Engineer to the Contractor after obtaining consent from the Employer.

(8) The material delivered to the Site and offered for Inspection shall be manufactured normally not earlier than one (1) year and their guarantee period shall cover the Defects Notification Period (DNP). However, the specified period of Manufacturer's Warranty shall commence from the date of commissioning of the Work and all the manufacturer's Warranties shall be in the name of the Employer.

(9) Manufacturing and testing of various equipment, components and fittings shall be as per approved technical requirement, Schedule of Guaranteed Parameters (SOGP) etc.

5.2 TESTING AND EQUIPMENT ACCEPTANCE

(1) The Contractor shall carry out all the tests and checks for good construction and the satisfactory operation of all power supply installations. Also, the Contractor shall co-ordinate and arrange testing equipment etc. required for testing purposes.

(2) The various high, medium, and low voltage equipment will be subjected to all the tests required under equipment test sheets, (lists are not exhaustive) as per the relevant RDSO or IEC or other standards mentioned in the technical specification of each equipment or otherwise.

(3) The Contractor shall be responsible for assembly and installation of all pieces of equipment mentioned in this specification. The maintenance equipment and the special tooling shall be delivered as soon as equipment installation shall be

completed. The Contractor shall arrange and witness all the tests at commissioning and supervision after energising. These tests will enable checking the quality of the equipment and its compliance with the specifications.

5.3 FACTORY ACCEPTANCE TEST PLAN

(1) The Contractor shall prepare and submit for review by the Engineer the Factory Acceptance Test Plan detailing the Contractor's plan, documents, inspections and tests that shall be conducted to verify and validate the Works prior to delivery to the Site. The plan shall consist of a narrative description supported by graphics, diagrams and tabulations as required.

(2) (a) The Contractor's strategy for inspection and Factory Acceptance Tests of all constituent parts of the Works and Procurement Management & Manufacturing Plan.

(c) These quenching and interrelations of the inspections and tests including all Quality Hold Points and Quality Control Points.

(d) The type and extent of inspection and Factory Acceptance Tests to be undertaken and the parts of the Works to be proven by that testing.

(e) The objective of each inspection or test, what particular design and operating criteria the test or inspection will prove and how the success of the test or inspection will be demonstrated or measured.

(f) The plan for the production and submission of the inspection and test procedures to the Engineer for review including the submission of the inspection and test reports and records; and Type Tests, Routine Tests, First Article Inspections and any other tests constituting the Factory Acceptance Tests.

(3) This plan shall clearly demonstrate the logic of all related processes the logical dependencies between the individual tests of the Works, and shall also show the interfaces and dependencies with the Contractor's delivery program. The Factory acceptance Tests shall be carried out in OEM's Premises/ factory/ Manufacturing place.

(4) Factory acceptance Tests (FAT) shall include Type, Routine, Acceptance, Special Tests, as approved by the Engineer at Original Equipment Manufacturer's (OEM) factory or the Accredited Test lab / test house. The accredited Test lab or test house. Shall be approved by the Engineer. .Routine tests shall include tests such as visual inspection, dimension check, electrical conductivity check, insulation check, calibration, mechanical and hydraulic tests and any other compliance tests etc. as per specification. Type tests shall be performed on a sample of the complete equipment of each type and rating etc. based on SOGP and agreed standards or specification. The FAT stage may also include some integration tests at the manufacturer's factory, which are performed to test the integration of the components that make equipment. Each software system shall be tested to simulate inputs and outputs including integration testing as possible, thereby reducing the overall integration risks to equipment at later stages. Each software FAT should take place in an environment as close as possible to the operational environment or suitably de-rated for application duty requirement.

(5) The FAT Plan shall include a comprehensive list of the tests, Tests to be witnessed by representatives of various parties i.e. the Contractors' representatives, the Employer and /or Engineer or their representatives, the duration of the test, Tentative dates. The Contractor shall give minimum 28 days prior notice period to all representatives to witness the test.

(6) The FAT Plan shall include details of inspection, testing and witnessing of the Contractor's and subcontractor's procurement and manufacturing activities at OEM's Factory, as a minimum, it shall include:

a. First Article Inspection;

b. Stage inspections;

c. Quality Hold Points;

d. Type Tests; and

e. Routine tests.

(7) The Contractor shall arrange for all equipment and systems manufactured for incorporation into the Permanent Works to undergo a Factory Acceptance Test (FAT) before shipment from the place of manufacture..

(8) The Contractor shall be responsible for re-inspecting and re-testing any failed inspection and Factory Acceptance Test including regression testing on previously passed items.

(9) Inspections and tests that are to be witnessed by the Employer's and /or Engineer's Personnel shall be grouped and scheduled so that as many inspections and tests as possible may be witnessed during a single visit.

(10) The Contractor shall prepare two copies of the inspection or test report immediately after the completion of each inspection or test whether or not witnessed by the Employer and/or the Engineer's Personnel. f the Employer's Personnel /the Engineer has witnessed the inspection or test, he may countersign the inspection or test **(**i.e. whether or not the equipment being inspected or tested has passed satisfactorily) contained therein. If the Employer's Personnel /the Engineer has not witnessed the inspection or test (i.e. if a waiver has been granted, or for some other reason in accordance with the Contract), the Contractor shall forward two copies of the inspection or test report without delay to the Engineer. In case the results of the inspection or test do not meet the requirements of the Specification, the Employer/ the Employer's Personnel/ the Engineer may call for a re-inspection or re-test.

(11) For standard equipment which is serial or bulk manufactured, manufacturer's type test certificates (or equivalent) may be acceptable, subject to review by the Engineer.

(12) Test equipment and instrumentation shall be subject to approved calibration tests within a properly controlled calibration scheme, and signed calibration certificates shall be supplied to the Engineer in duplicate. Such calibration checks shall be undertaken prior to testing and, if required by the Employer's Personnel/ the Engineer, shall be repeated afterwards.

(13) Materials and equipment shall not be released for shipment until all applicable inspections and tests including Factory Acceptance Tests have been satisfactorily completed.

(14) The Contractor shall maintain records to demonstrate evidence of quality and accountability. These records shall include results of inspections, tests, process controls, certification of processes and personnel, discrepant material and other quality control requirements.

(15) Inspecting and testing records shall be in ISO format and as a minimum, indicate the nature of the observations made, the number & types of deficiencies found and action proposed to correct deficiencies. Also, records for monitoring work performance and for inspecting and testing shall indicate action taken for the correction of deficiencies.

(16) The Contractor shall submit to the Engineer a request for a "Notice of No Objection to Supply" the manufactured items along with all the relevant manufacturer's test certificates and inspection certificates prior to shipping / transporting. However, the material which have been inspected and the testing of which has already been witnessed by the Employer's representative, the "Notice of No Objection to Supply" may be issued directly by the Employer's representative.

5.4 INSPECTION AND TESTING COST

(1) The testing and inspection of the material shall be done by Employer's and/or Engineer's representative and all costs associated with the testing/inspection shall be borne by the Contractor including travel/lodging/boarding charges. of Employer's and/or Engineer's representative. Employer may nominate any third party for testing and inspection of material also. Any testing/inspection charges to be paid to the Test Laboratories etc. shall also be borne by the Contractor.

(2) The Contractor shall bear all expenses of Employer's and/or Engineer's representative including hotel/travel/cost of witnessing the retesting/re-inspection(if any) caused by defects or failure of equipment to meet the requirements of the Contract in the first instance.

5.5 PACKAGING AND SHIPPING

(1) The packaging and shipping shall be done ensuring that the equipment and cables do not get damaged during transit. The Contractor's quality control personnel shall verify the inspection and preparation for shipment.

(2) Each case, crate or package shall be of robust construction and suitable for the intended purpose. Packaging material that are likely to suffer deterioration in quality as a result of exposure to environmental conditions likely to be met during transit from the factory of origin to the Site shall not be used.

(3) Each case, crate or package shall be legibly and indelibly marked in large capital letters with the address, Contract number, 'right way up', opening points and other markings like "fragile", "keep dry", "handle with care" etc. along with visual display of internationally accepted symbols as necessary to permit material to be readily identified and handled during transit and when received at Site.

(4) Each case, crate or package shall contain a comprehensive packing list showing the number, mark, size, weight and contents together with any relevant drawings. .The second copy of the packing list shall be enclosed in a watertight enclosure on the outside of each case, crate or package. Distribution of additional copies of each packing list shall be in accordance with the requirements of the Engineer.

(5) Care shall be taken to prevent movement of equipment within containers by the provision of bracing, straps and securing bolts as necessary.

(6) Bags of loose items shall be packed in cases and shall be clearly identified b ywell-secured metal labels on which the quantity and name of the part and its index or catalogue number have been stamped.

(7) Spare parts shall be suitably packed for storage over an indefinite period without deterioration and shall be clearly identified showing full name and part number without any need to unwrap packaging. Electrical and other delicate items or equipment shall be cocooned.

(8) Cable ends, cable entry points into equipment and other similar terminations and openings shall be sealed or blanked off to prevent the ingress of dirt, vermin or moisture.

(9) Tube ends and other similar openings shall be thoroughly cleaned and then blanked-off to prevent ingress of dirt or moisture.

(10) Particular care shall be taken to prevent damage to or corrosion of shafts and journals, where they rest on timber or other supports that may contain moisture.

(11) At such points wrappings impregnated with anti-rusting compositions shall be used, of sufficient strength to resist chafing under the pressures and movements likely to occur in transit.

(12) Care shall be taken to minimize risk of damage to ball and roller bearings and any fragile material in transit.

5.6 CABLE DRUMS

(1) Immediately after the tests at the place of manufacturing, both ends of every length of cables shall be sealed by enclosing them with approved caps, tight fitting and adequately secured to prevent ingress of moisture.

(2) The ends of the factory lengths of cable shall be marked "A" and "Z", "A" being the end at which the sequence of core numbers is clockwise and "Z" the end at which the sequence is anti-clockwise.

(3) The end which is left projecting from the drum shall be consistently "A" or "Z", and shall be protected against damage in such a manner that the enclosure cannot be easily removed during handling while in transit.

(4) Cables shall be supplied on drums in the longest possible lengths and within practical limits.

(5) The maximum allowable diameter of cable drum shall be 2000 mm. The use of cable drums with diameter in excess of 2000 mm shall be subjected to the review of the Engineer.

(6) The drums shall also be designed for use in conjunction with any special cable- laying equipment and accessories complete with spindles and cable drum braking gear, which shall be used to install the cables on Site.

(7) Each drum shall bear a distinguishing number and label "HRIDCL", either printed or neatly chiseled on the outside of a flange.

(8) Particulars of the cable, i.e. voltage, length, conductor size, number of cores, section and length, gross and net weights, shall be clearly shown on one flange of the drum.

(9) An arrow showing direction of rolling shall be shown. Both ends of the cables shall have heat shrinkable caps. The caps shall incorporate sealants which melt on heating at temperatures well above outdoor ambient expected in HORC area.

5.7 HANDLING, STORAGE AND DELIVERY

(1) The Contractor shall ensure Comprehensive Test and inspection instructions for handling, shipping, storage, preserving, packaging, packing, marking, and shipping to protect the quality of the equipment and to prevent damage, loss, deterioration, degradation or substitution thereof.

(2) Handling procedures shall include the use of special crates, boxes, containers, transportation vehicles, equipment and facilities for material handling.

(3) The Contractor shall provide adequate and storage (covered) facilities, at its own cost, for storing in a safe and secure manner all the plant & equipment and manufactured items to be supplied and erected as part of the Contract.

(4) The Contractor shall make its own arrangement of covered space for storage facility and security of material in the store. However, if the spare land is available with the Employer, the same shall be handed over to the Contractor free of cost, for the purpose of establishing temporary construction depot(s) with the condition that whenever the Employer requires this portion of land back, the same shall be handed over by the Contractor at one month notice at no extra cost/compensation to the Contractor.

(5) Contractor shall take suitable measures for protection against deterioration or damage to equipment in storage. Where shelf-life of the equipment / material is limited, this shall be clearly stated on the shipment. Secure compound and covered storage for the high value items shall be integral part of the safe storage. Spares to be supplied shall also be kept safe and secure until handed over to the Employer at the time of Commissioning.

(6) The Contractor shall include the delivery activities in his Monthly Schedule Updates for submission to the Engineer.

(7) The Contractor shall ensure the Site is ready and in good conditions for delivery.

(8) The Contractor shall remove temporary fittings, if necessary, for delivery of items to site and shall restore the fittings to the original state and to the satisfaction of the Engineer.

(9) No dangerous goods shall be delivered to the Site.

5.8 GENERAL PRECAUTIONS

(1) Spare parts shall be suitably packed for storage over an indefinite period without deterioration and shall be clearly identified showing full name and part number without any need to unwrap packaging. Electrical and other delicate items or equipment shall be cocooned.

(2) Cable ends, cable entry points into equipment and other similar terminations and openings shall be sealed or blanked off to prevent the ingress of dirt, vermin or moisture.

(3) Tube ends and other similar openings shall be thoroughly cleaned and then blanked-off to prevent ingress of dirt or moisture.

5.9 WARRANTY CERTIFICATES FROM OEM:

(1) All Original Warranty Certificates of OEMs of all Electrical system and equipment including contract spare, Commissioning spare, DNP spares and Special tools & Test and Measuring equipment shall be valid for three years or as specified in RDSO Specification of the equipment whichever is more and registered in the name of Employer. These warranty certificates received from the OEMs should be passed on to Engineer before final Taking over.

(2) Validity of period of Warranty Certificates shall start from date of Commissioning.

(3) Warranty period and defect liability support shall start from the date of Commissioning.

5.10 INSTALLATION METHOD STATEMENT

(1) Installation Method Statements shall be submitted to the Engineer for review at least 28 days prior to the installation activity commencing on site.

(2) The installation method statement shall include the details on the methods and procedures of installation, site arrangement, manpower resources, equipment and tools required. Drawings shall be included to illustrate the proposed installation details. Necessary safety items, first aid provision, emergency vehicles and means for evacuation of injured person to hospitals etc. in case of accident shall be incorporated.

(3) Prior to proceeding with installation, the Contractor shall submit, for the Engineer's consent, six copies of drawings showing all installations including dimensions, supports, hardware, installation methods and documents confirming the availability and location of special installation tools and equipment and all other pertinent data.

(4) The Contractor shall make certain that the installation of all supports, gaskets, hardware, etc., are accomplished so as to assure safe, accurate and trouble-free installation. The installation for major items such as important components and vital equipment such as transformers, DG set, HT panel, high masts, etc. shall be undertaken preferably in the presence of the manufacturer's field service representative.

(5) Upon noticing or being advised of any inconsistencies between the installation drawings and documentation and the installed equipment, the Contractor shall notify his acknowledgement to the Engineer and correct such errors within two weeks.

(6) Equipment that is improperly installed shall be removed, checked, tested and reinstalled. Any damage caused due to improper installation and removal shall be rectified before reinstallation at no extra cost to the Employer.

5.11 SITE ACCEPTANCE TESTS, COMMISSIONING AND TRIALS:

5.11.1 Site commissioning tests: The Contractor shall ensure that:

(a) All equipment, cabling, distribution etc. is electrically and mechanically safe.

(b) All interlocks, isolators and door and cover securing mechanisms shall be properly fitted and adjusted.

(c) All exposed metal work is properly bonded and grounded and all connections and points required to be grounded for a safe and satisfactory operation shall be properly grounded in accordance with the manufacturer's requirements.

(d) All cables, cores and terminations shall be secure, properly fitted and correctly identified and colored.

(e) All phases, polarities, neutral and common connections shall be correctly switched / connected as required, so that the power is correctly available at all points and that the voltage and frequency at all equipment is correct and in accordance with the requirements for correct work.

(f) All supplies shall be properly fused or otherwise protected, to give successfully discrimination and safe disconnection under fault conditions.

(g) All contacts shall be properly aligned / adjusted and not subject to excessive wear or corrosion.

(h) Batteries shall be correctly installed, connected, and fitted and checked that the battery chargers are working correctly.

(i) The insulation-resistance of all cabling and equipment shall not be less than specified.

(j) During the commissioning of major item like HT panel, Transformer, DG sets etc. the Contractor shall arrange expert Engineer of OEM of such item at respective sites. The expenditure for charges for the same including transport, lodging, shall be borne by the Contractor at no extra cost.

(k) All instruments and meters shall be energized with correct polarity and working properly.

(l) All fault indications and alarms shall be working correctly.

(m) In addition to all operational tests required for a successful hand-over, the operation of all interlocks, sequences and protections which are not utilized in normal operations shall be subject of acceptance by the Engineer.

(n) The on-site commissioning tests shall be conducted under the supervision of the Engineer.

(o) The Contractor shall prepare the check lists, proforma etc. of each equipment for recording the test results, with the consent of the Engineer.

(p) On completion of the site acceptance tests, the Contractor shall forward the test results certified by him to the Engineer. When the Engineer has received the results and deems that the plant has successfully passed the tests, he will write to the contractor to that effect.

5.11.2 Commissioning

(a) At least six weeks in advance of any particular site testing, the Contractor shall submit details of tests and details for the tests equipment proposes to use for that testing, to the Engineer for approval.

(b) All tests for statutory requirements and insurances including arrangements for such tests, inspections by Authorized bodies, persons or insurers, as necessary and the provision of certificates in the prescribed and approved forms necessary to enable plant and equipment to be put in to service, shall be made by the Contractor.

(c) The commissioning tests for each part of the plant shall be carried out on site.

(d) As installation proceeds, the insulation resistance of cables shall be checked and recorded. The identification of the cores shall be confirmed from end to end of each cable end. In the case of communication, alarm and control-cabling, identification of the cores from end to end of each circuit shall be done. Tests on cables shall be completed and accepted by the Engineer before the testing of the associated equipment starts.

(e) All tests for statutory requirements and insurances including arrangements for such tests, inspections by authorized bodies, persons or insurers, as necessary and the provision of certificates in the prescribed and approved forms necessary to enable plant and equipment to be put into service, shall be made by the Contractor.

(f**)** The final acceptance tests shall be done after all on-site commissioning tests have been successfully completed and all defects detected during those tests have been rectified, which are accepted by the Engineer. The tests shall include full operation tests on the works as a whole and selected technical tests on some or all of the equipment.

5.11.3 Energization :

1. The Contractor shall prepare operation safety rules and procedures for the review of the Engineer before Energization. The Contractor shall carry out all necessary

checks to ensure safe Energization.

2. All power equipments shall be subject to inspection by inspectors from the Electrical Inspectorate of Engineer before Energization. The Contractor shall ensure that all Employer's Requirements are met. Contractor shall be responsible for reliable operation of all Electrical equipments.

5.11.4 TRIAL OPERATION

(a) The trial operation shall be done with full responsibility of the Contractor. The trial operation shall take place after tests on completion.

(b) The trial operation shall show the evidence of a fully functional operation of the electrical system and that security is given during operation. Therefore, the trial operation shall occur without significant malfunctions. The Contractor shall test different operation cases during the trial operation (e.g., loss of different equipment etc.).

(c) The Contractor shall make all organizational measures during the trial operation, so that malfunctions can be rectified as soon as possible (within max. 2 days).

(d) The Contractor shall commence extended period of trial run to prove that all technical systems work properly to the satisfaction of the Engineer/Employer and Commissioner for Railway Safety or any other Authorized Official and to allow all technical systems to settle and also to train staff to become conversant with the working procedures. The Contractor's personnel shall be available throughout the scope of work over the whole of this period. After successful Trial Run and obtaining statutory clearances / approvals from CRS / EIG and / or other relevant authorities, the Works shall be commissioned with the consent of the Engineer. The results of the different tests during trial operation shall be signed by the Contractor and the Engineer.

5.12 INTEGRATED TESTING

(1) Integrated Testing shall include the Work of other Contractor(s) also to ascertain that all systems work properly. The details of integrated tests to be performed shall be prepared by the Contractor and shall be submitted to Engineer for approval. The Contractor shall, follow satisfactory completion of tests on his works, equipment, sub- systems or system, perform, as approved by the Engineer. Program of tests to verify and confirm the compatibility and complete performance of his works, equipment, sub- systems or system with the works, equipment, sub-systems or system provided by others.

(2) The Contractor shall submit to the Engineer the requirements and procedures in respect of the Contractor's scope of work for Integrated System Tests in conjunction with the other Contractors to demonstrate that the complete system provided under the Contract is fully operational and meets the specified performance criteria.

(3) Integrated Testing & Commissioning include all the tests undertaken in order to demonstrate that the various components of the railway systems operate satisfactorily between one another and meet all specified requirements for design, operability, safety, and integration with other systems.

(**5**) These tests shall be entirely within the requirements of one or more of the Project Contracts or they shall involve a multiplicity of Contract procedure. The final Integrated Testing and Commissioning shall be carried out after the SCADA system and OCC have become operational.

(6) Those systems that can be tested without depending on the running of trains, such as SCADA and Telecom system etc., will have their integration tests scheduled to commence as early as possible. It is preferable that any interface problem associated with these "trainless" system tests be identified and resolved prior to the commencement of test running.

(**7)** The Integrated Tests by the Contractor and other Contractors shall include a period of Trial Run.

(8) The results of the Integrated Testing and Commissioning shall be compiled and evaluated by the Contractor and shall be submitted to the Engineer

(9) If the Works, or a part thereof, or a Section, or a plant & equipment and manufactured item fail to pass Integrated Testing and Commissioning and the Contractor in consequence proposes to make any adjustment or modification to the Works or a part thereof, or a section, or the plant & equipment and manufactured item, the Engineer may, with the approval of the Employer, instruct the Contractor to carry out such adjustment or modification at his own cost to satisfy the requirements of Integrated Testing and Commissioning within such time as the Employer / Engineer may deem to be reasonable.

(10) If the Works, or a part thereof, or a Section, or a plant & equipment and manufactured item fail to pass the Integrated Testing and Commissioning, the Engineer shall require such failed Test(s) to be repeated under the same terms and conditions. If such failure and retesting results due to the fault of the Contractor and cause the Employer to incur additional cost, the same shall be recoverable from the Contractor by the Employer and shall be deducted by the Employer from any money due or to become due, to the Contractor.

5.13 TEST RECORDS

5.13.1 Tests Reports

(1) The Contractor shall submit manufacturer's type test and routine test certificates and reports for each equipment and device. Complete test results are to be submitted in clearly identified and organized booklet, indicating item of equipment, make, model, type, date of tests, and type of tests, descriptions and procedures. Test reports shall also include the Quality Assurance Certification, the standards to which the equipment comply, and the standards to which the equipment was tested.

(2) The Contractor shall submit to the Engineer for review, not less than three (3) months before testing and commissioning activities commence his proposed format for testing and the commissioning records. The records shall be appropriately sub-divided to make provision for the various parts of the Permanent Works covered by the Contract.

(3) The format of the records shall cover all tests, provide positive identification by serial number for assemblies and sub-assemblies of the Works and show modifications to Employer's drawings and diagrams or "As Built" data to be certified by the Engineer in the course of installation, testing and commissioning.

(4) The Contractor shall, during the execution of the Works, prepare such reports and record of design, manufacture, installation and testing, as may be required, in order that a license may be issued or statutory requirements may be met or approval given. Such reports or records shall be adequate to enable each part of the Permanent Works to be commissioned and to meet the requirements of the licensing authority or any standing statutory regulations and shall be reviewed by the Engineer.

(**5**) The Contractor shall obtain report of each inspection and/or test. Such report shall show the result of all the inspections and/or tests carried out and shall certify that the work has been inspected and/or tested in accordance with the requirements of the Contract and that the work complies with the requirements of the Contract.

(6) The Contractor shall prepare an inspection or test report immediately after the completion of each inspection or test whether or not witnessed by the Employer or the Engineer. If the Employer or the Engineer or Employer's Representative has witnessed the inspection or test, he may countersign the inspection or test report to indicate his review of the information and conclusions (i.e. whether or not the equipment being inspected or tested has passed satisfactorily contained therein).If the Employer or the Engineer has not witnessed the inspection or test (i.e. if a waiver has been granted, or the Employer or the Engineer has not witnessed the inspection or test for some other reason in accordance with the Contract), the Contractor shall forward two copies of the inspection or test report without delay to the Engineer. The Engineer will countersign the report to indicate his review of the information and conclusions (i.e. whether or not the equipment being inspected or tested has passed satisfactorily) and return one copy to the Contractor. Where the results of the inspection or test do not meet the requirements of the Specification, the Employer/ the Engineer may call for a re-inspection or re-test.

(7) The Contractor shall carry out an analysis of the results and certify that the work has been inspected/tested in accordance with the requirements of the contract and the work complies with the requirements of the Contract.

(8) Authorized representative of the Contractor, who has been assigned the required authority under the relevant quality plan, shall sign each report of inspection and/or test.

(**9**) In addition to any other requirements, the report shall contain but not limited to:

(a) Material or part of the Works tested.

(b) Location of the batch from which the samples were taken or location of the part of the Works.

(c) Place of testing.

(d) Date and time of tests.

(e) Weather conditions in the case of in-situ tests.

(f) Technical personnel supervising or carrying out the tests or inspection.

(g) Size and description of samples and specimens.

(h)Method of sampling.

(i)Properties tested or inspected.

(j) Method of testing or inspection.

(k) All relevant checklists and worksheets used during the inspection and /or test, including readings and measurements taken during the tests.

(l) Test results, including any calculations and graphs.

(m) Specified acceptance criteria; and

(n) Other details stated in the Contract.

5.13.2 After Commissioning of a part of the Works, the Contractor shall complete each commissioning record in the agreed format and shall forward copies of the record to the Engineer for review.

5.14 SPARES, TOOLS AND TEST EQUIPMENT

(1) The Contractor shall supply at least six weeks before the start of Defect Notification Period, the Spares, Tools and Test Equipment for various Systems/Sub- Systems, which are essential for day to day use in both corrective and preventive maintenance and for workshop use in repairing of modules/units.

(2) The list of Tools and Test Equipment is as under:

S. No	Description	Quantity in No's
1	Digital earth testers	2 nos.
2	Earth Leakage Detector 1000 V	2 nos.
3	Digital Insulation Tester 2.5 kV	2 nos.
4	Digital Insulation Tester 0 – 1000 V	2 nos.
5	Digital Vernier Caliper	5 nos.
6	Portable diesel Generating set 3 kVA 230 V.A.C.	1 nos.
7	Digital Micro Meter	5 nos.
8	Digital Multi-meter	5 Nos
9	Safety Helmet	10 Nos
10	Box spanner set	5 Nos
11	Portable grinder Electrically operated	2 Nos
12	Portable Electric drill	2 nos.

(3) The following spares shall be provided and rates of BOQ shall be applicable:

S. No	Description	Quantity in No's
1	Cable 2 core, 10 sqmm copper cable	1000 m
2	Cable 2 core, 16 sqmm copper cable	500 m
3	Cable 2 core, 35 sqmm copper cable	500 m
4	Cable 2 core, 70 sqmm copper cable	500 m
5	22 w LED tubular lamp	100 nos
6	40 W LED light	50 nos.
7	Emergency light 240 Watt	10 nos.
8	200 watt LED flood light for high mast	10 nos.
9	Metal clad plug socket 20A single phase with 32A MCB	5 nos.
10	Metal clad plug socket 16A single phase with 20A MCB	5 nos.
11	MCCB 200A, 4 pole, 440 volt, 36kA	1 no.
12	2 kVA, 240 V AC online UPS cum Inverter	1 no.
13	1200 mm sweep ceiling fans, 5-star rated with regulator	10 nos.
14	300 mm sweep 5-star rated exhaust fan	3 nos.

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CHAPTER – 6 MAINTENANCE AND TRAINING

6.1 INTRODUCTION

6.1.1 (a) The Contractor shall provide comprehensive training and documentation to the Employer's staff in accordance with the Employer's Requirements and the chapter of General Specifications. The training of maintenance staff for Electrical system shall be organised considering RDSO, Railway standards, Railway practices and guidelines of equipment manufacturers.

(b) This training shall enable the staff, to operate and maintain all the installations in the most efficient and safe manner, to achieve the maximum reliability and economy required by such System. All type of Routine, Preventative, Schedule Maintenance and breakdown maintenance work will be carried out at regular intervals, based on latest SMI's/ Instructions/Guidelines issued by RDSO; Railway Board and equipment manufacturers' recommendations.

6.1.2 Maintenance Management

(**a**) The management of the maintenance process entails defining various levels of responsibility and enabling them to implement the strategic orientations.

(**b**) The management process helps to improve the performance of the maintenance work of different components with quality, on time and at low cost. It shall be implemented at three levels:

i. At the level of human resources and management in the context of the scheduling of work, the allocation of human resources and the training of personnel.

ii. At the skills level to ensure quality, safety and suitable working conditions.

iii. At an economic and financial level to ensure responsible management of production, spare parts, purchasing and miscellaneous costs.

(**C**) The quality of this management depends on the capability of those entrusted with operation and maintenance responsibilities:

i. To exploit the results of management within their field of responsibility.

ii. To react in the event of any deviation from the action plans defined with a view to achieving the set objectives.

(**d**) The management control function ensures timely advice to be given to those with operational and maintenance responsibility:

i. By placing at their disposal, the tools and information required for piloting and diagnosis.

ii. By participating in carrying out this diagnosis.

iii. By participating in the task of defining the objectives to be achieved.

6.1.3 Requirements of Facilities and Tools

(a) The achievement of the objectives assigned to the maintenance division about quality, safety and regularity for the lowest possible overall cost requires mobilisation of various resources.

The facilities and tools are essential part of the resources placed at the disposal of the maintenance division to achieve the set objectives.

(b) When determining these requirements, in-depth knowledge in the dedicated maintenance plan is needed while taking due account of the experience acquired in similar fixed installation which has been in service for several years.

6.2 SUPERVISION AND PLANNING OF MAINTENANCE

1 General

The Contractor shall make use of all relevant information to provide supervision of maintenance. According to the maintenance strategy, all equipment and infrastructure supplied for the 'Project' must be such as to ensure for minimum or no maintenance. Maintenance activities required must be capable of being performed with little or no impact on the train service. In addition, the maintenance work systems shall ensure safety of personnel and equipment.

The Contractor shall ensure that to supervise maintenance during the DNP (Defects Notification Period) personnel are always available with the relevant skills and level of competence.

The Contractor, upon noticing any defects, deficiency in quality and quantity of spares and materials shall without delay, arranges for alternative source of supply and submit his proposal to the Engineer for review.

2 Planned Maintenance

Routine preventative maintenance will be carried out at regular intervals based on condition, reliability, usage, and service history, SMI's issued by RDSO, instructions of Railway Board and equipment manufacturers' recommendations. The Operating and Maintenance Manual shall describe the different levels of planned maintenance.

3 Supervisory Staff

The Contractor shall provide supervisory Maintenance staffs who are expert in all the different levels of fault finding, maintenance and repair of the various relevant systems supplied under the Contract:

i. Electrical system

ii. Switchgear/power supply arrangement

iii. Other works

4 Maintenance Requirements

(1) Testing and Commissioning of System and Equipment

In the event of a failure requiring modifications to the System, the Contractor shall undertake any testing and re-commissioning required. Any such modification shall be submitted for Engineer review.

(2) Temporary Alterations to Restore Service

The Contractor shall undertake any temporary modifications necessary to maintain service.

Any such modification shall be submitted for Engineer review.

(3) Discrepancies between Installation and Design Records

Should the Contractor discover inconsistencies between the maintenance drawings and documentation and the installed equipment, the Contractor shall correct all such errors within two weeks.

(4) Communications

The Contractor shall ensure that adequate communication facilities are provided to its staff during the DNP and maintenance period as per approval of Engineer.

(5) Location of Staff

The Contractor shall be responsible for locating staff such that the Contractor meets its contractual obligations and as per approval of Engineer.

(6) Maintenance System

(a) The Contractor shall provide document, and maintenance manuals to the Engineer upon for various schedule and preventive maintenance. The maintenance manuals shall be approved by the engineer. These manuals shall be followed by the Contractors during DNP.

(b) Corrective maintenance shall be available 24 hours per day, able to respond to all foreseeable circumstances**.**

(c) The maintenance system shall cover all parts and equipment of the system designed, installed and commissioned by the Contractor. The Contractor shall take into account the requirements of the operations and maintenance when determining and proposing its maintenance regime.

(7) Scope and Hours of Coverage

The schedule and corrective maintenance shall be robust in design. The Contractor shall provide full 24 hour On-Call coverage and shall be such that initial response and rectification of failure are in accordance with the following:

i. Assistance to first level and corrective maintenance within 30 minutes, upon request of first line maintainer.

ii. All elements of preventative maintenance shall be carried out and completed during non-traffic hours without interrupting train services.

(8) Routine and Corrective Maintenance Procedures

Routine and corrective maintenance procedures shall be supplied for all equipment. The format shall be as follows:

i. Uniform format and layout irrespective of equipment supplier.

ii. Colour coding for each activity.

iii. Cross referenced to the Operation and Maintenance Manuals.

iv. Document control information.

(9) Maintenance Manuals

The Contractor shall provide particulars of operating parameters, tools for dismantling and testing, methods of assembly and disassembly, tolerances, repair techniques and all other information necessary to set up a repair and servicing programme as per satisfaction of Engineer.

The Contractor shall provide documentation for all hardware and software for computer systems and other associated electronic equipment to meet the following requirements.

Such documents shall include but not be limited to:

i. manufacturers' documentation supplied as standard with the equipment.

ii. hardware configuration with details of expansion capabilities and options.

iii. programme loading instructions, including runtime environment configuration.

iv. programme listing including comprehensive 'comment statements' in hard copy and soft format for source code, compilers, and development tools necessary to modify and recompile software.

v. flow charts, data flow diagrams and state diagrams as appropriate.

vi. description of software modules including purpose, linkage with other modules, error routines and any special considerations.

vii. memory maps for both internal and peripheral memory showing description of all programmes, data files, overlay areas, memory available for expansion and the like.

viii. loading and operating instructions for diagnostic programmes and specifically developed debugging tools; and

ix. Programming manuals relevant to operating systems, languages, development tools, etc.

The manual shall also include inspection/overhaul procedure and periodicity of various inspection/overhaul schedules in detail including the tools, special tools/plants, and facilities required. The Operations and Maintenance (O & M) Manuals shall be prepared by the Contractor and shall be submitted to Engineer for review who shall obtain consent of Employer. The O&M manuals shall be submitted supplied at least 3 months prior to taking over of works by the Employer. The O&M Manuals shall supplied 10 copies in hard bound copies, two nos in pdf & editable (word) format in two nos. Hard Disc Drive (1 TB minimum capacity).

6.3 TRAINING:

6.3.1 General

(a) During the contract period, the Contractor shall provide training manuals, as well as onsite training and classroom training courses to ensure that the Employer/ Engineer's staff associated with this project acquire full knowledge and understanding of all aspects of the design, day to day operations, breakdown and routine maintenance and fault diagnosis of the power supply, the surveillance and control equipment as well as the hardware and software.

(b) The Contractor shall provide comprehensive training to the Employer/ Engineer's personnel about all equipment in theoretical and practical way. The Engineer shall nominate members of staff, who shall be attending the training courses.

(c) The Contractor shall nominate qualified instructors for imparting training. The Contractor shall obtain prior approval of the Engineer for the instructor giving full details of instructor's qualifications and experience in each case. The Instructors shall have minimum 10 years experience in operation and maintenance of Electrical general services work and degree/diploma in Electrical Engineering.

(d) The Contractor shall provide all relevant and necessary facilities which are needed for complete and effective staff training (such as video, TV, slide and film-projectors and others tools) and venue. Within three months after the signing of the contract, the Contractor shall submit detailed syllabus for the training courses for approval by the Engineer. Training shall be completed at least 3 months prior to the start of DNP.

(e) The training courses and/or sessions shall include system performance requirements and all major equipment and works designed, by the Contractor.

(f) The training instructors shall be qualified and experienced to impart training. The assessment criteria for adjudging the knowledge of Employer/ Engineer's staff shall be developed by the Contractor and submitted to the Engineer for review at least three months before any course is conducted.

(g) The Contractor shall provide full-time on-Site management and co-ordination of the entire training programme to ensure the continuity of classes, and proper distribution of training materials, and be responsible for interfacing with the instructors. The training courses in hard bound copies shall be delivered to all Employer/ Engineer's staff, including instructors, operation and maintenance Engineering staff. The Contractor shall supply training material to Engineer in four nos. hard bound copies, two nos. softcopies in pdf & word format in two nos. pendrives (1 TB minimum capacity).

6.3.2 Mock-Up for Training

The Contractor shall install mock-up equipment for system and any other facility(s) considered necessary for the training of Engineer's staff. The training mock-up shall include but not limited to the following: -

i. Clear Cut Section drawings/ photographs of various power supply equipment's such as Circuit Breakers, HT/LT panel, Power supply arraignment, Current Transformers and Potential Transformers, Submersible pumps.

ii. Cut Section drawings/ photographs of HT/LT cables.

iii. Cut Section drawings/ photographs of Gas Insulated Switchgear and other types of panels.

iv. Clear photographs of transformers, their windings, bushings etc.

v. Samples of various item used in substations.

vi. Clear drawings and photographs of Control panel, protection schemes, earthing and complete power supply arrangement system.

The Contractor shall submit full details of the training span and other mock up equipment, photographs etc. including proposed training activities and objectives.

6.3.3 Training of Employer/ Engineer's Training Instructors (ETI)

The objective of the training is to enable the Employer/ Engineer's Training Instructors to be competent to deliver future training courses for other employees of the Employer.

The Contractor shall provide training to the Employer/ Engineer's Training Instructors on the various Systems. Aspects covered shall include, but not be limited to, the following:

i. Configuration of the entire System, including interface with the Haryana Bijlee Vitran Nigam Limited (HBVNL) supply system at the feeding points.

ii. Feature and functional principles of the entire System.

iii. System design aspects including but not limited to design standards, design criteria and parameters, short-circuit and other calculations, insulation and protection co-ordination.

iv. Details of major equipment and material including but not limited to voltage and current transformers, Electrical fittings, assemblies and protection relays, and cables of different types and their joints used in the system.

v. System operation and maintenance management and procedures.

vi. Earthing arrangement, covering safety aspects of touch and step potential, safety to personnel, passengers and outsiders.

6.3.4 Operations Staff Training

The objective of the training is to enable the Engineer's operations staff to be familiar with the Systems, with focus on the operational aspects under normal and emergency conditions.

The training shall also enable the trainee to acquire full capability for identification, trouble shooting and rectification of faults in the specified duration. After classroom training which includes mock ups of equipment, the staff shall be trained in actual operation.

6.3.5 Training Requirements

Manweeks of Contractor's Training Instructors for training the Employer's maintenance personnel shall be as under.

S.No.	Training	Man-Weeks
1	HT/LT Panels, Transformer, Circuit Breakers, DG set, AMF Panel, Switchgear and Cables, Capacitor bank.	2
2	Electrical Wiring, Pumps, Submersible pumps, UPS, Battery, Conduits, fencing.	2
3	Electrical Safety & Earthing system	1

6.4 DEFECTS NOTIFICATION PERIOD (DNP)

6.4.1 The Contractor shall be responsible for rectification of all the Defects and deficiencies, till the expiry of period of 01 (one) year from the date of taking over of works by the Employer. The Contractor shall repair or rectify all Defects and deficiencies observed by the Employer/ Engineer during the Defects Notification Period within time period as may be determined by the Engineer in accordance with Good Industry Practice. In any case, the defect shall be removed within 4 hours.

6.4.2 Contractor's Office During Defect Notification Period

Contractor shall establish and maintain the 'Maintenance office' manned with the supervisory and maintenance staff with a Dedicated Desk Officer to attend the calls of the Employer's Personnel and inform their Head of Maintenance who would promptly act to attend the emergencies/ maintenance calls including organizing of all the resources i.e. artisans and Material. The Contractor Shall Maintain a computer based Failure Reporting, Analysis, and Corrective Action System (FRACAS) system to log all the events of Failure.

6.4.3 Man and Material Required During Defect Notification Period

The contractor shall resource the required staff and Material during the Defect Notification period at their own cost for 24 hours all 7 days of every week to attend the Defects. The deployment of staff shall be approved by the Engineer. The Material, if any, used from the spares shall be made good. The contractor shall arrange all the Tools & Plants needed to attend the defects during the Defect Notification period. The Contractor shall replace, the defective systems/sub-systems/ equipment /modules/items/parts during the Defect

Notification Period (DNP). For this purpose, the Contractor shall store adequate number of equipment/modules/items/parts so that the defect is rectified in the least possible time without adversely affecting the train operation. Contractor shall submit the list of DNP spares with types and quantity which contractor intends to hold during DNP, at least six months before start of DNP, to Engineer for review.

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CHAPTER – 7 TECHNICAL SPECIFICATIONS AND DRAWINGS

Appendix-1: Intelligent Addressable Fire Detection and Alarm System

1.0 General

This specification includes supply, installation, testing and commissioning of a complete, operative, coordinated microprocessor controlled, analog addressable intelligent fire detection and alarm system and components thereof.

2.0 Standards

The following Standards and codes shall be applicable to the fire detection ans alarm system and components thereof. The latest issue (irrespective of year mentioned below) of the standards and codes shall be applicable.

NBC	National Building Code of India
IS	2189 Latest
NFPA 70: 1996	National Electric Code
NFPA 70: 1996 Chapter 3	Guidelines for Fire Alarm Systems
NFPA 70: 1996 Chapter 5	Guidelines for Heat and Smoke Detectors
NFPA 70: 1996 Chapter 6	Guidelines for Notification Appliances
NFPA 70: 1996 Chapter 7	Inspection Testing of Fire Alarm Systems
NFPA 90 A: 1996	Installation of air conditioning and ventilation systems
NFPA 101: 1994	Code for safety to Life from Fire in buildings
UL 864	
BS 5839- 1: 2002	Code of Practice for System Design and Installation
EN 54 - 1	Introduction
EN 54 - 2	Control and Indicating equipment
EN 54 - 3	Audible Alarm Devices
EN 54 - 4	Power supply Units
EN 54 - 5	Point Type heat Detectors
EN 54 - 7	Point Type Smoke Detectors
EN 54 - 10	Flame Detectors
EN 54 - 11	Manual Call Points
EN 54 - 12	Linear Smoke Detectors
EN 54 - 13	System Requirements
EN 54 - 14	Planning and installation
EN 54 - 15	Multi Sensor Detectors
EN 54 - 16	Voice Alarm Control Equipment
EN 54 - 17	Short Circuit Isolators
EN 54 - 18	Input/ Output Devices

EN 54 - 20	Aspirating Smoke Detectors
EN 54 - 21	Routing Equipment
VDE 0833	Alarm System for Fire, intrusion and hold up (all Parts)
DIN 14675	Fire Alarm System, Design and operation
EN 12094- 1;	Fixed fire fighting system component of gas extinguishing system, requirements, and test methods for electrical automatic control & delay device
VDS 2095	Approval of installer for fire alarm system

Equipment shall be tested in accordance with the relevant EN or UL Standard.

Test certification issued by VDs and UL for the respective equipment shall be furnished by the tender.

3.0 System

The automatic intelligent addressable fire detection system shall be built in accordance with the requirements of the applicable standard and shall include, but not be limited to, alarm initiating devices, alarm notification appliances, control panels, auxiliary control devices, annunciators, power supplies and wiring and complete with licensed software to operate and maintain the overall system.

3.1 **System Capability**

The system shall be rated for:

(a) Minimum 99/125/150 addressable detectors and/ or devices
(b) Loop length of up to 1000 metres

3.2 **System Parameters**

The Fire Alarm System :

(a) Shall be intelligent in operation with decentralized intelligence technology.
(b) Shall fulfil the demanded performance features without restrictions.
(c) Shall be microprocessor-controlled and monitored.
(d) 2- wire technology with power for initiating devices from the main fire alarm control panel.
(e) Shall be designed on loop technology with signal transmission within the campus via a multiplex communication network.
(f) Automatic and non-automatic detectors input and output modules shall be directly connectible to a loop circuit.
(g) The assignment, reassignment and interconnection of detectors in to detector zones should be possible from any position on the loop circuit, regardless of the position.
(h) Subsequent extensions of a detector zone should be simple to implement and should not require that the addresses of other detectors be changed or that the other detectors require reprogramming.

(i) Automatic reprogramming in case of change of location of any Detector.
(j) Detectors zones can consist of detectors connected to different modules/loop circuits or control panels.
(k) Detectors which are connected to different modules and sub control units can be linked.
(l) Two Detectors dependency programmable.
(m) Free allocation of detector groups and single detectors.
(n) Programmable "pre-alarm" condition when a detector is at 80% of its alarm threshold in a 60 second period.
(o) Every detector and every controller module shall constantly check its own status and send status information to fire alarm control panel.
(p) False alarm shall be filtered out by backed-up digital data transmission between detectors and the fire alarm control panel.
(q) Faulty detectors and modules as well as short circuits or wire breaks shall be precisely located and the information send to control panel.
(r) Each intelligent addressable smoke detectors in the system may be independently selected and enabled to be an alarm verified detector. The FACP shall keep a count of the number of times each detector has entered the verification cycle. These counters may be displayed and reset by the proper operator commands.
(s) During maintenance, interchanging or removal of detectors shall not cause system failure.
(t) System configuration saved using flexible flash memory technology.

3.3 System operation

3.3.1 Alarm/ Fault Operation

When a fire alarm/ trouble/ supervisory condition is detected and reported by one of the system initiating devices or appliances, the following functions shall immediately occur:

(a) The respective system alarm/ trouble/ supervisory LED in the Control panel shall flash.
(b) A local piezo-electric audible device in the control panel shall sound a distinctive signal.
(c) The 80-character backlit LCD display shall indicate all information associated with the fire alarm/ trouble condition, including the type and its location within the protected premises.
(d) All system outputs assigned via preprogrammed equations for a particular point in alarm/ trouble shall be executed, and the associated system outputs (alarm notification appliances and/ or relays) shall be activated.
(e) All magnetic door holders to doors to adjacent zones on the floor from which the alarm was initiated shall be released.
(f) The ventilation system or close associated control dampers as appropriate shall be shut down.

(g) Printing and history storage equipment shall log and print the event information along with a time and date stamp.

3.3.2 Smoke Control System Operation:

(a) On/Auto/Off switches and status indicators(LED) shall be provided for monitoring and manual control of each fan, stairwell pressurization fan, and smoke exhaust fan. The control system shall be field programmable.
(b) The off LED shall be Yellow, the ON LED shall be Green, the Trouble/Fault LED shall be Amber/Orange for each switch. The Trouble/fault indicator shall indicate a trouble in the control and/ or monitor points associated with that switch.
(c) Each group of eight LED shall have a local Acknowledge/Lamp Test momentary switch.
(d) Each switch shall have the capability to monitor and control two addressable inputs and two addressable outputs. In all modes, the ON and OFF indicators shall continuously follow the device status not the switch positions. Positive feedback shall be employed to verify correct operation of the device being controlled. Systems that indicate on/off/auto by physical switch position only are not acceptable.
(e) It shall be possible to meet the requirement mentioned above utilizing wall mounted custom graphic annunciators.

3.4 System Operational Controls

The following shall be adjustable/ operated from the fire alarm & control panel:

(a) Supervise and monitor all intelligent/ addressable detectors and monitor modules connected to the system for normal, trouble and alarm conditions.
(b) Supervise all initiating signaling and notification circuits throughout the facility.
(c) Detect the activation of any initiating device and the location of the alarm condition.
(d) Operate all notification appliances and auxiliary devices as programmed.
(e) Visually and audibly annunciate any trouble, supervisory or alarm, condition on operator's terminal, panel display, and annunciators.
(f) Disablement of individual detectors.
(g) Smoke detector sensitivity of all addressable detectors.
(h) Daytime/ Nighttime operation mode, for each detector zone and each individually selectable.
(i) Automatic Day/Night sensitivity adjust (high/low).
(j) Device Blink Control (turn of detector LED strobe).
(k) Environmental Drift Compensation (selectable ON or OFF).
(l) Automatic compensation for dust accumulation and other slow environmental changes.

(m) Watchdog-logics for automatically monitoring the system.

3.5 System Reliability

All components of the system shall be fully operational and not compromised in the event of any of the following:

(a) Fault in the control panel or in peripheral devices.
(b) Any error in any electronic item or external device.
(c) A fault in an operating group or a detector.
(d) A failure, a short circuit, or a wire break in a detector or in the fire alarm system cable.
(e) The fault shall be detected and displayed whilst the system continues to function fully.
(f) Recognition and evaluation of the status of detectors (contamination).
(g) Permanent automatic cyclic tests of parts of the fire alarm system and programs.
(h) Automatic restart function of the fire alarm system.

3.7 System Programming

The system shall be programmable, configurable and expandable in the field without the need for special tools for the following:

a) Individual addressing and disablement of detectors, I/O modules, as well as operating zones.
b) Individual programmable alarms, faults, disablements and actuations messages with date and time.
c) Actuations can be programmed by flexible assignment of inputs and outputs.
d) Software-controlled two zone dependency or two detector dependency for alarm notification.
e) Software-controlled two zone dependency or two detector dependency for alarm notification.
f) Two levels of password protection shall be provided in addition to a key-lock cabinet. One level shall be used for status level changes such as point/zone disable or manual on/off commands. A second (higher-level) shall be used for actual change of the life safety program.
g) User – specific software for three programmable receipts.
h) Programming or editing shall be done without special equipment and without interrupting the alarm monitoring functions of the fire alarm control panel.

4.0 Control Panel

4.1 Main Fire Control Panel

The main fire control panel shall communicate with and control all intelligent addressable detectors and modules, local and remote operator terminals, printers etc and shall conform to all operational and functional requirements as per specifications including but not limited to the following:

(a) Corrosion protected surface mounted cabinets constructed with 14 SWG CRCA sheets with key operated hinged front door with a transparent opening for viewing all indicators.
(b) 32 bit microprocessor based central processing unit(CPU)
(c) The panel shall work in degraded mode in CPU.
(d) The panel shall work in degraded mode in CPU of loop card or any other main devices for making the panel virtually fault tolerant.
(e) Modular installation
(f) All wiring terminal block shall be the plug-in/removable type
(g) Connection of up to 8 external operating panels over a maximum distance of 1200 meter
(h) 9 free slots for detector/notification appliances
(i) Audible and visual alarms for all faults
(j) Alarm delay mode
(k) Intervention mode
(l) Self-activating, cyclical control panel testing system, with fully automatic fault reporting
(m) System status Reports
(n) Alarm Verification, by devices, with tally
(o) Non-Fire Alarm Module Reporting
(p) Upload/Download System Database of PC Computer
(q) One Man Walk test.
(r) Security Monitor Points.
(s) Online or offline Programming
(t) Menu controlled user guidance in national language.
(u) Protection against RFI (Radio Frequency Interference) and (Electro Magnetic Interference) EMI compliance to EN 50082-2 (Emissions for Industrial Environments).
(v) Data serial interface for external serial equipment, etc.
(w) Emergency power supply with batteries for a supply interruption period of continuous 24 hours

4.2 Operating Panel Built in the Control panel cabinet.

(a) Integrated LED operating for status of the following

Power	Power Off	Fault	Fire Alarm
	Sounder Fault	Earth Fault	System Fault
Delayed Mode	Disablement	Relays Disabled	Sounder Disabled
	Alarms Silenced	Acknowledged	Test

(b) Operator control switch for:

Sound Alarms	Silence/ Resound	Mute	Acknowledge/System Reset

(c) Alarm counter

4.3 Alphanumeric Display for Indication Purposes shall conform to

(a) Membrane alphanumeric keypad
(b) 4 line
(c) 20 characters per line
(d) Plain text indication for all system status
(e) Display of following

Device Status	Device Type	Custom Device Label	Software Zone Label
Device Zone Assignment	Detector Analog Value		
All alarm messages	All fault messages	Disablements	All program parameters
Smoke Detector Pre alarm Indicator	Smoke Detector Maintenance Alert		
Contaminated Detectors	Removal, disconnection, or failure of any control panel module		
Individual and group display for all status of alarms			
Indication of definable additional text			

(f) If the capacity of the alphanumeric display unit does not permit all messages, faults, disablements, and alarms to be simultaneously displayed, then the total number of fire alarms, faults, disablements, and actuations shall be individually displayed in a separate display.
(g) Failure of the alphanumeric display unit or of individual elements shall not precipitate the loss or misinterpretation of individual messages and this shall be transferred to the printers.

4.4 External operating panel/ Repeater Panel

Function	Repeat display of fault alarms from Main Fire Control Panel
Specifications	External menu based operating repeater panel Membrane keypad Four line LCD display Indication of all system status as on main Control panel Indication of all conditions alarm, fault, disablement etc. Locating at distance up to 1,200 meters from Main Control Panel.

Power Supply	240 volt AC with in built battery for 24 hour operation and with self contained battery charger
Protection	IP 30

5.0 Batteries and Battery Charger

Battery	Completely maintenance free 2 volt, Gell-Cell type
Battery Rating	Minimum twenty-four hours on continuous operation
Battery Charger	240-Volt AC, 50 Hz source. Completely automatic, with constant potential charger
Charger Rating	Rated to fully charge a completely discharged battery within 48 hours while simultaneously supplying any loads connected to the battery.
Protection	Prevent discharge through the charger. For overloads and short circuits on both AC and DC sides.

6.0 Networking

(a) It shall be possible to network multiple fire alarm systems by means of serial data interfaces.

(b) Communication between the multiple fire control panels shall be with redundantly (duplicated) constructed loop circuit, so that the connection remains fully functional even in the event of three simultaneous connection faults.

(c) The centralized structure should allow the serial data connection of as many fire alarm control panels as required at any time, even subsequently.

7.0 Software

The software for Controlling the fire alarm system through an external PC shall provide interactive control with history logging, manual override control through on screen tough switches and display status of each detector/ zone and its location.

- Operating system: Windows 10.0 or latest
- Hardware should be: Pentium Gold Processor with 32 GB RAM VGA Graphics card and supporting 1280x 1024 resolution in 256 colours mode

8.0 System Integration and External Connectivity

(a) Integration with Public Address and evacuation system
(b) Provision for external PC
(c) Provision for Serial Printer

9.0 Addressable Devices

9.1 Detectors – General

All Intelligent Addressable Detectors shall comply to the following general technical specification in addition to the relevant clauses as under	
Specification	• Microprocessor based intelligent(analog) addressable. • A magnetic switch to simulate an alarm condition and test the detector • Internal identifying type code to identify the type of device (PHOTO, THERMAL). • Address-setting with a microprocessor • Permanent self-monitoring
Short Circuit Isolator	**I**ntegrated or external with each detector and module
Signal Transmission	Serial biphase data transmission, 2 wire technology
Mounting	Inserted into or removed from the base by a simple push-twist mechanism to facilitate exchange or cleaning and maintenance
Indication	LEDs flashing under normal conditions steady illumination indicating an alarm condition. External remote alarm LED output connection in the base
Protection	IP 44
Ambient Temperature	(-)5°C to +60°C
Relative air humidity	Short term, no condensation 95% Long term, no condensation 70%
Case material	ABS (Acrylonitrile Butadiene Styrene) / PC, FR90
RFI and EMI	High immunity against RFI and EMI and compliance to relevant specifications

9.1.1 Addressable Photoelectric Smoke Detector

Function	Based on light scattering type photoelectric smoke sensor
Specification	• Totally free of radioactive component • Air velocities up to 0-2.54 m/sec without requiring specific duct detector housings. • Reversed polarity or faulty zone wiring shall not damage the detector.
Settings	Smoke detector element shall respond to invisible and visible smoke with smoke Obscuration per foot alarm field selectable set point over five sensitivity settings ranging from 1.0% to 3.5%
Compensation	Light source intensity shall automatically self-adjust to compensate for possible effects of dirt and dust accumulation in the sensor/lens.

9.1.2 Addressable Multi Criterion Detector

Function	Dual function photoelectric cum heat detector having light scattering type photoelectric smoke sensor two independent thermistors for combined rate of rise/fixed temperature heat detectors
Specifications	• Provision for disabling either element at site • Smoke detectors element shall respond to invisible and visible smoke • Time based algorithms to dynamically examine values from the two sensors simultaneously and initiate an alarm based on that data. • Totally free of radioactive components. • Air velocities up to 0-2.54 m/sec without requiring specific duct detectors housings. • Reversed polarity or faulty zone wiring shall not damage the detector.
Settings	Smoke detector element shall respond to invisible and visible smoke with smoke Obscuration per foot alarm field selectable set point over five sensitivity setting ranging from 1.0% to 3.5%. Temperature change of 35 Deg C or reaches a fixed temperature alarm set point of 57 Deg Centigrade nominal.
Compensation	Light source intensity shall automatically self-adjust to compensate for possible effects of dirt and dust accumulation in the sensor/lens. Automatic self-adjust Compensation against environment effects of dirt, smoke, temperature, age and humidity temperature

9.1.3 Intelligent Addressable Heat Detectors

Function	Two independent thermistors for Combined rate of rise/fixed temperature heat detectors
Specification	• Automatic compensation for changes in ambient conditions • Reverse polarity or faulty zone wiring shall not damage the detectors.
Setting	Temperature change of 35 Deg C or reaches a fixed temperature alarm set point of 57 Deg C nominal.
Compensation	Automatic self-adjust Compensation against environment effects of dirt, smoke, temperature, age and humidity temperature

9.1.4 Intelligent Addressable Beam Smoke Detector

Function	Smoke creating alarm by affecting Infra red beam between transmitter and a receiver unit Installation directly on the loop
Specifications	• Monitoring length …………5 to 100 m • Signal processing:……………. 8-bit microprocessor • Sensitivity:……………………….3 step adjustable (25, 50, 70%) Compensation :…Pollution of the optics is hourly compensated to ± 1%

9.1.5 Standard detector base

Function	Suitable for mounting different types of fire alarm detectors
Specification	• Surface mounting • Bayonet fitting of detector to base • Complete with removable dust cover to protect the contact area during installation and construction phase • The detector contact points shall be designed to ensure uninterrupted contact when exposed to continuous severe vibrations.
Protection	IP54 with Detector inserted

9.1.6 Intelligent addressable Manual call point

Function	Intelligent addressable manual release of a fire alarm for indoor use Installation directly on the loop
Construction	Case material : Plastic, reinforced with fiberglass The word FIRE shall appear on the front of the manual call box in raised letters, 50 mm or larger.
Operation	Smashing the glass panel and pressing the button which shall remain locked
Signal Transmission	Serial data transmission, 2 wire technology
Indication	Actuated state shall be indicated by means of a built-in LED
Protection	IP24
Location	Height 1400 mm above floor level

9.2 Notification Devices

9.2.1 Addressable Dry Contact Monitor Module

Function	Connect one supervised IDC zone of conventional alarm initiating devices (any N.O. dry contact device) to one of the fire alarm control panel SLCs.
Mounting	101.6 mm square 54 mm deep electrical box.
Indication	LED flashing under normal conditions

9.2.2 Addressable Control Module

Function	Supervise and control the operation of one conventional NACs The relay coil shall be magnetically latched to ensure that 100 % of all auxiliary relay or NACs may be energized at the same time on the same pair of wire.
Mounting	101.6 mm square 54 mm deep electrical box.
Indication	LED flashing under normal conditions

9.2.3 Isolator Module

Function	Automatically isolate wire-to-wire short circuits Automatically reconnect the isolated section when fault is removed. No reset/ replacement required after its normal operation.
Mounting	101.6 mm square 54 mm deep electrical box.
Indication	LED flashing under normal conditions and Steady to indicate fault/ alarm

9.2.4 Addressable Audio Loop siren

Function	• Direct connection to the loop. • Output sound level of at least 90 dBA measured at 3 m from the device. • Multiple selectable tones: • 3 different tones selectable directly from the control panel and field programmable • Adjustable volume by means of a DIP-switch
Mounting	101.6 mm square 54 mm deep electrical box.
Indication	LED flashing under normal conditions and Steady to indicate fault/ alarm

9.2.5 Response Indicator

Function	Remotely indicate status of loop technology detectors
Mounting	101.6 mm square 54 mm deep electrical box.
Indication	LED flashes Red when detector is set off Flashing frequency 1.8 Hz to 3.4 Hz

9.2.6 Base-mounted siren

Function	• Electronic siren in the detector base for local acoustic warning

	• Siren shall trigger simultaneously with alarm message
Mounting	Integrated with Detector base
Indication	• Intermittent acoustic alarm signal. • Sound source: Piezo buzzer.

9.2.7 Addressable Loop Flashlight

Function	• Optical indication of a fire alarm inside rooms • Direct connection to the loop technology
Mounting	Integrated with Detector base
Indication	• Adjustable flash rate and light intensity by means of DIP-switch. • Flash frequency: 0.5 Hz (slow) or 1 Hz (fast)

9.2.8 Strobe Lights

Strobe lights shall meet the requirements of the relevant Standards and shall have a maximum pulse duration of 2/10 of one second.

10 Copper Conductor Cables

10.1 Conventional Fire Detection System Cabling & Wiring

10.1.1 The type of conduit and the service shall be as shown below:

- Embedded in walls & slabs: Heavy gauge galvanized steel.
- Exposed/ surface run: Heavy gauge galvanized steel.

10.2 Multi core cables shall be XLPE insulated FRLSH type with copper conductors confirming to relevant IS standard. Single core cables shall be FR PVC insulated with copper conductor.

11 Approvals

The tender shall confirm the standards to which the equipment complies and obtain all approvals from concerned fire authorities.

12 Installation and Testing

12.1 Installation

(a) Installation shall be in accordance with the applicable codes.

(b) All equipment and components shall be installed in strict compliance with each manufacturer's recommendations.

(c) All Equipment shall be attached to wall and ceiling/floor assemblies and shall be held firmly in place. Fasteners and supports shall be adequate to support the required load.

(d) The main fire alarm control panel shall be connected to a separate dedicated branch circuit. This circuit shall be labelled at the main power distribution panel as FIRE ALARM. Fire alarm control panel primary power wiring shall be 4.0 sqmm FR PVC insulated copper wires. The control panel cabinet shall be grounded securely to the system earthing.

(e) All conduit, junction boxes, conduit supports and hangers shall be concealed in finished areas and may be exposed in unfinished areas.

(f) Smoke detectors shall not be installed prior to the system programming and test period. If construction is ongoing during this period, measures shall be taken to protect smoke detectors from contamination and physical damage.

12.2 Testing

Prior to energizing the system, the manufacturer of the fire alarm equipment shall technically supervise and participate during all of the following adjustments and tests:

(a) Check correct connection of all cables and wires and test for short circuits, ground faults, continuity, and insulation.
(b) Open initiating device circuits and verify that the trouble signal actuates.
(c) Open signaling line circuits and verify that the trouble signal actuates.
(d) Open and short notification appliance circuits and verify that trouble signal actuates.
(e) Ground initiating device circuits and verify response of trouble signals.
(f) Ground signaling line circuits and verify response of trouble signals.
(g) Ground notification appliance circuits and verify response of trouble signals.
(h) Check alert tone and pre-recorded voice message to all notification devices.
(i) Check installation, supervision, and operation of all intelligent smoke detectors using walk test.
(j) Introduce all faults and verify the proper receipt and the proper processing of the signal at the FACP and the correct activation of the control points.

12.3 Final Inspection

At the final inspection, a factory trained representative of the manufacturer of the major equipment shall demonstrate that the system function properly in every respect.

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CHAPTER – 7 TECHNICAL SPECIFICATIONS AND DRAWINGS

Appendix- 2: PORTABLE FIRE EXTINGUISHERS

1 SCOPE

The scope of work covers the supply and installation of portable fire extinguishers. The following types are envisaged in these specifications and provided as shown in the schedule of portable fire extinguishers:

a) Dry powder extinguisher.
b) Carbon-dioxide extinguisher.
c) Mono ammonia phosphate extinguisher.
d) Water expelling type.

2 Standards

The following standards and rules and regulations shall be applicable:

(a)	Fire protection manual of the Tariff Advisory Committee, Fire Insurance Association of India	
(b)	IS:4308 – 2003	Portable fire extinguisher dry power type
(C)	IS:2878 – 2004	Portable fire extinguisher carbon-dioxide type
(d)	Local Fire Brigade/Authority	

3 Extinguishers

3.1 **Dry powder type :**

The extinguishers shall be of 2, 5 and 10 kg capacity, cartridge type unless otherwise specified. The body shall be of cold rolled carbon steel grade D, 1.5mm thick up to 5 kg and 2mm for 10 kg. The construction shall be similar to 'Soda Acid type' but of the following dimensions:

Capacity (kg)	**Outside diameter (mm)**	**Filler opening (mm)**
2	100	45
5	150	45
10	175	45

(a) The discharge fitting shall be with 500mm, 10mm diameter hose up to 5 kg and 750 mm, 12.5 mm diameter for 10 kg with a trigger controlled nozzle capable of discharging 85% of the contents as follows:

Capacity	**Time (sec)**	**Throw (m)**
2	8 – 10	2
5	15 – 20	4
10	23 – 30	6

(b) A carbon dioxide cartridge conforming to IS: 4947 - 1985 shall be fitted in a cartridge holder with an inner shell. A spring loaded piercing device shall be provided in the cap for piercing the seal of the gas cartridge. A siphon tube of copper or PVC shall be provided for upright operation. The cap and neck ring shall be similar to Soda Acid type extinguisher.

(c) All internal and external components and surfaces shall have anti-corrosive coating of not less than 12 microns applied uniformly as indicated below:

(a)	Body	Mild Steel	Tin alloy
(b)	Cage for acid bottle and spring	Brass sheets	Lead or Tin alloy
(c)	Discharge fittings	Leaded-tin bronze	Tin alloy
(d)	Stainer	Brass sheets	Lead or Tin alloy

3.2 **Carbon dioxide type.**

(a) The extinguishers shall be rated for 2.0 and 4.5 kg by weight of carbon dioxide, unless otherwise stated. The contents shall be with a filling ratio not exceeding 0.667.

(b) The discharge head shall be simple and to operate conforming to IS: 3224 - 2002 with a safety release as per IS: 5903 - 1970 set to 18.0 to 20.0 N/mm^2. A siphon tube of copper or PVC shall be fitted. A non -conducting discharge horn and a high-pressure hose (27.5 N/ mm^2 pressure) shall be fitted with each extinguisher.

(c) The discharge system shall be to designed to expel 95% of the contents in continuous discharge as follows:

Capacity (kg)	**Time (sec)**
2	8 – 18
3	10 – 20
4	9 – 24

4 GENERAL REQUIREMENTS

(1) All extinguishers shall be standard products, approved by the Tariff Advisory Committee and Local Fire Authority, manufactured and tested strictly in accordance with the relevant Indian Standard. All markings and test results shall be stamped in the appropriate colour markings according to the Indian Standards.

(2) All Extinguishers shall have a structurally designed galvanized steel handle and a suitable wall-mounting bracket.

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CHAPTER – 7 TECHNICAL SPECIFICATIONS AND DRAWINGS

Appendix- 3: FIRETRACE TUBE SYSTEM

1 GENERAL

(a) The Fire Trace Tube System shall be simple self-activating system and shall offer the widest Versatility. The system shall not have any complex electronics or any moving parts.

(b) Fire trace tube system shall have a flexible detection and delivery system called Fire Trace Tubing. The tubing shall be manufactured from specially processed polymer materials to achieve the desired heat detection and delivery characteristics.

(c) The Fire Trace Tubing, which is pressurized, shall be placed within an enclosed aera above potential fire hazards and secured in place with brackets provided.

(d) The Fire trace system shall discharge the extinguishant directly from the burst hole in the tube, this will be the closest point to the fire, and will allow the fastest extinguishing time and minimum spread of the fire.

(e) The Fire trace automatic fire extinguishing systems shall not need any external energy / power supply. The fire trace system shall always operative even during energy break down.

(f) The Fire trace automatic detection shall be considered as a lineal heat/flame detector. When the temperature is increased to above 120 deg. C or the Fire trace automatic detection tube is touched by a flame, the tube bursts and initiates the diffusion of the extinguishing medium.

(g) The design of the Fire trace automatic fire extinguishing system shall be simple and allow for a minimum of maintenance work. The system shall have reduced risk of malfunction because there are virtually no moving parts and shall reduces the risk of false alarms. The Fire trace automatic detection tube shall be capable of working even when contaminated with oil, dust and debris as long as the contamination will allow heat to pass through to the tube.

(h) The System shall not require specialist equipment or highly trained installers.

(i) The Fire trace automatic fire extinguishing system shall be minimally affected by vibrations or similar disturbances since there are no mechanical function mechanisms or electric contacts.

(j) Fire traces systems shall be suitable for Clean Agent Gas and all other high pressure applications. Fire trace shall have the ability to provide automatic protection.

2 INSTALLATION:

(1) The red Firetrace Detection Tubing (FDT) shall run into and throughout the cabinet, ensuring that detection is close at hand should a fire start.

(2) Should a fire break out, the point on the pressurized FDT nearest the heat source will burst, allowing the fire suppression agent to flow from the Fire trace cylinder through the tubing and out of the rupture hole directly at the source of the fire. The result is a long discharge of agent in the immediate vicinity of the fire, suppressing the fire where it starts.

(3) The following items shall be provided for each panel:

i. 9.0 kg capacity $C0_2$, IHP Valve Assembly with automatic valve, push in connector for tube, 9.0 Kg $C0_2$ & mounting bracket — 2 nos.
ii. Filling Adopter — 2 nos.
iii. Outlet Adopter — 2 nos.
iv. Pressure Switches for monitoring system activation — 2 nos.
v. End of Line Adopter - 2 nos.
vi. Fire trace make linear pneumatic heat Detection Tube with all necessary fittings & supports 170 meter

vii. Master Control Unit for controlling each system complete with pressure switches buzzers and electronic hooters including all necessary accessories + electrical wiring to make each entire system functional — 2 nos.

viii. Auto weight measuring Unit for Cylinders with automatic audio/visual Alam — 2 nos.

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CHAPTER – 7 TECHNICAL SPECIFICATIONS AND DRAWINGS

Appendix- 4: Technical Specification for Compact Substation (CSS)

1. GENERAL:

Supply, installation, testing and commissioning of Compact Sub-Station (CSS) (11/0.44 kV) consisting of 11 kV Compact VCB panel (1 incoming isolator + 1 outgoing ACB with air insulated BUS PT metering module) with DRY type Transformer (250 kVA) Capacity and LT Switchgear with all HT & LT inter- connections, accessories, fittings & auxiliary equipment inside GI enclosure etc.

2. DESIGN CRITERIA

(a) Package substation consisting of 4 way, 11kV SF6 insulated switchgear with 630A at 11 kV vacuum circuit breaker, 11kV/440V, 250 kVA dry type transformer, 440V, 630A VCB incoming with all connection, accessories, fitting and auxiliary equipments in an enclosure to supply low voltage energy from high voltage system as detailed in this specification. The complete unit shall be installed on a substation plinth (base).

(b) The prefabricated package substation shall be designed for (a) compactness, (b) fast installation, (c) maintenance free operation, (d) safety for worker/ operator.

(c) The switchgear and component thereof shall be capable of withstanding the mechanical and thermal stresses of short circuit listed in ratings and requirements clause without any damage or deterioration of the materials.

(d) The continuous operation at specified ratings temperature rise of the various switchgear components shall be limited to permissible value stipulated in the relevant standard and/ or of this specification.

(e) The enclosure of high voltage switchgear-control gear, low voltage switchgear-control gear and transformer of package substation shall be designed to take minimum space for the installation including the space required for approaching various doors and equipment inside.

3. SYSTEM DETAILS

3.3 (a) The main components of prefabricated substation are transformer, high voltage switchgear-control gear, low voltage switchgear-control gear and corresponding interconnections (cable, flexible busbars) and auxiliary equipments. The components shall be enclosed by either common enclosure or by an assembly of enclosure. All the components shall comply with their relevant IEC standards.

(b) The enclosure shall be made of CRCA sheet powder coated 7 tank process for all weather conditions. The metal base shall ensure rigidity for easy transport & installation. The protection degree of the enclosure shall be IP23 for LT & HT switchgear compartment and transformer compartment. Proper/ adequate ventilation aperture shall be provided for natural ventilation by way of Louvers etc. The doors shall be provided with proper interlocking arrangement for safety of operator.

(c) The LV outgoing of the transformer shall be connected to incomer of the Low Voltage Switchgear by means of Copper Cables / Flexible Copper Busbars.

3.4 **Internal Fault:**

Failure within the package substation due either to a defect, an exceptional service condition or mal-operation may initiate an internal arc. Such an event may lead to the risk of injury, if persons are present. It is desirable that the highest practicable degree of protection to persons shall be provided. The design for internal arc fault shall be tested for 20KA as per IEC 61330/ 62271-202.

3.5 **Covers and Doors:** Covers and doors are part of the enclosure. When they are closed, they shall provide the degree of protection specified for the enclosure. Ventilation openings shall be so arranged or shielded that same degree of protection as specified for enclosure is obtained. Additional GI/stainless steel wire mesh shall be used with proper danger board for safety of the operator. All covers, doors or roof shall be provided with locking facility.

3.6 **Earthing:** All metallic components shall be earthed to a common earthing point. It shall be terminated by an adequate terminal intended for connection to the earth system of the installation, by way of flexible jumpers/ strips and lug arrangement. The continuity of the earth system shall be ensured taking into account the thermal & mechanical stresses caused by the current it may have to carry. The components to be connected to the earth system shall include:

(a) The enclosure of the package substation,
(b) The enclosure of high voltage switchgear and control gear from the terminal.
(c) The transformer tank
(e) Frame of substation.

3.7 There shall be an arrangement for internal lighting activated by associated switch for HV, transformer and LV compartments separately.

3.8 **Labels:** Labels for warning, manufacturer's operating instructions etc. shall be durable & clearly legible.

3.9 The Circuit Breaker shall control 11kV/ 415V transformer of rating 250 KVA and relay settings shall be selected accordingly.

3.10 **General Finish:** Totally enclosed, metal clad, vermin and dust proof suitable for tropical climate use as detailed in the specification.

3.11 **Ratings:** The busbars shall have continuous rating of 800A. Circuit Breaker shall have a continuous rating of 630A in accordance with relevant IEC standard. Switchgear shall be complete with all connections, busbars etc.

3.12 **Breaking and Making Capacity:** Circuit Breaker shall be capable of having rupturing capacity of 20 kA symmetrical at 11 kV.

3.13 **Isolator (Load Break Switch):** The Isolators shall conform to IS: 4710/9920 (latest version). The isolator shall be ON load type, triple pole, spring assisted, hand operated, non-automatic type with quick break contacts and fault indication. The operating handle shall have three positions 'ON', 'OFF' and 'EARTH' which shall be clearly marked with suitable arrangement to padlock in any position. A safety arrangement for locking shall be provided by which the isolator operation shall be prevented from 'ON' position to 'EARTH' position or vice versa.

3.14 **(a) (i) Vacuum Circuit Breaker (VCB):** The Unit shall consist of 630A, 11kV, 3-phase spring assisted three position, three pole vacuum circuit breaker, with integral fault making/ dead breaking earth switch. The function shall be naturally interlocked to prevent the main and earth switch from being switched 'ON' at the same time and the VCB shall not be allowed to trip in 'Earth On' position. The selection of the main/ earth switch lever on the panel, which is allowed to move only if the main or earth switches in the off position. The lever shall be able to pad locked in either the main or earth position.

(ii) The manual operation of the vacuum circuit breaker shall not have an effect on the trip spring. This should only be discharged under a fault (electrical) trip condition. The manual reset operation should recharge the trip spring and reset the VCB mechanism in 'main off' position.

(iii) **Protection Relay:** The CB shall be fitted with self-powered relay inside the front cover to avoid any tampering. The relay should be 3 Over Current and 1 Earth Fault, fed by protection CT mounted in the cable box.

3.15 (b) **(i) Air Circuit Breaker (ACB):** The Unit shall consist of 630A, 440V, 3-phase, tee-off spring assisted three position, three pole air circuit breaker, with integral fault making/ dead breaking earth switch. The function shall be naturally interlocked to prevent the main and earth switch from being switched 'ON' at the same time and the ACB shall not be allowed to trip in 'Earth On' position. The selection of the main/ earth switch lever on the panel, which is allowed to move only if the main or earth switches in the off position. The lever shall be able to pad locked in either the main or earth position.

(ii) The manual operation of the air circuit breaker shall not have an effect on the trip spring. This should only be discharged under a fault (electrical) trip condition. The manual reset operation should recharge the trip spring and reset the ACB mechanism in 'main off' position.

3.16 Cable Box:

The VCB shall be provided with suitable and identical cable boxes in front for connecting 2 runs of 3 core X 120 sqmm, 11 kV cable from vertically below. The cable boxes shall be so located at convenient height to facilitate easy cable jointing work. The height available for cable termination should be minimum 500 mm. The Cable termination shall be done by heat shrinkable termination method so adequate clearances shall be maintained between phases for termination. It shall be possible to terminate 2 runs of 3 Core X 120 sqmm cable.

3.17 Locking Arrangement: Suitable padlocking arrangements shall be provided as stated below.

(a) CB manual operating handle in the "OFF" position.
(b) Each feeder Panel operating handle in 'Closed', 'Open" or 'Earth' position.

3.18 Ratings:

	Vacuum Circuit Breaker (VCB)	
1)	**Circuit Breaker**	
a)	Type	Vacuum Circuit Breaker
b)	Rated voltage	11 kV, 3-phase
c)	Load Breaking current	20 kA
d)	Making current	50 kA
e)	Rated current	630 amp
f)	No. of poles	3
g)	Operating mechanism.	Trip free & free handle type with mechanically operated and pad locking
2)	**Busbars:**	
a)	Material	Copper
b)	Rated Current	630 Amp
c)	Short time rating for 3 Sec.	20 A

3)	**Isolator**	
a)	Type	Load break switch
b)	Rated current	630 Amps
c)	Rated breaking capacity	630 Amps
d)	Fault making capacity	50 kA peak
e)	No. of poles	3
f)	Operating mechanism	Operating handle with ON, OFF, Earth position with arrangement for padlocking in each position.
4)	**Isolator**	
a)	Type	Off Load break switch
b)	Rated current	630 Amps
c)	Rated breaking capacity	630 Amps
d)	No. of poles	3
e)	Operating mechanism	Operating handle with ON, OFF, Earth position with arrangement for padlocking in each position.

4 11kV/440V, 250 kVA, CAST RESIN DRY TYPE TRANSFORMER SPECIFICATION

SN	Descriptions	Unit	Specification
1	Service		Continuous
2	Type		Cast Resin Dry Type
3	Rating	kVA	250
4	Rated frequency	Hz	50
5	Number of Phase		
	HV Side		3
	LV Side		3
6	Rated Voltage		
	HV side	kV	11
	LV side	kV	0.440
7	Vector Group		Dyn 11
8	Type of Cooling		AN (Air Natural)
9	Class of insulations		Class F
10	Method of earthing- LV		Solidly Earthed
11	Duty		Continuous
12	Taps		
	a) Range	**%**	+5% to -5%
	b) No. of Steps		Five
	c) In steps of		2.5
	d) Tapping Provided on HV Side		Taps Provided on HV side
13	Tap Changer Type		Off Circuit Tap Links
14	Reference Standards		IS 2026/IS 11171
15	Fittings and Accessories		
	a) Off circuit tap links		Yes
	b) 02 nos. Earthing Terminal		Yes
	c) Rating and Diagram Plate		Yes
	d) Lifting Lugs for Complete Transformer		Yes

	e) Cover Lifting lugs		Yes
	f) Rollers		Yes

5 **Low Tension (LT) Panel:**

(a) **Nominal voltage**: 3 Phase, 440V, 50 Hz
(b) **Neutral:** Solidly earthed at substation**.**
(c) **Busbar:** 800A copper
(d) **Circuit Ways:** 630A, 3-pole, Air Circuit Breaker(ACB), fixed type with Over Current, short circuit and Earth Fault Releases (Microprocessor based).

(e) **Earthing:**

(1) Earthing arrangement shall be provided for earthing of each armoured cable, neutral busbar, chassis and framework of the cubicle with separate earthing terminals at two ends. The main earthing terminals shall be suitably marked. The earthing terminals shall be of adequate size, protected against corrosion, and readily accessible. These shall be identified by means of sign marked in a legible manner on or adjacent to terminals.
(2) Neutral bus bar strip shall be connected to Earthing terminal with help of GI strip of suitable capacity & GI nut, bolt, washer arrangement.

6 **ROUTINE TESTS FOR THE PACKAGE SUBSTATION COMPLETELY ASSEMBLED**:

(a) **Routine Tests:** The routine tests shall be made on each complete prefabricated substation. These tests shall include but not limited to the following:

(1) Voltage tests on auxiliary circuit.
(2) Functional test.
(3) Verification of complete wiring.
(4) VCB, ACB, busbars etc

(b) **Test Certificates**:

The test reports of all the tests carried out at the works shall be furnished in three (3) copies to the Engineer.

7 **CODES AND STANDARDS**

7.2.2.1.1 All equipment and material shall be designed manufactured and tested in accordance with the latest applicable IEC standards. The 11 kV package substation design must be as per IEC- 61330.

7.2.2.1.2 The package substation offered shall in general comply with the latest issues including amendments of the following standards:

Description	Standard
High voltage low voltage prefabricated substation	IEC-61330/ 62271-202
High voltage switches	IEC-60265
Metal enclosed high voltage switchgear	IEC-60298/ 62271-200
High voltage switchgear	IEC-60694/ 62271-100
Low voltage switchgear and control gear	IEC-60439/ 60947
Power transformers	IEC-60076

XXX

CHAPTER – 7 TECHNICAL SPECIFICATIONS AND DRAWINGS

APPENDIX-5: LIST OF DRAWINGS

LIST OF DRAWINGS

Electrical Drawings

SN	Description	Drawing No.
1	Indicative LT Supply System with Local, DG and Auxiliary Transformer Supply	GC-HRIDC-C5-DRW-ELE-001-A0
2	Indicative LT Supply Distribution Diagram	GC-HRIDC-C5-DRW-ELE-002-A0
3	Indicative Arrangement of street light pole at station and platform	GC-HRIDC-C5-DRW-ELE-003-A0
4	Indicative cable route plan for track crossing of power cable and route marker	GC-HRIDC-C5-DRW-ELE-004-A0
5	Indicative earthing arrangement of electrical system by copper cladded electrode	GC-HRIDC-C5-DRW-ELE-005-A0
6	Indicative schematic drawing of 11kV power supply arrangement	GC-HRIDC-C5-DRW-ELE-006-A0
7	Indicative LT Supply System with Local and Auxiliary Transformer Supply	GC-HRIDC-C5-DRW-ELE-007-A0
8	Indicative Compact Substation (CSS) single line diagram	GC-HRIDC-C5-DRW-ELE-008-A0
9	Indicative viaduct lighting drawing	GC-HRIDC-C5-DRW-ELE-009-A0

XXX

Section VII: Employer's Requirements
Section VII-7B: Signalling & Telecom (S&T) Works

Table of Contents

Chapter 1

Relocation of S&T Cables in Connection with Civil Works under Package C-5 of HORC Project

1. Introduction

1.1 Signaling & Telecom cables and location boxes in Prithla Station area and beyond are infringing into earth work of formation for laying of in connection with laying of New BG Double Railway line from Ch: (-) 2.296 Km to 10.00 Km including Prithla Station of HORC project. These cables and location boxes need to be shifted/ replaced with new cables and location boxes on alternate route, as decided by the Engineer.

2. Scope of the Works:

Scope of the Works broadly includes supply of material and execution of work as given below:

2.1 Supply of major materials-

2.1.1 Supply of Signaling cable 6, 12 & 24 core dia. 1.5 mm as per RDSO Specification IRS-S-63/2014 {Rev. 4.0}/(latest).

2.1.2 Supply of Location Box as per RDSO drg. no- RDSO/S-11500 & RDSO/S-11507 /(latest) and termination material etc.

2.1.3 Supply of relays Q-series as per specification BRS 930/ BRS 931/(latest).

2.1.4 Supply of 24F OFC as per RDSO specification IRS-TC-55/2006/ (latest).

2.1.5 Supply of 6 Quad Cable as per RDSO specification no. IRS TC: 30/2005 /(latest).

2.1.6 Supply of HDPE duct as per RDSO specification- no. RDSO/SPN/TC/45/2012 Rev 2.0/ (latest)

2.1.7 Supply of DWC pipe as per RDSO specification no. RDSO/SPN/204/2011 ver 0.1/ (latest).

2.1.8 Supply of material for OFC & quad cable jointing and Splicing termination etc as per RDSO/TEC specifications/ (latest).

2.2 Execution of work

2.2.1 Trenching, protection work and laying of cables and backfilling.

2.2.2 Installation of Location boxes with proper foundation as per drawings, providing fittings for installing equipment- & terminating cables etc.

2.2.3 Termination /Splicing of Cables and testing etc.

2.2.4 Transfer of S&T circuits in new cables laid.

2.2.5 Releasing of old material from site.

2.2.6 Documentation of completed work and handing over to DFC.

3. The Signalling and Telecom work shall be carried out as per technical requirements, approved guidelines, practices and drawings as enclosed in **Chapters 2** and **3 below**. For items where the specifications are not specifically indicated above, the material shall be as per RDSO/ TEC specifications or from approved sources as per BIS. The drawings for the execution of works are given in Section VII-8: Tender Drawings and Documents, Part 2-Employer's Requirements.

[End of Chapter 1]

Chapter 2

Technical Requirements- Signalling Cable Laying, Termination and Testing

1. Signalling Cables

1.1 The cables for carrying **outdoor Signalling circuits** shall be PVC insulated, PVC sheathed and armoured unscreened cable conforming to IRS specification, described in scope of work above. The cable shall be of **6/12/19/**24 core with annealed copper conductor having minimum cross-sectional area of **1.5 sq.mm.**

1.2 The cables for carrying **Signalling power supplies** outdoor shall be copper conductor, minimum conductor size **25 sq. mm,** Multi strand PVC insulated armoured, unscreened, underground power cable as per IRS specification described in scope of work above or equivalent BIS specifications.

1.3 The **Quad cable used for Axle Counter circuit** shall be 0.9mm 6 Quad Telecom underground polyethylene insulated jelly filled (PIJF) cable as per RDSO specification described in scope of work above.

1.4 The **Optic Fiber Cable** for the Signalling system shall be provided as per RDSO Specification described in scope of work above. The OFC shall be laid in 40/33mm HDPE duct and spliced/ terminated.

1.5 Indoor Cable/ Wire used shall be single/multi core, plain annealed high conductivity copper conductor, PVC insulated unarmored as per IRS specification described in scope of work above. All equipment shall, be wired as per the requirement of the relevant RDSO specification of the equipment and/or as specified by the OEM. The Q style relays shall be wired with 16/0.2 mm multi strand wire.

1.6 All cables shall be adequately rated for their current carrying capacity. All power cables shall be able to withstand full load current for peak operation.

1.7 A **labelling** scheme shall be applied for all cables installed. Each cable shall be uniquely identified. Labels shall be tied at both ends, at entry and exit points of cable trays, ducts and trenches and at other appropriate locations where necessary. The type of labels to be used shall be approved by the Engineer.

1.8 The **DWC-HDPE pipe/duct** used for protection of Signalling cables **below the track/ road, on the slope of embankment for crossing bridges, on the top of PCC/RCC bridges, Cable duct in tunnels** or any other place shall be supplied as per RDSO specifications described in scope of work above.

1.9 Medium type "B" Grade **GI Pipe** (blue colour strip) perforated shall be provided on the top level of all OWG bridges.

1.10 On top of PCC/RCC bridges, if concrete cable duct is not available then GI pipe with suitable support shall be provided with concrete cover.

1.11 Signalling cables shall be laid in RCC ducts in station areas, and protected with RCC covers. Since HORC has most of the railway alignment at 6-8 meters elevated from ground, the ducts shall be laid inside the edge of formation with approval of the Engineer. Outside the station area i.e., beyond Home Signals, the signalling cable shall be protected with 'B' class bricks laid perpendicular to trench.

1.12 Signalling and Telecom cables shall be laid in separate trenches to the extent possible. If that is not possible a brick separation shall be provided.

2. Cable Core Allocation

2.1 A cable core distribution plan shall be prepared for each installation. Separate cables may be considered for line wise and function wise cabling.

2.2 Preferably 6/12/24 core outdoor signalling cables shall only be used.

2.3 Adequate spare conductors, a minimum of **20% of the total conductors (min 2 core)** used shall be provided for each main cable up to home signal and **10% (2Crores min) up to distant signal**. All branch/tail cables shall have at least **10% spare cores** (min. 2 cores). The spare conductors shall be provided in the outermost layer. All spare cores shall be made through up to the end points and terminated. For signals far from relay room (viz. distant signal), **double cores in cable** may be provided.

2.4 Where a number of cables have been used, the circuits shall be so distributed that the cables can be disconnected for maintenance purposes with the least possible dislocation to traffic. Line-wise and if necessary, function-wise cables shall be provided.

2.5 A separate cable shall be used for operation of each point/crossover. **Operation and detection circuit** shall work on different cables.

2.6 **UP and DN track vacancy detection systems** shall be in different cables.

2.7 The quad cable used for signalling functions shall also **have 20% (2 core min) spare** conductors.

3. Cable Route Plan

3.1 After deciding the size and the number of conductors in the different types of cables to be used on a route, a foot survey along the track shall be done to determine the best route for the cable.

3.2 While planning the cable route, any future yard modification etc. shall also be kept in view.

3.3 As far as possible low-lying areas, platform copings, drainages, hutments, rocky terrains, points and crossings, shall be avoided.

3.4 The cable route plan shall **show the actual alignment of track, giving offsets from permanent way** or permanent structures at regular intervals. The diagram shall indicate the various **road and track crossings, crossings with electric power cables, oil & gas, water and sewage lines** and other items of importance.

3.5 All cable routes shall be carefully coordinated with all the interfacing parties. The cable trenching work shall be taken in hand only when the cable route plan has been approved by the Engineer.

3.6 The cable shall be laid in the HORC/IR land and as advised by Engineer.

4. Storing & transportation of cable

4.1 Cable drums shall not be stacked on flat side. Suitable stoppers shall be placed for stability.

4.2 Cable drums shall have easy access for lifting and moving.

4.3 When rolling the cable drum either for unloading or transportation, the drum shall always be rotated in the direction of the 'arrow' which is marked on the drum.

4.4 The drums shall not be rolled over objects that could cause damage to the protective battens of the cable.

4.5 When unloading is carried out from the vehicle the drum shall not be dropped on the ground directly to avoid damage due to impact. A fork lifter or ramp shall be used.

4.6 During all stages of storage, it is essential that the ends of the cable are effectively sealed by end cap or in any other approved manner to avoid water entry into the cable.

4.7 It is desirable that cable drums are stored in covered shed to protect against direct exposure to sun/rains.

5. Paying-out the Cable

5.1 For paying out cables, the cable drums shall be mounted on cable wheels. It shall be ensured that no kink is formed while paying out the cable.

5.2 Cable drum shall never be kept on its side and cable uncoiled since this can result in twisting of cable conductors resulting in damage to them.

5.3 The drum on the wheel shall be brought to one end of the trench and the end of the cable freed and the cable shall be laid along the trench.

5.4 The cable drum shall be brought as close to the cable trench if possible. The cable drum shall clear the ground by 5 to 10 cm.

5.5 The wooden battens on the drums shall be carefully removed shortly prior to laying and before the drum is mounted on the jack.

5.6 A party of labourers shall move along the trench carrying cable at suitable intervals so that cable is not damaged due to dragging along the ground or bent unduly.

5.7 The in-charge of cable laying shall ensure proper synchronization of all labourers for smooth laying.

5.8 In cases where the wheels are not available, the drum shall be mounted on an axle at one end of the trench and cable paid out and carried by labourers.

5.9 In no case, shall the drum be rolled off onto the road for laying the cable and the cable dragged on the ground for laying purposes.

5.10 Whenever mechanized equipment is used, the work shall be carried out by a trained operator under the supervision of the Engineer or its authorized representative.

5.11 Where the cable drum is in damaged condition the cable may be placed on a horizontal revolving platform and the cable paid out in the same manner as given in paras above.

5.12 Paying out of cable shall be done by rotating the cable drum and not by pulling the cable with excessive force.

5.13 Wherever flaking of cable is required, it shall be done by making a succession of loops in the form of Figure of '8', these loops being disposed on top of each other to avoid tangling of cable. Figure of '8' flaking shall only be carried out under the direct supervision of an experienced official.

6. Excavation and Backfilling of the Trenches

6.1 Manual trenching is recommended for laying of Signalling cables in the station yards from Home-to-Home signal and mechanized trenching is recommended beyond the Home signal.

6.2 Digging of trench between IR track and HORC track shall be manual or mechanized as proposed by the contractor as per site survey/feasibility and approved by the Engineer for every Station & Automatic section separately.

6.3 Excavation of Cable Trench shall be made in all kinds of soils including clearing roots of trees, rocks, etc. During excavation, the earth of the trenches shall not be thrown on the ballast. The earth shall be thrown by the side of the trenches away from track.

6.4 Trenches shall be straight as far as possible and steep angles shall be avoided.

6.5 The width of manually made cable trenches shall be commensurate with the number of cables. The approx. width shall be kept as **0.3 metres o**r as required to accommodate cables.

6.6 It is desirable that the excavation of the trenches is not done in long lengths and does not remain uncovered for long period. It shall be preferable that cables are laid and refilling done within-short time.

6.7 Before commencement of the laying, inspection of the trench and inspection of protection works shall be carried out by the Engineer so as to ensure their conformity with the specification.

6.8 After cable has been laid and until the whole of the cables to be laid in the trench have been covered with their protective covers, no sharp metal tool such as spades, crowbar or fencing pins shall be used in the trench or placed in such a position that they may fall into the trench.

6.9 For **road/platforms/railway track crossing**, trenchless horizontal directional drilling (HDD) technique shall be adopted under the supervision of competent staff for laying of RCC/GI/DWC-HDPE pipe. Both ends of RCC/GI/DWC-HDPE pipes shall be closed properly using accessories and the pits shall be properly backfilled. There shall be no damage to the road/platform/tracks or any such structures etc. enrooted during or after the HDD operations.

6.10 The backfilling of the trenches shall be done properly. The earth excavated shall be put back on the trench rammed and consolidated.

7. Cable Laying Underground

7.1 The cables may be laid underground, either in the trench, in ducts, in cement troughs, in pipes or in any other approved manner.

7.2 Cable laying in ducts-RCC ducts/ Half split DWC pipe be used for laying the cable from Home-to-Home Signal in Station yard. The ducts shall have suitable covers and shall rest on walls of duct as per Tender drawings (Guidelines of cable laying).

7.3 The cables shall generally be laid keeping in view all the relevant provisions of Signal Engineering Manual of IR and Tender drawings (Guidelines of cable laying)

7.4 Before commencing work on any part of the site, the Contractor shall ascertain that the Engineer and also, where applicable, the local and statutory authorities or other bodies/persons concerned have reviewed the cable route. The Contractor shall further ensure that all necessary permits in such cases have been obtained and notices served.

7.5 Every precaution shall be taken to ensure that cables and equipment are not installed in a manner or under conditions likely to cause electrolytic or other corrosive action or damage to, or be detrimental to, the performance of the cables and equipment during operation.

7.6 Signalling cables shall not run parallel with cables carrying high voltages or heavy currents and shall conform to the requirements specified in BS 7671. Signalling tail cables shall be mechanically protected by DWC pipe of outer diameter 120mm to avoid being damaged from track side maintenance activities and shall be immune to any malfunction from electromagnetic interference.

7.7 All cables shall be laid along the track preferably **one meter** inside the HORC/IR boundary. If it is necessary to lay the cable outside the HORC boundary it shall be laid on the berm with interface with Civil contractor and approval of the Engineer. After back filling, compaction of the formation shall be done properly.

7.8 The cable laid parallel to the track shall be buried at a depth of minimum 1.0 meter (topmost cable) from ground level. However, in case of rocky soil, the depth may be reduced suitably with precast cement concrete slab of minimum 10 cm. thickness provided for protection of cables. When it concerns the laying of tail cables which serve the track apparatus etc., the depth shall not be less than 0.50 meters.

7.9 No sharp object like stone chips, iron pieces etc. shall ever come in contact with laid cables irrespective of the method of laying the same. The bottom of the cable trench shall be levelled and got rid of any sharp materials/ edges. In the soft ground, the cable shall be laid at the bottom of the trench previously levelled. In both the above cases, the cable shall be covered with a layer of sand or soft soil/ earth of 0.10 meter thickness and thereafter a protective cover of trough or a layer of bricks shall be placed in Automatic section and half split DWC pipe in station area shall be placed.

7.10 At each end of the main cable an extra loop length of **4 to 5 meter shall** be kept.

7.11 Before starting cabling work, location boxes shall first be erected so that cable after laying is directly taken inside location box and its multiple handling/damage by re-digging and taking inside Location box/Signal equipment Room is eliminated.

7.12 Signalling and Telecommunication cable shall be laid in separate trenches to the extent possible, however if laid in same trench a Brick separation shall be provided. Telecom cable shall be laid on both side of the Railway track.

8. Cable Laying in Electrified Area

8.1 The cable shall be laid at not less than one meter from the nearest edge of the mast foundations supporting the catenary or any other live conductor, provided the depth of the cable does not exceed 0.5 meters with suitable cable protection measures provided. When the cable is laid at a depth greater than 0.5 meters, a minimum distance of 3 meters between the cable and the nearest edge of the O.H.E. structure shall be maintained. If it is difficult to maintain these distances, the cable shall be laid in concrete/heavy duty HDPE/Ducts or any other approved means for a distance of 3metres on either side of the mast and the distance between the cable and mast may be reduced to 0.5 meters. Protection of signalling cables from power surges is necessary.

8.2 In the vicinity of the SP/SSP, the cable shall be laid at least one meter away from any metallic body of the station, which is fixed in the ground, and at least 5 meters away from the station earthing. The distance of 5 meters can be reduced to one meter provided the cables are laid in RCC/GI/DWC/HDPE pipes or any other approved means.

8.3 Where an independent Earth is provided for an OHE structure, i.e. where the mast is connected to a separate Earth instead of being connected to the rail, the cables shall be laid at least one meter away from such Earth.

8.4 Where there are OHE structures along the cable route, the cable trenches shall be as far as possible, and not less than 5.5 meters away from the centre of the Track.

9. Laying of Different Type of Cable in Same Trench

9.1 The OFC cable shall be laid/blown in lubricated HDPE pipe as per Telecom manual.

9.2 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 of S&T

9.3 A distance of approximately **10 cm must be** maintained between Telecommunication cable and Signalling cables. The Signalling cables must be separated from power cables/Telecom cables by a row of bricks placed between them as per sketch shown in Tender drawings (Guidelines for cable laying) of this document.

10. Cable Laying in Ducts

10.1 In the station area it is desirable to protect the cables in RCC ducts/Concrete cover of suitable design. The ducts shall also be considered where it is not desirable to lay cables directly in the trench like in close to habitation, marshy, rock mixed soil areas.

10.2 Cables for longer distances shall be laid on the bottom layer. Duct shall be filled with sand after cable is laid to avoid entry of rodents.

10.3 The ducts shall be of such design as to prevent collecting water in the duct.

10.4 Cables in any conduits, Pipes or ducts shall not occupy cross-sectional space of more than 50%.

10.5 When cables are laid in Pipes /RCC duct, care shall be taken to see that no ballast or stones have been dropped inside the Pipes /RCC duct. The Pipes/ RCC duct shall be cleared of all ballast and stones before the cover is secured. When the ends of covers are joined together with cement plaster, a piece of paper or wood shall be placed under the joint to prevent the cement plaster from falling on the cable.

10.6 After placing the Pipes /RCC duct in the trench the ducts must be aligned using an 8 mm rod. For this purpose, a hole is left in the Pipes /RCC duct for insertion of rods. Wherever there is a diversion proper care shall be taken to cover the cables, either by smoothly forming a curve with duct or a masonry structure can be constructed to protect the cables. After laying the cables the ducts shall be covered with RCC slab and shall be continuously plastered at the end with trunking/RCC duct.

10.7 Where it is necessary to take the cables between the tracks, it shall be carried in trunking/RCC duct kept sufficiently below the ballast level.

10.8 In the station area the S & T cables shall be laid in RCC/ Half split DWC duct as per sketch given in Tender drawings.

11. Cable Laying in Solid & Rocky Soil Area

11.1 In case of rocky soil, the depth may be reduced suitably.

11.2 Sharp edges on the sides must be smoothened out and bottom of the chase shall be levelled. In the rocky ground the cable shall be laid normally on layer of sifted earth of 50 mm thickness previously deposited at the bottom of the trench. Cable shall be covered with a layer of sand or sifted earth of 100 mm thickness.

11.3 In case sharp edge of rocky ground cannot be protected with sifted earth, concrete/ RCC/GI/DWC-HDPE pipe shall be used if numbers of cables are small. If the number of cables is large, RCC duct shall be used. In isolated cases, it can be given smooth surface by using either masonry bricks or cement concrete.

11.4 A row of bricks shall then be placed lengthwise on the top and joined with cement mortar and a layer of concrete with cement plaster shall be provided on the top of the same.

11.5 A sketch showing the laying of cables in rocky area is placed at Tender drawings of this document.

11.6 Laying in special soil condition: Cable shall not be run through abnormally high acidic or alkaline soil or through sewage. If this is unavoidable special measures shall be taken to prevent corrosion. Cable may be laid in the concrete/ RCC/GI/DWC-HDPE pipes properly jointed to prevent ingress of moisture.

Cable laying in residential area: When laying the cable in residential area, the cable shall be specially protected on both sides up to a distance of about 50-100 meters beyond the building line subjected to approval of Engineer. In such cases, the cable shall be protected by means of concreting of 50 mm as proposed for rocky soil/ in concrete/ RCC/GI/DWC-HDPE pipes. This is better than using bricks as in residential area bricks are usually found while digging and its special significance of cable protection may be overlooked.

12. Track Crossing

12.1 As far as possible, the cable shall be crossed from one side of the yard to the other, a minimum number of locations.

12.2 Track crossing shall be **through trenchless** method. The following precaution shall be taken:

(i) The cable crosses the track at right angles.

(ii) The cable does not cross the track under points and crossings.

(iii) The cable is laid in concrete/RCC/GI/DWC-HDPE pipes or suitable ducts or in any other approved manner while crossing the track.

(iv) Cable laid across the track must be1.0metre(minimum)below the bottom of the rail.

(v) No digging shall be done below the sleepers.

(vi) A sketch showing track crossing is placed in Tender drawings of this document.

13. Road Crossing

13.1 Road crossing shall be done through **trenchless** method. The cable shall be laid in concrete/ RCC pipes or in any other approved manner while crossing the road at the depth of **1 meter from the ground** level. It shall extend **1 meter (minimum)** on each side of the road keeping in view the future increase in the width of the road.

13.2 When crossing roads, it is necessary to lay the cables in such a manner as to avoid the necessity of bending the cable sharply and minimize the excavation of road surface as far as possible.

13.3 The crossing of main roads often involves difficulties, especially if traffic is heavy. Precautions to avoid accidents to workmen, pedestrians and vehicles shall be taken. On minor roads, which can be temporarily closed to traffic it is possible to open up across the entire width of the road, pipes shall be installed quickly in the cutting, which is then filled in there by reducing to a minimum the time for which the road is closed.

13.4 Some roads, which are broad, may be opened for half their width allowing the other half for use of traffic, pipes are laid, trench filled in the first half and the other half opened up after the first half is opened half is linked with those laid in the first half.

13.5 Whenever a cable is laid across an important road, particularly one with a special surface, space for future expansion may be provided. Either of the following methods may be adopted: -

(i) The size of the pipe shall be so chosen that provision for laying of additional cables in future is kept. Pipes having diameters ranging from 100 to 200 mm are suggested, or

(ii) A spare pipe may be laid, through which a cable can be drawn when required. It will be advantageous to leave a lead wire of G.I wire in the pipe for drawing the cable in future.

(iii) A separate pipe of suitable diameter shall be used for telecommunication cable.

(iv) A sketch showing the track crossing is placed at Tender drawings of the document.

14. Cable Laying on Bridges/Culverts

14.1 Wherever practicable, the cable may be taken underground across the drain bed at a suitable depth for crossing small culverts with low flood level. A sketch showing cable laying on culverts with low flood level is placed at Tender drawings of this document. Wherever cable may not be taken underground across the drain bed, cable shall be taken on the approach slopes of culvert through **GI pipe** of suitable sizes **with concrete cover** and blocks. A sketch showing cable laying on culverts with high flood level is placed at Tender drawings of this document. **The Civil contractor shall provide ducts on the concrete bridges, culverts, Viaduct and Tunnels on both sides.** The same may be used by the S&T contractor for laying of S&T cables. The cables in these ducts shall be laid in **HDPE/DWC** pipes.

14.2 When cables have to cross a **metallic bridge**, they shall be placed inside a GI pipe/ metallic through (filled with an anti-theft measure as sealing compound). The cable shall be supported across the bridge in a manner which would involve minimum vibrations to the cable and which will facilitate maintenance work. Adequate cable length to the extent 5 to 6 meters shall be made available at the approaches of bridge. A sketch showing cable laying on metallic bridges is placed at Tender drawings **(Guidelines for cable laying)** of this document.

14.3 In case of arch bridges, cable shall be taken through **GI pipes on top of** the arch adjoining the parapet wall. The pipe shall be covered with ballast. Cement Concreting of 50 mm shall be done throughout from entry/exit end of cable up to diversion point including slope on either side. The entry and exit ends of the cable from the pipe to the diversion point of the cable shall be concreted for 1 metre (minimum). A sketches showing cable laying on arch bridges are placed at Tender drawings of this document.

14.4 On PCC/ RCC box Bridges, concrete duct (300mmx300mm minimum) on the side of HORC tracks shall be provided by the **Civil Contractor** for laying of cables. All Outdoor Signalling cables and Telecommunication Cables (OFC cable, Telecom Quad Cable & PIJF Telephone Cables etc.) on these Concrete Bridges & Culverts shall be laid inside DWC Pipes. OFC cable shall be laid inside the HDPE duct. Entry/Exit of the Cables to/from Bridges & Culverts shall be suitably protected by concrete cover. The Contractor shall carry out necessary co-ordination with Civil, Structure & Track Contractor in this matter. Cable shall be laid in Double Wall Corrugated (DWC) Pipes in the slope to climb from ground to top level of bridges. It shall be so laid to maintain a continuous depth of 1 meter (top of DWC Pipe) from the nearest ground level. The slope of track formation shall be restored to its original condition after laying of cables.

14.5 On steel girder bridges, GI pipe shall be laid with suitable clamps/channels etc.

14.6 As the laying involves movement of a large number of staff over the bridge the line shall be blocked, and flagman posted on other side. On a double line only the line near which the cable is being laid shall be blocked but care shall be taken to see that staff is aware of this and measures taken to prevent staff from straying on to the unblocked line.

14.7 Damage to cable is likely to occur if care is not taken in laying cable where the bed changes from solid support such as a foundation, pier of bridge to soft support such as soft soil. The cable must not press against the edge of the solid support. The soft soil near the edge must be tamped and the cable raised slightly.

14.8 To prevent theft and miscreant activities on the approach of cable to bridge/culvert where it is not possible to ensure adequate depth, **concrete protection** is proposed.

14.9 To cross the bridges full DWC pipe shall be provided on the slope at the distance of about 500mm from the edge of retaining wall.

15. Cable Laying in Monsoon Season

15.1 Cable laying in monsoon when the precipitation is heavy shall be avoided. The trenches will be inundated and visual inspection of the bedding of the trench will be rendered difficult. Threading the cable in pipes will also be more difficult.

15.2 When cable laying is necessary during the rainy season, the cable ends shall be inserted in a pipe sealed at one end and the pipe buried. Termination work shall be started only when there is a likelihood of a clear weather for three to four days.

16. Laying of Cable Above Ground

16.1 Signalling cables for outdoor circuits shall not normally be laid above ground. In exceptional cases where it becomes unavoidable, the following precautions shall be taken:

(i) The cable shall 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 condition.

(ii) The cable supports shall be so spaced as to avoid sag.

16.2 **Cable Markers:** Underground Cable Route shall be identified by **concrete markers** directly buried inside the trench at **100 m interval** and at diversion and track crossing points within the Station section from home to home with the approval of Engineer. Outside station section **concrete type cable route route marker** be provided **at every 100 m interval and at diversions, track road/crossing points bridge approach** with the approval of Engineer

17. Entry of Cable at Cabin, Relay-room, Location-boxes etc.

17.1 All cable entry points in the Signal/Telecom equipment room, battery room, SM's room, IPS room, MSDAC room at Station or S&T Huts, location boxes, junction boxes etc. shall be **properly sealed** using modular based cable and pipe sealing system/other approved means. All cable entries from/to adjacent rooms through overhead duct/ladder shall also be sealed.

17.2 All cable entrance ducts must **be closed with suitable masonry works, sand covered and plastering** to prevent entry of rats etc. RCC slab shall be provided on the cable pit of the Signalling/Telecom equipment rooms at the Stations and S&T Huts.

17.3 Cable shall be protected on both sides up to a distance of **10 meter beyond the building line** of Signalling/Telecom equipment rooms, Battery room, Power supply room, SM's room of Station and S&T Huts.

17.4 Damage to cable is likely to occur if care is not taken in laying cable where the bed changes from solid support such as a foundation/masonry to soft support such as soft soil. The cable must not press against the edge of the solid support. The soft soil near the edge must be tamped and the cable raised slightly.

18. Termination of cables

18.1 No jointing of Signalling cables is permitted. All cables shall be terminated. The number of termination locations shall be minimized, preferably by laying full length cable.

18.2 The cable termination of Signalling cables shall be undertaken on approved type of terminations with ease of maintenance and disconnection facility on CT racks/ location boxes/junction boxes.

18.3 All wire and cable conductors shall be clearly identified and numbered at each end using durable shrink on or tag type labels. A description of the terminating function shall be included. Each core so terminated shall be provided with identification marking on cable and on conductors/terminals and ferrules with letters or/numbers embossed on them as per requirement of circuitry. This will enable easy identification of conductors in case of any failures or cable disconnections or cable cut by outsider/miscreants. Proper marking and termination practice ensures quick and easy restoration during failures.

18.4 Unused cable cores/pairs of multi-core/pair cables shall also be terminated and marked so.

18.5 Crimping or other standard industry practice shall be used for terminating all conductors. Solder terminations shall only be used with the approval of the Engineer.

18.6 Wherever practical, multiple pin plugs and sockets shall be used to connect multi- core cables and wiring loops to all items of equipment. These shall have some form of keying to prevent incorrect equipment modules from being installed.

18.7 The cable terminations shall be secured enough to withstand vibration level that is likely to be experienced in the HORC environment.

19. Cable Termination Rack (CTR) and Location Box

19.1 Cable Termination Rack (CTR) with **20% extra** capacity for future expansion shall be provided.

19.2 **Only screw less terminals with isolation facility** shall be used for cable terminations. The terminals and fuses used shall meet the requirements of RDSO specification described in scope of work above. If any alternative terminal type is proposed for use, it should be got approved by the Engineer.

19.3 All external power/ signalling / data lines susceptible to lightning or high induced voltage shall be provided with **Stage-3 surge protection devices** as per available Para of this specification.

19.4 The Cable Termination Rack (CTR) shall be equipped with copper earth bar to which all cable shields shall be connected and soldered. The copper earth bar shall be connected to the earth.

19.5 The Outdoor cables shall be terminated in Location Boxes.

19.6 Location boxes shall be rugged and free from ingress of rodents, insects, dust, moisture, and water.

19.7 Location boxes shall be able to withstand vibration level, likely to be experienced alongside the track.

19.8 Location boxes shall be theft and vandal proof as far as possible and shall be able to withstand the climate of the region.

19.9 Cable entry points in the location boxes shall be filled with sand and plastered with cement.

19.10 Separate Location boxes shall be used for UP and DN line cables.

19.11 All location boxes shall be provided with 110 V AC LED lighting arrangement with ON/OFF switch to assist maintenance/repair work undertaken during the night.

19.12 The installation of Location boxes shall not be done on loose earth/ water logger area. It should be installed on proper concrete foundation. The foundation drawing shall be proposed by the Contractor and approved by the Engineer.

20. Testing of cable

20.1 Before the cable is laid in the trench, a visual inspection of the cable shall be made to see that there is no damage to the cable. It shall be tested for insulation and continuity of the cores. Thereafter, the cable shall be laid into the trench. Record of insulation and loop resistance must be maintained.

20.2 Testing of all main and tail cables after laying of the cable in trenches and also after termination in apparatus cases, in boxes and in relay room shall be done.

20.3 If any defect is noticed during the testing after laying the cable the same shall be replaced.

20.4 The insulation resistance tests shall be made when conductors, cables and insulated parts are clean and dry. An insulation tester shall be used for insulation testing. Any metallic sheath or metal work of any rack or apparatus case shall be bonded to earth during the test.

20.5 Insulation resistance so measured shall not be less than 5 mega ohms per km at buried temperature. If the insulation resistance is found to be lower than 5 mega ohms, the cause shall be investigated, and immediate steps taken to repair or replace the cable to prevent any malfunctioning of the equipment and circuits.

20.6 Supervision of cable laying: The work shall be supervised personally by an **official authorized by the Engineer. The cable trench shall be inspected by the authorized** person and jointly signed by him/her and the Contractor's authorized person before cable laying is undertaken on the request for inspection (RFI). The record of joint inspection of the trench shall be maintained.

21. Earthing and Bonding

General: Earthing shall be provided for all Indoor & Outdoor Signalling installations to achieve the following objectives:

21.1 Efficiently dissipate heavy fault currents and electrical surges, both in magnitude and duration, to protect equipment from being damaged to minimize down time, service interruption and replacement cost.

21.2 Provide a stable reference for electrical and RF circuits at the installation to minimize noise during normal operation.

21.3 Protection of personnel who work within the area from dangerous electric shock caused due to "step potential" or "touch potential".

21.4 To achieve the primary goal of assuring personnel safety and damage control, a low impedance path shall be made available to the current generated due to lightning or power system fault. The potential differences between any two points should be as low as possible. Safety considerations also require the equipment chassis or enclosure to be earthed to minimize shock hazards to system staff.

21.5 To achieve the secondary goal of providing protection for sensitive and interconnected electronic and electrical systems, earthing shall be designed to minimize the noise voltage generated by currents from two or more circuits flowing through common earth impedance and to avoid creating earth loops susceptible to magnetic fields and differences in earth potential.

21.6 The Earthing and Bonding system shall meet or exceed the requirements of IEEE 1100, NFPA 780, IEC 62561-7 and IEC 62305.

21.7 To minimize the effect of circulating earth loops and to provide equipotential bonding, "star type" bonding connection shall only be provided as required.

21.8 The contractor shall submit the design for Earthing and Bonding of Signalling and Telecommunication systems for review and approval by the Engineer. OEM's original data sheets of the proposed devices shall also be submitted along with the protection methods adopted in their design.

22. Indoor Signalling installation

22.1 The equipment rooms housing Indoor Signalling equipment and their power supply shall be provided with suitable earthing and bonding system.

22.2 There shall be one earth busbar in each equipment rooms viz. Signalling, power, telecom room etc. called sub equipotential earth busbar (SEEB). The earth bus bar located in the power supply equipment room shall be directly connected to Class 'B' SPD and the main earth pit, termed as main equipotential earth busbar (MEEB).

22.3 The SEEB shall have pre-drilled holes of suitable size for termination of bonding conductors. The SEEB shall be insulated from the building walls using low voltage fire resistant insulators. All terminations on the SEEBs shall be using copper lugs with spring washers.

22.4 All the equipment/racks in the equipment room shall be directly connected to its SEEB. Each of sub-equipotential earth busbar (SEEB) installed in the rooms shall be directly connected to main equipotential earth busbar (MEEB) using bonding conductors.

22.5 The routing of bonding conductors from equipment/racks to SEEB and from SEEB to MEEB shall be as short as possible and direct with minimum bends and separated from other wiring. The connection from SPD to MEEB shall be as short as possible and preferably without any bend.

22.6 The connection between any two moving parts like doors with Bonding Ring Conductor, etc. shall be connected by 316L Stainless Steel Flexible braids, which are UL listed, RoHS compliant and meeting IEC 60439.1 & IEC 61439.1.

22.7 All bonding connections, whether it is from equipment or SPD to respective lugs on bus bars or of the Main earth bond with the Main Earth electrode, shall be with stainless steel nuts and bolts and exothermic welding while keeping in mind the conditions of UL listing, IEEE 837 & tamper proof weld metals.

22.8 The Earthing system shall use maintenance free loop earth as per RDSO specification with latest amendment and shall be designed to give an earth resistance of less than 1 ohm. The design should be based on calculation methods as per IEEE 80 which require the parameters like target ohmic resistance value, soil resistivity, electrode length, electrode diameter etc. SM room equipment, Signalling equipment rooms/Object controller equipment room, IPS room, MSDAC room etc. shall be connected with this earth.

22.9 The earth electrode shall be made of high tensile low carbon steel circular rods, molecular bonded with copper on outer surface to meet the requirements of UL 467. The Ground Enhancement material should meet the requirement of IEEE 80's Clause 14.5 (d) and should be tested as per IEC 62561-7 standard. All the earth electrodes shall be bonded together using Galvanized Steel tapes or Copper Bonded Steel Conductors of suitable size in continuous length of max. up to 100 meter to achieve equipotential bonding. For Power supply equipment, MSDAC equipment etc. separate maintenance free earthing arrangement shall be provided.

22.10 Despite the provision of earthing, as specified above, if failures of solid state electronic equipment occur on account of finite earth resistance, particularly due to high voltage transients and lightning, further protection as necessary shall be provided.

23. Outdoor Signalling installation

23.1 All the Outdoor Signalling equipment viz. Signals, Location boxes etc. shall be provided with suitable Earthing arrangement with earth value **<5Ω.**

23.2 The target earth resistance value for outdoor Signalling equipment shall be in accordance with the requirement specified for the equipment by the OEM/RDSO specification.

23.3 The Signalling equipment having Solid State components and the enclosures housing them shall be provided with maintenance free earth using copper bonded steel electrode, earth enhancement compound and bonding connection through exothermic welding as per RDSO specification with latest amendments. Each MSDAC DP shall be provided separate one maintenance free earth electrode or more with Earth value shall be **<1Ω or OEM's design.**

23.4 In order to arrive at the required target resistance value, the number of earth electrodes should be decided based on the calculations involving soil resistivity as per the standards above, all interconnected in parametric ring form or in parallel manner.

23.5 Where the equipment to be earthed is in close vicinity they should be connected to a common earth in star configuration.

23.6 For **outdoor Signalling items installed in Location boxes**, one earth busbar of suitable size shall be provided in each location box and earth point of all equipment and cable armour etc. shall be terminated on this busbar. This busbar shall be connected to a normal earthing electrode.

23.7 **All Apparatus Cases and Signals shall be earthed with General/ Conventional earth pit.** Multi-strand single core PVC insulated copper cable as per IS:694, **10 Sq mm cable** shall be used to connect the Apparatus cases of signals with the earth pit. Cable shall be protected with the conduit.

23.8 **GI wire as earthing bond** shall not be used.

23.9 All earth pits shall have **concrete cover, painting of earth value and date of testing.**

[End of Chapter 2]

Chapter 3

Technical Requirements for laying of HDPE Duct, OFC, QUAD, PIJF Telecom and Other Cables

1. Telecom Cables

The following types of underground cables but not limited to shall be used for various telecom circuits:

1.1 PIJF cable 6 Quad 0.9 mm conductor Dia, as described in scope of work above, suitable for underground laying and are used for control circuits, block working and axle counters etc.

1.2 Multi pair (10 pairs to 200 pair), Multi Dia (0.5mm/ 0.63mm/ 0.9mm) PIJF (Polythene insulated Jelly Filled) Cable as per RDSO specifications, suitable for underground laying and are generally used for Telephone exchange subscriber lines or branch/ tail cables. A minimum of 10 pair PIJF armoured cables shall be used in this project.

1.3 OFC cable as per RDSO specification described in scope of work above.

1.4 HDPE duct as per RDSO specification described in scope of work above.

2. Cable Laying

2.1 The detailed guidelines for Signalling cable laying detailed in Chapter 2 and Tender drawings (Guidelines for Cable laying) are also applicable for telecom cable laying.

2.2 The outdoor cables (optical fibre cable inside HDPE duct, telecom PIJF Quad cable & PIJF telephone cables etc.) shall be laid within IR/HORC boundary and as far away from the track as possible. If it is necessary to lay cable outside the IR/HORC boundary, permission shall be obtained in advance from the concerned authority or cable can be laid on berm with interfacing with civil contractor and proper compaction after backfilling.

2.3 The Contractor shall prepare a Cable Route Plan in consultation with Civil structure Contractor and get it approved by the Engineer before starting the trenching work.

2.4 The Contractor shall supply all protection material like ducts/troughs/GI pipes/DWC/RCC pipes/ bricks etc. required for cable laying.

2.5 HDPE duct for OFC cable shall be laid in a trench with depth of 1.2 meter from the natural earth profile or from the rail level whichever is lower and width of 0.3 meter or as required and suitably protected.

2.6 The outdoor cables (PIJF Quad/ telephone cables etc.) shall be laid at 1 meter depth. Spare loop of min. 10 meters shall be kept before equipment room/location boxes /approach of bridges/ road & track crossings etc. Such spare cables in pits shall be adequately covered on suitable pits to protect against damage and theft.

2.7 The cable entry into equipment rooms/location boxes etc. shall be suitably sealed to prevent entry of rodents etc.

2.8 While splicing OFC cables, correctly coloured fibre splice protector shall be used to enclose each individual splice. Each fibre splice shall be tested to ensure correct fibre continuity and splice loss.

2.9 Before the cable is laid, it shall be tested for insulation and continuity of the cores. The continuity of armour and screen of the cable also need to be checked before laying.

2.10 Bedding and armouring of the cable shall also be inspected to see that there has been no damage during transit or in storage.

2.11 Thermo-shrinkable jointing kit shall be used for jointing PIJF/Quad cables.

2.12 The screen and armour of cables shall be jointed with suitable wires. This is essential to get the specified screening factor in association with its earthing at stations. This should be done first to avoid any electric shock due to induction.

2.13 To achieve the specified screening factor and human safety, the metallic armour of the optical fiber cable, PIJF Quad and telephone cables, earthing (<10 ohm) shall be provided at stations and at required intervals in block section, user premises etc.

2.14 PIJF Quad cable and telephone cables shall be terminated on disconnection type terminal blocks complying with IEC 60947-7-1. These terminal blocks shall be made of polyamide 6.6 insulating material and shall use non-corrosive metal parts. These terminal blocks shall have provision for identification/number for each termination and shall be securely attached to mounting rails.

2.15 Wherever possible, standard multi-pin plug/socket shall be used to terminate multi-core cables for connecting to the equipment. Heat-shrinkable sleeves shall enclose all exposed and terminated contacts inside multi-pin connectors.

2.16 Splicing of OFC cable shall be done as per standard practice of Railways in RDSO/ TEC approved joint enclosures. Joint pits of approved type shall be provided to protect the OFC joint.

3 Testing of Cables Laid

3.1 During cable laying work cables section shall be tested after each joint is made to facilitate tracing of a fault during jointing. On discovery of a fault during the cable laying, the last joint must be opened out and defect rectified.

3.2 The wires in the cable must be tested just before laying and after laying and jointing and also regularly on the laid cable for the following:

i. Continuity

ii. Absence of crossed pair/quad

iii. Absence of conductor cores contacts

iv. Insulation resistance

v. Absence of contacts between wires forming a pair (short circuit)

vi. Transmission loss & crosstalk

vii. Continuity of armour and screen of the cable need to be checked before laying

3.3 To facilitate testing, every wire at the starting end shall be twisted with its mate to form a loop in each pair, each twist being insulated from other pairs by means of PVC sleeves.

3.4 In the case of multi-layer cable, the layers of the cable shall be separated with cotton thread or twine to keep the wires in their proper places, so that the position of faulty wire or pair may be easily ascertained.

3.5 The tests shall be conducted from the other end of the cable. After the test is over, the end shall be cut and sealed or terminated as per the requirements at site.

3.6 For continuity test, all conductors are to be bunched together and then earthed through the armour and screen of the cable with a soft bare copper wire and connected to one probe of the Multimeter. Now any of the wire from the bunch may be separated and when touched to the other probe of the Multimeter, it should give continuity buzzer sound and loop resistance value. If the loop resistance value is substantially less than the calculated value as per the loop length, it indicates shorting within the pair.

3.7 Disconnect the mate of the wire under test from the bunch and this buzzer sound should disappear proving the absence of crosses and wrong contacts. If any of the wire shows the cross or contact, they should be earthed again to trace wires with which they are crossed or are in contact. Each pair of conductors should be tested in the above manner before jointing the next length. Where the test proves that wires have been cross jointed, the joints shall be opened and the fault rectified to avoid crosstalk. Re-crossing in the next jointing does not clear the fault.

3.8 The insulation test shall be taken on half of the pairs of the cable bunched together, the other half being earthed to the armour and screen. The second half shall then be tested in a similar manner to the first half earthed. The test shall be carried out with a megger before connecting it to the terminal equipment. If a contact between the wires forming a pair exists, it will be shown by the megger registering a dead earth. In this case, each pair shall be tested individually until the faulty pair is found.

3.9 Insulation test of newly laid U/G cable shall be done with a megger of 5OOV and after wards it shall be done with a megger of 100V/500V depending upon the overall condition of cable and spares available.

3.10 Underground cables shall be tested once every year for continuity, transmission loss, cross-talk, loop resistance, armour continuity, insulation resistance and tracing & updating of cable route diagram and the results of tests shall be recorded.

3.11 Underground cable installations when laid strictly in accordance with the recommended practice then it will hardly need any maintenance throughout their anticipated span of life. As far as the buried portion of the cable is concerned, no repairs are generally possible except in cases where moisture or water has entered the cable and is detected before it has damaged the insulation.

3.12 No digging operations by other departments shall be carried out close to the cable route without prior notice to the Telecommunication Engineer who shall supervise or arrange supervision to ensure necessary precautions to protect the cable from damage has been taken or being taken during the work.

4. CABLE FAULTS

4.1 TYPE:

i. Low insulation in one limb or both.

ii. Open/break in one limb or both.

iii. Short/Earth.

iv. Multiple faults.

v. Foreign potential

4.2 Localisation of faults- Various types of cable fault locators available generally work on the following principle:

i. Potential distribution method

ii. Pulse reflection (ECHO) method

4.3 Rectification of faults- After localisation of faults, the defective portion of cable may be replaced by healthy piece of cable with proper joint.

5. Identification

5.1 Descriptive labels shall be provided for all cabinets, enclosures, panels, assemblies and sub-assemblies. Labels shall be of engraved type, metallic with durable markings and shall have character size not less than 6 mm high.

5.2 The details of the labels including the material and size of the characters and sample of the labels shall be submitted to the Engineer for review.

5.3 Labels and notices on equipment shall be fixed with roundhead brass screws or self- tapping screws. Stick-on labels or fixing by adhesive shall not be accepted.\

6. Earthing of Telecom system

At Station/TSS/SP/SSP/ S&T Huts separate maintenance free earth electrode shall be provided for earthing of the telecom equipment.

6.1 The metallic sheath and armouring of all cables (RF Cables/Optical Fibre Cable/Quad cable/PIJF telephone cable/ Leaky cables etc.) shall require earthing. The earthing shall be done at the equipment room and termination points, as per the established practices in RE areas of the Indian Railways.

6.2 The earthing electrodes for the clean earth shall be located at least 20 m away from the main electrical power earth.

6.3 The route for the clean earth shall be so chosen as to minimise the effect of any inductive interference.

6.4 For the purpose of measurement of earth resistance, a small interconnecting copper strip of appropriate cross-section shall be provided in the ring earth in a small manhole chamber so that the ring earth can be broken from the loop.

6.5 The earth resistance at any point on the clean earth shall **be below 0.5 Ohm**, and that for the main earth shall not **exceed 1.0 Ohm at any** location and under any soil and/or climatic condition.

6.6 All metal work and metallic items shall be earthed to the main earth to ensure the safety of personnel.

6.7 At every kilometer armour of OFC cable shall be cut for 5cm length and this piece shall be removed and covered by heat shrink tube.

6.8 The earthing methods and details shall be submitted to the Engineer for review.

Armour of optical fibre cable and Quad cable shall be directly earthed at TER end and earthed through a surge protection device at the other end station;

6.9 Unless specified otherwise, all equipment to be housed in outdoor environment (open areas etc.) shall be with IP 65 enclosures as a minimum.

7. TESTING AND COMMISSIONING

7.1 General

7.1.1 The Contractor shall perform stage-wise testing and commissioning activities in accordance with the requirements given in this Specification.

7.1.2 The Contractor shall ensure that prior to the commencement of tests; documentation associated with tests has been reviewed No Objection by the Engineer.

7.1.3 The Contractor shall ensure that the Equipment/Subsystem/System is in a state ready for Testing and Commissioning before the commencement of the tests. The Contractor shall conduct Trial tests and satisfy himself before offering the Equipment/Subsystem/System for the tests. Test results of the Contractor's own trial tests shall be made available to the Engineer on demand. This is to indicate the readiness of the Equipment/Subsystem/System for tests.

7.1.4 The Contractor shall provide all necessary Test instruments, Special tools and Test software to carry out the tests.

7.1.5 The Contractor shall extend full support to the Engineer and provide all necessary facilities to enable convenient inspection of materials, work and testing.

7.1.6 The Contractor shall investigate and provide corrective actions for all the faults detected during the tests. The tests shall be resumed only after all the faults are properly cleared. The Contractor shall submit Fault report to the Engineer to describe the symptom and causes of the Faults and the Corrective actions taken.

7.2 TESTING STAGES

7.2.1 The Contractor shall carryout testing and commissioning activities in the following phases:

i. Factory Acceptance Tests;

ii. Installation Tests;

iii. System Acceptance Tests;

7.3 FACTORY ACCEPTANCE TESTS

7.3.1 The Contractor shall prepare and submit, at least three months before the tests, for review by the Engineer the Factory Acceptance Test Plan, detailing and explaining how the contractor shall plan, perform, and document all inspections and tests that shall be conducted to verify and validate the works prior to delivery to Site. In addition, the Factory Test Plan shall also include the following:

i. A list of equipment and cables for individual Subsystems to have Factory Acceptance Test;

ii. The program of all the activities related to factory acceptance tests;

iii. The locations where factory acceptance tests to be carried out;

iv. The estimated duration of tests activities at each location; and

v. Submission of schedule of all the factory acceptance test procedures for equipment and cable.

vi. Submission of specifications and standards, reviewed design documentation for reference for FAT of equipment and cable.

7.3.2 Factory Acceptance Test shall be carried out for equipment and cables of all the Subsystems as per RDSO guidelines. The inspection shall generally be done by RDSO or Engineers' representative.

7.3.3 Where any part of testing is carried out by an independent laboratory, a copy of Test Certificate issued by the relevant authority of that laboratory shall be submitted along with the Factory

Acceptance Test Procedure.

7.3.4 The Factory Acceptance Tests are considered completed only if the Engineer without objection reviews the Factory Acceptance Test results.

7.4 INSTALLATION TESTS

7.4.1 Installation Tests shall be carried out on individual Subsystem location by location after the completion of equipment's physical installation. This shall include following tests but not limited to:

7.4.2 Pre-Installation test/inspection shall include the verification of FAT/Quality test report, Invoice, OEM manuals, Warranty certificates etc. RFI shall be submitted for this test/ inspection.

7.4.3 Post installation test shall include the installation of equipment as per approved drawing, Particular specification etc. Power supply test shall be the part of post-installation test.

7.4.4 The Objective of the installation tests shall be to ensure the following:

- The equipment is installed in accordance with the reviewed design documentation
- The equipment is installed in accordance with the requirements detailed in this Specification
- All cables are properly and accurately connected and terminated
- All installation works are of acceptable workmanship

7.4.5 The Contractor shall develop procedures for Installation Tests and shall submit to the Engineer for review. The Installation test procedures shall describe in detail all tests to be performed on the equipment and cables along with Pass/Fail criteria (i.e. the standards or limit to be achieved).

7.4.6 The Contractor shall measure the end-to-end performance of all cores of the copper cables and optical fibre cables, including all spare cores, laid between different locations.

7.4.7 All the **installation test results, physical locations of the equipment and serial numbers** shall be captured in the test record forms. The Contractor shall include completed test record forms in the Test Report and submit to the Engineer for review.

7.4.8 The Installation Tests are considered completed only if the Engineer without objection reviews the Installation Test results.

7.5 SYSTEM ACCEPTANCE TESTS

7.5.1 The Contractor shall carry out System Acceptance Tests after the completion of the Installation Test. System Acceptance test shall include the functional test of all equipment.

7.5.2 System Acceptance Tests shall be carried out on individual Subsystem as well as whole System to verify the functional, operational performance, electrical performance and services coverage at the stage:

i. After successful completion of the Installation Tests;

ii. After the Subsystems have been configured with correct settings and parameters;

iii. Properly connected to the power supply and can be switched on for System Acceptance Tests; and

iv. Before the equipment of different locations are ready for Integrated Testing& Commissioning.

7.5.3 The Contractor shall develop System Acceptance Tests procedures for each Subsystem and System as a whole and submit to the Engineer for review.

7.6 Where performance across interfaces to other System within this Contract is required to be verified during the System Acceptance Tests, the Contractor shall include **a list of other systems and the interface test procedures** in the System Acceptance Tests procedures for the relevant Subsystem.

7.7 Where performance across interfaces to Project Contractors or to other parties is required to be verified during the System Acceptance Tests, the Contractor shall include a list of Project Contractors and the interface test procedures agreed with the relevant Project Contractors in the System Acceptance Tests procedures for the relevant Subsystem.

7.8 The Contractor shall conduct end-to-end circuit test to verify the circuit integrity and electrical performance for all circuits including spare.

7.9 The System Acceptance Tests are considered completed only if the Engineer with No objection reviews the System Acceptance Test results.

7.10 Upon completion of the System Acceptance Test, the individual Subsystem shall be operational and shall be ready to be connected to other Subsystems and interfacing systems for testing.

[End of Chapter 3]