Tender Document for Works

(Two-Envelope Tendering Process Without Prequalification)

Procurement of:

Contract Package C-23: Design and Construction of Civil Works (Earthwork, Bridges, Station Buildings, Retaining Walls and other miscellaneous Works) from km 29.68 to km 49.70 & from km 55.60 to km 61.50 and its connectivities to IR network from New Patli to Patli station & New Patli to Sultanpur station including modifications/civil works at Sultanpur Station in connection with laying of New BG Double Railway line of HORC project.

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Specific Procurement Notice (SPN)

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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. However, certain part of the Project falls in specified area of Aravalli range. The clearance for specified area of Aravalli range is under process and is likely to be obtained before the award of contract.

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	**:**	**Rail 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,
- Outline Construction Specification,
- Tender drawings,
- Employer's Requirements (Functional),
- Employer's Requirements (Design),
- Employer's Requirements (Construction),
- Employer's Requirements (General),
- Employer's Requirements (Appendices),
- Indian and other International Standards referenced herein,
- Indian and other International Standards.

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 (iv) (b) above, for those elements identified under Clause 2(vi) 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. The Contractor shall also introduce appropriate Project Management Systems during the project execution phase.

11 CO-ORDINATION WITH INTERFACTING 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 laise 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, sun shine, 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 design and performance of the Permanent Works shall comply with the specific core requirements contained in these Employer's Requirements – Functional and Employer's Requirement- General Electrical Services.

1.2 The Permanent Works shall be designed and constructed to the highest standards available using proven up-to-date good Engineering practices. The Specification shall in any case not specify standards which, in the Engineer's opinion, are less than or inferior to those described in the Outline Design Specifications (ODS) and Outline Construction Specifications (OCS). Construction shall be carried out employing the procedures established by the Contractor as per approved quality assurance plan and Environmental, Social, Health and Safety (ESHS) Plan.

1.3 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.

1.4 Employer's Requirements- Functional shall be read in conjunction with Employer's Requirements-Design, Construction, Outline Design specification, Outline Construction Specifications, General Electrical Services and other requirements of the Contract.

1.5 Jurisdictional Sketch of Civil works under C-23 package is given in Section VII-8, Tender Drawings and Documents, Part 2 , Employer's Requirements.

2. SCOPE OF WORK

2.1 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.

2.1.1 Design and construction of railway formation

The Contractor shall design and construct railway formation for 32.5 t axle load as per RDSO Specifications "Comprehensive Guidelines and specifications for Railway Formation-Specification No. RDSO/2020/GE: IRS-0004, Sept 2020" from Chainage 29680 m to Chainage 49700 m and from Chainage 55600 m to Chainage 61500 m for double track of Main line; from Chainage 614 m to Chainage 2700 m for connecting single line from New Patli to Patli; from Chainage 703 m to Chainage 4114 m for connecting single line from New Patli to Sultanpur; and at Sultanpur station from Chainage +689.546 m on Farukhnagar side and from Chainage +530.00 m on Badsa side to Chainage -861.218 m on Garhi Harsaru side as shown in Tender drawings and shall include earthwork in cutting/filling, subgrade,

prepared subgrade and blanketing including compaction. The Contractor shall arrange borrow areas for earthwork in embankment at its own cost.

2.1.2 Design and construction of slope protection works

The Contractor shall design and construct protection work of embankment in the approaches of bridges by pitching as shown in Tender drawings. The balance length of slope of embankment shall be protected by turfing in accordance with Section VII- 6 Outline Construction Specifications-Civil (OCS). On embankments/cuttings higher/deeper than 4 m turfing shall be provided using coir netting as per IS: 15869, IS:15872 and IRC: 56.

2.1.3 Design and construction of precast RCC drains on berms and catch water drains & side drains in cuttings

The Contractor shall design and construct precast RCC longitudinal drains on berms of embankments/cuttings to collect surface runoff from the slope. 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 in embankments or to side drain in cuttings as shown in the Tender drawings. RCC collecting chambers shall be provided at the junction of longitudinal berm drains and chutes.

In cuttings the Contractor shall design and construct following additional items:

a. RCC catch water drains of adequate capacity to intercept and safely dispose of the surface runoff from adjoining areas from entering into the cutting.

b. RCC side drain of adequate capacity on both sides near toe of cutting to safely carry the surface runoff from cutting slope and formation.

2.1.4 Design and construction of minor bridges

The Contractor shall design and construct minor bridges (RUBs and waterway bridges) as per list given in **Annexure-F-1.** Minor bridges shall include all components of bridges such as RCC box/RCC hume pipe, wing wall, return wall, face wall, curtain/drop wall, flooring, ground improvement if required, protection of approach embankment slopes for a length of 15 m on each side, boulder backing, granular backfill, inspection steps on both sides of embankment and other incidental works to complete the bridge in all respects as shown in the Tender drawings. RUBs shall be provided with height gauges on each approach road as per RDSO drawing No. M-0001. Drainage arrangement shall be provided for RUBs wherever natural drainage is not available. Repairs to approach roads during execution shall also be carried out by the Contractor. Design and construction of permanent diversion or widening of existing approach roads of RUBs shall also be carried out by the Contractor as shown in the Tender drawings. Cost of temporary diversion of roads, wherever required, is covered in the lump sum cost of Schedule 'A' for all RUBs irrespective of their spans.

2.1.5 Design and construction of major bridges including bearings

The Contractor shall design and construct major bridges as per list given in **Annexure- F-2**. Superstructure including bearings of all major bridges shall be as per standard RDSO drawings as detailed in Section VII-5, Outline Design Specifications-Civil. However, Open Web Girders (OWG) and Composite Girders of 30.5m span shall be designed and provided with spherical bearings by the Contractor. Major bridges shall include all components of bridges such as foundation, abutment/pier, bearings, girders, wing wall, return wall, ground improvement if required, protection of approach embankment slopes for a length of 30 m on each side, boulder backing & granular back fill behind abutment/wing/return wall, side pathway on outer side of both Up & Dn girders as per RDSO drawing No. CBS 0045, trolley refuse, access ladder & inspection platforms at each abutments/piers, inspection steps on both

sides of approach embankment, inspection arrangements for connections of top chord of OWG as per RDSO report No.BS-113, bridge boards, bridge plaques and other incidental works to complete the bridges in all respects. RUBs shall be provided with height gauges on each approach road as per RDSO drawing No. M-0001. Drainage arrangement shall be provided for RUBs wherever natural drainage is not available. Repairs to approach roads during execution shall also be carried out by the Contractor. Design and construction of permanent diversion or widening of existing approach roads of RUBs shall also be carried out by the Contractor as shown in the Tender drawings. Cost of temporary diversion of roads, wherever required, is covered in the lump sum cost of Schedule 'A' for all RUBs irrespective of their spans

For construction of Br No. 150 and 153, temporary diversions of existing roads will be required first. Then existing roads will be lowered by about 1.90 m at the site of the bridges and regraded to join the existing roads. Thereafter Br Nos. 150 and 153 will be constructed. However, permanent regrading of road by lowering will be paid under Schedule 'B'. Similarly, for construction of Br. No. 71, temporary diversions of existing roads will be required first. Thereafter, RCC box bridge will be constructed on the original alignment over which roads will be restored back by suitable regrading. Permanent regrading of road by raising will be paid under Schedule 'B'.

2.1.6 Linking of track on Open Web Girders (OWG)

The Contractor shall supply H- beam sleepers & track fittings and link track on OWG bridges including providing and fixing guard rails and gang pathway as per list given in Annexure F-2.

Rails for linking of track shall be supplied free of cost by the Employer at the stock yard of T-1 Contractor.

2.1.7 Design and construction of stations

The Contractor shall design and construct five stations namely Dhulawat, Chandla Dungerwas, Pachgaon, New Patli & Sultanpur as shown in Tender drawings. The work mainly includes design and construction of station buildings, platforms, subway for inter platform transfer of passengers including stairs & ramps, lift well, approach FOB, RCC underground water storage tank, RCC overhead water storage tank, water supply distribution system from overhead water storage tanks to station building and platforms, all retaining walls within station area , precast RCC fencing at end platforms, barbed wire fencing with RCC posts at ROW, firefighting system in accordance with Section VII-5: Outline Design Specifications (ODS), Section VII-6 Outline Construction Specifications (OCS) and as shown in Tender drawings. Passenger Facilities to be designed and provided at these stations are given in **Annexure- F-3**.

2.1.8 Design and construction of approach road of stations

The Contractor shall design and construct Vacuum Dewatered Concrete (VDC) station approach road including retaining walls, earthwork in filling, longitudinal and hume pipe cross drains as shown in Tender drawings.

2.1.9 Rainwater harvesting

The Contractor shall design and construct rainwater harvesting system for surface runoff from platforms of all stations as per Section VII-5: Outline Design Specifications (ODS) and Section VII-6 Outline Construction Specifications (OCS).

2.1.10 **Design and construction of yard drainage system**

The Contractor shall design and construct yard drainage at Dhulawat, , New Patli and Sultanpur stations consisting of covered/underground longitudinal and cross drains as shown in Tender drawings.

2.1.11 Design & construction of RCC precast fencing at end platforms at Dhulawat, Chandla Dungerwas, Pachgaon, New Patli and Sultanpur stations.

2.1.12 Design and construction of S&T huts at Dhulawat, New Patli and Sultanpur stations on both ends of station yard as shown in Tender drawings.

2.1.13 Design and construction of RCC hume pipe (NP-4) of 450 mm dia/precast RCC box (500mm x 500mm, clear opening) in the embankment at approximately 500m interval for crossing utilities in future.

2.1.14 Design and construction of Portico 20 m long and covering entire road width at subway entrance at Dhulawat, & New Patli stations.

2.1.15 Design and construction of RCC longitudinal drain of required capacity with suitable slope and outfall at places where HORC embankment overlaps with KMP expressway embankment to safely cater the surface runoff from the slopes of HORC embankment and KMP expressway embankment.

2.1.16 Design of precast and cast in-situ retaining wall along the alignment at locations given in Annexure F-4. These retaining walls shall be constructed and paid under Schedule 'B'.

2.1.17 Design of circulating area of Dhulawat & New Patli station including land scaping, traffic movement plan, parking space and storm water drainage as shown in Tender drawings. Execution of these works shall be carried out by the Contractor and paid under Schedule 'B'.

2.1.18 Design of bridges including protection works as mentioned in Schedule 'B' in para 2.2 below. Construction of these bridges shall be carried out by the Contractor and paid under Schedule 'B'

2.1.19 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 is also included in the lump sum scope of Schedule 'A'. It also includes reinstatement of land/structure/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.

2.1.20 Design and construction of one deep tube-well of 12,000-15,000 litre/hr yield with pump house and overhead gantry for lowering-taking out pumps at New patli & Dhulawat stations and 750-1000 litre/hr. yield at Sultanpur, Chandla dungarwas & panchgaon stations, providing & installing submersible pumps of required capacity with all accessories including panels, cables distribution boxes, electrical cable upto

main control panel in stations, providing GI/Mild Steel pipeline from tube well to underground storage tank and from underground storage tank to overhead storage tank with all accessories and pump for pumping from underground tank to overhead tank including all accessories.

2.1.21 Design and application of water proofing system of subway at stations.

2.1.22 Design & construction of temporary structures including construction methodology, erection/launching, formwork and support system for RCC works and getting it approved from third party.

2.1.23 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 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. 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 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 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 Requirement, Section VII-9

i) Results of sub-surface investigations conducted at project site are enclosed with the Tender document. 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. . It is brought out here that bore holes could not be drilled at locations of all the piers and abutments of Br. No. 106 over NH-48 due to standing water in Annexure- F-2 of these Employer's Requirements (Functional-Civil). The Contractor shall drill these bore holes on his own and determine geotechnical parameters required for design of structures located in that area. No claim whatsoever on account of any discrepancy 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 KMP Expressway and IR

Alignment is passing adjacent to KMP Expressway/IR Tracks. The Contractor should ensure that the design and construction should be carried out with adequate measures for the safety & protection of KMP/IR structures. Any of the construction activity shall be planned without affecting the operations of the existing system. It should be ensured that no damage is caused to any such element/person/ property and Engineer/ Employer shall be indemnified against such damage 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 , 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 erection 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), two plots of land of area approx. 10,000 Sq. m each will be made available 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. 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) Procurement, supply and installation (including joining and grouting) of precast retaining wall along the embankment at locations as given in Annexure F-4 for heights upto 2 m from ground level.

b) Construction of cast in-situ retaining wall generally for heights more than 2m from ground level at locations as given in Annexure F-4.

c) Construction of minor bridges other than those covered in Lump Sum Schedule 'A' given above. Tentative details of bridges covered under the Schedule 'B' is as under-

S. No.	Chainage (m)	Type of crossing	Type of Bridge	Tentative Span (m)
New Patli- Sultanpur connectivity*				
1.	585	GAIL Pipe Line	Inverted U/ Slab	1 x 5m x 5m (110m long)
2.	1785	GAIL Pipe Line	Inverted U/Slab	1 x 5m x 5m (100m long)
3.	3733	GAIL Pipe Line	Inverted U/Slab	1 x 5m x 3.1m (20m long)
*Chainages are from centre line of New Patli station				
Main line**				
4.	30528.0	Syphon	RCC box	2x3x2
5.	30839.0	Syphon	RCC box	2x5x2.5
6.	31145.0	RUB	RCC box	2x6.2x5.65
7.	34280.218	RUB	RCC box	2x5.x5.65
8.	41962.645	RUB	RCC box	2x7x5.65

**Main line Chainages start from Prithla station of HORC

d) Permanent regrading of roads at major bridge Nos. 150, 153 on main line.

e) Development of circulating area of stations, parking space, storm water disposal of circulating area etc.

f) Plantation and any other horticulture work.

g) Construction of roads, footpath and structures other than those covered in Lump Sum Schedule 'A' of Employer's Requirements.

h) 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-7: General Electrical Services, Employer's Requirements

2.4 **Scope under Schedule 'D' (Item Rate for miscellaneous works)**

Under this Schedule, the Contractor is required to carry out works which are not covered in Schedule 'A', Schedule 'B' and Schedule 'C' as given below:

a) Diversion of all uncharted utilities, if required, as per approved plan.

b) Any other activity as directed by the Engineer

2.5 REFERENCE TO THE STANDARD CODES OF PRACTICE

2.5.1 All Standards, Outline Construction Specifications, 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-Civil (OCS), the order of precedence shall be as given below:

a. Outline Design Specifications-Civil

b. Outline Construction Specifications-Civil.

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 also 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. 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**

a) 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.

b) 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**.**

2.9 **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-Civil. 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 (a) & (b) above.

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

2.11 **FUNCTIONAL REQUIREMENTS OF PUMPING ARRANGEMENTS**

Water pumps shall be designed for unmanned operation, controlled through liquid level controllers, capable of pumping the requisite amount of water to the utility or to the ground / overhead tanks. The pumping installation shall withstand the corrosive effects of normal water supply and serve for the anticipated life of the equipment. The pipe line size should be such that the velocity head does not exceed the normal static head except for the fire pump which is governed by separate criteria. The valve controls and regulating mechanisms shall be designed for automatic operation.

2.12 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.

2.13 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.

2.14 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.

2.15 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

MAIN LINE						
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)	
1	75	31365.0	RUB	RCC Box	1X6X4	2
2	76	32022.0	RUB	RCC Box	1X6X4	2
3	77	33155.0	RUB	RCC Box	1x6x4.5	2
4	78	33269.230	RUB	RCC Box	1x2x2	2
5	79	33450.0	Drain	PIPE Culvert	1x1.8	2
6	80	33673.045	Bitumen Road	RCC Box	2x7x5.65	2
7	80A	33976.50	Road	RCC Box	1x6x5	2
8	83	35371.018	Cart Track	RCC BOX	1x5x3	2
9	84	35916.064	Cart Track	RCC BOX	1x5x3	2
10	85	36984.1	Bitumen Road	RCC BOX	2x7x5.65	2
11	86	37317.678	Balancing Culvert	RCC PIPE	1 x 1.8	2
12	87	37804.099	RUB	RCC BOX	1x5x3.15	2
13	89	39552.5	CC ROAD	RCC BOX	1x5x3	2
14	91	40357.531	Balancing Culvert	RCC PIPE	1 x 1.8	2
15	92	40671.025	RUB	RCC BOX	1 x 4 x 2.5	2
16	93	41312.174	Cart Track	RCC BOX	1 x 4 x 3.0	2
17	94	41666.592	Balancing Culvert	RCC PIPE	1 x 1.8	2
18	95	41925.899	Balancing Culvert	RCC BOX	1 x 2 x 2.0	2
19	97	42238.9	Balancing Culvert	RCC BOX	1 x 2 x 2.0	2
20	98	42578.906	Bitumen Road	RCC BOX	1X6X2.5	2
21	99	43506.9	Cart Track	RCC BOX	2x7x5.65	2
22	100	43758.3	Cart Track	RCC BOX	1 x 4 x 3.1	2
23	102	44281.4	Balancing Culvert	RCC BOX	1 x 4 x 5	2
24	103	44401.6	Balancing Culvert	RCC BOX	1 x 4 x 5	2
25	104	44420.2	RUB	RCC BOX	1X6X5	2

26	107	46283.634	Station	RCC BOX	1X6X2.5	2
27	108	46635.175	Balancing Culvert	RCC BOX	1 x 6 x 6	2
28	109	46768.341	Cart Track	RCC BOX	1 x 6 x 6	2
29	110	46915.023	Balancing Culvert	RCC BOX	1 x 5 x 5	2
30	111	47300.018	Bitumen Road	RCC BOX	2 x 5 x 5	2
31	112	47500.360	Balancing Culvert	RCC BOX	1 x 4 x 4	2
32	113	47824.336	Balancing Culvert	RCC BOX	1 x 4 x 3	2
33	114	48093.515	Balancing Culvert	RCC BOX	1 x 4 x 4	2
34	115	48231.618	RUB	RCC BOX	1 x 4 x 4	2
35	116	48594.592	Balancing Culvert	RCC PIPE	1 x 1.8	2
36	118	48794.629	Cart Track	RCC BOX	1 x 4 x 4	2
37	119	49167.307	Cart Track	RCC BOX	2X5X3.6	2
38	120	49583.348	Balancing Culvert	RCC PIPE	1 x 1.2	2
39	137	56117.4	Balancing Culvert	RCC Box	1x5x4	2
40	138	56290.6	RUB	RCC Box	1x5x4	2
41	139	56465	Balancing Culvert	RCC Box	1x5x4	2
42	140	56755	Balancing Culvert	RCC Box	1x5x4	2
43	141	57167.9	RUB+ Culvert	RCC Box	1x5x4+1x2x2	2
44	142	57546	Balancing Culvert	RCC Box	1x5x4	4
45	143	57670.8	RUB	RCC Box	2x7x5.25	5
46	144	57987	Balancing Culvert	RCC Box	1x2x2	5
47	145	58203.1	RUB	RCC Box	1x5x3	5
48	146	58564.9	Balancing Culvert	RCC Box	1x2x2	5
49	148	59884.9	RUB	RCC Box	2x5x5.25	2
50	149	60161.3	RUB+ Balancing Culvert	RCC Box	2x5x3+1x2x2	2
51	154	61163.5	Balancing Culvert	RCC Box	1x2x2	2

*Main line Chainages start from Prithla station of HORC.

CONNECTING LINES						
S.No.	**Br. No.**	**Chainage (m) (From Centre line of New Patli station)**	**Type Of Crossing**	**Type of Bridge**	**SPAN No. x L (m) x H (m)**	**No. of Tracks**
NEW PATLI TO PATLI						
1	1	1046.5	RUB	RCC Box	1x5x3.25	1
2	2	1277.9	Balancing Culvert	RCC Box	1x2x2	1
3	3	1986.8	RUB	RCC Box	1x4x3.25	1
4	4	2518.4	RUB	RCC Box	1x5x5.25	1
5	5	2687.0	Balancing Culvert	RCC Box	1x2.5x3	1
NEW PATLI TO SULTANPUR						
1.	2	1548.9	Balancing Culvert	RCC Box	1x2x2	1
2.	4	2189.8	Balancing Culvert	RCC Box	1x2x2	1
3.	5	2823.6	RUB	RCC Box	1x5x4.25	1

ANNEXURE-F-2

LIST OF MAJOR BRIDGES

A. MAIN LINE

S. No.	Br. No.	*Chainage (m)	Type of Crossing	Type of Bridge Super structure	Span Arrangement	Type of Foundations	No. of Tracks
1	71	30155.0	4 Lane ROB	RCC Box	1x12x10.5	Open	2
2	82	34899.0	Bitumen Road	PSC SLAB	2x12.2	Open foundation	2
3	101	44246.344	Culvert	PSC GIRDER	1 x 18.3	Open foundation	2
4	105	44570.310	CART TRACK	PSC I GIRDER	1x18.3	Open foundation	2
5	106	45495.969	NH-8	OWG with COMPOSITE GIRDERS	4X18.3 +1X30.5 +8X24.4 + 1X76.2 +2X24.4+1 X61	Open foundation/pile foundation	2
6	117	48663.628	Viaduct	PSC I GIRDER	1 x 18.3	Open foundation	2
7	136	55724.7	Rail Fly Over (RFO)	**CG+OWG	18.3(CG)+ 76.2(OWG) + 18.3(CG)	Open foundation	2
8	147	59107	RUB	OWG	1x45.7 m	Open foundation	2
9	150	60457.6	RUB (KMP)	CG	1x30.5 m	Open foundation	2
10	151	60563.3		CG	1x24.4 m	Open foundation	2
11	152	60642.6		CG	1x24.4 m	Open foundation	2

12	153	60754.5		CG	1x30.5 m	Open foundation	2

*Chainages start from Prithla station of HORC.

**CG- Composite Steel Girders

B. CONNECTING LINE

S. No.	Br. No.	*Chainage (m)	Type of Crossing	Type of Bridge Superstructure	Span Arrangement	Type of Foundation	No. of Tracks
New Patli to Sultanpur							
11	1	951.4	Road Crossing (RUB)	OWG	1x45.7 m	Open Foundation	1
12	3	1767.9	RUB	PSC U-Slab	1x12.2	Open Foundation	1

*Chainages start from centre line of New Patli station of HORC.

ANNEXURE-F-3

PASSENGER FACILITIES TO BE PROVIDED AT STATIONS

The following passenger facilities to be provided at New Palti, Sultanpur, Dhulawat, Chandla Dungarwas & Pachgaon Stations:

S. No	Passenger Facilities	New Patli	Sultanpur	Dhulawat	Chandla Dungarwas and Panchgaon
1.	Platform (High level)	01 No. Island platform and 01 No. end platform as per Tender drawings	01 No end platform as per Tender drawings	01 No. Island platform and 01 No. end platform as per Tender drawings	02 No. end platforms at each station as per Tender drawings
2.	Drinking Water Booths	05 Nos on each platform	04 Nos on each platform	04 Nos on each platform	04 Nos on each platform
3.	Waiting Hall	As per Tender drawings	As per Tender drawings	As per Tender drawings	As per tender drawings
4.	PF shelter	02 Nos. of 20 m each on both platforms for entire width.	-	02 Nos. of 20 m each on end platform for entire width	-
5.	PF mini shelter	04 Nos on each platform as per Tender drawings.	04 Nos on each platform as per Tender drawings	04 Nos on each platform as per Tender drawings	04 Nos on each platform as per Tender drawings
6.	Toilet block	01 on each platform as per Tender drawings.	01 on each platform as per Tender drawings	01 on each platform as perTtender drawings	01 on each platform as per Tender drawings
7.	Seating arrangement	48 Nos stainless steel seats on each platform	36 Nos stainless steel seats on each platform	36 Nos stainless steel seats on each platform	24 Nos stainless steel seats on each platform
8.	Subway with staircase and ramps including hand railings	01 No. as per Tender drawings	-	01 No. as per Tender drawings.	01 No. as per Tender drawings.
9.	Lifts (with audio facility)	03 Nos	-	-	-
10	Mild Steel Station name board at platform	At each end of platforms	At each end of platforms	At each end of platforms	At each end of platforms

11	RCC underground storage tank of net capacity (cum)	50	20	*50	*20
12	RCC overhead water storage tank of net capacity (cum)	20	10	*10	*10
13	Septic tank with connecting sewer lines to toilets in station area	01 No. at each platform for 50 users and 01 No. at station building for 100 users.	01 No. at platform for 50 users and 01 No. at station building for 50 users.	*01 No. at each platform for 50 users and 01 No. at station building for 50 users.	*01 No. at each platform for 50 users.

Note - * Payment of these items will be made in Schedule "B"

Annexure-F-4
Approximate Details of Retaining Wall under Schedule 'B'

Main Line (RHS)				
S. No.	Chainage (m)		Length (m)	Approx. Height(m) above ground level
	From	To		
1	40240	40280	40	2.50-3.50
2	40280	40300	20	1.75-2.0
3	40300	40320	20	1.25-1.75
4	40320	40360	40	2.50-3.50
5	40360	40380	20	1.75-2.0
6	40380	40400	20	1.25-1.75
7	40400	40420	20	1.75-2.0
8	40420	40460	40	1.25-1.75
9	40460	40480	20	0.50-1.00
10	40480	40500	20	1.25-1.75
11	40500	40520	20	0.50-1.00
12	40540	40560	20	0.50-1.00
13	42480	42520	40	1.0-1.25
14	42520	42540	20	2.50-3.50
15	42560	42600	40	1.0-1.25
16	42600	42660	60	0.50-1.00
17	44120	44220	100	3.50-4.50
18	44300	44340	40	3.50-4.50
19	44340	44360	20	1.75-2.0
20	44880	44900	20	0.50-1.00
21	44900	44920	20	1.25-1.75
22	44920	44940	20	4.50-5.50
23	44940	44960	20	5.50-6.50
24	44960	45000	40	1.0-1.25
25	45000	45020	20	1.75-2.0
26	45020	45040	20	0.50-1.00
27	45160	45200	40	4.50-5.50
28	45800	45820	20	3.50-4.50
29	45820	45860	40	3.50-4.50
30	45860	45940	80	1.75-2.0
31	45960	46000	40	1.0-1.25
32	46600	46620	20	3.50-4.50
33	46620	46640	20	4.50-5.50
34	46640	46660	20	5.50-6.50
35	46660	46680	20	4.50-5.50
36	46680	46700	20	6.50-7.50
37	46700	46780	80	4.50-5.50
38	46780	46840	60	3.50-4.50
39	46840	46860	20	5.50-6.50
40	46860	46900	40	6.50-7.50
41	46900	46920	20	5.50-6.50
42	46920	46980	60	4.50-5.50

43	46980	47000	20	3.50-4.50
44	47000	47100	100	4.50-5.50
45	47100	47140	40	3.50-4.50
46	47140	47160	20	4.50-5.50
47	47160	47240	80	3.50-4.50
48	47240	47260	20	4.50-5.50
49	47260	47320	60	3.50-4.50
50	47320	47380	60	2.50-3.50
51	47380	47400	20	3.50-4.50
52	47400	47440	40	2.50-3.50
53	47440	47520	80	1.25-1.75
54	47520	47540	20	1.75-2.0
55	47540	47560	20	1.25-1.75
56	47560	47580	20	1.0-1.25
57	47580	47640	60	0.50-1.00
58	47640	47680	40	2.50-3.50
59	47680	47720	40	3.50-4.50
60	47720	47740	20	1.25-1.75
61	47740	47780	40	1.0-1.25
62	47780	47800	20	3.50-4.50
63	47800	47820	20	1.75-2.0
64	47840	47860	20	1.0-1.25
65	47860	47900	40	3.50-4.50
66	47900	47920	20	1.0-1.25
67	47920	47940	20	2.50-3.50
68	47940	47960	20	1.75-2.0
69	47960	47980	20	3.50-4.50
70	47980	48140	160	0.50-1.00
71	48000	48020	20	1.25-1.75
72	55600	55640	40	7.50-8.50
73	55800	55820	20	3.50-4.50
74	55820	55860	40	2.50-3.50
75	55860	55880	20	1.75-2.00
76	55880	55920	40	1.25-1.75
77	55920	55960	40	1.0-1.25
78	55960	56000	40	0.50-1.00
79	56000	56040	40	1.0-1.25
80	56040	56100	60	3.50-4.50
81	56120	56160	40	3.50-4.50
82	56160	56200	40	1.25-1.75
83	56200	56260	60	0.50-1.0
84	56260	56270	10	3.50-4.50
85	56270	56280	10	4.50-5.50
86	56300	56440	140	3.50-4.50
87	56440	56460	20	2.50-3.50
88	56480	56520	40	2.50-3.50
89	56520	56560	40	1.75-2.00
90	56560	56580	20	1.25-1.75

91	56580	56640	60	2.50-3.50
92	56640	56680	40	1.75-2.00
93	56680	56740	60	1.25-1.75
94	56760	56780	20	1.00-1.25
95	56780	56820	40	0.50-1.00
96	56820	56900	80	2.50-3.50
97	56900	56940	40	1.75-2.00
98	56940	56980	40	0.50-1.0
99	57080	57100	20	0.50-1.00
100	57140	57160	20	0.50-1.00
101	57320	57520	200	5.50-6.50
102	59040	59060	20	2.50-3.50
103	59160	59240	80	2.50-3.50
104	59240	59260	20	1.25-1.75
105	60500	60520	20	0.50-1.00
106	60660	60700	40	3.50-4.50
107	60740	60760	20	2.50-3.50
108	60780	60800	20	1.0-1.25
109	60800	60840	40	3.50-4.50
110	60840	60920	80	2.50-3.50
111	60920	61000	80	3.50-4.50
112	61000	61040	40	2.50-3.50
113	61040	61100	60	1.75-2.00
114	61100	61140	40	1.25-1.75
115	61140	61160	20	0.50-1.0
		Total	**4500**	
Main Line (LHS)				
S. No.	Chainage (m)		Length (m)	Approx. Height(m) above ground level
	From	To		
	55600	55620	20	3.5-4.5
	55620	55640	20	5.5-6.5
	55640	55660	20	6.5-7.5
	55800	55860	60	3.5-4.5
	55860	55960	100	4.5-5.5
	55960	56040	80	3.50-4.50
	56040	56080	40	3.50-4.50
	56080	56100	20	4.50-5.50
	56120	56160	40	3.50-4.50
	56160	56200	40	1.25-1.75
	56200	56220	20	1.00-1.25
	56220	56280	60	0.50-1.00
	56320	56460	140	3.50-4.50
		Total	**660**	
New Patli- Sultanpur Connectivity (LHS)				

S. No.	Chainage (m)		Length (m)	Approx. Height(m) above ground level
	From	To		
1	1140	1180	40	4.50-5.50
2	1180	1300	120	5.50-6.50
3	1300	1360	60	4.50-5.50
4	1360	1400	40	3.50-4.50
5	1400	1520	120	2.50-3.50
6	1520	1540	20	3.50-4.50
7	1540	1580	40	4.50-5.50
8	1580	1640	60	3.50-4.50
9	1640	1660	20	1.25-1.75
10	1720	1800	80	1.25-1.75
11	1800	1860	60	2.50-3.50
12	1860	1900	40	1.75-2.00
13	1900	1920	20	1.25-1.75
14	1940	1960	20	1.75-2.00
15	2000	2020	20	0.50-1.00
16	2020	2040	20	1.25-1.75
17	2040	2060	20	1.75-2.00
18	2060	2080	20	1.00-1.25
19	2080	2100	20	1.25-1.75
20	2100	2220	120	3.50-4.50
21	2220	2340	120	2.50-3.50
22	2340	2360	20	0.50-1.00
23	2360	2380	20	1.00-1.25
24	2380	2400	20	0.50-1.00
25	2420	2520	100	0.50-1.00
26	2520	2560	40	1.00-1.25
27	2600	2620	20	1.25-1.75
28	2620	2720	100	1.75-2.00
29	2720	2760	40	1.25-1.75
30	2760	2800	40	0.50-1.00
31	2820	2920	100	0.50-1.00
32	2920	2940	20	1.25-1.75
33	2940	3000	60	0.50-1.00
34	3880	3960	80	0.50-1.00
		Total	**1760**	

New Patli- Sultanpur Connectivity (RHS)

S.No.	Chainage (m)	Length (m)		Approx. Height(m) above ground level
		From	To	
1	1140	1160	20	0.50-1.00
2	1360	1380	20	0.50-1.00

3	1380	1400	20	1.00-1.25
4	1400	1420	20	1.25-1.75
5	1420	1460	40	1.75-2.00
6	1460	1520	60	2.50-3.50
7	1520	1540	20	3.50-4.50
8	1540	1580	40	4.50-5.50
9	1580	1640	60	3.50-4.50
10	1640	1660	20	1.25-1.75
11	1720	1800	80	1.25-1.75
12	1800	1860	60	2.50-3.50
13	1860	1900	40	1.75-2.00
14	1900	1940	40	1.25-1.75
15	1940	1960	20	1.75-2.00
16	2120	2180	60	0.50-1.00
17	2180	2220	40	1.25-1.75
18	2220	2240	20	1.00-1.25
19	2240	2320	80	0.50-1.00
20	2620	2720	100	0.50-1.00
		Total	**860**	

New Patli-Patli connectivity (LHS)

S.No.	Chainage (m)		Length (m)	Approx. Height(m) above ground level
	From	To		
1	840	860	20	4.50-5.50
2	860	1020	160	3.50-4.50
3	1020	1200	180	2.50-3.50
4	1140	1180	40	1.75-2.00
5	1200	1220	20	0.50-1.00
6	1300	1320	20	0.50-1.00
7	1360	1420	60	1.25-1.75
8	1440	1460	20	1.25-1.75
9	1460	1480	20	2.50-3.50
10	1480	1500	20	0.50-1.00
11	1500	1540	40	1.00-1.25
12	1540	1660	120	1.25-1.75
13	1660	1720	60	1.00-1.25
14	1720	1780	60	0.50-1.00
15	2520	2540	20	0.50-1.00
16	2540	2560	20	4.50-5.50
		Total	**880**	

New Patli- Patli Connectivity (RHS)

S.No.	Chainage (m)		Length (m)	Approx. Height(m) above ground level
	From	To		
1	840	860	20	5.50-6.0
2	860	920	60	4.50-5.50
3	880	900	20	5.50-6.0

4	920	940	20	5.50-6.0
5	940	1060	120	4.50-5.50
6	1060	1080	20	5.50-6.0
7	1080	1200	120	4.50-5.50
8	1200	1240	40	3.50-4.50
9	1240	1280	40	0.50-1.00
10	1280	1300	20	3.50-4.50
11	1300	1320	20	4.50-5.50
12	1320	1360	40	3.50-4.50
13	1360	1420	60	4.50-5.50
14	1420	1440	20	1.25-1.75
15	1440	1480	40	4.50-5.50
16	1480	1500	20	2.50-3.50
17	1500	1520	20	3.50-4.50
18	1520	1540	20	2.50-3.50
19	1540	1580	40	1.75-2.00
20	1580	1620	40	1.25-1.75
21	1620	1640	20	1.00-1.25
22	1640	1680	40	0.50-1.00
23	2380	2460	80	0.50-1.00
24	2460	2480	20	1.00-1.25
25	2480	2500	20	1.25-1.75
26	2500	2540	40	1.75-2.00
27	2540	2560	20	2.50-3.50
		Total	**1040**	

Section VII: Employer's Requirements

Section VII-3: Design (Civil)

EMPLOYER'S REQUIREMENTS – DESIGN (CIVIL)

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 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.

2.4 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.

2.5 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.

2.6 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.

2.7 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.

2.8 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, i.e. C-1, T-1, C-4, C-6 and ST-1. 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

a) 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.

b) 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;

c) CONTRACT SPECIFICATION

The Specification included in the Outline Design Specifications and Outline Construction Specifications for Civil Works shall be amplified so as to specify comprehensively the design and construction of the Permanent Works.

d) 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.

e) 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.

f) TESTING AND COMMISSIONING REPORT

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

g) 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.

i) 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.

ii) 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.

iii) 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.

iv) 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.

v) INSTALLATION ANALYSIS REPORT

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

vi) 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.

vii) PROJECT SCHEDULE REVIEW

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

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.

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.

6. 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.

7. DESIGN SUBMISSIONS - CONSTRUCTION REFERENCE DRAWINGS SUBMISSIONS

7.1 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.

7.2 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.

7.3 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.

7.4 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.

8. DESIGN SUBMISSIONS – CONSTRUCTION PHASE

8.1 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.

8.2 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.

8.3 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.

8.4 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.

8.5 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.

8.6 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.

9. DESIGN SUBMISSIONS - REVIEW PROCEDURES

9.1 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.

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

9.3 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.

9.4 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.

10. DESIGN SUBMISSION PROGRAMME

10.1 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.

10.2 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.

10.3 The Contractor shall submit the Design Submission Programme to the Engineer within thirty (30) days of the date of commencement., and thereafter up-dated versions thereof at intervals of not more than one (1) month throughout the Design Phase.

11. 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.

12. CALCULATIONS

12.1 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.

12.2 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.

12.3 Similarly, the Contractor shall submit such further calculations as have been prepared in connection with the Construction Reference Drawings.

12.4 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.

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

13. DOCUMENTS REQUIREMENTS

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

13.2 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.

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

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

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 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) <u>Notice of 'No Objection' from the Engineer:</u>

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		

<u>Section C</u>

[Contractor to attach copies of necessary and required approvals]

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.

Sr.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 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.

NOTE:

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.

Section VII: Employer's Requirements

Section VII-4: Construction (Civil)

Contents

EMPLOYER'S REQUIREMENTS – CONSTRUCTION (Civil)

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 videography by drone 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. Videography 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	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	✓	✓	
	Concrete strength	Schmidt hammer tests	✓		✓
	List of bridges	List of bridges	✓	✓	
	Pile load test	Pile load test parameters	✓		
	Steel Girder	Material test record, fabrication, welding & trial assembly records, dead load camber	✓		✓
	Bearings	Acceptance test record	✓	✓	

Structure	Inspection Item		Inspection Method		
			Confirmation of "As-Built" Records	Visual Inspection	Measurement Test Check
	Track on OWG	Track parameters at every sleeper location	✔		✔
	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 structures on platform as per SOD	All structures	✔		✔
	Staircase and pavement	Results of stair width measurement	✔	✔	
	Drainage of platform & yard	Section & slope at every 20m	✔		✔
	Safety fence, etc.	List of facilities (clearance from platform end to fixed/movable fence, etc.)	✔	✔	

Structure	Inspection Item		Inspection Method		
			Confirmation of "As-Built" Records	Visual Inspection	Measurement Test Check
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) Bridges

9.1 Upon award of the Contract, the Contractor shall engage Sub-Contractor for fabrication, assembly & launching of Open Web Girders (OWG) Bridges. The Contractor shall submit details of Sub-Contractor proposed to be engaged for fabrication, assembly & launching of OWG Bridges. Sub-Contractor for Construction of ballast less track system 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).

9.4 The Contractor/ Sub-Contractor must own RDSO approved workshop or must submit an undertaking to the effect that on award of contract 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 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.

ATTACHMENT - C-1

MINIMUM ORGANISATION STRUCTURE REQUIRED

The figures indicated in Table 1 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 Annexure-C-2

TABLE-1 LIST OF MINIMUM ORGANISATION STRUCTURE REQUIRED

S.No.	Designation of Project Personnel	Minimum no. of Project-Personnel required	Penalty for Non-deployment per week or part thereof per person
1.	Project Manager (Team Leader)	1	Rs 50,000/-
2.	Planning Engineer	1+1	Rs 40,000/-
3.	Quality Assurance /Quality Control Expert	1+1	Rs 50,000/-
4.	Safety, Health & Environment Expert	1+1	Rs 50,000/-
5.	Surveyor	1+2	Rs 30,000/-
6.	Deputy Project Manager (Formation)	1+1	-
7.	Deputy Project Manager (Bridges & station)	1+1	-
8.	Civil Engineer (Formation)	3+3	-
9.	Civil Engineer (Bridge)	2+2	-
10.	Civil Engineer (Station)	1+1	-
11.	Civil Engineer (Fabrication & launching of steel OWG)	1+1	-
12.	Procurement Manager	1+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. 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.

iii. 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.

iv. 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.

UNDERTAKING:

i. We confirm to deploy project-personnel required to achieve progress of work as per construction work program submitted along with the tender or as approved by the Engineer.

ii. We confirm to deploy manpower over and above the minimum numbers, if the work so requires.

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ATTACHMENT C-2

MINIMUM ORGANISATION STRUCTURE REQUIRED

Minimum level of supervision & qualification/ experience of site staff is as follows:

S. No.	DESIGNATION	QUALIFICATION	EXPERIENCE LEVEL
1.	Project Manager (Team Leader)	Graduate in Civil Engg.	Minimum total experience of 15 years out of which, minimum 10 years as In-charge in *Infrastructure projects.
2.	Dy. Project Manager (Formation)	Graduate/Diploma in Civil Engg.	Minimum total experience of 10/12 years out of which minimum 05/08 years in Infrastructure projects
3.	Dy. Project Manager (Bridges & station)	Graduate/Diploma in Civil Engg.	Minimum total experience of 10/12 years out of which minimum 05/08 years in Infrastructure projects
4.	Civil Engineer (Formation)	Graduate or Diploma in Civil Engineering	Minimum total experience of 5 years for Degree & 8 years for Diploma out of which 2 year experience in relevant field in Infrastructure projects
5.	Civil Engineer (Bridge)	Graduate or Diploma in Civil Engineering	Minimum total experience of 5 years for Degree & 8 years for Diploma out of which 2 year experience in relevant field in Infrastructure projects.
6.	Civil Engineer (Station)	Graduate or Diploma in Civil Engineering	Minimum total experience of *5* years for Degree & 8 years for Diploma out of which 2 year experience in relevant field in Infrastructure projects.
7.	Civil Engineer (Fabrication & launching of steel OWG)	Graduate or Diploma in Civil Engineering	Minimum total experience of 5 years for Degree & 8 years for Diploma out of which 2 year experience in relevant field in Infrastructure projects.
8.	Planning Engineer	Graduate in Civil Engg. With certification Primavera software	Minimum total experience of 10 years out of which minimum 05 years in relevant field in Planning of Infrastructure projects.
9.	Quality Assurance (QA) /Quality control Expert	Graduate/Diploma in Civil Engg.	Minimum Total Experience Of 10/13 out of which minimum 05 Yrs. in QA (Field) and at least one Year as In-Charge in Infrastructure Project
10.	Procurement Manager	Graduate in Engineering / Diploma in procurement	Minimum Total Experience Of 05/08 in Procurement in Infrastructure Project.

11.	Safety, Health & Environment Expert	Graduate/Diploma in Engineering/Science with Diploma in Industrial safety	Minimum Total Experience of 06/08 with relevant experience of 3 years in Infrastructure projects.
12.	Surveyor	Diploma in Civil Engineering / ITI	Minimum Total Experience of 05/08 Years in Survey Work for Infrastructure project

NOTES:

i. *Infrastructure project includes Railway, DFC, Metro, RRTS and Highway projects.

SIGNATURE OF AUTHORIZED SIGNATORY OF CONTRACTOR

ATTACHMENT C-3

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	Construction Equipment	
a)	Excavator (75 cum/hr)	03+03
b)	Grader	02+02
c)	Dozer (150 Cum/hr)	04+04
d)	Vibratory Roller (10 T)	04+04
e)	Tippers	30+30
f)	Pugmil/Crusher(200MT/hr)	01+01
g)	Concrete Batching Plant	01+01 Min. capacity of batching plant 30 cum/hr
h)	Concrete Pumps (36 cum/hr)	02+02
i)	Transit mixtures	06+06
j)	Survey Instruments (Total Station)	01+01
k)	Lab Testing equipment- fully equipped for site tests.	01 Appendix 12
l)	Digital Level (Leica, Sokia)	2+2

Note:

i. The work of C-23 is located in two different stretches. The list of equipment given above in the form of x+y means that a particular equipment is required in x nos. in one stretch and in y nos. in another stretch.

ii. 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.

iii. The Tenderer must demonstrate that it has a tie up for fabrication of steel bridge girders included in this tender with RDSO approved plant/workshop in Part-A.

UNDERTAKING:

We confirm to deploy resources as per the above-mentioned minimum requirement and also confirm to deploy plants & equipment over and above the minimum numbers indicated above, if the work requires so.

SIGNATURE OF AUTHORIZED SIGNATORY OF CONTRACTOR

Section VII: Employer's Requirements

Section VII-5: Outline Design Specifications (ODS) – Civil

CONTENTS

1. INTRODUCTION

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

The broad parameters covered in these specifications are listed below:

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

2. OUTLINE DESIGN SPECIFICATIONS- GENERAL

2.1

The bridges, stations and other structures to be designed in C-23 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 GAD and preliminary design. 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 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.

2.2 Employer's Inputs

The Employer shall furnish following documents to the Contractor: -

a) Plan and L-section of the main line

b) Plan and L-section of the connectivities

c) ESP of station yards

d) Conceptual GAD of bridges

e) Conceptual layout plan for station

f) Preliminary Geo-technical investigation reports

2.3 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 the foregoing paras.

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

2.4 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 bridges shall be 100 years.

b) Structures of the Building works

The design life of all building and 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 20 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.

2.5 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.

2.6 Soil Parameters

Preliminary Geo-technical investigation reports shared with 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 (>15%) in the design soil parameters compared to the parameters as per 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 design soil parameters.

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 by

(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 minimum3.0m higher than the Base value for evaluation of effects for liquefaction design purposes.

2.7 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.

2.8 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 substructure 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 meters correct to three decimal places and shall be 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 New Prithala 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) The Contractor shall refer to the Standard Specifications and Code of Practice published by the Indian Roads Congress and/or consult with the competent authority to maintain the appropriate clearance over the road as required accordingly.

e) Horizontal and vertical alignment has been given in the Alignment Drawings. Proposed Right of Way (ROW) has been also marked on the Alignment Drawings. The Contractor should check the feasibility at site and may propose any minor modification, if required.

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

g) 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".

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

i) Backfill on bridge approaches shall be placed in accordance with IRS Substructure Code.

j) The data like bridge length, size, barrel length, type of crossing, high flood level (HFL), 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. While designing the bridges, it shall be obligatory that in case of parallel section, the total bridge length, Box opening and/or HFL for an individual bridge for HORC tracks shall not be less than that of the corresponding KMP/DFC bridge. Also, the span configuration for the proposed bridges shall match the span configuration of the corresponding KMP/DFC bridge, to the maximum extent possible, to avoid obstruction and to bring the abutment/piers in line with the existing abutment/piers. Deviation from above shall be in consultation and with approval of the Engineer.

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

l) In case of pile foundation, bored cast in-situ concrete piles of diameter 1.2m shall be designed.

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

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

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) The embankment on approaches of bridges shall be protected by stone pitching/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, for a length of 30m on both sides for major bridges and subway & 15m on both sides for RCC boxes. Toe wall shall be designed at the end of the embankment slope as shown in tender drawings.

q) Inspection steps (1m wide) on either side of formation shall be designed with CC of M20 grade.

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

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

t) In station area 100m on both side of station building, general earth filling of about 1m

height shall be done in complete ROW. This standard of earth filling shall be similar to that of earthwork in formation.

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 that are coming in C 23 Package. 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 hume pipe (NP-4)/RCC box crossings for utilities

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.

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.

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 should 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.

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.

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 from one end to the other towards cess/drain provided in between.

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

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.

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 100m center to center on both Up and Dn tracks in a staggered manner.

3.3.5 NP-4 pipe of 450mm diameter, conforming to IS 458, shall be provided at about 500m interval throughout the alignment in embankments having fill heights upto 5m. In embankments having fill heights more than 5m precast RCC box of 500mmx500mm clear size shall be provided for the purpose of future utilities. Installation conditions for the pipe shall be designed as per the IS-783, according to the fill height.

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) The Contractor shall submit the 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) Details of earthwork balance (cut & fill), properties of materials to be imported/exported, and management of excess materials. 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 -: BRIDGES

4.1 General

This part lays down specifications for design of bridges.

The Bridges in HORC Project comprises of simply supported Prestressed Girders (I/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 has been kept as 5.3m according to IR-SOD(BG). Maximum length of the track is ballasted except at OWG locations.

4.2 Details of Structures to be designed

The details of the items to be designed in this group are described as follows:

a) Bridges with superstructure of Steel Open Web Girder (OWG)

This group includes the bridges having steel OWG superstructure. Following standard RDSO drawings of OWG for 45.7m and 76.2m span for "DFC loading (32.5t Axle load)" shall be used:

S.No.	Span	Reference RDSO Drawings
		DFC loading (32.5t Axle load)
1	45.7 m	B-17081 to B-17098
2	61.0 m	B-17121 to B-17138
3	76.2 m	B-17101 to B-17118

Note: The above drawings are available in the office of the Engineer for reference.

All connection in OWG shall be HSFG bolted connections instead of rivets as shown in the drawings. Grade of bolts to be used shall be of property class 8.8.

Spherical bearings shall be used instead of roller rocker bearings.

Side pathway for maintenance shall be provided as per RDSO drawing No.: CBS-0045, on one side of the truss. Arrangement for prevention of train droppings on road/rail users underneath the track shall be provided.

The Contractor shall design substructure and foundation of these bridges.

The substructure of these bridges shall be designed for "DFC loading (32.5T axle load)". 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. Load on bearings, design and drawings of bearings including bearing pedestals, inspection platforms including arrangements for access from track. Spherical bearings shall be used.

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

v. Seismic arrestors in pier/abutment cap

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

vii. Provision of supports for placing OHE mast for traction system

viii. Protection works of abutments

ix. Inspection steps on approaches of bridges

x. Side pathway on bridges for maintenance

xi. Drainage arrangements

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

xiii. Arrangement for prevention of train droppings on road/rail users' underneath track

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. Construction methodology

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

b) Bridges with superstructure of Composite Girder (CG)

This group includes the bridges having superstructure of steel CG. Standard RDSO drawings for "25t Loading-2008" will be used for superstructure of CG. However, the Contractor shall verify the adequacy of RDSO standard drawings of CG for double stack containers. The Contractor is required to design foundation and substructure for these bridges for "DFC loading (32.5T axle load)".

Spherical bearings shall be used for 30.5m composite girders instead of standard elastomeric bearing. Standard RDSO elastomeric bearings shall be used for composite girders span less than 30.5m, if not in gradient.

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. Load on bearings, design and drawings of bearings including bearing pedestals, inspection platforms including arrangements for access from track. Spherical bearings shall be used at locations where Composite girders are placed at gradient.

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

v. Seismic arrestors in pier/abutment cap

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

vii. Provision of supports for placing OHE mast for traction system

viii. Protection works of abutments

ix. Inspection steps on approaches of bridges

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

xi. Drainage arrangements

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

xiii. 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.

xiv. Construction methodology

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

c) Bridges with superstructure of PSC U- slab

This group includes the bridges having superstructure of **PSC U- slab (**post tensioned). Standard RDSO drawings for "25t Loading-2008" will be used for PSC superstructure. The Contractor is required to design foundation and substructure for these bridges for "DFC loading (32.5T axle load)".

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. Load on bearings, bearing pedestals, inspection platforms.

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

v. Seismic arrestors in pier/abutment cap

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

vii. Provision of supports for placing OHE mast for traction system

viii. Protection works of abutments

ix. Inspection steps on approaches of bridges

x. Drainage arrangements

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

xii. 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.

xiii. Construction methodology

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

d) 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 and height gauge

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

Standard RDSO drawing for box culvert shall be followed to the maximum extent. If standard RDSO drawing is not available for desired sizes/fill height, box shall be designed

by the Contractor. However, thickness and reinforcement of the box shall not be less than the closest available box size & fill height of RDSO drawing.

RDSO box culvert for double track are available upto 2m fill height. In case of higher fill heights, the size and reinforcement of box shall not be less than that of box for single track with fill height of 2m more than actual fill height.

Any variation from the above, if required due to site constraints shall be adopted after the prior approval of the Engineer.

4.3 Design Requirements

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

The superstructure/bearing, sub-structure 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 the most onerous cases.

a) Railway Bridges

i. Superstructure and bearings shall conform to standard RDSO drawings for "25t Loading-2008" except for OWG bridges and CG bridges of 30.5m span. Standard RDSO drawings for "DFC loading (32.5t Axle load)" shall be used for OWG.

ii. Substructure and foundation of bridges shall be designed for DFC loading (32.5T loading) as per IRS Bridge Rules and other relevant codes.

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

iv. All ballasted deck bridges shall be capable of carrying long/continuously welded rail (LWR / CWR) as per the provisions of "UIC-774(3R) and RDSO guidelines.

v. Side pathway with hand railing shall be provided on bridges on outer side of Up & Down track.

vi. Hand railing shall be provided for trolley/man refuge and inspection platforms on bridges. The design shall be such that it can be easily maintained and replaced, if required.

vii. 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.

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

ix. Bridge bearings shall be as per corresponding standard RDSO drawings for bearings (except for OWG & 30.5 m span CG superstructure). All bearings shall be replaceable without major disruption to railway operations or to any activity underneath the bridge. 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.

x. 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.

xi. Height gauge for road – under – bridges shall be as per RDSO drawing no. RDSO/M-0001.

b) RCC Box Bridges

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.

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. Any variation, due to site constraints, shall be done with the consent of the Engineer

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

iv. The clear inner dimension of the box shall cater to the requirements of type of crossing. The height of box shall include the thickness of wearing coat provided inside the box.

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 floor shall be protected by curtain wall at upstream side and drop wall at downstream side, wherever applicable.

vii. Other Requirements:

a. All RUBs shall be provided with 1m wide walkway on one side of the carriageway.

b. The approaches / approach ramps to the RUBs shall be of concrete of M25 grade.

c. Suitable Height Gauges shall be provided on both sides of RUBs.

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

e. Inspection Steps shall be provided wherever required.

f. Provision for lighting shall be kept.

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

h. Suitable drainage system including sump and discharge arrangement (as required) and protection works / ancillary works shall be designed.

Detailed Design criteria for the Bridges shall be as per the design criteria given in Clause 4.4 below.

4.4 Outline Design Specifications 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:

b) CLEARANCES FOR ROAD TRAFFIC

Vertical clearance for road traffic shall generally be as per clause 104.4.2 of IRC-5 plus 100 mm.

General Arrangement Drawings at road crossings shall be approved by the relevant authorities/stake holders.

c) CLEARANCES FOR ROLLING STOCK

Clearance for railway traffic shall be as per Schedule of Dimensions of Indian Railways. General Arrangement Drawing at railway crossings shall be approved by the relevant Railway Authority.

d) MATERIALS PARAMETERS

i. CONCRETE

1) Grade of Concrete & Cover

Grade of concrete shall be M-35 for RCC works and M-20 for plain cement concrete including levelling course. However, grade of concrete for bearing pedestals and seismic restrainers can be higher, if required.

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 25 kN/m^3 for PSC and RCC, 25 kN/m^3 for Plain cement concrete and 26 kN/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 ^oC 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 (REBARS)

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

Young's Modulus	=	200,000 Mpa
Yield Stress(fy)	=	500 MPa.
Density	=	78.5 kN/m3

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 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, E350 – B0) shall be as per IS: 2062.

2) Structural Steel for Open Web/Composite Bridges

(a) General

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

Fabrication shall be done as per 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-RCC 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 21,100 kg/mm2 as per IRS- Steel Bridge Code.

(c) Density: 7850 kg/m3

(d) Poisson's Ratio: 0.30 as per IRC: 24-2010.

(e) Thermal Expansion Coefficient: 12x10-6 as per IRC: 24-2010

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

e) LOADS TO BE CONSIDERED FOR DESIGN

Following are the various 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 loads include all the weights of materials on the structure that are not structural elements but are permanent. It includes weight of track form 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 490 kg/sqm. 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) Centrifugal Forces Due to Curvature of Superstructure

The horizontal centrifugal force due to moving load in curved superstructure is to be considered as per IRS: Bridge Rules.

C= (Wv^2)/127R

Where W is Live load & C is Centrifugal force (unit of C & W shall be same), v is maximum design speed in km/h and R is radius of curvature in m. This force shall be assumed to act at a height of 3m (same as in case of DFC loading) above rail top level on the safer side as cg is not defined for double stack containers.

For sharper curves, speed restrictions as per SOD shall be followed.

(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 in the absence of any provisions in IRS code.

(b) Rail Structure Interaction (LWR Forces)

A rail structure interaction [RSI] analysis for continuing Continuous Welded Rail/Long Welded Rail over ballasted bridge decks shall be done as per provisions of "RDSO Guidelines for carrying out Rail-Structure Interaction studies on Indian Railways (BS 114 (version-2))".

- The following shall be adhered to:

a. Track resistance in loaded and unloaded conditions shall be obtained from cl. 3.2.6 Track Stiffness of BS 114 (version-2). As per the clause, the recommended values for track stiffness for ballasted tracks are 60kN/m and

20kN/m for loaded and unloaded track respectively. The elastic limit is 2 mm for ballasted tracks. No change in track stiffness is permitted on account of actual track behavior.

b. The temperature variations, to be used for analysis, shall be taken as per provisions of cl. 3.2.8 Temperature Variations of "BS 114 (version-2)". The following shall be used for analysis:

- The temperature of the bridge does not deviate from the reference temperature by more than + 35 ^{0}C
- The temperature of the rail does not deviate by more than + 50^{0}C.
- The difference in temperature between deck and track does not exceed + 20^{0}C.
- The reference temperature is the temperature of the deck and the rail when the rail is fixed.

c. 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. 3.3.1 of "BS 114 (version-2)" for additional stresses in Rails 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.

d. The provisions of cl. 3.3.2 of "BS 114 (version-2)" Displacements of Bridge Elements shall be adhered to.

e. Checks must be performed for break in rail continuity due to unusual conditions such as fractures or for maintenance purposes. The provisions of cl. 4.7 of "BS 114 (version-2)" for Rail Gap Analysis shall be followed.

f. Minimum (unfactored) LWR force of 1.6t/m of span length shall be considered for design irrespective of number of tracks.

- Software and general methodology to be used for carrying out Rail Structure interaction analysis must be validated before adopting the same. A well-established document such as UIC 774-3R may be used for validation.
- Representative stretches must be chosen for carrying out Rail-Structure interaction which shall include special spans. The same shall be got approved from the Engineer.

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 (as per IS 875 IS 87).

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 vsT) 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 = normalized pseudo spectral acceleration for corresponding to relevant damping of load resisting elements (pier/columns) depending upon the fundamental period of vibration T

(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 abridge component resulting from the analysis in the two orthogonal horizontal directions shall be combined according to the expressions given below.

± 〖EL〗_X ± 〖0.3EL〗_Y

± 〖.3EL〗_X ± 〖EL〗_Y

ELX = Force resultant due to full seismic force along X direction, and

ELY = Force resultant due to full seismic force along Y direction

When vertical seismic forces are also considered, the design seismic force resultants at any cross-section of a bridge component shall be combined as below:

± 〖EL〗_X ± 〖0.3EL〗_Y± 〖.3EL〗_Z

± 〖.3EL〗_X ± 〖EL〗_Y± 〖.3EL〗_Z

±.3 〖EL〗_X ± 〖0.3EL〗_Y± 〖EL〗_Z

Where ELX and ELY are as defined above and ELZ is the force resultant due to full seismic force along vertical direction.

Seismic on soil mass behind the abutment and confined between the retaining wall shall 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)

Check 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: as per of IRC: 6.

Rules specifying the loads for design of superstructure and sub-structure of bridges and for assessment of the strength of existing bridges should be done as per IRS: Bridge Rules.

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.

f) 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 earth quake loads shall not be assumed to be acting simultaneously.

Load combination for 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.

g) 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.

h) 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.

i) 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 be in accordance with provision of UIC-776-3R.

j) 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 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 Clauses-10.4.1.1 & 15.2.2 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.

The drain pipe of double wall HDPE corrugated pipes with water collection box at top, shall be provided to discharge the water along pier with most pleasant aesthetics.

4.6 BEARING SYSTEM

(a) Type of Bearing System

Spherical bearings for OWGs or any non-standard superstructure shall be designed as per IRC: 83 part-IV.

In case of other RDSO girders, standard bearing drawings shall be followed.

(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 500mm as per IRC: 78.

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. Ductile detailing is mandatory.

The design of pier shall be done as per IRS CBC.

Shear reinforcement & ductile detailing shall be done as that of RCC column. In all SLS combinations, column shall remain in compression.

4.8 FOUNDATION SYSTEM

Foundation shall be designed as per IRS Bridge Substructure & Foundation Code, IRS Concrete Bridge Code, IRC-78, Manual on the design and construction of well foundation, IS- 2911.

4.8.1 Open foundation has been contemplated as first choice. 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.

4.8.2 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 done as per Table-1 of 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 (not on working pile) will be conducted as per IS: 2911 - Part IV. Initial test is proposed to 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 1997. 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 as per IRC 78.

v. The structural design of the pile cap shall be carried out as IRS CBC. Crack width shall be checked for load combination 1 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.

4.8.3 Well Foundation & Open foundation

Well Foundation & Open foundation shall be designed as per IRS Bridge Substructure & Foundation Code/ IRC: 78, IRS-CBC.

4.9 CODAL PREFERENCE

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 HRIDC.

5. OUTLINE DESIGN SPECIFICATIONS: STATION

5.1 General

Master Plan & Concept Plan of the station building shall be provided to the Contractor. 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 at Stations of HORC project station which do not support IR/Road live loads.

5.2 Details of Structures to be designed

The details of the items to be designed in this group are described as follows:

a) Stations

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 five stations namely New Patli, Sultanpur, Dhulawat, Chandla Dungerwas and Panchgaon.

The design of station shall include, but not limited to, the following -

i. Station Buildings

ii. Platform face wall of RCC, platforms, platform shelter, water booths & toilets and seating arrangement

iii. Water supply, drainage & sewerage system

iv. Rain-water harvesting system for PF water

v. RCC retaining walls for embankment slope and approach road

vi. Yard drainage

vii. Subway for inter-platform transfer including stairs & ramp with covering and lift

viii. Bore well, pump house, pipe connections, underground & overhead water storage tanks

ix. Septic tank

x. Land scaping, circulating area, internal roads, ramp, Parking etc.

xi. RCC portico at sub-way entrance

xii. Steel FOB along with stairs and ramp at Pachgaon station

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

a) 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. 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.

v. 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.

vi. Loading due to earthquake shall be assessed based on the provisions of IS: 1893 (Part I) and IRS seismic code, with latest revision.

vii. Loads and load combinations shall be for most unfavorable effects and shall comply with relevant Indian Standards including IS: 456 and IS:800.

viii. Overall stability and serviceability requirements shall be checked in accordance with the provisions of relevant Indian Standards.

ix. 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.

x. 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.

xi. Station signages shall be designed as per IR standards.

xii. Benches at platform shall be four-seater bench with backrest, with seat partition as per RDSO drawing no. RDSO/WKS/2018/2.

b) 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.

c) Other requirements

The minimum requirement of the facilities for Operation and Maintenance shall be as specified below: -

i. Amenities for passengers as per norms for 'Recommended Level' as specified by Railway Board shall be provided at stations considering category of station as 'NSG-6' Maximum Number of passenger "Nmax" shall be considered as 250 for New Patli & Dhulawat and 150 for other stations.

ii. Main Platforms Shelters of length 20 m each (two nos.) and covering entire platform width shall be provided on each platform at New patli and on end platform at Dhulawat station as per detailed design.

iii. On island platform urinals shall be provided at the end of platform with wash basins nearby separately for ladies and gents.

iv. 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.

v. In stairs, riser shall be kept maximum as 125mm and tread minimum as 250 mm in the station area and inter-platform connectivity.

vi. External Development of the station area shall include, but not limited to, the following:

(a) Providing RCC Land Boundary Pillars of size 200mm x 200mm x 1500mm all around the stations (except along KMP side in case of parallel section) and to be fixed @ 50m center to center and at every change in direction.

(b) Entrance to each station

(c) Internal roads and footpaths as per applicable standards and statutory requirements

(d) Street lighting including high mast lighting per applicable standards and statutory requirements. Illumination of all service roads shall be as per IS: 1944-1981

(e) Potable water supply system with borewells, overhead and underground water tanks and pumping system

(f) Storm water collection, carriage and disposal systems as per applicable standards and statutory requirements.

(g) Septic tanks shall be provided for disposal of sewage from stations.

(h) Landscaping as required.

vii. Connecting road from entrance of each station to the existing public road for providing road access to the station. All the internal roads within the station area and connecting road to nearest existing public road shall be of cement concrete double/single lane with 1.0 m wide foot path and side/cross drains as shown in tender drawings. The roads shall be designed for 450 commercial vehicle /day & for a design period of 30 years or more as per IRC:58-2015

viii. Lift capacity at stations shall be adequate for minimum 15 persons.

ix. Covered underground water storage tank having minimum capacity of 50,000 liter at New Patli & Dhulawat stations and 20,000 litre at Sultanpur, Chandla Dugarwas & Panchgaon stations. Depth of tank shall be kept about 1.5 m to 2.0 m. RCC Overhead tank of minimum capacity of 20,000 liter at New Patli & Dhulawat stations and 10,000 litre at Sultanpur, Chandla Dugarwas & Panchgaon stations on staging. Pipe

connections and Pump with sensor-based auto pumping facility for filling of overhead tank.

x. Platform-

- All platforms shall be high level.
- Platform surface shall be smooth and provided with fiber reinforced Vacuum de watered concrete (VDC) flooring.
- End platforms shall be provided a slope of about 1:60 away from the track.
- Platform coping shall be of approximate size of 1125mmx530mmx100mm prefabricated from M-30 or higher grade concrete by vibro compaction in a factory under controlled environment.
- Effluent from drinking water taps etc. shall be collected and disposed of safely through underground drainage system.
- Two underground ducts of suitable size (100 to150 mm) with manholes at about 30 m interval along the length of platform shall be provided for electrical and S&T wiring etc.

xi. Subway for inter-platform transfer including stairs and lift.

xii. At sub-way entrance of New-Patli & Dhulawat stations a RCC portico 20 m long as shown in tender drawings shall be provided.

xiii. Steel FOB at Pachgaon station - The contractor shall design the FOB, stairs, ramp adopting detailing as per nearest available standard RDSO drawing of FOB. The size/thickness of members shall not be less than the nearest standard RDSO drawing.

5.4 OUTLINE DESIGN CRITERIA

a) Objective

The objective is to lay down the structural analysis & design of proposed station building. It also incorporates the design process to establish the overall design philosophy to be adopted in the Analysis and design.

b) 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.

c) 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

d) Structural Arrangement

The proposed building is considered to be of RCC frame structure with Isolated/ Strip /Raft/Pile foundations.

e) 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) -1987

ii. Imposed live load as per IS: 875(Part-2) -1987

iii. Wind loads as per IS: 875(Part 3) – 2015

iv. Seismic Loads as per IS: 1893-2016

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 1893:2016, with due consideration for the structural detailing as per provisions of IS 13920-2016 and SP 34-1987.

(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.

Note:

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

a. For RCC structures as per IS: 13920

b. 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.

f) Deflection Criteria

The deflection limitations as per IS: 456 for Plain and RCC Structures.

g) 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).

h) 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.

i) 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.

j) 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/m3 for Reinforced concrete & Prestressed concrete

(b) 25 kN/m3 for Plain concrete

(c) 26 kN/m3 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

k) 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.

l) 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.

m) 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

n) Fire Resistance Period

All the structural elements shall be designed for 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.

o) 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.

p) 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/ Etabs. 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.

q) 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 $ba^2/6$

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. UNDERGROUND SUMP COMBINED WITH WTP/OVERHEAD WATERTANK

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.

The walls and base slab would be designed as per the provisions of IS: 3370 (Part1-Part4)-1965 using the working stress method.

Overhead water tank would be designed to sustain the water load at full tank condition as per the provisions of IS: 3370 (Part 1- Part4) -1965 using the working stress method.

vii. Expansion &Construction Joints:

Seismic Expansion joints are recommended when structure exceeds 45m length. The width of the joints is being calculated as per IS-1893-2016, clause7.11.3.

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: 456-2000, IS 13920-1993 and IS: SP 34 will be followed for the purpose of detailing of reinforcement.

r) Design of water retaining structures

The underground tank in a station shall be designed as a water retaining structure based on IS: 3370. 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.

s) 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.

t) SUBWAY FOR INTER-PLATFORM TRANSFER

Subway shall be designed to cater to DFC loading (32.5T) from the tracks along with the other loads from the platform. It shall be placed on firm bed (strata)/pile foundation to avoid the settlement/differential settlement. 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.

Lift well in the subway shall be founded on firm strata below the ground level.

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 C23 Package.

Retaining wall is required to be provided at some of the locations along the alignment due to limited availability of ROW. Retaining wall shall be located at the edge of ROW. On Left Hand Side (i.e. on KMP side) of main line, no retaining wall shall be provided except at locations where private land falls between HORC ROW and KMP ROW. Further, some additional land is proposed to be acquired along the alignment. In case additional land is made available before undertaking the construction, provision of retaining wall shall be deleted and earthen slope shall be provided at that location. Cost of additional earthwork due to provision of slope shall be paid under the Schedule B.

Precast RCC retaining walls shall be used upto minimum 2m height above ground level. The Contractor may use cast in-situ retaining wall for more heights. Minimum grade of concrete for precast retaining wall shall be M 40. 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) Wherever sufficient land is not available to provide a stable slope for the formation along the alignment without infringing ROW, suitable earth retaining structure as per the IRS-Bridge Substructure & Foundation Code shall be provided.

b) Earth retaining structure if required at any other critical location, shall be proposed by the Contractor and shall be subject to approval of the Engineer.

c) The earth retaining structures, if required, shall be designed 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.

d) Design and reinforcement detailing shall suit the lifting and handling requirements of the segments of precast retaining wall.

e) Joints between the segments shall be properly designed for required lap length also.

f) Expansion joints shall be provided at an interval not exceeding 30m.

LIST OF CODES

6.4 Introduction

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 of 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.

6.5 Relevant Standards

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 approval of design/drawings by the Engineer. 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. Fabrication Specification (B1)

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-114 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

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.

Section VII: Employer's Requirements
Section VII-6: Outline Construction Specifications (Civil)

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)

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

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)
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 by the Engineer equipped with the following minimum apparatus ISI marked, materials and competent trained staff required for carrying out tests, as specified in the relevant sections of the specifications: -

i. 1 Set of standard sieves for testing grading of sand with mechanical sieve shaker.

ii. Sieves with openings respectively of 4.75mm, 10mm, 20mm, 25mm, 30mm for testing and grading of aggregates.

iii. Weighing Balance of capacity up to 10 Kg. reading up to 5 gm.

iv. Electric Thermostat controlled oven and pans for drying of sand and aggregates.

v. Glass measuring flasks of 1/2, 1 liter & 2 liter capacity.

vi. Flask for determining moisture content of sand.

vii. Slump cone with rod, flow table to measure slump.

viii. Apparatus to measure permeability of concrete

ix. Minimum 24 Nos. steel moulds for 150mm x 150mm x 150mm concrete test cubes. It may be necessary to provide more steel cube moulds depending upon concreting program.

x. 25mm dia vibrator for compaction of concrete in test cubes and also vibrating table.

xi. Concrete cube testing machine of 200 tonnes capacity with 3 dial gauges electrically operated.

xii. Work benches, shelves, desks, sinks and any other furniture and lighting as required by the Engineer.

xiii. Abrasion, Flakiness & Impact testing Equipment for testing coarse aggregate.

xiv. Silt Testing Equipment.

xv. Equipment for field lab as per Appendix 12 of Employer's Requirements Section VII-9.

xvi. Any other equipment specified by Engineer.

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 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. Over loading 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 expense 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 make 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 test 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 Wherever there are tension / suspended concrete members which are suspended from upper-level structural members, the shuttering / scaffolding of such members at lower level shall have to be kept in place till the time the upper level supporting members gain minimum required strength. Cost of such larger duration of keeping in place the shuttering/scaffolding shall be deemed to be included in the price quoted for respective structural members.

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 Casting yard to have following minimum facilities:

i. Casting beds as required.

ii. All handling facilities for precast elements.

iii. Curing arrangements as required.

iv. Stacking arrangements for precast elements.

v. Storing of materials.

vi. Proper drainage and approach roads.

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 an 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 videography 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 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

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 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
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
Cement		
44.	IS:269	33 grade ordinary Portland cement
45.	IS: 455	Portland Slag Cement
46.	IS: 650	Specification for standard sand for testing cement
47.	IS: 1489 (Part 1)	Portland pozzolana cement: Fly ash based
48.	IS: 1489 (Part 2)	Portland pozzolana cement: Calcined clay based
49.	IS: 3535	Method of Sampling Hydraulic Cements
50.	IS: 4031	(Parts 1 to 13) Methods of physical tests for hydraulic cement
51.	IS:4032	Methods of chemical analysis of hydraulic cement
52.	IS: 6925	Methods of test for determination of water-soluble

		chlorides in concrete admixtures
53.	IS:8042	White Portland Cement
54.	IS: 8112	Specification for 43 grade ordinary Portland cement
55.	IS:12269	Specification for 53 grade ordinary Portland cement
56.	IS: 12330	Specification for sulphate resistant Portland cement
57.	IRS: T40	Indian Railways standard specification for special grade cement for use in concrete sleepers
Concrete		
58.	IS:456	Code of practice for plain and reinforced concrete
59.	IS: 457	Code of practice for general construction of plain and reinforced concrete for dams and other massive structures
60.	IS: 460 (Part I TO III)	Specification for Test Sieves
61.	IS: 516	Methods of tests for strength of concrete
62.	IS: 1199	Methods of sampling & analysis of concrete
63.	IS: 1200	Methods of measurement of building and civil engineering
64.	IS: 1343	Code of practice for prestressed concrete
65.	IS: 1607	Methods of Test Sieving
66.	IS:2386	Parts I-VIII. Methods of tests for aggregates for concrete.
67.	IS:2430	Methods of Sampling of Aggregates of Concrete
68.	IS:2438	Specification for roller pan mixer
69.	IS:2514	Specification for concrete vibrating tables
70.	IS:2571	Code of practice for laying in-situ cement concrete Flooring
71.	IS:2645	Specifications for integral cement water proofing Compounds
72.	IS:2722	Specifications for portable swing batchers for concrete (double bucket type)
73.	IS:2770	Methods of testing bond in reinforced concrete part I pull out test
74.	IS:3025	Methods of sampling and test (physical and chemical) for water & waste water
75.	IS:3370	Code of practice for concrete structures for storage of Liquids
76.	IS:3935.	Code of practice for composite construction
77.	IS:4326	Code of practice for earthquake resistant construction of Building
78.	IS:6925.	Methods of test for determination of water soluble chlorides in concrete Admixtures

79.	IS:7242	Specifications for concrete spreaders
80.	IS:7251	Specifications for concrete finishers
81.	IS:7861	Parts I & II. Code of practice for extreme weather concreting
82.	IS:7969	Safety code for handling and storage of building materials
83.	IS:8989	Safety code for erection of concrete framed structures
84.	IS:8142	Methods of test for determining setting time of concrete by penetration resistance
85.	IS: 9103	Specification for admixtures for concrete
86.	IS: 9013	Method of making, curing and determining compressive strengths of accelerated cured concrete test specimens
87.	IS: 9284	Method of test for abrasion resistance of concrete
88.	IS:10262	Recommended guidelines for concrete mix design
89.	IS: 4926	Code of Practice ready mixed concrete needs to be included in list
90.	MORTH	Specifications for Road and Bridge Works, Ministry of Road Transport and Highways (Roads Wing)
91.	SP 34	Handbook on Concrete Reinforcement and Detailing
92.	IRS	Concrete Bridge Code
93.	IRC 112	Code of Practice for Concrete Road Bridge
94.	IRC 83 (Part 4)	Statndard Sepcifications and code of practice for road bridges Section IX Bearings (Spherical & Cylindrical)
95.	ASTM-C-94	Ready Mix Concrete
Construction Plant and Machinery		
96.	IS: 1791	Specification for batch type concrete mixers
97.	IS: 2505	General requirements for concrete vibrators: Immersion type.
98.	IS: 2506	General requirements for screed board concrete vibrators.
99.	IS: 3366	Specification for pan vibrators

100.	IS: 3558	Code of Practice for use of immersion vibrators for consolidating concrete
101.	IS: 4656	Specifications for form vibrators for concrete.
102.	IS: 4925	Specification for concrete batching and mixing plant.
103.	IS: 11993	Code of Practice for use of screed board concrete vibrators.
Formwork		
104.	IS: 4990	Specifications for plywood for concrete shuttering work
105.	IRC: 87	Guidelines for the design and erection of false work for road bridges.
106.	IS: 806	Code of practice for use of steel tubes in general building construction.
107.	IS: 1161	Specification of steel tubes for structural purposes.
108.	IS: 1239	Specification for mild steel tubes, tubular and other wrought steel fittings
Gypsum and Gypsum Board		
109.	IS: 2095	Gypsum plaster boards
110.	IS: 2542 (Part 1/Sec to 12)	Methods of test for gypsum plaster, concrete and products: plaster and concrete
111.	IS: 2542 (Part 2/Sec 1to 8)	Methods of test for gypsum plaster, concrete and products: Gypsum products
112.	IS: 2542 (Part1)	Gypsum building plaster: Excluding premixed lightweight plaster
113.	IS: 2547 (Part 2)	Gypsum building plaster: Premixed lightweight plaster
Handling and Storage		
114.	IS:4082	Recommendation of Stacking and Storage of construction materials
115.	IS:8348	Code of practice for stacking and packing of stone slabs for transportation
116.	IS:8759	Code of practice for maintenance and preservation of stones in building

Instruments for Testing Cement and Concrete		
117.	IS:5513	Specification for vicat apparatus.
118.	IS:5514	Specification for apparatus used in Le-Chaterlier test.
119.	IS:5515	Specification for compaction factor apparatus.
120.	IS:7320	Specification for concrete slump test apparatus.
121.	IS:7325	Specification for apparatus to determine constituents of fresh concrete.
122.	IS:10080	Specification for vibration machine.
123.	IS:10086	Specification for moulds for use in tests of cement and concrete.
124.	IS:10510	Specification for vee-bee consistometer.
	Joint Fillers	
125.	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		
126.	IS:102	Ready mixed paint, brushing, red lead, non-setting, priming
127.	IS:109	Ready mixed paint, brushing, priming, plaster, to Indian Standard Colour No. 361 and 631 white and off white.
128.	IS:218	Creosote and anthracene oil for use as wood preservatives
129.	IS:347	Varnish, shellac, for general purpose
130.	IS:348	French Polish
131.	IS:2074	Ready mixed paint, air drying, red oxide-zinc chrome, priming
132.	IS: 4833	Methods of field testing of preservatives in wood
133.	IS:10013 (Parts 1 to 3)	(Part -1) Water soluble type wood preservatives

134.	IS:10013 (Parts 1 to 3)	(Part-2) Acid-copper-chrome preservative
135.	IS: 10013 (Part 1 to 3)	(Part-3) Copper-chrome-boron wood preservative
136.	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
137.	BS:EN:10152	Specification for electrolytically zinc coated cold rolled steel flat products. Technical delivery conditions
138.	ASTM A 164-71	Specification for electrodeposited coatings of zinc on steel
Pigment for cement		
139.	BS:1014	Specification for pigments for Portland cement and Portland cement products
Reinforcement & Structural Steel		
140.	IS:206	Code of Practice for use of Steel Tubes in General Building Construction
141.	IS:210	Grey Iron Castings
142.	IS:280	Mild steel wire for general engineering purposes
143.	IS:432	Part I. Mild steel and medium tensile steel bars. Part II Hard drawn steel wire.
144.	IS:451	Technical Supply conditions for Wood Screws
145.	IS:806	Code of practice for use of steel tubes in general building construction
146.	IS:815	Classification coding of covered electrodes for metal arc welding of structural steels
147.	IS:1239	Specification for mild steel tubes, tubulars and other wrought steel fittings

148.	IS 1343	Code of Practice for Prestressed Concrete
149.	IS:1363	Black hexagon bolts, nuts and lock nuts and black hexagon screws.
150.	IS:1365	Slotted countersunk screws.
151.	IS:1566	(Part I) Specifications for hard-drawn steel wire fabric for Concrete reinforcement
152.	IS:1786	Specification for high strength deformed steel bars and wires for concrete reinforcement.
153.	IS:2502	Code of Practice for bending and fixing of bars for concrete reinforcement.
154.	IS:2629	Recommended practice for hot-dip galvanising of iron and steel.
155.	IS:2751	Code of Practice for welding of mild steel plain and deformed bars for reinforced concrete construction.
156.	IS 4000	Code of practice for high strength bolts in steel structures
157.	IS:4759	Hot-dip zinc coating on structural steel and other allied products.
158.	IS:5525	Recommendations for detailing of reinforcement in reinforced concrete works
159.	IS:9417	Recommendations for welding cold-worked steel bars for reinforced concrete construction.
160.	IS:14268	Uncoated stress relieved low relaxation steel class 2 for Prestressed concrete
161.	IS:226	Structural steel (Standard Quality)
162.	IS:800	Code of practice for use of structural steel in general building construction.
163.	IS:813	Scheme of symbols for welding
164.	IS:814	Covered electrodes for metal arc welding of structural steel. (Part I & Part II)

165.	IS:816	Code of practice for use of metal arc welding for general construction in mild steel.
166.	IS:822	Code of practice for inspection of welds.
167.	IS:961	Structural steel (High Tensile)
168.	IS:1024	Code of practice for use of welding in bridges and structures subject to dynamic loading.
169.	IS:1030	Carbon steel casting for General Engineering Purposes
170.	IS:1120	Coach Screws
171.	IS:1367	Technical Supply Conditions for Threaded Fasteners
172.	IS:1161	Steel tubes for structural purposes.
173.	IS:1182	Recommended practice for radiographic examination of fusion welded butt joints in steel plates.
174.	IS:1915	Code of Practice for Steel Bridges
175.	IS:2016	Plain Washers
176.	IS:2062	Structural steel (Fusion welding quality)
177.	IS:3063	Single Coil Rectangular Section Sprint Washers for Nuts, Bolts and Screws
178.	IS:3443	Crane Rail Sections
179.	IS:3757	Specification for high tensile friction grip bolts
180.	IS:5624	Specification for foundation bolts
181.	IS:3600	Code of practice for testing of fusion welded (Part I) joints and weld metal in steel
182.	IS:4923	Hollow steel sections for structural use.
183.	IS:6227	Code of practice for use of metal arc welding in tubular structure.
184.	IS:801	Code of practice for use of cold formed light gauge steel structural members in general building construction.

185.	IS:811	Specifications for cold formed light gauge structural steel sections.
186.	IS:8500	Structural steel Micro alloyed (Medium and high strength qualities)
187.	IS:8910	General requirements of supply of weldable structural steel
188.	IS:9595	Recommendations for metal arc welding of carbon & carbon- manganese steels.
189.	IS 16172	Reinforced Couplers for Mechanical Splices of Bars in Concrete
Sand		
190.	IS:383	Coarse and fine aggregates from natural sources for concrete.
Scaffolding		
191.	IS:2750	Specification for steel scaffoldings
192.	IS:3696 (Part 1)	Safety Code of scaffolds and ladders: Scaffolds
193.	IS:3696 (Part 2)	Safety Code of scaffolds and ladders: Ladders
194.	IS:4014 (Part 1)	Code of practice for steel tubular scaffolding: Definition and Materials
195.	IS:4014 (Part 2)	Code of practice for steel tubular scaffolding: Safety regulations for scaffolding
196.	IRC:87	Guidelines for the design and erection of falsework for Road bridge
Sealants		
197.	IS: 10959	Glossary of terms for sealants for building purposes
198.	IS: 11433 (Part 1)	One part grade polysulphide base joint sealant: General requirements
199.	IS: 11433 (Part 2)	One part grade polysulphide base joint sealant: Methods of test
200.	IS: 13055	Methods of sampling and test for anaerobic adhesives and sealants

201.	BS: 5889	Specification for one part gun grade silicone based sealants.
Wood		
202.	IS: 303	Plywood for General Purposes
203.	IS: 848	Synthetic resin adhesives for plywood (phenolic and aminoplastic)
204.	IS: 1141	Seasoning of Timber – Code of Practice
205.	IS:1328	Veneered decorative plywood
206.	IS: 1659	Blocks Boards
207.	IS: 2046	Decorative thermosetting synthetic resin bonded laminated sheets
208.	IS: 2202 (Part 1)	Wooden flush door shutters (solid core type): Plywood face panels
209.	IS: 2202 (Part 2)	Wooden flush door shutters (solid core (type): Particle face panels and hardboard face panels
Bearing		
210.	IRC: 83 Part-II	Standard specifications and code of practice for road bridges Elastomeric Bearings
211.	IRC: 83 Part-III EN 1337gh	Standard specifications and code of practice for road bridges Pot Bearings
212.	IRC: 83 Part-IV	Standard Specifications and Code of Practice for Road Bridges (Section – IX) Bearings (Spherical and Cylindrical)
Piling		
213.	IS: 2911 (All Parts)	Bored Cast in-situ Concrete Piles
214.	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		
215.	IS: 276	Austenitic manganese steel castings
216.	IS: 733	Wrought aluminium and aluminium alloy bars, rods and sections for general engineering purpose.
217.	IS: 737	Specifications for wrought aluminium and aluminium alloy sheet and strip for general engineering purpose.

218.	IS: 3614 (Part 1)	Specification for fire check doors: Plate metal covered and rolling type
219.	IS: 3614 (Part 2)	Specification for metallic and non-metallic fire check doors: Resistance test and performance criteria
220.	IS: 7196	Specification for Hold Fasts
221.	ASME set 2 Part A	Ferrous Material Specification
222.	ASTM B 221	Specification for aluminum-alloy extruded bars, rods, wires, shapes, and tubes
223.	BS: 4873	Specification for Aluminum alloy windows
224.	BS: 7352	Specification for strength and durability performance of metal hinges for side hanging applications and dimensional requirements for template drilled hinges
225.	BS EN: 10143	Specification for continuously hot-dip metal coated steel sheet and strip. Tolerances on dimensions and shape
Stone and Facings/Linings		
226.	IS:1121-(Parts 1 to 4)	Methods of test for determination of strength properties of natural building stones
227.	IS:1121-(Parts 1 to 4)	(Part-1 Compressive strength)
228.	IS:1121-(Parts 1 to 4)	(Part-2 Transverse strength)
229.	IS:1121-(Parts 1 to 4)	(Part-3 Tensile strength)
230.	IS:1121-(Parts 1 to 4)	(Part-4 Shear strength)
231.	IS:1122	Method of test for determination of true specific gravity of natural building stones.

232.	IS:1123	Method of identification of natural building stones.
233.	IS:1124	Method of test for determination of water absorption, apparent specific gravity and porosity of natural building stones.
234.	IS:1125	Method of test for determination of weathering of natural building stones
235.	IS:1126	Method of test for determination of durability of natural building stones.
236.	IS:1127	Recommendations for dimensions and workmanship of natural building stones for masonry work.
237.	IS:1128	Specification for Limestone (Slabs and Tiles)
238.	IS:1129	Recommendation for dressing of natural building stones.
239.	IS:1130	Specification for marble (blocks, slabs and tiles)
240.	IS:1597 (Part 2)	Code of practice for construction of stone masonry Ashlar masonry
241.	IS:1706	Method for determination of resistance to wear by abrasion of natural building stones
242.	IS:1805	Glossary of terms relating to stones, quarrying and Dressing
243.	IS:3620	Specification for laterite stone block for masonry
244.	IS:3622	Specification for Sandstone (slab & tiles)
245.	IS:4101 (Part 1)	Code of practice for external facing and veneers: stone Facing
246.	IS:4101 (Part 2)	Code of practice for external facing and veneers: Cement concrete facing
247.	IS:4101 (Part 3)	Code of practice for external facing and veneers: Wall tiling and mosaics
248.	IS:4121	Method of test for determination of water transmission rate by capillary action through natural building stones

249.	IS:4122	Method of test for surface softening of natural building stones by exposure to acidic atmospheres
250.	IS:4348	Method of test for determination of permeability of natural building stones
251.	IS:5218	Method of test for toughness of natural building stones
252.	IS:8381	Recommended practice for quarrying stones for construction purposes
253.	IS:14223 (Part 1)	Polished building stones: Granite
254.	BS: 8298	Code of practice for design and installation of natural stone cladding and lining

Chapter 2. EARTHWORK IN FORMATION,HUME PIPES AND RETAINING WALLS

2.1 FORMATION IN EMBANKMENT/CUTTING

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.

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.

Soils mentioned in Clause 3.7 (a) of the RDSO Guidelines shall not be used.

SQ-1 type of soils shall not be used in prepared subgrade and top layer of subgrade.

MDD in laboratory shall be determined by using Heavy Proctor test as per IS 2720 Part- 16.

MDD achieved in the field compaction trial shall not be less than 98% of the MDD achieved in laboratory.

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.

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

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.

Blanketing material shall be as per RDSO Guidelines.

The type of test, frequency and acceptance criteria for quality check of earthwork and blanketing shall be as given in Chapter 7 of RDSO Guidelines.

2.2 NP-4 pipe of 450mm diameter, conforming to IS 458, shall be provided at about 500m interval throughout the alignment in embankments having fill heights upto 5m. In embankments having fill heights more than 5m precast RCC box of 500mmx500mm clear size shall be provided for the purpose of future utilities. Installation conditions for the pipe shall be designed as per the IS-783, according to the fill height.

2.3 Precast retaining wall shall be manufactured from high strength reinforced concrete in factory under controlled environment and shall be steam cured. Dimensional

tolerance shall be 0+/- 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. Where retaining walls are required to be constructed for retaining embankment, earthwork may be carried out upto the height of the retaining wall prior to construction of retaining wall leaving sufficient space for construction of retaining wall and backfill. 500 mm width of bank shall be cut in proper slope and the cut soil removed from the Site and used at other places. Retaining wall shall be constructed as per approved drawings. Backfilling shall be carried out in layers with proper compaction as per RDSO Guidelines. Complete space between retaining wall and the embankment shall be filled up and compacted with backfill material. Thereafter earthwork will proceed further above the height of the retaining wall as per approved method statement. Wherever retaining walls are not provided, the side slopes of the banks after cutting of 500 mm width at both edges shall be compacted with mechanical vibrators before providing erosion control measures.

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

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 bridges of length exceeding 1000 Metres, base lines and reference

towers will have to be established. Provision of all assistance in form of measuring instruments, linear tapes as may be required by the surveyor, technical and skilled staff and labour required to assist them, fixing pegs, pillars and towers including all building materials and maintaining and guarding them including supply of all materials, tools and plant shall be done by the Contractor at his cost. Nothing extra will be payable to them on this account. Important points to be observed in this activity are:

1) Linear Measurement shall be carried out with invar tape or electronic distance measuring instruments

2) Spring balances shall be used for giving specified tension to the tape. Tape readings shall be corrected for tension, temperature and slope.

3) Concrete pillars with steel plates fixed over them shall be located at intermediate points (at tape lengths) and ends.

4) Reference pillars at pier and abutment position along centre lines and reference pillars on base lines shall be to standards to be prescribed by the Engineer. During construction, since centre line pillars at abutment / pier locations will be disturbed, reference pillars and lines shall be fixed around each structure by the Contractor under Site Engineer's supervision. Reference diagrams at Annexures 4/1 and 4/2 and Clause 401 of IRBM shall be referred to for more details.

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 shown on the drawings. 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 Bored cast in-situ Piling

Piling shall be carried out by hydraulic piling rig.

3.5.1 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.

3.5.2 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**

The stabilizing material to maintain the sides of pile bores shall preferably be natural drilling mud. If natural mud is not available, then stabilizing fluid having bentonite, controlled with a polymer like CMC (Carboxyl Methyl Cellulose), shall be used. The stabilizing material shall be approved by the Engineer. Bentonite, when used, shall conform to IS 2911 (Part 1/ Section 4).

3.5.3 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.

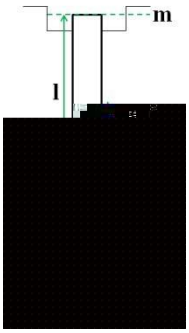
x. The Contractor shall record all the information during installation of piles,

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 1.0 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 2.0 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 comprise of bentonite, complying with the specifications of IS 2720, IS 2911 (Part 1/ Sec2; ANNEX D) or otherwise 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 Contractor shall obtain manufacturers' certificates of the bentonite powder consigned to the Site giving properties of each consignment and shall submit them to the Engineer prior to commencing the work and whenever required.
- 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. Such control tests on the bentonite suspension as required or as approved by the Engineer shall be carried out during the 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 bentonite suspension in the Site 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

3.5.4 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 by 150 mm as per the Drawings and as agreed by the Engineer. 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.

3.5.5 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.

3.5.6 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.

3.5.7 **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.

3.5.8 **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 5.5.8(d) to Sub-Clause 3.5.8(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 The Low Strain Method as per IS 14893 to verify the structural integrity, shape and continuity of pile as detailed in Sub-Clause 3.5.8(i).

e) Number of Tests:

i. **Initial pile-load tests:** The number of load tests shall be as per IS 2911 (Part 4) depending upon the total number of piles but not less than two (2). Wherever the soil strata are erratic or there is change in structure type (such as river bridge, rigid frame), additional tests shall be required as directed by the Engineer.

ii. **Routine pile-load tests:** The number of tests may generally be 0.5 percent of the total number of piles required, but not less than one (1). The number may be increased up to 2% depending upon the nature, type of structure and sub-strata condition.

iii. Initial and routine tests may 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 on Working Piles (other than piles subjected to routine load test):

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).

j) 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.

3.5.9 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.

3.6 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.

3.7 Substructure

3.7.1 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 20 unless otherwise specified / approved. The number of horizontal construction joints shall be kept to minimum. Construction joints shall be avoided in splash zones unless specifically permitted by the Engineer and provided they are treated in accordance with special provisions. No vertical construction joint shall be provided. Shear

connectors in the form of vertical plumbs, dowels, bond bars or rail cut pieces shall be provided at all horizontal joints as directed by Engineer. The work shall conform strictly to the drawings or as directed by the Engineer.

b) In case of tall piers and abutments, use of slipform shall be preferred. The design, erection and raising of slip form shall be subject to special specifications which will be furnished by the Contractor. The concrete shall also be of higher grade and subject to additional specifications as necessary. All specifications and arrangements shall be subject to the approval of the Engineer.

c) The surface of foundation / well cap / pile cap shall be scraped with wire brush and all loose materials removed. In case reinforcing bars projecting from foundations are coated with cement slurry, the same shall be removed by tapping, hammering or wire brushing. Care shall be taken to remove all loose materials around reinforcements. Just before commencing masonry or concrete work, the surface shall be thoroughly wetted.

d) In case of solid (non-spill through type) abutments, weep holes as shown on the drawings or as directed by the Engineer, shall be provided.

e) The surface finish shall be smooth, except the earth face of abutments which shall be rough finished or left as form finished.

f) In case of abutments likely to experience considerable movement on account of backfill of approaches and settlement of foundations, the construction of the abutment shall be followed by filling up of embankment in layers simultaneously with filter backing behind to the full height to allow for the anticipated movement during construction period before casting of superstructure.

3.7.2 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.

3.7.3 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. 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.

3.7.4 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.

3.7.5 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

3.7.6 For construction of Br Nos. 150 and 153 temporary diversions of existing roads will be required first. Then existing roads will be lowered by about 1.90 m at the site of the bridges and regraded to join the existing roads. Thereafter Br Nos. 150 and 153 will be constructed. Similarly, for construction of Br. No. 71, temporary diversions of existing roads will be required first. Thereafter, RCC box bridge will be constructed on the original alignment over which roads will be restored back by suitable regrading.

3.8 Bridge Work : Superstructure

3.8.1 GENERAL

a) Coverage

This chapter covers specifications for the following types of superstructures:

i. RCC Box

ii. Prestressed concrete girders and slabs

iii. Steel- Open Web Girders (OWG) and Composite Girders

3.8.2 RCC BOX

All concrete works for RCC box shall conform to Annexue OCS-1 & 2.

3.8.3 STEEL Open Web Girders (OWG) and Composite Girders

Fabrication and erection of steel girders shall conform to Annexure OCS-3.

Concrete and reinforcement for composite girders shall conform to Annexue OCS-1 & 2.

3.8.4 PRE-STRESSED CONCRETE GIRDERS AND SLABS

All prestressed works for bridges shall be carried out in accordance with Annexure OCS-1 to 4.

3.8.5 Linking of Track on Open Web Girder (OWG)

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.

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 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 of 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 2nd 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 40mm 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

Masonry work has to be in well burnt clay bricks of class designation 7.5 in general and class 12.5 for external walls which are neither plastered nor rendered on the outer face, free standing walls, and parapets, as approved by the Engineer. 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. Fly ash bricks or cement concrete blocks (hollow/solid) confirming to the BIS or stone masonry can be used as per local availability in lieu of clay bricks, but nothing shall be paid extra on this account.

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. Underside of the 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 50/100 No. 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, PVC 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

PVC 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. Chlorinator 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 and heat insulation of roofs:

Water proofing of roof shall be carried out by the Contractor as approved by the Engineer.

Heat treatment as approved by the Engineer shall be provided for roof of buildings.

4.2.7 Drip courses

Drip course of approved design shall be provided all around the building, chajjas etc.

4.3 EI Building

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) **Tele/OFC Room**

Tele/OFC Room, Equip Room, maintenance room IPS room, , store etc. : 40mm thick, cement concreate flooring with M-25 CC laid in one layer finished with cement slurry to a true smooth surface with proper joints duly 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 conforming to IS 4457-1967 as approved by the Engineer over 20m thick cement sand mortar 1:4, over 100mm thick CC M-10 over 100mm thick sand filling over well rammed consolidated earth filing. Acid proof tiles also to be provided in dado as per requirement up to 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 1:3 and 150 mm height skirting of same Kota Stone 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 & Ground Floor Passage**

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 1:3 over 100mm thick CC M-10 over 100mm thick sand filling over well rammed consolidated earth filing and 150 mm height skirting of same Kota Stone as per Clause 11.22 of CPWD Specification Volume-I 2019. Kota stone tile 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. 300x300mm ceramic anti-skid floor tiles of minimum 10 mm thickness conforming to IS 13630-1993 of Kajaria, Nitco or similar make and shade and approved by Engineer laid over 20mm thick bed of cement and sand mortar 1:4 with neat cement slurry mixed with pigment to match the shade of tiles between joints and over the base in floors laid over 100mm thick CC M-10 over 100mm thick sand filling on well rammed and consolidated earth filling on ground floor. On subsequent floors the tiles will be laid directory 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 gaps between them.

f) **Interlocking cum Axle Counter Rooms**

Interlocking/Axle counter room,, Panel Room and other S&T structures etc. 1st quality 600x600mm vitrified floor tiles of minimum 10 mm thickness conforming to IS 13630-1993 of Kajaria, Nitco or similar make and shade as approved by Engineer laid over 20mm thick bed of cement and sand mortar 1:4 with neat cement slurry mixed with pigment to match the shades of tiles between joints and over the base in floors over 100mm thick CC M-10 over 100mm 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 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 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 manufactured from hot rolled steel section as per IS:7452-1990. Sizes of steel sections used for manufacture of door, window & ventilator frames shall be as per IS:7452 and IS:1038. Requisite number of holes shall be made in the frame for fixing fittings.

b) **Door Shutter**:

35mm thick flush door shutter, commercial type thermosetting synthetic resin bound core of block board construction with lipping of 1st class commercial quality timber, such as elm or its equivalent, battens on all edges and well-matched commercial ply veneering with vertical grains on both faces of shutters. Veneer and board shall as per BIS specifications with brass fittings of approved size and make as per requirement.

c) **Windows/Ventilators**

Steel windows shall be manufactured from rolled steel sections and shall conform to 7IS:452 andIS: 1038. Glass panes 4mm thick with glazing clips and special metal sash putty, of approved make with brass fittings of approved size and make as per requirement.

d) Windows in relay room shall be mix of double shutters/fix panes to provide insulation for effective air conditioning.

e) MS grill of approved design/drawing shall be provided in the windows and ventilators.

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. 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**

The door shutters shall be of 35mm thick flush door shutter, commercial type thermosetting, synthetic resin bound core of block board construction with lipping of 1st class commercial quality timber, such as elm or its equivalent, battens on all edges and well-matched commercial ply veneering with vertical grains on both faces of shutters. Veneer and board shall be of BIS specifications. These door shutters may be partially glazed as per requirement, as per drawing approved by the Engineer. Glazing shall be of glass pane of 6mm thickness. Doors shall be finished with duco painted of desired shade and colour of melamine polished complete with all fittings including door closures.

d) **Windows/Ventilators Shutters**

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.

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 600x600mm vitrified floor tiles of minimum 10 mm thickness conforming to IS 13630-1993 of Kajaria, Nitco or similar make and shade as approved by Engineer laid over 20mm thick bed of cement and sand mortar 1:4 with neat cement slurry mixed with pigment to match the shades of tiles between joints and over the base in floors over 100mm thick CC M-10 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 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 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.

b) Stairs-

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 and sand mortar 1:3 and 150 mm height skirting of same Kota Stone 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.

c) Toilets

Finished floor to be kept 25mm below the normal floor of the building. 300x300mm ceramic antiskid floor tiles of minimum 10 mm thickness conforming to IS 13630-1993 of Kajaria or similar make and shade as approved by Engineer laid over 20mm thick bed of cement and sand mortar 1:4 with neat cement slurry mixed with pigment to match the shade of tiles between joints and over the base in floors 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 13630-1993 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 20mm thick on with neat cement slurry 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 600x600mm vitrified floor tiles of minimum 10 mm thickness conforming to IS 13630-1993 of Kajaria, Nitco or similar make and shade as approved by Engineer laid over 20mm thick bed of cement and sand mortar 1:4 with neat cement slurry mixed with pigment to match the shades of tiles between joints and over the base in floors over 100mm thick CC M-10 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 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 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) **Ramp**

Slope of ramp shall not be steeper than 1:12. Width shall be sufficient to permit smooth movement of passengers and stainless steel railing (SS 304) shall be provided on both

edges. Facilities provided shall be as per the provisions of "The persons with disabilities" (Equal opportunities protection of rights and full participation): Act 1995. Flooring of ramp shall be of Chequered terrazzo tile 22mm thick with graded marble chips size up to 6mm fixed with neat cement slurry mixed with pigment to match the shade of tile including rubbing polishing complete on 20mm thick cement sand mortar 1:4 over 100mm thick CC M-10 over 100mm thick sand filling on well rammed and consolidated earth filling as per Clause 11.12 & 11.13 of CPWD Specification Volume-I 2019.

e) **Portico**

At subway entrance a RCC portico 20 m wide and covering entire road width shall be provided as per approved drawing and Annexure-OCS-1 & OCS-2.

f) Foot Over Bridge (FOB)

Steel FOB shall be fabricated as per Specification No. B-2 for Steel Structures (other than Girder Bridges)- Part 3. Flooring of FOB shall be of Chequered terrazzo tile 22mm thick with graded marble chips size up to 6mm fixed with neat cement slurry mixed with pigment to match the shade of tile including rubbing polishing complete on 20mm thick cement sand mortar 1:4 over 100mm thick CC M-10 over 100mm thick sand filling on well rammed and consolidated earth filling as per Clause 11.12 & 11.13 of CPWD Specification Volume-I 2019.

4.4.5 Subway & inter platform connectivity

a) **Flooring**

Kota stone 25 mm thick to be provided in flooring laid on with neat cement slurry mixed with pigment to match the shade of kota stone including rubbing polishing complete on 20mm thick cement and sand mortar 1:3 as per Clause 11.22 of CPWD Specification Volume-I 2019. Kota stone tile 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**

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 and sand mortar 1:3 and 150 mm height skirting of same Kota Stone 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) **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**

Roofing with Galvalume Sheets pre painted Al-Zn alloy coated sheeting CRCA (Cold Rolled Close Annealed) steel, minimum thickness shall be 0.90 mm and steel shall comply with requirement of Gr.60 as per ASTM A 792 M.

4.4.6 Platform Covering

a) **Main Platform Shelter**

Main Platforms Shelters of length 40 m and covering entire platform width shall be provided on each platform at New Patli and on end platform at Dhulawat station as per approved drawings. It shall be fabricated from rolled steel sections conforming to IS:2062/4923. Roof shelter shall have arrangement for collection and safe outlet of rain water. Shelter roofing shall consist of Galvalume Sheets pre painted Al-Zn alloy coated sheeting CRCA (Cold Rolled Close Annealed) steel thickness shall be 0.90 mm (+- 0.2 mm) and steel shall comply with requirement of Gr.60 as per ASTM A 792 M.

b) **Mini Shelter**

All mini shelter shall be with seating capacity of 6 passenger as shown in tender drawing. Roofing with 6MM thick multiwall translucent Polycarbonate sheet both side UV protected make in curved shape as shown in tender drawing .

c) **Shelter Flooring**

Kota Stone 25 mm thick to be provided in flooring laid on with neat cement slurry mixed with pigment to match the shade of kota stone including rubbing

polishing complete on 20mm thick cement and sand mortar 1:3 as per Clause 11.22 of CPWD Specification Volume-I 2019.

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-**

Two underground ducts of about 100mm size with manholes at about 30 m interval shall be provided along the entire length of platform to carry electrical and S&T cables.

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
8-	Soap Rack for each wash basin	CP Brass

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: 2003	Specification for Precast Concrete Pipe
IS 783: 1985	Code of Practice for Laying of Concrete Pipes
IS 1172: 1993	Code of Basic Requirements for Water Supply, Drainage & Sanitation
IS 1239 (Part-1):2004	Steel Tubes, Tubulars and Other Wrought Steel– 2004 Fittings, Part 1: Steel Tubes
IS 1239 (Part-2):2011	Steel Tubes, Tubulars and Other Steel Fittings– 2011, Part 2: Steel Pipe Fittings
IS 1726: 1991	Specification for Cast Iron Manhole Covers & Frames
IS 3624: 1987	Specification for Pressure and Vacuum Gauges
IS 4984: 1995	Specification for Water Supply HDPE pipes
IS 7634 (Part 2): 2012	Specification of Installation for Water Supply HDPE Pipes
IS 8110:2000	Well screens and slotted Pipes.
IS 8329: 2000	Centrifugally Cast (spun) Ductile Iron Pressure Pipes for Water, Gas and Sewage
IS: 9439:2002	Glossary of terms used in Water-well drilling technology.
IS 9523: 2000	Ductile Iron Fittings for Pressure Pipes for Water, Gas and Sewage
IS:11189: 1985	Method of Tubewell Development
IS 12288: 1987	Specification for Laying Ductile Iron Pipes
IS:12818: 2010	Unplasticized polyvinyl chloride (PVC-U) Screen

	and casing pipes for Borewell/tubewell specification
IS 16098 (Part-2) :2013	Structured-wall Plastics Piping Systems for Non-Pressure Drainage and Sewerage
BIS - SP (QAWSM) 56: 1994	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 Sub-Clause 6.4.4.3 of '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 Sub-Clause 4.4.10 under 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.

5.2.8 Rainwater Harvesting System

The Contractor shall provide rainwater harvesting system as per the drawings approved by the Engineer. The Contractor shall follow provisions of "Manual for Rainwater Harvesting and Conservation" (CPWD), IS: 15792 (Guidelines for artificial recharge to ground water) and guidelines issued by CGWB and local authorities.

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 90 mm 63 mm 45 mm 22.4 mm	100 90-100 25-60 0-15 0-5
2.	63 mm to 45 mm	90 mm 63 mm 53 mm 45 mm 22.4 mm	100 90-100 25-75 0-15 0-5
3.	53 mm to 22.4 mm	63 mm 53 mm 45 mm 22.4 mm 11.2 mm	100 95-100 65-90 0-10 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 6.7.1.

Aggregates shall conform to one of the two gradings given in Table 6.7.2 depending on the compacted thickness; the actual grading shall have the consent of the Engineer.

Table 6.7.1

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	AASH T-182 TO	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 6.7.2

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
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 1,000 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.

1.1. 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	10 0
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 6.9.1 below.

Table 6.9.1

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

6.8.2 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 6.9.2.

Table 6.9.2

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 6.9.2. 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 6.9.1)

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 6.9.3.

Table 6.9.3

Permissible variations from the job-mix formula

SL 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.

6.8.3 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.

1.2. 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

1.3. 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.

iii) 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.

iv) 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.

v) 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.

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:

$$H = 0.76x \frac{(NFxMF)+(NCxMC)}{} \text{ (kg/m3)}$$

100

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

1. 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.

2. During rainy and cold weather periods, the aggregates shall be stored undercover for at least 48 hours before being used and kept sufficiently dry.

3. 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.

4. The coarse aggregates shall, be stored as per the procedure of relevant IS: codes.

5. 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.

6. The stockpiles shall be built up in horizontal or gently sloping layers.

7. Trucks and bulldozers shall be kept off the stockpiles to prevent breakage and impairing the cleanliness of aggregate.

8. A hard base shall be provided to prevent contamination from underlying materials in storage areas in continuous use.

9. Overlap of different sizes of materials shall be prevented with suitable walls or by ample distance between storage piles.

10. 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

10.1 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.

10.2 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).

10.3 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

10.4 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.

10.5 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.

10.6 Mixing Concrete

10.6.1 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.

10.6.2 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.

10.6.3 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 32º nor below 5ºC 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.

10.7 Concreting in Extreme Weather Conditions

Concreting in extreme weather conditions shall conform to the provisions laid down in IRS: CBC (Cl. 8.6.1).

10.8 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.

10.9 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).

11. Curing of Concrete

11.1 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 in forcement.

   b. Where members are of considerable size and length, with high cement content, accelerated curing methods may be applied, as approved by the Engineer.

11.2 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).

11.3 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.

12. 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.

13. 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.

14. 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

Measurement Items	Inspection Method	Place to be Inspected
Presence or absence of honey combing, cold joint, discoloration, and cracking	Visual inspection at point-blank range	All parts
Presence or absence of cavity, float, and cracking	Hammering Inspection	As per approved Method

Clear cover to the outermost reinforcement	Non-destructive test using a probe	Statement, and as directed by the Engineer

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.

15. 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.

16. 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.

17. 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.

18. 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.

19. 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.

20. 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.

21. 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.

22. 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.

23. 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.

24. 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.

25. Tolerance

Tolerances for the finished concrete structures shall be as specified in the Contract.

26. 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.

27. Precast Concrete

27.1 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.

27.2 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 sutterings over required PCC base with proper drainage arrangement for proper working and curing.

27.3 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.

27.4 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.

27.5 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.

27.6 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.

28. Falsework and Formwork

28.1 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.

28.2 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.

28.3 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.

28.4 Cleaning and Treatment of Forms

Cleaning and treatment of forms shall conform to IRS: CBC(Cl.6.3).

28.5 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.

28.6 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.

28.7 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.

28.8 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/IISCO. 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

Type of bolting assembly		System HR	
General requirements		EN 14399-1	
Suitability for preloading		EN 14399--2 and, if any, additional testing specified in the product standard	
Bolt & Nut		EN 14399-3	
Marking	Bolt	HR8.8	HR10.9
	Nut	HR8 or HR10	HR10
Washers		EN 14399-5[a] or EN 14399-6	
Marking		H or HR[b]	
Direct tension indicator and nut face washer or bolt face washer		EN 14399-9	
Marking	Direct Tension Indicator	H8	H10
	Nut Face Washer	HN	
	Bolt Face Washer	HB	

[a] EN 14399-5 can only be used under the nut.
[b] At the choice of the manufacturer.

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. 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.

9. 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.

10. 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.

11. 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.

12. 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.

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-7: General Electrical Services

CHAPTER – 1 SCOPE OF WORK

1.1 GENERAL

A general description of the broad scope of work, relating to works covered in this Tender under Schedule C, is given below. It shall, however, be clearly understood that the description is for the purpose of general guidance only and is not exhaustive. For complete appreciation of the Scope, the specifications, drawings and other relevant paragraphs of the Tender documents shall be referred to.

1.2 ITEMS OF WORK

The following items of work are within the Scope of this Tender:

i. Electrification of New Patli, Pachgaon, Chandla Dungerwas, Dhaulawat and Sultanpur Station Building and Yard area with allied facilities and complete power supply arrangement as per Standard Railway Practice and guideline issued by Railway Board/ RDSO/ CPWD specification in Package C-23 for HORC Project.

ii. Supply, Installation, testing and commissioning of substation (11/0.44 kV, 2x250 kVA CSS with DRY type transformer (250 kVA) and silent type DG of 125 kVA capacity including AMF, APFC Panel of 100kVAR & LT Panel) including earthing system and all Safety equipment with complete power supply arrangement at New Patli station. The Location of Compact Sub Station (CSS) with all accessories shall be proposed by contractor in Station Area for approval of Engineer.

iii. Supply, Installation, testing and commissioning of substation (11/0.44 kV, 2x250 kVA CSS with DRY type transformer (250 kVA) and silent type DG of 125 kVA capacity including AMF, APFC Panel of 100kVAR & LT Panel) including earthing system and all Safety equipment with complete power supply arrangement at Dhaulawat station. The Location of Compact Sub Station (CSS) with all accessories shall be proposed by contractor in Station Area for approval of Engineer.

iv. Supply, Installation, testing and commissioning of High Mast Towers (16 mtrs) and octagonal poles (5 mtrs) with luminaries at yards, platform and circulating area with complete cabling arrangement to meet standard LUX level as per guideline issued be RDSO/ Railway Board.

v. Supply, Installation, testing and commissioning of CLS PANEL with cabling arrangement of suitable size and rating at each station as per RDSO specification.

vi. Supply, installation, testing and commissioning of Single sided and Double sided LED signage board with pictogram/symbol at each station as per specification.

vii. Supply, Installation, Testing and Commissioning of 2 Nos Lifts(G+1) (13 Passenger ,884 Kg) at New Patli and 02 Nos lifts(G+1) (13 Passenger,884 Kg) at Dhaulawat station with all safety equipment and 02-year or warranty given by OEM whichever is higher including all schedule maintenance as per OEM, attending breakdown with in prescribed time.

viii. All equipment testing, system acceptance test, integrated testing, and Commissioning of all erected equipment.

ix. Provision of all the construction drawings, documents and as-built drawings required to supply, install, test and commission the above installations.

x. Deal and resolve in co-ordination with the Engineer the Interface with other Contractors to ensure timely completion of the Works.

1.3 SCOPE

1.3.1 General

In general, The Contractor is responsible for all electrical works relating to electrification of station building/Yard with allied facilities including provision of lifts and (11/0.44 kVA) substation of rated capacity in this Section.

Table -2.1 Scope of work

S.NO	NAME OF SECTION	SCOPE
1	New Patli Station	Various Electrical General Services Work including SITC of Passenger Lifts
2	Panchgaon Station	Various Electrical General Services Work
3	Chandla Dungerwas Station	Various Electrical General Services Work
4	Dhulawat Station	Various Electrical General Services Work including SITC of Passenger Lifts
6	Sultanpur Station	Various Electrical General Services Work
7	Design	All General Services Work

NOTE: - The Contractor shall arrange the approval of Sample of all required item and lay out plan of Complete HT/LT power supply arrangement from Engineer before commissioning of work.

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CHAPTER 2 — DESIGN AND PERFORMANCE REQUIREMENTS

2.1 General

2.1.1 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 PS.

2.1.2 Design Environment

Adequate Margin shall be built in Design, particularly to take care of Climate Conditions/Operating Environment. Wherever the equipment is installed in open at the surface level or inside service buildings at surface level, the same shall be designed for working in the tropical conditions existing here and the ambient temperature and humidity levels pertaining to HORC Project area.

2.2 Basic Design Philosophy and Requirements

2.2.1 Proven Design

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 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. The contractor shall make any 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.

The contractor shall submit a schematic block diagram of the equipment showing the manner, in which the functional requirements of this specification shall work together. 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 also of any information, required for the Engineer in connection with the design of the contract works.

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.

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.

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.

2.2.2 The design philosophy should meet the following criteria:

a) Application of state-of-the-art Technology
b) Service proven design
c) Design life 30 years

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.

2.3 AS-BUILT DRAWINGS

Preparation of the as-built drawings shall be part of these specifications. As-built drawings will 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, DVDs with all as-built drawings shall be handed 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 Engineer requirement.

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.

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.

2.4 System Requirements :

2.4.1 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. CEA Regulations 2010
ii. Indian Electricity Act 2003 with latest amendments.
iii. Central Safety regulations, 2010
iv. Regulations laid down by Chief Electrical Inspector to the government.
v. Regulations laid down by EIG Indian Railways.
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

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CHAPTER –3 INSTALLATION AND CONSTRUCTION

3.1 REQUIREMENTS

3.1.1 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 also 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 before commissioning of work.

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. The contractor shall set up at least one main store/ depot for receiving and storing materials & other equipment at his own cost.

3.1.2 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.

3.2 Construction and Installation Plan

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.

3.2.1 Manual Handling

To facilitate handling of equipment during installation and maintenance thereafter, the Contractor shall closely co-ordinate and interface with other contractors travelling hoists and unloading jib cranes for sub-stations. The entire material handling plan for movement of bulky item 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. Road crane for handling heavy materials at the contractor's depot for loading and unloading of material will be arranged by the contractor who will also arrange his own crew for its operation and maintenance. All charges including pay and allowances of the crew and all running expenditure will be borne by the contractor.

3.3 Site Supervision/ Deployment of Technical Staff: -

3.3.1 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 Engineer, 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	Sr. Engineer (Overall in charge of all type of General Services work)	Graduate in Electrical Engineering with 10 or more- year experience in Electrical General Services work or HT & LT works.	1

No	Post	Minimum Eligibility	Minimum Requirements in nos.
2	Electrical Engineer (Site Engineer)	Graduate in Electrical Engineering with 7 or more-year experience in General Services work or HT & LT works. **Or** Diploma in Electrical Engineer with 10 or more 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 CV's 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.

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. In case replacement is required, contractor shall be responsible for replacement of such personnel.

iv. In case the contractor fails to employ the technical staff as aforesaid to the satisfaction of the Engineer-in-charge, the recovery shall be as mentioned below per each calendar month or part thereof of default.

Sl. No.	Post	Amount to be recovered per person per each calendar month or part thereof of default. (Rs)
1	Sr. Engineer	1.0 Lakhs
2	Electrical Engineer	50,000 /-
3	E&M Engineer	50,000/-

v. Contractor is to abide by the provisions of Payment of Wages act & Minimum wage act.

vi. The Contractor's supervision system shall be responsible not only for the supervision of the concerned system installation but also for the supervision of the installation of the primary fixing system, earth mats and systems, etc. The supervisors shall work on a full-time basis during the entire installation process.

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. All drawings and details shall be endorsed by the Contractor.

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 Contractors staff be found incompetent or unlicensed he shall be removed from the site until their Competency has been established.

3.4 Workmanship

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.

3.4.1 Installation of Cables

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.

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.

The maximum pulling force of any cable during installation shall not exceed the design force of cables.

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.

All materials used for termination, jointing and installation of cables in confined spaces shall have flame retardant, low smoke, halogen free characteristics.

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CHAPTER – 4 TESTING AND COMISSIONING

4.1 TESTING

This Chapter describes the testing & commissioning related to the Various General Services works in conformity with the requirements of RDSO/Railway Board Standards and standard Railway practices.
Testing constitutes an essential obligation to satisfy the Railway System.

4.2 Testing Conditions and Equipment Acceptance

The Contractor will have to carry out all the tests and checks required guaranteeing the Engineer of the good construction and the satisfactory operation of all power supply installation. Also, the contractor shall co-ordinate & arranges testing equipment etc. required for testing facilities.

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 IEC or other standards mentioned in the technical specification of each equipment or otherwise.

It is reminded that the contractor is totally entrusted with full responsibility of assembly and installation of all pieces of equipment mentioned in this specification, with supplying the maintenance equipment and the special tooling which shall be delivered as soon as equipment installation will be completed and with the various duties he is bound to regarding witnessing of tests at commissioning and supervision after energising.

4.2.1 **In-plant testing**: -

In plant testing concern type, routine tests and factory acceptance test.

i. Type tests are tests performed on one or two of an equipment series
ii. Routine test are tests performed on each equipment
iii. Factory acceptance tests are tests on a sample size as per standards.
iv. These tests will enable checking the quality of the equipment and its compliance with the specifications.
v. Following equipment, if desired by the Engineer shall be tested at third-party (duly approved by the Engineer)/ RITES during Factory Acceptance Test.:
    1. DG sets
    2. Transformer of any capacity
    3. Switch gears
    4. Different size of cables (LT/HT)
    5. LED light fittings
    6. Different types of HT/LT panels and APFC panel etc.
    7. Earthing material.
    8. Any other material decided by Engineer

Once the equipment will have passed the in-plant acceptance tests, it shall be delivered and installed under the contractor responsibility.

Concerning some type tests, test certificates issued by recognised agencies will be able to be supplied if the contractor cannot carry out these tests himself and if the test certificates are related to a similar equipment of same capacity and design.

The final factory tests will be carried out on the fully assembled equipment as specified. Thereafter, if required and permitted by the technical features of the equipment, the

equipment may be dis-assembled for transportation purposes. The dis-assembly should not, however, cause any deterioration of the technical performance of the equipment.

These tests will be carried out by the contractor, under his responsibility and in the presence of the Engineer and of the consulting Engineer. The cost of Factory Inspection/Site Inspection/Lab Test/Documentations will be borne by contractor.

Each of these tests will be subjected to a certificate. Provisional acceptance will be granted only after execution of the both sets of tests.

NOTE: For type tests, the contractor can provide test reports performed according to the corresponding IEC standard, on similar equipment of same capacity and design.

4.2.2 Third Party Tests

i. During execution stage Engineer may conduct the Test on any type of equipment from third party independent lab at its own cost, to ensure the quality of material supplies. If any of the samples fail in the test, the cost of the Test along with the complete replacement of whole lot shall be borne by the Contractor.
ii. If contractor represents, two random samples from the failed Lot shall be collected by the contractor in the presence of Engineer duly sealing the samples and send to two different NABL accredited labs (as approved by Engineer) for conducting all those tests, which were conducted on the failed sample. Cost of the testing including the collection of sample and transportation of sample will be borne by the contractor.
iii. If both the samples pass all the Tests, the Lot will be deemed as accepted by HRIDC, but in the case of failure of any of the samples collected by the contractor, complete Lot will be deemed as rejected and contractor will replace the whole Lot.
iv. The delay, if any for the procurement of the material due to failure, shall be considered as non-compliance and applicable penalty shall be imposed on the contractor.

4.2.3 System Acceptance Tests

At least six weeks in advance of any particular site testing, the contractor shall submit details of tests and details for the teste equipment the proposes to use for that testing to the Engineer for his approval.

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.

If each section of plant is installed, commissioning tests for each section shall be carried out on site. At least six weeks in advance of any particular site testing, the contractor shall submit details of tests and details for the test equipment he proposes to use for that testing to the Engineer for his approval. 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, from end to end of each circuit. Tests on cables shall be completed and accepted by the Engineer before the testing of the associated equipment starts.

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.

4.2.3.1 On-site commissioning tests being subject of acceptance by the Engineer shall include:

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 that 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 coloured.
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.

4.2.3.2 (a) The final acceptance tests shall begin after all on-site commissioning tests have been successfully completed and all defects detected during those tests have been rectified / corrected, which is 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.

(b) 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. During the site acceptance tests the Engineer shall inform the contractor of minor

faults detected and which of these minor faults shall be corrected before the beginning of the tests on completion.

4.2.4 TRIAL OPERATION

The trial operation shall occur with full responsibility of the contractor. The trial operation shall take place after finishing the tests on completion. For starting the trial operation, it is required, that all tests on completion are finished positive for the entire installation and shall occur within 21 days.

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.).

The contractor shall make organizational measurements during the trial operation, so that malfunctions can be rectified as soon as possible (within max. 2 days).

The results of the different tests during trial operation shall be shown in a protocol. This protocol shall be signed by the contractor and the Engineer.

4.2.5 Energization: -

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.

All power equipment shall be subject to inspection by inspectors from the Electrical Inspectorate of Engineer before Energization. The Contractor shall ensure all Engineer requirements are met. Contractor shall be responsible for reliable operation of all Electrical equipment.

4.3 COMMISSIONING

4.3.1 General

The Commissioning description, based on the following frame, will have to be defined by the contractor and submitted to the Engineer.

Once the contractor will have completed the above tests, and the various pieces of equipment installation, the assignment should include:

i. Putting into service tests

ii. After energising

The Engineer will be empowered to ask for any additional testing they may deem necessary. The contractor will have to supply the testing installations and measuring apparatuses required to this effect in accordance with the stipulations, provisional acceptance will then take place, followed by final acceptance at the end of the guarantee time.

4.3.1.1 Putting into Service Tests

It should be performed at this stage the tests verifying that the different equipment is acting correctly when energised.

4.3.1.2 Integrated Testing and Commissioning

The general testing having shown proper operation, an overall integrated test of the installations, should be performed, after the first 15 days of operation, during which the various actuation and operation situation (putting into service, normal actuation, failure tripping) will be simulated.

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CHAPTER – 5 MAINTENANCE AND TRAINING

5.1 INTRODUCTION

This Chapter describes the maintenance philosophy and training of maintenance staff for Electrical system considering RDSO/ Railway board standards and Railway practices.

The Contractor shall provide comprehensive training and documentation to the Engineer staff in accordance with the requirement of this chapter and the chapter of General Specifications.

This training shall enable all the installations, to be operated and maintained in the most efficient and safe manner, to achieve the maximum reliability and economy required by such System.

Note: - All type of Routine, Preventative and Schedule 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.

5.1.1 Maintenance Management

The management of the maintenance process entails defining various levels of responsibility and enabling them to implement the strategic orientations defined by the directing authority:

i. By defining their respective missions,
ii. By setting objectives for each person,
iii. By translating these objectives into action plans,
iv. By implementing the means required to carry out action plans,
v. By diagnosing the causes of any deviation from the set objectives,
vi. By taking corrective measures concerning the action plans or the objectives.

This management process requires a global approach and helps to improve the performance of the maintenance work of different components with quality, on time and at low cost. It must 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.

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.

Within the context of this approach, 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.

In conclusion, the process of maintenance management must incorporate two major components:

i. the management of human resources and the study of the most suitable means of achieving the set objectives.
ii. This is one of the first guidelines of maintenance organisation in the various relevant centres.

5.1.2 Determining Requirements in Terms of Facilities and Tools

The achievement of the objectives assigned to the maintenance division about quality, safety and regularity for the lowest possible overall cost requires the implementation of a number of resources which must be perfectly tailored to the requirements.

The facilities and tools are part and parcel of the resources placed at the disposal of the maintenance division to achieve the set objectives.

Owing to the cost of these facilities, the number of maintenance centres to be equipped and the necessity of keeping the maintenance actions consistent and uniform, the main choices of facilities and tools are integral part of the System maintenance policy and program.

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.

5.2 SUPERVISION AND PLANNING OF MAINTENANCE

5.2.1 General

The following outlines the Engineer maintenance strategy, various levels of maintenance, the Maintenance Management System and the arrangement for maintenance.

The Contractor shall make use of all relevant information to provide supervision of maintenance.

5.2.2 Engineer's Maintenance Strategy

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.

5.2.3 Planned Maintenance

Routine preventative maintenance will be carried out at regular intervals based on condition, reliability, usage, and service history, SMI 's issued by Railway Board/ RDSO and equipment manufacturers' recommendations. The Operating and Maintenance Manual shall describe the different levels of planned maintenance.

5.2.4 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. Switch gear/power supply arrangement
iii. Other works

5.2.5 Maintenance requirements

I. Testing and Re-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.

II. 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.

III. 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.

IV. 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.

V. 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.

VI. Maintenance Regimes

The Contractor shall provide documented maintenance regimes to be followed by the Engineer upon substantial completion of various components of the work until the end of the DNP.

The Contractor shall produce a maintenance regime for the equipment that shall comprise two constituent parts, corrective and routine/preventative maintenance.

Routine/preventative maintenance shall be non-intrusive to the day-to-day operation of the train service and be capable of being pre-planned in advance of the work.

Corrective maintenance shall be available 24 hours per day, able to respond to all foreseeable circumstances**.**

The maintenance regime 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.

VII. Scope and Hours of Coverage

The regime and structure of 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.

VIII. 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.

IX. Maintenance Manuals

The Contractor 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.

5.3 TRAINING:

During the contract period, the contractor shall provide training manuals, as well as onsite training and training courses to ensure that the Engineer staff associated with this project may acquire full knowledge and appreciation / understanding of all aspects of the design, day to day operation, breakdown and routine maintenance and fault diagnosis of the power supply, the surveillance and control equipment as well as the belonging hard- and software. The contractor shall train the Engineer personnel about all equipment in theoretical and practical way. Also, the maintenance staff shall be trained. The Engineer will nominate members of his staff, who are attending the training courses.

The contractor shall nominate qualified instructors. It shall be essential that prior approval of the Engineer is obtained for the instructor and the instructor's qualifications in each case. 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) and venue. The contractor shall provide all facilities including accommodation, transport and catering of all trainees. Within three months after the signing of the contract, the contractor shall submit a detailed syllabus for the training courses for approval by the Engineer.

5.3.1 General Requirements

The Contractor keeping the above aspect in view shall provide comprehensive training to the Engineer's staff in accordance with the requirements contained in this Particular specification and general specification. The training courses and/or sessions shall include system performance requirements and all major equipment and works designed, by the Contractor.

The specific objectives of each course, training facilities to be used, the qualification and experience of the training instructors and the assessment criteria shall be developed by the Contractor and submitted to the Engineer for review at least three months before any course is conducted.

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 shall be delivered to all relevant Engineer's staff, including instructors, operation and maintenance Engineering staff.

5.3.2 Mock-Up for Training

The Contractor shall install mock-up equipment for system and any such facility(s) considered necessary for the training of Engineer's staff in the training school.

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.

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.

5.3.3 Training of Engineer's Training Instructors (ETI)

The objective of the training is to enable the Engineer's Training Instructors to be competent to deliver future training courses for other employees of the Engineer.

The Contractor shall provide training to the 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 DHBVNL 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;

5.3.4 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.

5.3.4.1 Maintenance Staff Training

The objective of the training is to enable the Engineer's maintenance staff and Engineering staff to be familiar with the Systems focus on the maintenance aspects of the System including but not limited to the following: -

i. Full understanding of all the equipment, sub-systems and system, their function, maintenance and overall requirements.
ii. Procedures to be followed for unscheduled maintenance and repair.
iii. Identification of failed components and sub-systems in electronic equipment by use of special test kit as necessary.
iv. Modification in the software to extend or modify the control, monitoring and protection functions.

5.3.4.2 Training Requirements

Man weeks of contractor's Training Instructors for training Engineer's maintenance personnel in India.

S. No	Training	Man-Weeks
1	HT/LT panels, Transformer, Circuit Breakers, DG set , Switchgear and cables	2
2	Other General services Equipments/Electrical wiring	2
3	Electrical safety & Earthing system	1

5.4 Defects Notification Period (DNP)

The Contractor shall be responsible for all the Defects and deficiencies, till the expiry of a **period of 01 (One) year**. The Contractor shall repair or rectify all Defects and deficiencies observed by the Authority Engineer during the Defects Notification Period within time period as may be determined by the Engineer in accordance with Good Industry Practice.

5.4.1 Warranty Certificates from OEM:

i. All Original Warranty Certificates of OEMs of all Electrical system or 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 later and registered in the name of Engineer. These warranty certificates received from the OEMs should be passed on to Engineer before final Taking over.

ii. Validity of period of Warranty Certificates shall start from date of Commissioning.

iii. Original invoice shall also be submitted with the OEM warranty certificates in a

booklet form before Commissioning.

iv. Warranty period and defect liability support shall start from the date of Commissioning.

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CHAPTER – 6 TECHNICAL SPECIFICATION

6.1 TECHNICAL SPECIFICATION OF GENERAL SERVICES WORKS: -

S.No	Description of work	Work to be Done	Relevant IS Code/Standards	Reference Make
1.	Wiring for light/ceiling fan/exhaust fan/call bell etc. points including circuit wiring, sub-main wiring with Fire Retardant (FR), PVC insulated, multistranded, copper conductor, single core cable on surface/in recessed PVC conduits, distribution boards, sub distribution boards, earthing and suitable number of modular switch and socket.	1. The point/ circuit wiring is to be done by 03 x 1.5 sqmm insulated multi-strand copper wire for phase, neutral and earth inside pvc duct/ conduit 19/20 mm. 2. Wiring of sub-main with single core insulated, multi-stranded 3x2.5/3x4.0/3x6.0 sqmm PVC CU cable in PVC conduit ISI mark 19/20mm concealed in stone/ bricks masonry wall separate conduit & 2.5/4.0/6.0 sqmm PVC CU cable insulated multi-stranded for earth wire respectively. 3. Wire for phase, neutral and earth shall be laid/done in concealed with heavy duty ISI marked PVC conduit pipe, minimum 19/20 mm dia and thickness 1.5 mm along with bend / junction. 4. SITC of 5/6 and 15 Amp plug 5-pin 230V or above modular type switch socket of standard size on existing board and connection with 2.5sqmm and 4.0 sqmm PVC CU cable respectively. 5. Supply and fixing of PVC cable duct 40 x 60 (w x h) 1 M STD slot greenish grey. 6. SITC of Double Pole MCB of 32 Amp, 10 kA C series is to be provided in the metal enclosure. 7. SITC of 02/04/08/12 Module modular Plate MS Box (GI) for fixing of switches and sheet metal box of thickness 2/3 mm, of good quality and standard size. 8. SITC of Double Door MCB DB SP 12 way (10+ 2 module), neutral and earth link and suitable IP protection, with one no DP MCB 40amp, one no	i. IS: 694-2010 for PVC conductor. ii. IS: 3854/1997 for switches iii. IS: 1293/2005 For Plugs & socket iv. IS: 371/1999 for celling rose. v. IS: 8828/1996 for MCB vi. IS 13947 (Part -1) 1993 for MCCB vii. IS:9537/2000 for PVC conduit The Electricity Act- 2003 or Latest. All CPWD Norms for electrical wiring	PVC CU conductor- Finolex / Polycab / KEI / Havells or similar as approved by Engineer. i. Modular switch/ socket – Anchor /Roma / Schneider / Legrand / Havells or similar as approved by Engineer. ii. MCCB/RCCB/ MCB/DB – Legrand, ABB, Schneider and similar. iii. PVC conduit – BEC / AKG / Polypack or similar as approved by Engineer.

S.No	Description of work	Work to be Done	Relevant IS Code/Standards	Reference Make
		DP RCCB 40 amp 30 mA and eight no SP MCB 32/25/16/10/6 amp. 'C' series. 9. SITC of Double Door MCB TPN DB 8 modules 4 row, neutral and earth link, and suitable IP protection with one no 4 pole MCB 40 amp, one no FP RCCB 40 amp 30 mA and twenty-four no SP MCB 40/32/25/16/10/6 amp. Min 02 Nos of DB should be installed at each floor of station building or as per requirement.		
2	Supply, installation, testing and commissioning of pre-wired 22 watt energy efficient Tube light fitting(4 feet) on wall bracket connections from junction box/light point etc. to luminary with 1.5 sq.mm FRLS PVC insulated multistranded copper conductor single core/three cable as instructed & earthing etc.	1.SITC of LED tube light (22 Watt) suitable for IP-20 for indoor application operating voltage (140-270) V minimum 2000 Lumens, Colour temperature 6500ºK, CRI>65, CRCA steel sheet type enclosure. **2.** SITC of rechargeable batten type Emergency light 60 LEDs, 4 watt or higher with one-hour minimum backup.	CEE Spec No:CEE/NR/121-Elect/PS/2019(REV-04) Dated-04.11.2019 or latest for LED light.	Bajaj, Philips, Crompton or similar as approved by Engineer.
3	Supply, installation, testing and commissioning of 230V A.C. ceiling fan (1200/1400MM)/Exhaust fan and fan Regulator.	1. SITC OF ceiling fan 230V A.C. 1200/1400 mm ISI mark 5-star energy rating issued by BEE. 2. SITC of heavy duty exhaust fan 300mm sweep with louver shutter. 3. SITC of modular type electronic fan regulator, 5 step type on existing board.	i. IS: 374/1979 for ceiling fan ii. 2312/1967 for Exhaust fan. iii. IS:11037/1984	i. Crompton Greaves / Usha / Bajaj /Havells / Schneider or similar as approved by Engineer. ii. Anchor /Roma / North-West / Schneider / Legrand / Havells Crabtree or similar as approved by Engineer for fan regulator.

S.No	Description of work	Work to be Done	Relevant IS Code/Standards	Reference Make
4	Provision of High Mast Tower (16 Mtrs) with LED Flood Light fitting (200 Watt) complete in all respect and as per requirement. Minimum 06 Nos of LED light fitting at each HMT.	**1.** SITC of hot dipped galvanised (inside & outside), 16m high mast system (in two sections), complete with accessories, foundation bolts with nuts, washers, anchor plates & templates etc. manufactured from special steel, head frame, 2-point suspension system with steel wire rope 6mm dia (7/19 construction), double drum winch, galvanised lantern carriage arrangement suitable for required luminaries symmetrically arranged & control gear boxes and lighting finial etc. The mast shall have integral type power tool at the base compartment for its raising and lowering operation, twin dome LED aviation obstruction lights. construction of foundation as per recommendation of manufacturer and approved drawing and its fixing arrangements etc. 2. SITC of Control Panel consist of - (a) 1X63 A TPN MCB for incoming supply (b) 3X32 A SPN MCB for outgoing (50% lighting, 100% lighting, motor) (c) Automatic timer with Power contactor for controlling above lights of suitable capacity. (d) 1 no multi plug socket 16A 1. High mast shall be provided with fencing panel of size 2Mx2Mx1.5M in square shape (If required by Engineer) for protection of erected high mast tower wherever required as directed by Engineer. **2.** SITC of LED flood light fitting (200 Watt) pre die cast aluminium, IP-66 protection, with high power LED lamp complete with all accessories.	i. IS:875(Part-3)/1987 for High Mast Structure, ii. BSTN-10025/1993 for High Mast Shaft, iii. IS:2026 for other component IS: 2629 / 1985, BSEN ISO-1461 for Galvanization. iv. CEE Spec No:CEE/NR/121-Elect/PS/2019(REV-04) Dated-04.11.2019 or latest for LED light.	Bajaj, Philips, Crompton or similar

S.No	Description of work	Work to be Done	Relevant IS Code/Standards	Reference Make
		3. Provision of Pipe Earthing system of each HMT. (Minimum 02 earth is required for each high mast tower).		
5	Provision of Octagonal poles (5 metres) with street light fitting (40 Watt) and 70-30% arrangement with complete accessories.	1. SITC of 5 mtrs. long octagonal pole made with 3 mm thick GI sheet, Top Dia 70 mm, Bottom dia 130 mm with single /double arm hot dip galvanized steel octagonal Poles with galvanized base plate of 220 x 220x 12 mm (as per IS 2062) and GI bolt size M20 X 600mm X4 no in position including excavation of pit and filling the same with concrete M-20 including supply of material as required or recommended by pole manufacturer. 2. SITC of 40-Watt LED Energy efficient LED based 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 lm/W, colour temperature 6500K, CRI>65. Complete with all accessories. 3. SITC of modular digital timer for automatic operation of platform, circulating area, street light etc. complete with required power contractor, digital timer and MCB etc. in enclosure of suitable size and power Contractor.	i. IS:2629/1985, BESN ISO-1461 for Galvanization. ii. CEE Spec No:CEE/NR/121-Elect/PS/2019(REV-04) Dated-04.11.2019 or latest for LED light.	Bajaj, Philips, Crompton or similar as approved by Engineer.
6	Provision of Passenger Lifts (13 Passengers, 884 Kg) (G+1) with complete accessories at New Patli and Dhaulawat Staion.	1. Supply, installation, testing and commissioning of passenger Lifts (13 Passanger,884 Kg) gearless machine room less, single landing(GF&FF), Minimum load 13 persons speed 1m/s to 1.5 m/s, Automatic door with two side opening, microprocessor base variable frequency, variable voltage derive controller with ARD, Stainless Steel Hairline Finish Car and Car Door, 1.00 MPS. Simplex Collective, Selective Control, Emergency	i. IS-14665/2000 for Lift ii. RDSO/2013/EM/SPEC/0016 Rev (0) for Lift iii. All CPWD Norms for installation of Lifts.	OTIS, KONE, Mitsubishi, Jonson or similar as approved by Engineer.

S.No	Description of work	Work to be Done	Relevant IS Code/Standards	Reference Make
		Light, Fireman's switch, Alarm Button, Phase Failure & Phase Reversal Protection, Automatic Rescue Device, Vacuum fluorescent display in Car and other safety device with minimum guarantee/ warranty of 02 years. 2. Contractor should provide all the safety parameters/ License/ Insurance certificate and other required clearness issued by state authorities. 3. During Warranty period contractor will ensure all Preventive and Schedule maintenance/checks will be done by OEM only with in time interval as decided by Engineer. 4. During warranty period all the Breakdowns like defective/ broken of lifts Light, Fan, Batteries ARD and various electronic cards with in 3 hrs otherwise penalty may be imposed as per decision of Engineer. (Detail Technical specification of LIFT is also given at Para 6.2 for reference only)		
7	Supply, Installation, Testing and Commissioning of Sub-Station (11/0.440 KV) including CSS-1 and CSS-2. Each CSS Shall be consisting of 11KV Compact VCB/SF6 CB panel (1 incoming isolator + 2 outgoing ACB with air insulated BUS PT metering module) + DRY type Transformer (250 kVA) Capacity + L.T. Switchgear with all HT & LT inter-	1. Each CSS comprising of 11 kV compact substation suitable for outdoor installation with natural cooling, having type tested equipment comprising of dry-type (CRT) distribution transformer and SF-6 insulated compact switchgear enclosed in robotically sealed stainless steel tank, low – voltage switchboard, interconnection between HT switchgear and transformer using cables and transformer to LT-switchgear using aluminium bus bars, factory built ready for connection type, internal GI earthing provided complete with other associated equipment etc. complete as required as regards to	IEC 62271-202	ABB/Raychem/Voltamp/Schneider/Siemens/CG or similar as approved by Engineer.

S.No	Description of work	Work to be Done	Relevant IS Code/Standards	Reference Make
	connections, accessories, fittings & auxiliary equipment inside GI Enclosure as per technical specification. CSS also include 1 RMU 11kVA 630 Amp 21 KA, LT panel as per spec., APFC panel 100 kVAR MPP type heavy duty, all HT and LT cable with proper termination arrangement of suitable size and length, Suitable H-pole arrangement with GO/DO switch (if required) supply, fixing and commissioning of silent type 125 kVA DG set with AMF panel, Provision of Copper Plate earthing as per requirement and CT/PT for Metering system as per technical specification and supply & fixing of all safety items required for 11/0.440 substation as per rules.	design, manufacturing, type-testing, route-testing, pedestrian and operator safety (IAC AB 21ka/1-sec). The enclosure shall have modular construction using G.I. Sheet and shall be power-coated from exterior. The transformer compartment will have IP-54 protection. 2. HT SWITCHGEAR shall comprise of 03-Way Ring Main Unit having 01nos. Fixed-Type VCBs feeding to transformer in CSS, all enclosed in common tank, made of robotically welded non-magnetic/non-ferritin Stainless Steel Sheets, and filled with SF6 gas acting as insulating medium to suitable pressure, the tank design meeting IP-67 criteria with SF6 gas leakage rate less than 0.1% per annum, whereas it shall be Arc-Proof design with internal Arc classification IAC 20ka/1-sec individually. The complete Ring Main Unit should be a front-accessible design with associated Capacitive Voltage LED Indicators for each arc-proof cable box, along with associated Terminal Protector boots and front-facia semaphore mechanical indication for isolator/breaker ON/OFF/EARTH. The breaker will have provided with integrated Self-Powered 30C +1EF relay with low and high set for over current and earth fault. Relay should have facility to display the maximum loaded phase current also. Relay shall record minimum 5 fault records with time stamping, and shall be actuated via Resin cast Ring Core Protection CTs of suitable ratio and burden installed in the cable box.		

S.No	Description of work	Work to be Done	Relevant IS Code/Standards	Reference Make
		3. 01no. 250 KVA 11KV/433V Dyn11 Dry Type Distribution transformer having cast resin design Bushings for HT and LT with Off load tap switch of rating +5% to -5% @2.5% and WTI scanner. Temp Rise – 115 deg C, Class 'H' insulation, Losses = 2.2 kW (NLL/7.25KW(FLL) (Subject to IS Tol.), Impedance 5% (Subject to IS Tol.) and 01no. WTI Alarm/Trip Scheme and Surge arrestor in the HV side. 4. LV-PANEL shall be a totally enclosed, floor/Wall mounted, dead-front access, min IP2X protected panel which has a type tested design, aluminium busbars, suitable switchgear configuration and indication scheme as describe below 01no. 433V, 400 Amp, Aluminium Busbar Arrangement with suitable colour coding scheme for identification for each phase.01no. 800A, 433V, 50Ka, 4P Fixed, Manual ACB with microprocessor based over current, short circuit and earth fault release acting as IC-OG arrangement 01set. LED based ON/OFF/TRIP Indication for mains ACB. 01no. Multifunction Meter for measurement of various parameters like Voltage, Amp, kVA, kw, PF etc. of reputed make for mains ACB. (along with associated CT where applicable) 5.OUTDOOR ENCLOSURE shall comprise of having construction of Galvanised Sheet Steel of thickness at least 1.5mm. The Enclosure shall have IP54 degree of protection for HT & LT switchgear compartment & IP23 degree of protection for Transformer compartment. The enclosure shall be Power coated. Each compartment will be provided with the door and pad locking arrangement. The compartment illumination lamp with the door		

S.No	Description of work	Work to be Done	Relevant IS Code/Standards	Reference Make
		operated switch shall be provided for HV and LV compartment. The successful tenderer shall submit the arrangement GTP and other relevant drawings for approval as per standard make prior to supply and execution of work.		
8	Provision of Inverter type Split AC (1.5 Ton, Heavy duty, 5 Star Rating with Stabilizer) and other accessories as per site requirement	1. SITC of 1.5 Ton heavy duty, 5-star inverter type split air conditioner with required suitable size nuts, bolts, fasteners, cu pipe & petty hard ware in all respect. Top up the required refrigerant & maintain the pressure (If required) as per company recommendation or latest Eco-friendly refrigerant. 2. SITC of Metal Clad Plug Socket 20A single phase with 32A MCB 10kA ,c series including fixing and sheet metal enclosure box with one 20A plug top (Ray roll type) to be supplied with board for each AC.	IS:1391/1992 for Air conditioning	Voltas, Blue Star, Carrier, Hitachi, O -General, Mitsubishi or similar as approved by Engineer.
9	Provision of LED Signage Board & LED Station Name Board (Single Sided/Double Sided) with all accessories	1. Design, SITC 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 SMPS driver, without battery backup. Operating voltage 80-270VAC. LED with L70 life of minimum 50,000 hours, LPM technology, including fabrication and supply of clamping arrangements as desired. 2. 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	IS:16101-2012 and 16102-2012 part 1 and 2.	PHILIPS, NICHIA, OSRAM and SEOUL or similar as approved by Engineer.

S.No	Description of work	Work to be Done	Relevant IS Code/Standards	Reference Make
		can be seen in the standard book of signage available in office. 3. Depth of box shall be approximately 3.5 inches (for single sided) 5.5 inches (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.		
10	Supply and laying of different sizes 1.1 kV grade LT XLPE insulated armoured, aluminium conductor cable, in trench/ air/ HDPE pipe. making good the damages, end terminations with aluminium crimping sockets/lugs, provision of cable route markers, etc.	1. Supply of 1.1 KV grade 4x16,4x35,4x50,4x70,4x95,4x120 and 4x185 sqmm LT XLPE insulated armoured aluminium conductor cable, making good the damages, end terminations with aluminium crimping sockets/lugs, gland, testing and meggering etc. as per required Technical specifications. Note: -The contractor shall arrange inspection of cable at manufacture's works before dispatch at his own cost if required by the Engineer. 2. Supply & laying of HDPE pipe in already excavated trench under road/ground/floor/railway track etc. as per site requirement size 75/80 and 50 mm Dia wall thickness 3mm PN-4 conforming to IS 4984:1995 or latest as per site requirement. Pipe should be laid in trench such that It shall be possible to withdraw the cables for repair or replacement without disturbing the work. 3. Supply & laying of HDPE pipe in already excavated trench under road/ground/floor/railway track etc. with technical specification 160 mm dia (OD), wall thickness between 6.2 mm to 7.1 mm, material grade PE-80 and class of pipe should be PN-4. 4. Laying of underground cable under the road/Railway track, recessing in platform /wall	i. IS: 7098 Part-II-1985 for cable ii. IS: 8130-1984 for cable iii. IEC-502 standards with latest amendment. iv. IS 4984:1995 or latest for HDPE pipe	i. KEI, Finolex, Havells and Universal or similar as approved by Engineer for cable. ii. Duraline/Godavari/Rex Polyextrusion/ Eflex or similar as approved by Engineer for HDPE pipe. iii. Comet / Dowells / Lapp Kabel/Hummel or similar as approved by Engineer for Lugs and glands.

S.No	Description of work	Work to be Done	Relevant IS Code/Standards	Reference Make
		along with Railway Track. in laid HDPE /GI pipe as required 1.1 KV grade LT XLPE insulated armoured, aluminium conductor cable including making chase & plastering after laying of cable/digging of cable trench, sand cushioning, protective covering with second class bricks, provision of cable route marker (200x150x3mm thick M.S. Plate and welded to MS rod of min 5 mm dia including bending and fixing) as per tech. spec. 5. Excavation & Refilling of 0.5 Mtr Width 1.20 Mtr Deep trench in all kinds of soil for laying of HDPE/GI pipe for underground cable crossing. Contractor will clear all metallic parts & stones etc. in trench. 6. Drilling of horizontal bore below Rly track by pushing method for laying of HDPE/SPUN/DWC/CI/GI pipe up to 450 mm by pushing method. Horizontal boring will be done at minimum 1.5 Mtr. Below or as per site requirement from ground level. 7. SITC of LT heat shrinkable straight through joint with required accessories complete in all respect suitable for LT XLPE 4 core cable as per site requirement.		
11	SITC of Water Cooler (150 Ltrs) capacity with MS Cage & suitable protection arrangement as per site requirement.	1. SITC of self-contained drinking water cooler 150 litres capacity (cooling capacity 150 Lts. per hour), ISI marked, min 3 star rated, suitable for operation on 230 volts+/-10%, 50Hz, AC supply system complete with all connected standard fittings, accessories etc. and 5KVA, wall mounted, I.C. controlled electronic auto-voltage corrector.	i. IS:1475/2005 ii. IS: 1475 Part-1/2001	Blue Star, Kelvinator, Shriram, Voltas or similar as approved by Engineer.

S.No	Description of work	Work to be Done	Relevant IS Code/Standards	Reference Make
12	Provision of Water Pumping Arrangement system with 10 HP Submersible Pump set,120 LPM or Above; Head range: 160M or above; Phase: 3 Phase; HP: 10 Submersible pump set ,2 HP and 5 HP Monoblock submersible pumps with Suitable Starter , 3 core copper cable 6/10 Sq mm and other accessories as per site requirement.	1. SITC The pump set shall Energy Efficient Pumps (3 star or above) confirm to latest relevant IS and shall be guaranteed for the pump discharge range of head between +25% and - 10% of the specified head. The pump set shall be suitable for 8" dia bore well. Rotor dynamically balanced suitable for operation on 3-phase 50Cycles 415Volts -10% +5% AC Sup-ply. Motor squirrel cage induction type and shall be adequate capacity to provide the pump discharge within the range as specified. The Electric motor shall be water-cooled and water lubricated sealed against pollution from outside water. The thrust bearing shall be hydrodynamic Mitch well type preferably and provided with tilting thrust pads de-signed to make up all outward loads at the most unfavourable conditions. The motor shall be of ISI 410grade material; starter of motor should be impregnated with superior quality epoxy paint having type it thermal insulation as per IS5831-1970 or latest the rotor shall be dynamically balanced. All nut-bolts in contact with water of bore well should be of stainless steel. 2. Supply, fixing, testing and commissioning of single stage Mono-block open well submersible pump set with control panel rating 2HP/1.5KW, Head range (M) :26 meters and above, size (MM) suction X delivery 50X40, Discharge (LPM):180 or above at 26-meter head suitable for single phase 50Hz AC supply make as per ref list. 3. Supply and laying of flat submersible cable copper 3Cx6/3Cx10 sq.mm for pump set ISI mark as per requirement. Supply, fixing and connecting of Three phase, monoblock Horizontal/sump pump, 05 HP,	i. IS:8034/2002 for submersible pump set. ii. IS: 9283/1995 for Motor of submersible pump set. iii. IS: 14220/1994 for open well submersible pump set. iv. IS 694 Part-I 1964 or latest for CU cable.	i. ABB / BBL / Crompton Greaves / Kirloskar or similar as approved by Engineer. ii. Finolex / Polycab / KEI / Havells / Lapp or similar as approved by Engineer for CU cable.

S.No	Description of work	Work to be Done	Relevant IS Code/Standards	Reference Make
		3.75KW (dia 150 mm), 20-25 mtrs. Head, discharge 11 LPS complete with all accessories.		
13	Supply, Installation Testing and Commissioning of Earthing System	1. The earthing shall be done with 3 meters long 50 mm dia. 'B' class G.I. Pipe earth electrode with l2 mm dia. holes around the pipe at distance of 30 cm, down side tapered. Earth electrode to be put vertically 3-meter-deep with alternate layer of salt & charcoal approx. 50 kg charcoal and l0 kg salt. 8 SWG hot dip G.I. or 7/4 mm dia. galvanized steel stranded earth wire shall be connected from earth electrode top with l2 mm dia. G.l. nut bolt to main board / equipment with masonry / RCC earth enclosure of size 300x300x300 mm (ln side to inside) with I25 mm wall thickness & suitable size MS/RCC pull out cover. The G.l. wire shall run in l2 mm 'B'class G. I. Pipe along with wall / pole up to height of 1.5 meter. The depth of 8 SWG hot dip G. I. or 7/4 mm dia galvanized steel stranded earth wire including connections from earth pipe to main board / equipment /H pole/Tower in ground shall be 30 cms. 2 Supply and providing of Maintenance Free Earthing with primary MS conductor 40 mm dia 3000 mm long and secondary MS Electrode 80 mm dia 3000 mm long includes digging pit of size 5ft.x5ft.x10ft. And using earth enhancement chemical compound minimum 75 kg. Per pit suitable for 40 KA current capacities. 3. supply of Copper earthing of size (600x600x3 mm) thick copper earth plate & suitable size of 40 X 5 mm copper strip. The price shall also cover erection including digging of earth pit in any kind of soil at	i. IS:1239 or latest IS: 3043 ii. RDSO specification No. iii. RDSO/PE/SPEC/PS/0109 (REV-0)-2008	1) TATA, Jindal, Prakash, Surya Sail or similar as approved by Engineer for MS pipe for earthing. 2) Erico / Indlec / Duvalmession or similar as approved by Engineer for maintenance free earth.

S.No	Description of work	Work to be Done	Relevant IS Code/Standards	Reference Make
		the specified location. The work shall also cover the earth treated to obtain earth resistance of less than 1 ohm. Connection of earth electrode should be made by providing Copper clamps nuts, bolts.		
14	Supply and fixing of suitable size feeder pillars and Junction Box	1. Supply, erection, testing and commissioning of feeder pillar size 900x600x300 mm fabricated from 16 SWG MS sheet (tolerance as per IS permitted) hut shape suitable for outdoor installation, painted/ with red oxide and enamel/ powder coated complete enclosed type dust and vermin proof, with gland plate in bottom as required including connecting incoming & outgoing cables with aluminum lugs and brass glands, with 63 amp MCCB and 4 nos. aluminum bus bars suitable for 200A, complete with locking arrangement with MS angle stand 2 feet height angle size 40 x40 x6 mm Grouted in cement concrete mixture 1:3:6. 2. Supply and fixing of junction box size 390x305x170mm comprising of SMP/FRP material with rubber gasket, padlock arrangement, zinc pas- sivated earth bolt, etc. similar to Sintex model no. GSJB 3525 or similar with 4 no. aluminums bus bar cap 200 Amp. Suitable for 415-volt supply requirement. The box shall be fixed robustly with clamps at pole/ wall as per requirement.	Relevant IS code	Popular make of ISI mark
15	Supply and fixing of CLS panel suitable for 25 kVA/10 KVA capacity AT supply with complete accessories and protection system as per RDSO	1.SITC of CLS panel including automatic changeover complete as per connections as required.	RDSO specification No.TI/SPC/PSI/CLS/0020 (12/02) with A&C slips No. 1 to 4 or latest,	RDSO approved make.

S.No	Description of work	Work to be Done	Relevant IS Code/Standards	Reference Make
	specification			
16	Supply and fixing of Phase selector of size (610x450x190mm) with I/P MCCB- 100/ 63 amp and O/P MCCB- 63 Amp	1. SITC of 1.6 mm thick CRCA power coated box of size 610 x 450 x 190 mm approximate with Din rail. 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 wire of size 10 sqmm. 2. It consists of 01 no. 100 amp TPN MCCB as incomer,01 no. 100/63 amp (as per requirement) SPN MCCB as outgoing, 04 nos. integrated LED pilot lamp (3 incoming+1 outgoing),01 no. 63-amp selector switch (phase selector switch) without OFF Three pole three ways (Three phase incoming & only one phase outgoing.	Relevant IS code	
17	Design, supply, testing Erection and commission of Indoor type LT panel with one incoming MCCB of suitable rating and Min 6 Nos of Output MCCB of suitable rating.	1. SITC of 1.5 mm CRCA sheet steel fabricated, cubicle, having outdoor type LT panel distribution board, having suitable IP protection, floor mounted front operated, mounted on MS 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 min 2.5 sq mm copper wires. The panel should consist of(A) incoming 2x250 amp 4 pole MCCB's with changeover provision (if required) with microprocessor release having integral	IS: 2147-1952 IS:2675-1966	Rittal / ABB / Schneider or similar as approved by Engineer.

S.No	Description of work	Work to be Done	Relevant IS Code/Standards	Reference Make
		overload, short circuit, earth fault and neutral protection and breaking capacity 60 KA (Ics=100%Icu). (B)outgoing 2x125 amps, 2x100 amps and 2x63 amp 4 poles MCCB's with adjustable overload and adjustable short trip unit and breaking capacity 36KA (Ics=100%Icu). the panel is to be provided with over voltage protection with suitable relay. The bus bar shall be insulated by heat shrinkable sleeves. The instrument shall be of flush type ammeter, voltmeter, and selector switches with CTs, feeder name & danger board.		
18	Supply, fixing commissioning, installation and testing of 2 kVA pure sine wave 24-volt online inverter consist of intelligent battery charging mechanisms with adaptive battery charging and 150 AH tubular battery of voltage 12 volt suitable for heavy duty application. Warranty of invertors is 24 months and for Battery -36 months	1.SITC of 2 kVA, 24-volt pure sine wave Online UPS cum inverter. 2. SITC of 150 AH 12 volt heavy duty tubular Battery with 3 year warranty.	IS:13314/1992 for Inverter	Luminous, Microtek, Exide, Amaron or similar as approved by Engineer.
19	Supply, fixing, commissioning and installation of Perforated Cable Tray of size 150x50 mm made out of MS sheet and hot dip galvanized (85 microns) 1.6 mm thick with suitable fixing Arrangements.	SITC of 150x50 mm and 1.6 mm tick galvanised cable tray for laying of cable with all accessories.	Relevant IS code	Adarsh / Indiana / Mahesh Wari or similar as approved by Engineer.
20	Extension of load /Load Augmentation complete in all respect and as per specification.	Contractor is responsible for taking electrical connection(HT/LT) from DISCOM authorities for each station building as decided by Engineer. It also	-	-

S.No	Description of work	Work to be Done	Relevant IS Code/Standards	Reference Make
		includes all the interface/ liaising and electrical work as per requirement.		

6.2 DETAILED SPECIFICATION FOR PASSANGER LIFTS (FOR 13 PERSONS)

1	Type of Lift	Passenger lift
2	Number of lift required	As per requirement
3	Load: no. of person	13 Person
4	Related speed	1.0 metre per second
6	Number of floor served	2
7	a) Inside size of lift well	Approx. size 2500 mm x 1900 mm deep or as Per site feasibility
	b) Pit depth	1600 mm or as per site feasibility
	c) Head room	4800 mm or as per site feasibility
8	Clear inside size of lift car	Approximate size : 2000x1100x2200(H) mm or as per site feasibility
9	Dimension of machine room	Not Applicable(No machine room is being provided)
10	Position of counter weight	At the back / side of the car
11	Position of machine room	Not applicable
12	a) Type of control	Microprocessor based AC variable voltage variable frequency
	b) Type of operation	Simplex selective – collective without attendant
	c) Potential free contacts	Yes potential free contacts for each floor position and up and down movement of the lift shall be provided in the controller which can be used for the building automation system at later
13	Car entrance door	
	a) Number	1 No. center/side opening stainless steel
	b) Size	Approx. size900x2000 mm high or as per site feasibility
	c) Type of doors	Horizontal sliding-center / side opening
	d) Car open in front only or open through	Open in front at ground floor and opposite / reverse opening at first floor
14	Construction design and finish of car body work	Stainless steel Hairline finish with stainless steel drop ceiling and led lights fittings for lightning inside the car and axial flow fan, 5 mm thick antiskid PVC flooring. All other item as per CPWD general specification for lifts 2003 with up to date amendments.
15	Type of signal system	(a) Digital floor position indicator in the car and all landings (to be provided above the car/ landing doors).
		(b) Travel direction indicator in the car and at all landings. (to be provided above the car/ landing doors).
		(c) Gongs & visual indication through directional arrows on all landings pre arrival of the car at all floors.
		(d) Over load warning audio & visual indica-tor , inside the car (lift should not start on overload)
		(e) Battery operated alarm bell and emergency light.
		(f) Car operating panel with fade proof luminous buttons in in the car and with intercom. Braille switches to be provided in the lift.

		(g) Luminous hall buttons at all landings with Braille switches.
		(h) Fireman's switch at ground floor.
		(i) Voice annunciation system. This will announce the position of the car landing in Hindi & English facilities for any other announcement to be made from the central control room / reception of the building.
		(j) Protection against over – voltage, under voltage and single phasing should be provided.
16	Landing entrance	
	a) Location of landing entrance in different floors	Front at ground floor and opposite / reverse at first floor
	b) Number	2 pairs
	c) Size	Approx. size 900 mm wide x 2000 mm high or as per site feasibility
	d) Type of doors	Horizontal sliding – canter / side opening
	e) Lift in use / lift out of order sign	Suitable box above the landings with LED illuminated bilingual (in English & Hindi) sign of "LIFT OUT OF ORDER" coming up simultaneously on all floors.
17	Electric supply	a) Power 415 V, AC, 50 Hz, 3 Phase, 4 Wire system.
		b) Lighting : 230 V, AC, 50 Hz, 1 Phase
18	Is neutral wire available for control circuits	Yes
19	Proposed date for commencement of site	-
20	Proposed date for completion	-
21	Environmental condition at site of installation	Summer condition Winter condition Monsoon condition Height above sea level
22	Storage space provided	_
23	Additional item, if any	
	a) Firemen's switch	Required for all lifts
	b) Emergency power supply	Available
	c) The firm's offer should include beam and all structural steel required for work	
	d) Automatic Rescue Device (ARD)	Provisions of automatic rescue device for the purpose of bringing the lift car to the nearest floor should be provided, one each for individual lift. ARD's are to be provided. The each shall consist of 1. Control panel with necessary interface /integration of device with main controller 2.Invertor of required capacity 3. Maintenance free batteries of Ampere –hours 4. Battery charging unit 5. "Rescue Operation On "indicator in the lift car.

S.NO.	**Particulars of detail**	
A	General	
1	Name of manufacture	As per CPWD approved 'A' category manufacture
2	Capacities (Persons/Weight)	13 Person/884 kg
3	Service	Passenger
4	Speed of travel	1.0 MPS
6	No. of floor served	02
7	No. of openings	02
8	Position of counterweight	At the back / side of the car or as per site feasibility
9	Type of levelling method	Automatic +/- 5 mm
B	**Machine**	
1	Position of machine	Top of lift shaft in hoist way / Machine room less
2	Motor	Permanent magnet synchronous Motor, Gear less machine
3	Electric supply particulars for which it is suitable for operation	3 PH 415 V 50 HZ 4 wire system
C	**Brake**	
1	Type	Electromagnetic brake
D	**Car & Doors**	**Horizontal sliding, centre / side opening**
1	Outside dimension of car	AS PER SITE CRITERIA
2	Inside clear dimension	Approximate size : 2000x1100x2200 (H) mm or as per site feasibility
3	Construction of car	Stainless steel Hairline finish with stainless steel drop ceiling and LED lights fittings for lighting inside the car and axial flow fan. 5 mm thick antiskid PVC flooring. All other item as per CPWD general specification for lifts 2003 with up to date amendments.
4	Design/ type of enclosure of car	Rectangular / as per site condition, stainless steel scratch proof (HAIR LINE FINISH)

5	Details of flooring	6 mm thick aluminium/5 mm SS Chequered plate
6	Attachment and fitting inside the car	Axial flow fan & LED light fittings with anti – theft arrangement (As per requirement)
7	Car doors	HORIZONTAL SLIDING, CENTRE/SIDE - OPENING
	a) Size	Approx. size 900mm x 2000 mm or as per site feasibility
	b) Operation	Power operated automatic door
	c) Construction, design & finish	Stainless steel scratch proof (HAIR LINE FINISH)
8	**Landing Doors**	
	a) size	Approx. size 900 mm x 2000 mm high or as per site feasibility
	b) operation	Power operated automatic door
	c) Construction, design & finish	Stainless steel scratch proof (HAIR LINE FINISH)
E	**SAFETY DEVICE**	
1	Car safety type	Progressive / instantaneous type
2	Counter weight safety- type	-
3	Door inter locks in car- type	Electrical type
4	Door locks in landing- type	Electromechanical type
F	**For physically challenged**	Note below
	Voice Response System.	Required in Hindi, English / local language if needed
	Luminous Push Button with Brail script.	Required
	Hand Rails	Stainless steel hair line finish, SS - 304

Note: -

a) All materials used in the work shall be procured from RDSO approved sources or ISI marked only and of the best quality and of the class suited for the purpose specified.
b) Design codal life of all type of material/equipments should be as per RDSO codal

life standard.

c) The contractor shall be solely responsible for the correctness of the position, levels and dimensions of the works according to approved drawings, notwithstanding that he may have been assisted by the Engineer or his men in setting out the same.
d) Notwithstanding anything given anywhere else all work execution shall be as per latest design and drawing of RDSO and latest guideline issue by Railway Board.
e) The contractor should follow all the clearances as per latest CEA regulation.
f) Meet the all protective provisions relating to electrical safety.

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