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UTTARAKHAND PROJECT DEVELOPMENT AND CONSTRUCTION CORPORATION

SONG DAM DRINKING WATER PROJECT
UTTARAKHAND (INDIA)

UPDCC

BIDDING DOCUMENTS
(NATIONAL COMPETITIVE BIDDING)

Tender Notice No : 01/GM/PIUS/Dam/2023-24

FOR

CIVIL WORKS INCLUDING HYDRO-MECHANICAL WORKS FOR CONSTRUCTION OF 130.6 M HIGH CONCRETE GRAVITY DAM AND APPURTENANT WORKS ACROSS RIVER SONG

OF

SONG DAM DRINKING WATER PROJECT IN DISTRICT DEHRADUN (UTTARAKHAND)

VOLUME - IV

(SECTION IX)

PART B: TECHNICAL SPECIFICATIONS

Invited By: General Manager
Project Implementation Unit,
Song Dam,
Ground Floor, Lakhwad Field Hostel, Yamuna Colony
Dist. Dehradun- 248001

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1. GENERAL TECHNICAL SPECIFICATIONS – CIVIL WORKS

1.1. Detailed Design and Planning of the Works

The Contractor shall perform engineering services pertinent to planning and detailed design of the Works in accordance with accepted standards as stipulated herein. In addition, Employer will introduce a design monitoring and design review procedure. The Project Management Consultant (PMC), appointed by Employer, will, in stages monitor, review and comment design and design changes and will enforce such changes subject to approval by statutory authority viz. CWC/CEA/CSMRS etc. The procedure includes, but not limited to design meetings, milestones for design and request for information (RFI).

All Designs shall be performed in accordance with the requirements given in the Employer's Requirements. The Design responsibilities of the Contractor shall be as follows:

a) The Contractor shall carry out the Detailed Design and prepare construction drawings of the Works to be performed under this Contract and the site investigations laboratory testing deemed necessary for detailed design;

b) The Contractor shall prepare Construction Method Statements and Execution and Implementation Plan and construction materials planning.

c) As time is the essence of the contract the contractor shall submit his written commitment with the bid to deploy adequate number of construction plants and machineries. The adequate number shall be arrived based on the construction schedule, target date of completion, cycle time and out-turn of each machine.

The activities to be performed under the detailed design are outlined below:

- Additional investigations and laboratory testing;
- Additional topographic survey and pre-construction / construction survey;
- Expansion and clarification of design criteria and parameters;
- Review of the work done and prepare a summary of all tests and investigations planned to be carried out in connection with the Detailed Design;
- Detailed Design calculations;
- Works Construction Drawings;
- Report on construction methods to be used for all major works;
- Procurement and delivery Schedule for major equipment;
- Principal aspects of Processing, Production & Construction plant to be used;
- Quality Control and Quality Assurance plans and procedures for Construction;
- Plans for borrow areas and for disposal areas of spoil material;
- Health, Safety and Security plans;
- Operation and Maintenance Manuals

- Training Manuals for each component of the scope of works, the Contractor shall prepare Detailed Design documentation to include as a minimum for the review by the EMPLOYER:
- Description of each structure;
- Review of assumptions and design procedures adopted, design criteria, loads, load cases used and the safety factors;
- Short description of each method of analysis, computer programs, software, etc. used;
- Calculations and principal results of the detailed design analyses;
- Detailed design drawings and specifications for construction;
- All other information necessary for construction and completion of the Works;
- Any geological surprises, issues concerning with geology during costruction phase shall be got vetted/approved by appropriate authority of GSI as and when required.

Note: The Contractor shall initiate the construction works only after receiving written confirmation of “Approved" to the submitted design from the Employer subject to approval from statutory authorities.

1.1.1. Detailed Design

The design of all the structures shall be carried out based on recognized standards and or guidelines widely accepted and adopted by the engineering professional bodies including studies and research to be carried out by the Contractor such as seismic, geotechnical, among others. The design standards adopted should as for as possible be from a single authority and be available in the language of the contract.

Prior to commencing design, the Contractor shall submit to the Employer for approval all the proposed design standards and / or guidelines.

The design of civil work shall at least meet the following requirements.

- The structures shall remain stable during and after construction with appropriate factors of safety under all probable loads and combinations as specified in applicable Indian Standards and Codes of Practice or to standards as specifically shown elsewhere in these Employer’s Requirements.
- Stresses shall not exceed recognized limits
- Foundation materials shall not be over stressed.
- Settlements induced by imposed loads shall not reduce structural stability.
- Seepage quantities and pressure shall be limited to prevent internal erosion, piping and / or uplift that could cause instability.
- Load conditions shall be categorized as follows:
- Normal loading which applies to normal long-term operation, or repetitive short-term operations,
- Exceptional loading which applies to maximum, minimum, one off short term and operating basis earthquake loads shall be applied pseudo statically in addition to normal loading.
- Extreme loading which applies to exceptional loading conditions acting in conjunction with maximum design earthquake loads.

Prior to beginning any construction work, the Contractor shall submit for consent a Basic Design Basis Report (DBR). The DBR shall define all finished structural dimensions and / or performance characteristics of all elements of the scope of works except those dependent on subsurface geotechnical conditions. For those dimensions and / or performance characteristic dependent on geotechnical conditions, best estimates shall be made based on the Contractor's own investigations and experience. The results and interpretations of the geotechnical investigations shall be presented in the DBR.

The DBR shall include but not limited to the following results and interpretation of the Geotechnical investigation including a report on construction material availability.

- The result and interpretation of the seismic studies.
- The result and interpretation of the topographical surveys, pre-construction survey.
- The geotechnical, and structural designs (including design standards and calculations)
- Drawing to details sufficient to show all significant structural features
- Detailed design and planning report on all the structures.

1.1.2. Construction and Construction Management

The Contractor shall manage and carry out the construction of the Works and ensure the expeditious construction thereof in accordance with the terms and provisions of the Contract. The Contractor shall inspect, or cause to be inspected, all materials and equipment to be incorporated in the Works and shall reject those items determined not to be in compliance with the Contract.

The Contractor shall establish and maintain works management control systems and provide construction management services in accordance with the requirements of the Contract and otherwise as necessary for the achievement of the Contractor's obligations under the Contract.

The Contractor shall co-ordinate and integrate construction of the Works, including those performed by any of the Contractor's Sub-Contractors. The Contractor shall be fully responsible for the construction services provided by him and the construction work carried out by his Sub-Contractors.

1.1.3. Procurement

The Contractor shall procure and pay for, in the Contractor's name as an independent Contractor and not as agent for Employer, all the Contractor's and subcontract labor, materials, equipment, supplies, manufacturing and related services (whether on or off the Site) for construction and incorporation into the Works which are required for completion of the Works in accordance with the Contract. The Contractor warrants that all such items shall be new and of the good quality, reliability and performance described in the Contract. Where no express requirements are set out in the Contract, the aforementioned purchases shall be of good quality, reliability and performance consistent with best engineering practices.

1.1.4. Standard of Design and Works

The design and construction of the Works shall be in accordance with the provisions of the appropriate Indian Standards and Codes of Practice, as well as all applicable laws and regulations of the Government of India and local codes and ordinances should such provisions exceed the requirements of Indian Standards.

A consistent and coherent set of standards shall be used. Plant and materials specified to conform to a given standard shall be clearly and indelibly marked with the reference specified wherever possible.

Plant, materials and Equipment shall be of new manufacture, unless otherwise stated. All Materials and items of Plant shall be of good quality and shall be suitable for operating under the local climatic and environmental conditions with due regard to the specified service life. The specified service life is 50 years for civil works.

1.1.5. Testing

All material, equipment, if any, related to or intended for incorporation in the works, shall, be subject to such tests and inspections as may be necessary, to prove compliance with the requirements of the Contract documents.

1.1.6. Program for Supply of Drawings

Fifteen (15) days after the Commencement Date, the Contractor shall submit to the Employer's Representative a Design Program showing the order and procedure in which he proposes to carry out the Design and Engineering services. The Design Program will include among others a schedule of submission of design reports, documents, and drawings necessary for completing the Works within the specified Time of Completion. This schedule shall match with the Work Program issued for the entire Works. Such Design Program shall be subjected to review and revision by the Contractor in consultation with the PMC in order to achieve completion of work with the Time of Completion.

1.1.7. Contractor Drawings and Documents

As part of the Design Documentation, the Contractor shall provide a complete and clear set of calculations, specifications and drawings of all construction works, service utilities.

The Contractor shall successively submit design, documents and drawings for review, comment and approval of the Employer's Representative in accordance with the schedule of submission of design documents and drawings in the Contractor's Work Program.

In order to adhere to the stringent time schedule, the PMC shall submit to the Employer his review comments/recommendations on all design and drawings within 15 days from receipt date for all the documents submitted by the Contractor to the Employer. The only submittals to be submitted by the Contractor at Site are those relating to minor design changes occasioned by discussions and observations during Site progress meetings.

1.1.8. Civil Works

The following documents / drawings will be submitted by the Contractor for consent of the PMC;

(a) Detailed technical specifications

(b) General arrangement and layout drawings

(c) Good for Construction Drawings

(d) General reinforcement arrangement, if any, for the structures.

1.1.9. Temporary Site Installations/Facilities for Contractor's Staff

The Contractor shall design, install and maintain throughout the execution of the Works all temporary facilities, such as, but not limited to, Survey control points, workshops, accomodations, offices, site laboratory (to carry out all necessary tests) and stores, required for the Work.

On completion of the Project, the Contractor shall remove all such temporary facilities, including their foundations that are not to be handed over to the Employer, and restore the area to a level acceptable to the Employer.

1.1.10. Temporary Facilities

At the Completion date all temporary facilities shall be removed from the site by the Contractor.

1.1.11. Provision of Power and Water Supply

1.1.11.1. CONSTRUCTION POWER REQUIREMENT

Construction power will be made available at five points by Employer as mentioned in the following Table 1.1-1.

Table 1.1-1 : Location wise Breakup of Construction Power load

Sl. No.	Location	Power Requirement in kW	Power Requirement in kVA
1	Dam Complex (Diversion, Dam and Intake)	350.00	437.50
2	Water Conductor Pipe (5 locations)	1150.00	1437.50
3	Central Work shop & laboratory	110.00	137.50
4	Crusher Plant	580.00	725.00
5	Colony, laboratory and Office	55.00	68.75
	Total	**2255.00**	**2806.25**

1.1.11.2. CONSTRUCTION POWER ARRANGEMENT

The following arrangements have been considered to meet the construction power requirement for the project. Nearest grid sub-station of 33 kV is to be assessed for construction power of the project.

Power from 33 kV voltage level may be drawn to project site for requirement of power during construction. 33 kV overhead lines to dam site shall be drawn and distribution line 11kV shall be laid to various load centres. 33 kV voltage level shall be suitably stepped down to 11kV/415V by means of a step-down transformer. Necessary sub-stations shall be installed at following strategic locations:

- Dam site
- Along Water conductor pipe (5 locations)
- Project Colony and various facilities.

The above grid supply work will be done by relevant authorities as a deposit work. The main scope of construction power works is detailed in Table 1.1-2.

Table 1.1-2 : Main scope of works for construction power

Sl. No.	Description
1	Construction of 33/11kV substation near Dam complex with 2 Nos. Transformers each of capacity 2 × 2.5 MVA) with provision for incoming 33kV lines from nearby sub-station)
2	Construction of 11kV/0.415kV substation at Dam site with 2 transformers each of capacity 1.7 MV
3	Construction of 11 kV / 0.415 kV substations at Colony with 2 nos. Transformers each of 750 kVA capacity.
4	HT/LT switchgears.
5	Associated civil work.

1.1.11.3. CONSTRUCTION POWER WITH DG SETS

For supply of reliable construction power as described above, it is proposed to install two transformers (11/0.415 kV) each of 1.7 MVA capacity at dam site for catering to requirement of dam site, crusher plant, two transformers each of 1.0 MVA at suitable place along water conductor system for catering to requirements of construction power supply for water conductor system, central workshop and laboratory. In order to ensure reliable power supply at the 3rd location to project colony & other facilities it is proposed to install two transformers (11/0.415kV) each of 750 kVA capacity in the Sub Station. Breakers/ Switchgears, LT panels and cabling will be provided for further distribution of power supply to the construction equipments. Same arrangement will be kept for back-up supply project operation after commissioning of the project

Contractor shall keep the provision of Diesel Generator sets of adequate capacities as back up supply as given below in Table 1.1-3. The minimum requirement of DG Sets location wise is envisaged for construction of the project is provided in Table 1.1-4.

Table 1.1-3 : DG Sets Requirement for Construction of Project

Sl. No.	Total DG Sets requirement	Number of DG Sets
1	DG 500 KVA	1
2	DG 320 KVA	7
3	DG 125 KVA	3
4	DG 25 KVA	1
	Total Number of DG sets	**12**

Table 1.1-4 DG sets requirement for different component of the project

Sl. No.	Location	DG Set capacity (KVA)	No. of DG Set	Power requirement as per DG Set (KVA)
1	Dam Complex (Diversion, Dam and Intake)	320 & 125	1 – For 320 1 – For 125	445
2	Water Conductor Pipe	320	5 no.	1600
3	Central Workshop & laboratory	125 & 25	1 – For 125 1 – For 25	150
4	Crusher Plant	500 & 320	1 – For 500 1 – For 320	820
5	Colony and Office	125	1 no.	125
	Total Power availability			**3140**

Sl. No.	Location	DG Set capacity (KVA)	No. of DG Set	Power requirement as per DG Set (KVA)
	(as per DG set)			

State Electricity Board will made power available upto transformers at above mentioned locations and beyond this point contractor has to make necessary arrangements of distribution for his own use, at his own cost. Contractor will be charged by concerned Deptt.

For details, bidders are required to confirm the charges/tariff from State Electricity Board.

The Contractor shall be responsible for the supply of potable water as well as treatment of waste water and acceptable disposal of refuse.

1.2. Quality Assurance / Quality Control

The Contractor shall submit a Quality Assurance Plan in accordance with the relevant International Standards ISO 9001: 2000. This plan shall include among others, a detailed description of the organization, procedures and facilities proposed to ensure that the construction is carried out in accordance with the Contract Specifications and Drawings.

The Contractor shall submit his Quality Assurance Plan to the Employer for review and approval prior to the commencement of work. The Contractor's Quality Assurance Plan shall be periodically reviewed as the work proceeds.

The Quality Assurance Plan shall include, but not be limited to, detailed procedures, instructions or statements covering the following items.

1.2.1. Documentation

The Quality Assurance Plan shall include a system to ensure that the documentation necessary to attest the completion of any phase of the work, use of correct materials, completion of required inspections and tests, and acceptability of results is generated, reviewed, maintained and submitted to the Employer at the required time. The system shall ensure that such documentation is reviewed by the Contractor for legibility, completeness, validity of data, traceability of document to activity or equipment and acceptability of results. Non-conformance reporting (NCR,s) shall be part of the Quality assurance plan.

1.3. Environmental Compliance

1.3.1. General

Reference is made to the environmental requirements given in:

a. The Law and Regulation of Government of Uttarakhand/India and relevant Standards.

b. Employer's Requirements for Environmental Compliance.

c. As per General Condition of Contract and any other clause or sub-clause having any relevance to Environment.

d. Local traditions and customs of Project area.

1.3.2. Environmental Compliance & Miscellaneous

The Contractor shall within one month of receipt of Commencement Date, appoint an Environmental Officer for the Works, whose broad responsibilities are to guide the construction personnel on environmental matters, to communicate and to make liaison with the Employer, the PMC, Government of Uttarakhand and local authorities. The Environmental Officer will submit a Monthly Environment Report every month incorporating monitoring, evaluation and institutional measures to be taken during implementation and operation in the project site and immediate vicinities to reduce the pollution to acceptable levels. The report will be written in English language in a format acceptable to the PMC and Owner.

1.3.3. Photographic Records

The Contractor shall maintain a monthly photographic record (date wise) of all key project activities to demonstrate progress of construction on the Site. The Contractor shall also keep a daily site diary in which all activities and events affecting the site and construction works are logged.

1.4. Contractor's Documents

1.4.1. Submission

The Contractor shall submit all documents, drawings, suggestions, information directly to the PMC for necessary vetting and comments and onwards transmission to the Employer for final acceptance / approval.

1.4.2. Procedure

The sequence in which documents are submitted shall follow a logical progression such that all information is available to the Employer to facilitate review of each submittal when it is received. The program for detailed design shall allow the required time for review by the Employer.

All submittals shall include one copy in Digital form as well as the prescribed number in hard copies. In general, digital submittals shall be in:

- MS Word format for all text and reports
- MS Excel format for all calculations
- AutoCAD release 2014 or later for all drawings (Main plant layout only, others as PDF.)
- Relevant design and analysis software formats/files.
- MS Project for planning and progress schedules

The Contractor shall provide on each submittal a clear space for the Employers review stamps and comments.

Drawings and all supporting data, catalogues, or similar information prepared either by the Contractor or his suppliers and sub-Contractors, shall be submitted as instruments of the Contractor.

The PMC shall review all drawings, design, data or any other informations submitted by the contrctor and forward the same to the Employer with their comments and suggestions However, Employer at his discretion may forward any of the such submittals to the statutory authority viz. CWC/CEA for vetting before release the same for costruction.

The Employer will review the submittal and release them with any of the following comments:

- (1) “Approved”
- (2) “Approved with comments”.
- (3) “Revise and resubmit”.
- (4) “Rejected”.

When submittals are returned marked with either “Revise and re -submit” or “Rejected” by the Employer, the Contractor shall make such revisions and/or corrections and resubmit the drawings or other material in the same manner as specified. The second period for review or approval by the Employer shall not be more than 10 days, if such approval may be granted without recourse to Statutory Authority.

When drawings and submittals are returned with authorization to proceed with the work, Contractor shall provide the number of prints or copies of drawings as is required for field distribution.

1.4.3. As-Built Drawings

The Contractor shall provide five (5) copies of detailed "as-built" drawings for the entire scope of works as per the instructions of PMC. These are to be based on the Contractor’s “approved” drawings and field information.

All drawings shall be provided in hard copy and "AutoCAD" files, on computer hard disk or compact disk.

1.4.4. Completion Reports

At the end of the Defect Liability Period and prior to the Performance Certificate being issued by the Employer, the Contractor shall submit the Completion Report of the Project.

1.5. Standards

1.5.1. General

All equipment and materials shall conform to Indian Standards, unless agreed otherwise by the Employer or specified elsewhere in the Employer’s Requirements. The Contractor shall supply copies of specified standards at the Employer's request, clearly identifying or marking the particular chapters or sections that are being applied.

1.5.2. Materials

All materials procured by the Contractor to incorporate in the works shall conform to the Indian Standards.

The material grades proposed by the Contractor, shall, unless otherwise specified, are subject to the PMC’s as well as Employer’s approval in writing.

1.6. Use of Site

1.6.1. Site

The Site and its boundaries are shown in the Drawing Volume of this Contract. The Site includes areas for the Permanent site installations, Residential buildings, Offices etc. and temporary installations area of the Contractor.

The Contractor shall make his own arrangements for any areas outside the land provided by the Employer (the "Site") that he requires, at his own cost.

1.6.2. Setting out site installation

Setting out site installation shall be carried out in accordance with the approved drawings. Should in any instance discrepancies occur between the drawings and the actual conditions at site (topography, geology etc.) the Contractor shall immediately notify the Employer.

1.6.3. Regular maintenance and cleaning of site installation

During the entire construction period and until the end of the Contract duration, Contractor has cleared site after the completion date, the Contractor shall provide a daily refuse collection and disposal service including loading, transportation dumping at areas where prior permission from the concerned authority has been obtained in order to keep the site in a proper clean and safe condition.

1.6.4. Car park areas

Site installation shall include the construction, maintenance and removal of the temporary car park areas, if any, as indicated on the layout plan for site installation to be submitted by the Contractor.

1.6.5. Storage areas

The Contractor's site installation shall include the construction, maintenance and removal of temporary storage areas at the site and at off-site locations chosen by the Contractor. They shall be indicated in the general layout drawings, inclusive of any additional temporary storage areas required in connection with the construction works. Temporary storage Areas shall include drainage facilities, sumps, oil traps, separators and isolation in case of storing chemicals and oil. Any land not located within the site which the Contractor considers necessary for his site installation, shall be acquired by the Contractor at his own expense.

Storage areas and all other areas which are to be used for any project's construction activity shall, as a minimum, be furnished with a drainage layer of sand and gravel as per Indian Standards.

1.7. Program & Program Reports

1.7.1. Program

The Contractor shall submit the proposed program for the design and execution of the Works. The proposed program shall be in two levels as per following details:

(a) The Overall Program which shows the Milestones completion dates of the Works.

(b) The Detailed Working Program which shows further breakdown of the major work items into activities involved in the sub-items.

The Contractor shall identify critical activities and key dates and shall present the program in bar chart form indicating activities and dates critical to completion of the Work on time.

The Contractor shall submit an explanatory report covering any aspect of the chart or network that the Contractor cannot show on the bar chart. The Contractor shall agree with the PMC and the Employer on the work section, activities, sub-activities, interface and other critical dates, which the Contractor has to identify in the programme. Upon agreement by the PMC and the Employer, the proposed Overall Program shall become the Project Baseline Program based on which the Contractor shall complete the Works and progress be monitored. This Overall Works Program shall not be changed unless agreed with the Employer.

The Detailed Working Program shall also define main dates for submittal of Contractor's Documents and approval by Employer.

1.7.2. Progress Reports

Each month the Contractor shall submit a report on an agreed day, in a format and media approved by the PMC and the Employer, the progress and financial status of the Works of the previous month. The report shall accurately estimate the work completed on each activity including the design activities shown on the accepted Baseline Program and the Working Program. The Contractor's progress report shall include Manpower, Machinery, Materials, QA/QC. HSE, Environmental issues and NCR's, if any for the reporting period along with relevant progress photographs. The Contractor shall agree with the PMC and the Employer before implementing progress control procedures.

The Contractor's execution of the construction work shall not deviate from the sequenceshown in the approved Baseline Program without prior written permission from the Employer.

1.7.3. Monthly Progress Meetings

Monthly progress meetings will be held with the Employer and the PMC. Bottlenecks will be discussed and resolved. Special meetings will be held as and when required. The program and the corresponding progress shall be presented in the meeting.

1.7.4. Photographic Records

The Contractor shall take progress photographs in digital camera during progress of work, which shall be attached to the monthly progress report.

1.8. Submittals

1.8.1. Description

The Employer shall undertake a comprehensive review of the design submitted by the Contractor for the Works pertaining to the information described. To facilitate this review, submittal requirements noted in this section shall be met by the Contractor.

1.8.2. General Aspects of Submittal and Review

1. Review of designs for the Project by PMC shall be carried out in two stages whereby the proposed conceptual design is reviewed first, after which the detailed designs, drawings, technical specifications, etc. shall be submitted for review.
2. All criteria, design statements, design calculations, computer input and output, specifications, method statements, drawings, catalogue cuts, and any other information submitted, shall be individually numbered on each sheet, indexed, collated, bound, and with summary sheets for discrete portions of the records so that adequate monitoring of revisions, modifications, and the general flow of the design process can be easily understood. Text shall include both line numbering and pagination, and computer programs used shall be explained in a summary statement of the input, output and analytical process. The Contractor shall make available, at the Employer's request, any and all information upon which the Project design is based - suitably collated and indexed - including, but not limited to the results of survey, geotechnical and materials investigations and manufacturers' data.
3. In order to facilitate the design review process, the Contractor shall make arrangement for full-time representatives of the Employer in any or all of the Contractor's design offices, and such representative shall be given full and complete access to the development of design concepts, and detailed design process.
4. Five (5) copies of all final detailed construction drawings shall be issued to the Employer not later than 14 days before commencement of construction of any structure. The Employer will not carry out a formal review of final construction drawings, details and schedules but reserves the right to require revisions where design aspects do not comply with those reviewed.
5. When drawing up the program, the Contractor shall make adequate allowance for reviews and approval by the Employer and relevant authorities.

1.8.3. Level 1 Review

The Contractor shall, within approximately 28 days of the Commencement Date submit Design Basis Report (DBR) as per point. Within 21 days of the Contractor’s submittal, a design review meeting shall be held between the Contractor, the PMC and the Employer in order to review and discuss the DBR.

Reviews may be carried out section by section following discussions on particular aspects of the design proposals.

1.8.4. Level 2 Review

Following agreement in principle to the Level 1 design concepts, the Contractor shall submit detailed general arrangement drawings, specifications and calculations of all principle component parts of the Project for review by PMC. The Contractor shall also submit a schedule of all inspections and tests to be carried out on major materials and a list of drawings and documents together with a schedule for submission of same. The Drawings and Document list and schedule shall be updated and resubmitted at intervals throughout the Level 2 review period. Drawings and documents shall be submitted in a logical sequence and in a structured manner and the Employer will review and comment.

1.9. Quality Assurance / Quality Control

1.9.1. Description

The Contractor shall be completely responsible for implementing a Quality Assurance Plan covering all the Works contained in the Contract including the design. The Quality Assurance Plan will be prepared by the Contractor and be reviewed and authorized by the PMC and the Employer and will be implemented by the Contractor. The Contractor's Quality Assurance Plan shall ensure the control and quality of all design functions, all fabrication by the vendors and sub-Contractors and all construction activities carried out by work forces and sub- Contractors. Non-conformance reports (NCR) shall be part of the quality assurance plan.

1.9.2. The Contractor's Quality Assurance Plan

The Contractor's Quality Assurance Plan shall meet all the requirements of the International Standards Organizations. As appropriate the Contractor shall impose on his designers, vendors, and sub-Contractors the requirements of IS0 9001:2000, 14001:2004 and 18000:2000.

1.10. Environmental Protection

1.10.1. Health, Safety and Security

a) The Employer has a goal to create a zero-incident work environment with a safety culture based on team work and leadership. Nothing is more important than the safety, health and well-being of all persons involved in our projects. The Employer emphasize that all injuries and occupational illness are preventable and that it is the Contractor’s obligation to make sure that all procedures are in place a crate a zero-incident work environment.

b) The Contractor will be responsible for the security, safety & health and Group insurance of his Employees.

c) Provide and maintain at his own cost, fencing, warning signs and watch & ward, when and where necessary or required by the Employer or by any duly constituted authority, for the protection of works or for the safety and convenience of the public or others, and

d) Take all reasonable steps to protect the environment on and off the site and to avoid damage or nuisance to persons or to property of the public or others resulting from the pollution, noise or other causes arising as a consequence of his method of operation.

e) The contractor will protect the environment following the principles of Approved Environment Management Plan.The contractor will submit with his tender a written statement assuring compliances with all environments safeguard.

f) The Officer-in-Charge of Safety will submit monthy safety report.

1.10.2. Borrow and Disposal of Materials

(a) Surplus Suitable Materials

The Contractor shall disposed-off all surplus suitable materials to areas designated by the Employer.

(b) Borrow Pits and Stockpiles

The Contractor shall submit proposals for the Employer's approval giving the location of borrow pits and stockpiles and proposals for their management to ensure acceptability of the materials.

The Contractor shall be responsible for locating borrows pits and stockpiles, in addition to, designated borrow pits and stockpiles. Whether the Contractor obtains materials from the designated or his own borrow pit, it shall be the responsibility of the Contractor to ascertain the suitability of the pit with respect to the quantity and quality of the materials, which shall be acceptable to the PMC. The Contractor shall pay all necessary leases, fees, taxes, levies or royalties to the appropriate authorities and follow all relevant regulations. The Contractor shall keep the borrow pits free from ponding water and shall carry out necessary erosion protection and other mitigation measures as acceptable to the PMC.

Where suitable material is stockpiled for later use, the Contractor shall ensure that the formation is cleared of all vegetation unless otherwise approved by the Employer. Stockpiled material shall be finished with a sloping surface to ensure run-off to keep the stockpile free of ponding water. Where required the Contractor shall provide a drainage ditch around the stockpile to prevent the ingress of water or other measures acceptable to the PMC. The Contractor shall also be responsible for disposal of surplus materials to designated places as approved by Employer.

1.10.3. Notice to Service Authorities

The Contractor shall make at his own expense all necessary arrangements for notifying the service authorities of required connections, removals and relocations of all public utilities and services, if any, affected by the Works.

Sufficient time shall be allowed for such notification as may be required by the relevant authorities so that appropriate action can be taken regarding the execution of the removals and relocation.

1.10.4. Project Signs

The Contractor shall design, supply, erect and maintain one signboard, approximately 2 m wide by 1.5 m high, at each entrance of the Site or at a location to be agreed by the Employer. The Employer's Representative shall review and agree the Contractor's design. The Contractor shall employ an experienced sign-writer to prepare the signboard.

The Contractor shall not display any advertisements within or around the Site without the prior written approval of the Employer's Representative.

2. GENERAL & STANDARDS

2.1. General

This Chapter of the Employer's Requirements covers the Standard Technical Requirements for all of the civil and hydro-mechanical works for the Facility. For the purpose of this Contract, "Drawings" means the drawings included in the Employer's Requirements prior to the Contract Date and drawings in the Contractor's Specification and/or Approved Contractor's Documents (as appropriate) on and after the Contract Date. Where "Drawings" has been referred to in the Employer's Requirements, but no drawings or details exist prior to the Contract Date, then the details specified in the Employer's Requirements shall be shown on drawings included in the Approved Contractor's Documents. Such definition does not void the use of any other drawings included in the Employer's Requirements for the purpose of evaluation of the Contractor's compliance with its obligations under the Contract.

2.2. Standards

The specifications, production, sampling testing and storage of construction materials shall conform to the following latest Indian Standards or, where not covered by these Standards, to the equivalent International Standards.

The Design, fabrication and the construction of the structures shall be based on the following latest Indian Standards or, where not covered by these Standards, to the equivalent International Standards.

General	SP 7 : 2005 National Building Code of India 2005	
Concrete	IS 4031 : Part 9 : 1988	Methods of Physical Tests for Hydraulic Cement – Part 9 : Determination of Heat of Hydration
	IS 9103 : 1999	Concrete Admixtures - Specification
	IS 1727 : 1967	Methods of Test for Pozzolanic Materials
	IS 516 : 1959	Methods of Tests for Strength of Concrete
	IS 1199 : 1959	Methods of Sampling and Analysis of Concrete
	IS 1489 : Part 1 :1991	Portland-pozzolana Cement -Specification - Part 1 : Fly Ash Based
	IS 1489 : Part 2 : 1991	Portland-Pozzolana Cement - Specification - Part 2 : Calcined Clay Based
	IS 383 : 1970	Specification for coarse and fine aggregates from natural sources for concrete
	IS 2386 : Part I to VIII	Methods of Test for Aggregates for Concrete
	IS: 8112 -1989	Specification for Cement Grade 43
	IS: 12269 -1987	Specification for Cement Grade 53
	IS: 12330-1988	Sulphate Resistance Portland Cement

	IS 12600-1989	Low Heat Portland Cement
	IS: 383-1990	Specification for coarse and fine aggregates from natural sources for concrete
	IS 456 - 2000	Plain and Reinforced Concrete - Code of Practice
	IS 14591 - 1999	Temperature Control of Mass Concrete for Dams- Guidelines
	ACI 207.1R-05	Guide to Mass Concrete
	ACI 207.2R-07	Report on thermal and Volume Change Effects on Cracking of Mass Concrete.
	ACI 224R-01	Control of Cracking in Concrete Structures
	ACI 350.4R-04	Design Considerations for Environmental Engineering Concrete Structures
Masonry	IS 1905 : 1987	Code of Practice for Structural Use of Unreinforced Masonry
	IS 2212 : 1991	Brick Works - Code of Practice
	IS 2185 Part 1 to 4	Concrete Masonry Units
Reinforcing Steel	IS 432 : Part 1 and 2	Indian Standard Specification for mild steel and medium tensile steel bars and hard-drawn steel wire for concrete reinforcement
	IS 1786 : 2008	High Strength Deformed Steel Bars and Wires for Concrete Reinforcement - Specification
	IS 1566 : 1982	Specification for Hard-drawn Steel Wire Fabric for Concrete Reinforcement
	ASTM A497/A497M-07	Standard Specification for Steel Welded Wire Reinforcement, Deformed, for Concrete
Joint Filler	IS 1838 : Part I and 2	Specification for Preformed Fillers for Expansion Joint in Concrete Pavement and Structures (Non-Extruding and Resilient Type)
Water stop	IS:12200-1987	Code of practice for provision of water stops at transverse contraction joints in masonry and concrete dams
	IS:15058-2002	Specification for PVC water stops at transverse contraction joints in masonry and concrete dams
Joint Sealer	IS 1322 : 1993	Bitumen Felts for Water-Proofing and Damp-Proofing - Specifications
	IS 2645 : 2003	Integral Waterproofing Compounds for Cement Mortar and Concrete - Specification
Steel Structures	IS 9595 : 1996	Metal-arc Welding of Carbon and Carbon Manganese Steels - Recommendations
	IS 808 : 1989	Dimensions for Hot Rolled Steel Beam, Column, Channel and Angle Sections
	IS 2062 : 2006	Hot Rolled Low, Medium and High Tensile Structural Steel
	IS 800 : 1984 and IS 800 : 2007	General Construction in Steel - Code of Practice
	SP 6 : Part 1 : 1964	Handbook for Structural Engineers - Structural Steel Sections

	IS: 226-1975	Specification of structural steel (standard quality)
	IS: 2825 : 1969	Code for Unfired Pressure Vessels
Bolts	IS 1369 : Part 1 to 3	Dimensions for Screw Thread Run-Outs for External ISO Metric Threads
	IS 1363 : Part 1 to 3	Hexagon head bolts, screws and nuts of product grade C
	IS 1364 : Part 1 to 5	Hexagon head bolts, screws and nuts of product grade A and B
	IS 1367 : Part 1 to 20	Technical supply conditions for threaded steel fasteners
Washers	IS 6649 : 1985	Specification for Hardened and Tempered Washers for High Strength Structural Bolts and Nuts
EOT Crane	IS 3443 : 1980	Specification for Crane Rail Sections
	IS:3177-1979	Code of Practice for Electric overhead travelling cranes and gantry cranes other than steel works cranes
	IS:807 : 2006	Design, Erection and Testing (Structural Portion)of Cranes and Hoists - Code of Practice
Truss and Hand rails	IS 1161 : 1998	Steel Tubes for Structural Purposes -Specification
Galvanization	IS 2629 : 1985	Recommended Practice for Hot-Dip Galvanizingof Iron and Steel
Formwork	IS 14687 : 1999	Falsework for Concrete Structures -Guidelines
	IS 6461 : Part V :1972	Glossary of Terms Relating to CementConcrete - Part V : Formwork for Concrete
Wood	SP 33 : 1986	Handbook on Timber Engineering
	IS 401 : 2001	Preservation of Timber - Code of Practice
Paint	IS 1477 : Part 1 and 2	Code of practice for painting of ferrous metals in buildings
Grouting	IS 4999 : 1991	Recommendations for Grouting of Pervious Soils
	IS 12584 : 1989	Bentonite for Grouting in Civil Engineering Works - Specification
	IS 14343 : 1996	Choice of Grouting Materials for AlluvialGrouting - Guidelines
	IS 6066 : 1994	Pressure Grouting of Rock Foundations in River Valley Projects - Recommendations
Planning and Layout	IS 7720 : 1991	Criteria for Investigation, Planning and Layout for Barrages and Weirs
	IS 14592 : Part 1 : 1998	Planning and Design of Barrage Power Houses - Guidelines - Part 1 : Investigation, Planning and Layout
	IS 9120 : 1979	Guidelines for Planning, Layout and Design of Cavities in Underground Hydroelectric Power Stations
Hydraulic Engineering	IS 6518 : 1992	Code of Practice for Control of Sediment in Reservoirs
	IS: 6966 Part 1 : 1989	Hydraulic Design of Barrages andWeirs - Guidelines - Part 1 : Alluvial Reaches

	IS:11155-1994	Construction of Spillway and similar overflow structures
	IS:4880 : Part 1 to 7	Code of practice for design of tunnels conveying water
	IS: 2951: Part 1 & 2	Recommendations for estimation of flow of liquids in closed conduits
	IS:7365-1985	Criteria for hydraulic design of bucket type energy dissipaters (first revision)
	IS:11772-1986	Guidelines for design of drainage arrangements of energy dissipaters and training walls of spillways
	IS:12804-1989	Criteria for estimation of aeration demand for spillway and outlet structures.
	IS:9761-1995	Hydropower intakes – Criteria for hydraulic design (first revision).
	IS:10135-1985	Code of practice for drainage system for gravity dams, their foundations and abutments (first revision).
	IS 7396 : Part 1 to 5	Criteria for Hydraulic Design ofSurge Tanks
	IS: 6512 : 1984	Criteria for Design of Solid Gravity Dam
	IS 5186 : 1994	Design of Chute and Side Channel Spillways -Criteria
	IS 11625 : 1986	Criteria for Hydraulic Design of Penstocks
	IS: 11388-1995	Recommendations for Design of Trash Racks for Intakes
Geotechnical Engineering	IS 11309 - 1985	Method of conducting pull out test of anchor bars and rock bolts
	IS 14448: 1997	Indian Standard Code of practice for Reinforcement of Rock slopes with Plane Wedge failure
	IS:4880 (part VI)-1971	Code of practice for design of tunnel conveying water (Tunnel supports)
	IS: 8237 – 1985	Code of Practice for Protection of Slope for Reservoir Embankment
	IS:5878 : Part 1 to 7	Code of practice for construction of tunnels conveying water
	IS:5878 (Part 2/Sec1):1970	Code of practice for construction of tunnels conveying water: Part 2 Underground Excavation in rock, Section 1 Drilling and Blasting (Amendment 1).
	IS:13195:1991	Preliminary design operation and maintenance of protection works downstream of spillway – guidelines
	IS 13365 : Part 1 to 3	Quantitative Classification Systemsof Rock Mass - Guidelines
Earthquake Engineering	IS 1893 (Part 1) 2002	Fifth edition, Indian Standard Criteria for earthquake resistant design of structures
	IS:1893: 1984	Criteria for Earthquake Resistant Design of Structures (Fourth Revision)
Structural Engineering	IS: 875-1987 Part 1 to 5	Criteria for Structural Safety of Buildings
	IS 456 : 2000	Plain and Reinforced Concrete - Code of Practice
	IS 800 : 1984 and IS 800 : 2007	General Construction in Steel - Code of Practice
	IS: 11130 - 1984	Criteria for Structural Design of Barrages and Weirs
	IS 11150 : 1993	Construction of Concrete Barrages - Code of Practice
	IS 7349 : 1989	Barrages and Weirs - Operation and Maintenance- Guidelines
	SP 16 : 1980	Design Aids for Reinforced Concrete to IS 456 :1978

	SP 34 : 1987	Handbook on concrete reinforcement and detailing
	IS: 13551 : 1992	Structural Design of Spillway Pier and Crest- Criteria
	IS: 3370 (Part II)-1965	Code of Practice for Concrete Structures for storage of Liquids, Reinforced Concrete Structure
	IS: 4880 (part IV) – 1971	Code of practice for design of tunnel conveying water (Structural design of concrete lining in rock)
	IS:11527: 1985	Criteria for structural design of energy dissipaters for Spillways
	IS:12720: 1993	Criteria for structural design of spillway training walls and divide walls
	IS:13551: 1992	Criteria for structural design of spillway pier and crest
	SP- 55: 1993	Design aid for anchorages for spillway piers, training walls and divide walls.
	IS: 4247: Part 1 to 3	Code of Practice for Structural Design of Surface Hydel Power Stations
	IS: 7207-1992	Criteria for Design of Generator foundation for Hydel Power Stations
	IS: 7418-1991	Criteria for Design of Spiral Casing (Concrete and Steel)
	IS:11105:1984	Code of practice for design aspect of tunnel plugs
	IS: 7357-1974	Code of Practice for Structural Design of Surge Tanks
	IS: 7563 - 1985	Code of Practice for Structural Design of Cut and Cover Concrete Conduits
	IS: 11639 Part 1 to 3	Criteria for Structural Design of Penstocks
	IS 5186 : 1994	Design of Chute and Side Channel Spillways -Criteria
	IS:2974 Part 1 to 5	Code of Practice for Design and Construction of Machine Foundations
Water supply drainage and dewatering	SP: 35-1987	Handbook of Water Supply and Drainage
	IS 4721 : 2000	Code of Practice for Drainage and Dewatering of Surface/Underground Hydroelectric Power Station
Roads and Bridge	IRC: 5-1998	"Standard Specifications And Code of Practice for Road Bridges", General Features of Design Section -I Seventh Revision
	IRC: 6-2000	"Standard Specifications And Code of Practice for Road Bridges", Loads and Stresses Section -II Fourth Revision
	IRC: 21-2000	"Standard Specifications And Code of practice for Road Bridges", Cement Concrete Plain and Reinforced Section -III Third Revision
	IRC: SP: 48-1998	Hill roads Manual
	IRC: 73-1980	Geometric design standards
	IRC: 37-2001	Guidelines for the design of flexible pavements
	IRC: 58-2002	Guidelines for the design of rigid pavements

3. MATERIALS

3.1. Scope

(i) The specifications described hereinunder relate to materials, equipment and services required for construction of various works under this contract.

(ii) The specifications of the major construction materials are given hereinafter.

(iii) Submittals after Order to commence

a) Within 30 days from the date of Order to Commence, (Contractor or consortium of contractors) shall submit more detailed and updated version of the submittals described as below.

- Contractor's proposed organisational setup for the project for
  - Overall project management
  - Planning, design and engineering services
  - Execution of civil works
  - Execution of Hydro-mechanical works
- An outline of the project components proposed along with drawings
- Management of planning, design and engineering services
- Brief on construction methodology of different components proposed
- Outline of Hydro-mechanical equipment proposed and its erection methodology.
- Proposed deployment of key personnel
- Proposed deployment of construction equipment
- Proposed subcontractors, if any
- Proposed sourcing of key materials
- Proposed construction schedule of the project
- An outline of quality assurance system proposed for the project
- Details of the Projects under execution by the bidder
- Technical Specifications

b) Within 30 days from the date of Order to Commence, the contractor shall submit detailed Technical specifications for the civil engineering works proposed. Besides other things, these specifications shall specify the submittals to be submitted by the contractor for approval of the Engineer-in- charge during the course of execution of civil engineering works.

(iv) Fixed Parameters of the Project

Following parameters of the project are fixed and bidder's proposal should be based accordingly.

- Dam Location As per drawing given in project profile

• Intake & Water Conductor System	As per drawing given in project profile
• Full Reservoir Level	El. 980.00 m
• Minimum drawdown level	El. 923.00 m
• Tail-water level at design flood	El. 880.00 m
• Spillway design Flood discharge	1229.00 cumec

(i) In case of conflict between the above Standards and the Specifications given herein, the Specifications shall take precedence.

(ii) All applicable is not listed here shall be followed.

3.2. Stone

(i) All stones used on the Works shall be of sound, hard, durable and tough quality approved by the Owner.

(ii) The stones shall be fine or medium grained, hard bright in colour, breaking with a clean fracture and such as make a ringing sound when struck with a hammer.

(iii) The stones be free from decay, vesicles, holes, flaws, cracks and other defects and must have, as far as possible, uniform colour and texture. Porous stone absorbing water more than 1 percent of its dry weight after 24 hours immersion, shall be rejected. No stones shattered or cracked by blasting operations or having any skin or earthy cover shall be used.

(iv) The location of the quarries for stones / aggregates, and sand shall be approved by the Owner. Stones obtained after excavation from underground and other works, if found suitable after necessary testing, subject to the approval of the Owner may be used. Necessary permission for obtaining stone from quarry shall be obtained bycontractor from appropriate authority. Cost of Royalty, tax etc shall be borne by contractor.

(v) Stone not considered free from dust, or dirt etc. shall be screened, washed and / or treated before being used.

(vi) Samples of stone intended to be used shall be submitted for approval of the Owner and used only after approval.

3.3. Aggregates

3.3.1. General

(i) Use of aggregates (coarse and fine) containing excessive amount of zeolites, secondary minerals and such other components which cause alkali reactivity of theaggregates and consequent reduction in durability of the concrete is prohibited.

(ii) Aggregates crushing plant shall be installed for crushing of aggregates from stones extracted from approved quarries or obtained after excavation from underground or other works.

(iii) The quality of all aggregates used in the works, as also the preceding activity such as washing, classifying, screening, re-screening, crushing and blending shall meet the required specifications.

(iv) The aggregates shall be supplied only from the sources / quarries approved by the Owner.

(v) The aggregate shall be sampled and tested in accordance with the Indian Standards referred in these technical specifications.

(vi) The tests shall be made on samples that are representative of the grading that will be used in concrete and the aggregates shall be processed by the equipment proposed for the Works.

(vii) The Owner shall at all times, have access to and association with sampling and testing of aggregates.

(viii) Proper aggregate type shall be used.

3.3.2. Coarse Aggregate

(i) The term coarse aggregates apply to pieces of natural or crushed rock ranging in sizes from 4.75 mm to 150 mm.

(ii) The aggregates shall be composed of clean, hard, strong durable pieces of stone, angular or rounded in shape obtained naturally or by crushing from suitable approved stones. Coarse aggregates shall be of regular shape and free of flat or elongated particles.

(iii) Coarse aggregates delivered to the batching plant shall have a uniform and stable moisture content.

(iv) The coarse aggregates shall be free from objectionable materials such as wood or other deleterious substances, the percentage of which in any size of coarse aggregates shall conform to the relevant standards except that the coarse aggregates shall contain not more than 0.30 percent by weight of deleterious (reactive) iron sulphides. The sum of percentage of all deleterious substances in any size shall not exceed 3 percent by weight. Coarse aggregates having a specific gravity (saturated surface-dry basis) less than 2.60 shall be rejected.

(v) The aggregates shall be resistant to deleterious, chemical or physical change such as cracking, swelling, softening, leaching or chemical alterations after its incorporation in concrete.

(vi) For concrete exposed to the flowing water at high velocities, the coarse aggregates having high abrasion resistance shall be used and loss not more than 30% as determined by Los Angels abrasion test as specified on IS:2386 (Pt. IV)

(vii) When subject to sodium sulphate soundness test, coarse aggregates shall not suffer more than 12 percent loss of weight after five cycles.

(viii) The aggregates shall be crushed in approved type of stone crushers and different sizes of the coarse aggregate shall be separated into nominal sizes by screening over vibrating screens as under:

Designation of size	Nominal size range		
10 mm aggregate	4.75 mm	to	10 mm
20 mm aggregate	10 mm	to	20 mm

40 mm aggregate	20 mm	to	40 mm
80 mm aggregate	40 mm	to	80 mm
150 mm aggregate	80 mm	to	150 mm

(ix) The grain size distribution of the coarse aggregate for the various maximum sizes of aggregates shall be as set out in the relevant standards.

(x) These may be altered from time to time, if necessary, on the basis of actual tests carried out regularly in the laboratory so as to get the best possible coarse aggregate grading.

(xi) The percentage of weight of all the significant under sizes shall be less than 5 percent when tested on the designated test screens having openings 5/6 times the normal minimum size of the material. No oversize (i.e. material that would be retained on the designated test screens having openings 7/6 times the normal sizes of the material) shall be permitted.

3.3.3. Fine Aggregates (Sand)

3.3.3.1. GENERAL

a) Sand or fine aggregates shall be used for mortar in stone masonry and as fine aggregates in concrete work. It shall be either natural river sand or manufactured sand crushed from rock / stones or mixture of both in specified proportions. The sand shall be composed of hard, clean and gritty pieces of stone and of a quality approved by the Owner. It shall not contain any salt and amount of clay, soft and flaky particles, vegetable or organic matter, loam, mica and other deleterious substances shall be limited to the provision of relevant Indian Standards.

(b) The fine aggregates shall conform to the requirements of IS:383-1970 (Reaffirmed1980). Varying amount of moisture in fine aggregates contributes to lack of uniformity in concrete consistency. The fine aggregates shall therefore have uniform and stable moisture content. Dry sand shall be preferred; hence sand stockpiles shall be protected from rain.

(c) The percentage of deleterious substances in the fine aggregates shall conform to relevant standards except that the fine aggregates shall contain not more than 0.10 percent by weight of deleterious (reactive) ferrous sulphides. The total percentage of deleterious substances must not exceed 5 percent of the weight.

(d) Fine aggregates having a specific gravity of less than 2.60 shall be rejected. Fine aggregates when subjected to a soundness test with a solution of sodium sulphate, after 5 cycles of tests, shall not suffer a loss of weight in excess of 10 percent.

(e) The sand shall be well graded and, when tested by standard sieves, shall conform to the prescribed limits of gradation. The best gradation shall be determined after experiments and tests.

(f) The sand, as delivered to the batching plant shall have a fineness modulus of 2.6±0.4

(g) The grading of fine aggregates shall be so controlled that the fineness module of at least 9 out of 10 samples of fine aggregates delivered to the batching plant shall not vary more than 0.20 from the average of 10 samples tested.

(h) The fine aggregates shall have a uniform and stable moisture content. The amount of moisture shall be less than 6% of weight.

3.3.3.2. NATURAL SAND

(a) Natural sand shall be obtained from an approved source. No sand affected by salty water shall be used. The sand shall be screened and thoroughly washed, preferably in flowing water so as to remove all earthy impurities and very small fines as provided in the relevant Indian Standards.

(b) Natural sand shall be free from laterite and other softer grains and all sources of sand showing appreciable percentage of these impurities shall be rejected.

(c) The presence of mica in the fine aggregate has been found to reduce considerably the compressive strength of concrete. If the presence of mica exceeds the allowable limit in the fine aggregates, either the mineral will be eliminated, or the source of the fine aggregates will be shifted accordingly.

(d) The contents of the organic matter shall conform to relevant Standards.

3.3.3.3. MANUFACTURED SAND

(a) Whenever natural sand conforming to the required specifications is not available, recourse shall be taken to manufacture sand of desired quality by crushing of stones. The stone that will be used in crushing for getting fine aggregates shall conform in all respects to the stone / coarse aggregates specified under these technical specifications.

(b) In case the natural sand or the manufactured / crushed sand is not as per Specifications, the same will be rejected outright or the sand may be allowed after processing, provided the sand conforms to the requirements after such treatment.

c) For improving workability of pumpable concrete mixes, a combination of natural and manufactured sands may be considered.

3.3.4. Storage of Aggregates

(i) At all times, a storage of all grades of aggregates for at least two weeks requirement shall be maintained.

(ii) Adequate drainage of stockpiles shall be provided.

(iii) The stockpiling of the processed aggregate and withdrawal there from shall be such as to ensure that the variation in the free moisture in the aggregate, during any one shift of working, does not exceed 1 percent.

(iv) The coarse aggregates shall, as far as possible, be stored in a shade or covered storage and arrangement made for sprinkling of water to ensure wetting of the aggregates.

(v) 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.

(vi) The stockpile shall be built up in horizontal or gently sloping layers.

(vii) Trucks and bulldozers shall be kept off the piles to prevent breakage and impairing the cleanliness of aggregate.

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

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

(x) If the height of fall of aggregate from conveyor belt to the stockpiles is large, it is likely to get segregated. In such cases, rock ladders will be used unless the height is reduced.

(xi) Arrangements 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.

3.4. Water

(i) Water is available from natural sources within the project area. The reliable water supply for construction purposes shall be installed and maintained. Required measurers shall be applied whenever the River water is used for construction materials and for any other application (concrete, shotcrete, cooling …). All mix designs which include the River water shall be subject to the Client's approval.

(ii) Adequate water storage facilities shall be provided at the batching and mixing plant and other work sites so that various operations of works including curing, do not suffer due to temporary breakdown in the main supply system.

(iii) Water samples from the intended sources shall be got tested for their suitability.

(iv) The suitability of water to be used for construction purposes shall be established and shall conform to IS:456.

(v) Water for washing of aggregates, mixing mortar, concrete or grout shall be clean and free from earth, vegetable or organic matter, injurious amount of oils, acids, sugar, salt and alkaline substances in solution or in suspension and shall conform to relevant Standards. The maximum allowable contents of sulphates (SO4) shall be 1000 mg/litre and those of chlorides (Cl) shall be 100 mg per litre for plain concrete works and reinforced concrete works. Turbidity shall be within 1000 ppm (or 0.1 percent by weight) and preferably lower.

(vi) Water used for curing shall be clean and free from contamination and from excess amounts of acids or alkalis or other matter combining chemically with and thus, disfiguring the concrete surface.

(vii) Average 28 days compressive strength of at least three 15 cm concrete cubes prepared with water proposed to be used shall not be less than 90 percent of the average of strength of three similar concrete cubes prepared with distilled water. The cubes shall be prepared, cured and tested in accordance with the requirements set out in the specifications.

3.5. Cement

3.5.1. General

(i) Cement to be used for various works shall be of different types such as Ordinary Portland Cement or Portland Pozzolana Cement or Sulphate Resistant Cement as required and shall conform to the relevant standards at the time of its use.

(ii) The Contractor shall procure the cement of the specified quality as per relevant Indian Standards or IS: 8112.

(iii) Aggregate which has alkaline reactive tendency, shall be avoided for use in concrete. Cement with alkali contents (e.i. K_2O and Na_2O expressed in equivalent weight of Na_2O) not exceeding 0.6 percent by weight of cement shall only be used.

(iv) The cement shall be sampled and tested for strength and physical properties and chemical analysis will be carried out as set out in relevant Standards.

3.5.2. Transportation

(i) Cement shall be delivered on Site in 50 kg bags or in bulk containers.

(ii) All bulk containers / carriers shall be clean and dry prior to filling / loading with cement and equipped with weather proof closures on all openings.

3.5.3. Storage

(i) Sufficient storage facilities shall be provided at the batching plant for ensuring uninterrupted availability of cement for concrete/shotcrete.

(ii) Cement shall be stored above ground, adequately protected against rain, sun and moisture. Bulk storage bins and silos shall be emptied completely and cleaned of all cement periodically as required.

(iii) As far as practicable cement shall be used in the order in which it is received at site.

(iv) Handling and storage facilities shall be such that no cement is stored before use for more than 120 days. Should any cement be unavoidably kept in storage longer than120 days, it shall be tested and if found defective, shall be condemned for use on the project.

3.6. Steel for Reinforcement

3.6.1. General

(i) Steel reinforcement shall conform to relevant Indian Standards or equivalent.

(ii) Steel reinforcement of the specified quality shall be procured from the reputed manufacturers.

(iii) Steel shall be free from loose mill scale, rust, oil, grease, dirt, paint or other deleterious matter, when examined immediately before concrete being placed.

(iv) Wire for tying reinforcement steel shall be black annealed iron wire or acceptable equivalent, with a diameter not less than 1.6 mm.

3.6.2. Transportation and Storage.

(i) Transportation shall be undertaken in such a manner that no damage is done to the steel.

(ii) Reinforcement steel shall be stored off the ground in separate groups according to size and length. Reinforcement steel, which has been cut and bent according to the schedules shall be marked with bar number, as shown in the schedule, by using same form of weather proof tag of by placing in marked bins, and shall be stored in such a manner as to be readily accessible when required to facilitate inspection.

3.7. Structural Steel

3.7.1. General

(i) Structural steel of the specified quality shall be procured only from reputed manufacturers.

(ii) All structural steel shall be of new / unused stock, clean and straight, free from excessive rust or scale and without any sharp kinks, bends or other objectionable defects.

(iii) Structural steel including steel plates and steel to be used for supports for tunnel and cavities as also for bolts, nuts and washers etc. for steel supports shall conform to relevant standards.

(iv) The material used in splices shall conform to the specifications of the material being spliced.

3.7.2. Transportation and Storage

(i) Structural steel shall be transported, handled and stored in such a manner that no damage is done to the materials or the structure.

(ii) All timber to be used for support accessories shall be stored in separate secure location.

3.8. Miscellaneous Steel Materials

Miscellaneous steel materials shall be conforming to the following IS specifications.

Expanded Metal Steel Sheets for General purposes	IS:412
Specification for mild steel and medium tensile steel bars and hard drawn steel wire for concrete reinforcement (grade I) (for mild steel bars of anchor bolts, rungs, metal inserts, grating etc.)	IS:432
Hexagonal head bolts, screws & nets of product grade C	IS:1363
Cold formed light gauge structural steel sections	IS:811
Technical supply conditions for threaded steel fasteners	IS:1367
Plain washers	IS:2016

Steel wire ropes for general engineering purposes	IS:2266
Thimbles for wire ropes	IS:2315
Bulldog grips	IS:2361
Mild Steel Tubes, tubulars and other wrought steel fillings. (for Hand rail tubular sections).	IS:1239
Drop forged sockets for wire ropes for general engineering purposes	IS:2485
Steel chequered plates	IS:3502
Hexagonal bolts and nuts (M42 to M150)	IS:3138

Anchor Bolts: Material for Anchor Bolts such as MS bars, washers, nuts, pipe sleeves and plates etc. shall be as per relevant IS Codes mentioned above.

3.9. Waterstops

3.9.1. Scope of Work

(i) The work under this Section include all labour, materials and equipment required for the supply, fabrication (if any), storage, handling, placing and splicing of waterstops to be incorporated in the movement joints in concrete structures as shown on the approved Construction Drawings, or as required by PMC.

(ii) The work shall include all the necessary supports and ties required for placing water-stops.

3.9.2. Standards

(i) The concrete materials, production, methods, testing and admixtures shall minimally conform to the latest revisions of the following Indian Standards or, where not covered by these standards, to the equivalent International Standards: IS 15058: 2002 (PVC Waterstops)

3.9.3. Submittals

(i) The Contractor shall submit the detailed design/drawings for Joints including PVC Waterstops, Copper waterstops, if required, that he proposes to use in various structures.

(ii) At least 90 days prior to procuring or dispatch to the Site of the particular item of work to which the submittal relates, the Contractor shall submit to the Engineer-in-Charge the details covering the properties and performance, including the certified copies of reports of all tests made by the manufacturers, along with material samples of the products, of:

- Waterstops (PVC),
- Waterstops (copper),

3.9.4. Joint Types

Movement Joints in General Concrete Structures

- The term movement-joints comprise both, the expansion and the contraction joints in concrete structures. Movement joints shall be constructed at such locations and to such dimensions as shown on the approved Construction Drawings or as directed by the PMC.
- The Contractor shall supply and install the various joint components as specified herein, as shown on the approved Construction Drawings and in accordance with the manufacturer's recommendations.
- No fixed metal/reinforcement embedded in the concrete shall be continuous through a movement joint except where expressly shown on the approved Construction Drawing.
- Expansion joints may be comprised of the following elements:

  a) Flexible PVC waterstop,
  b) Copper waterstop,
  c) Any other joint proposed by the Contractor

- Contraction joints may be comprised of the following elements:

  a) Flexible PVC waterstop,
  b) Copper waterstop,
  c) Any other joint proposed to be used by the Contractor.

3.9.5. Material

3.9.5.1.1. PVC Waterstops

- Waterstops shall be made of extruded polyvinyl chloride (PVC) conforming to relevant standards. Material for waterstops shall be clean, homogeneous and free from porosity and other imperfections of fabrication:
- Waterstops will have suitable width for joints at various locations including in the cut-off trenches.
- The properties of waterstops shall meet the following requirements:
  - Specific Density: Not less than 1.3 g/cm^3,
  - Tensile Strength: Not less than 120 kg/cm^2,
  - Tear Resistance: Not less than 50 kg/cm^2
  - Ultimate Elongation: Not less than 33%,
  - Stiffness in Flexure: Not less than 28 kg/cm^2,
  - Cold bend: No crack when bent at 180o after being exposed for two hours to a temperature of 5o C,
  - Resistance to alkalis: Testing on alkalis shall result after 7 days in a variation in weight within the limits of -0.1% to +0.25%; after 28 days the variation in weight shall be within the limits of -0.30% to +0.40%.
- The wings of the PVC water-stop shall be provided with corrugations or bulbs to achieve good bond. PVC water-stops in expansion joints shall be provided with hollow centre bulb.
- Water-stops must have been tested by the manufacturer as follows:

- Tensile strength and ultimate elongation shall be tested in accordance with IS 412, specimens being cut by means of Die "C". Conformity shall be determined on the average of results from test on five specimens.
- Modulus of elasticity shall be tested by clamping the specimen on the testing machine in such a manner to form a cantilever beam with the 25 mm dimension as the beam width. The specimen shall be held between the centre line and nearest width on one side of the piece so as to result, with the load applied at the farthest rib from the clamp, in a nominal span of 4 cm in length. Load shall be applied across the full width of the specimen by a rigid, blade type, loading head of 1 mm contact edge radius. With load value being that obtained for a deflection rate of 5 mm/min., the modulus of the material shall be calculated from the formula E = PL3/3DI, in which:
- E = modulus elasticity (N/mm^2)
- P = applied load (N)
- L = span length (mm)
- D = deflection under applied load (mm)
- I = moment of inertia of the specimen section (mm^4)

- The average thickness of specimen may be used for calculation of moment of inertia. Conformity shall be determined on the average of results from tests on three specimens. Each specimen shall be 25 mm in length and of the full cross section of the finished waterstop.
- Cold bend test: Each specimen shall be 25 mm wide and approximately 150 mm long. The specimen shall be cooled to 5°C, then immediately bent through 180° around a 6 mm diameter mandrel. Any cracking shall constitute failure. Conformity shall be determined from the test conducted on three samples of flat pieces in the shape of a sheet with a thickness similar to that used as a waterstop.
- Effect of alkali:
  - either a single sample cut from the finished waterstop, weighing between 75 and 125 gm or
  - six strips from a sheet of PVC compound, each being 150 mm long and approximately 20 mm wide.
- For the test on the single sample, the sample shall be weighed to the nearest milligram. For tests on the 6 strips, the strips shall be weighed together, not singly, also to the nearest milligram. The hardness shall be measured in accordance with IS:3400 (Part 2).
- The specimen shall be totally immersed in a solution consisting of 5.0 gm C.P. sodium hydroxide and 5.0 gm C.P. potassium hydroxide dissolved in 1 litre of distilled water. The solution shall be maintained at 20°C to 25°C and shall be replaced every 7 days with a fresh solution at the same temperature. At 7 and 28 days, the specimen shall be removed, rinsed, surface dried, air-dried for 10 minutes and then checked for changes in weight. At 7 days it shall also be checked for any change in hardness. Weight changes shall be recorded as a percentage of the original weight and hardness change in durometer units.

- Storage of material prior to placement shall be made in such a way as not to alter the properties of the material during storage. Water stops shall be stored so as to permit free circulation of air around them. All materials shall be protected from contact with oil and grease. Waterstops shall be stored in a place protected from the direct rays of Sun or to any other heat source.

- Waterstops shall be joined and fixed in place in accordance with manufacturer's recommendations to form a continuous watertight barrier. All crosspieces, T-pieces and corner-pieces shall be factory produced. All joints shall be welded with approved, thermostatically controlled electric heat equipment. The temperature at which the splices are made shall be sufficient to melt but not char the plastic material. All splices shall be neat with the ends of the joined waterstops in true alignment. A mitre-box guide and portable knife shall be provided for cutting the ends to be joined to insure good contact between joined surfaces.

3.9.5.1.2. Copper Waterstops (if proposed by Contractor as required)

(i) Copper waterstops shall be of the shapes and dimensions shown on the approved Construction Drawings and shall be pressed from hard, de-oxidised 0.8 mm thick copper strip conforming to relevant standards.

(ii) The number of joints in the waterstop shall be the minimum practicable but shall not be closer than 3.5 m. Joints in copper waterstop shall be made by lapping the waterstop between 10-25 mm and brazing the lapped surface completely taking care to seal all corners with solder so that the joint is watertight. Brazing alloys shall be 96% tin and 4% silver.

(iii) The outside of the central rib of the waterstop shall be painted with bituminous paint and the central rib shall enclose a neoprene rod and polyurethane foam filler.

(iv) A copper waterstop hypalon band 6 mm thick shall be placed between the 6 mm thick hypalon band copper waterstop and mortar joint pads where required on vertical construction joints. The copper waterstop shall be fixed at spacings not exceeding 1 m.

(v) The welding or brazing of copper waterstops at joints shall be subject to tests. The welding method shall be given by the Item Rate Contractor in his Method Statement to be submitted 28 days prior to such work and seek approval of the Engineer-in-Charge. Only qualified and certified personnel shall be allowed to perform such work.

(vi) Copper should not be in direct contact with steel, in order to avoid the electrolysis of the material.

3.9.5.1.3. Installation

a) Movement Joints in General Concrete Structures

- Where grouting is not required, the movement joint surfaces shall be formed with F1 finish. If grouting is required, joint surfaces shall be formed with F2 finish.

- The Contractor shall supply all necessary supports and ties required for placing the waterstop and shall position it so that its central axis coincides with the joint centre. Care shall be taken that waterstop does not bend or deflect during concreting. Concrete adjacent to the waterstop shall be thoroughly worked to ensure full compaction and full contact with the waterstop but without damaging it. PVC materials shall be protected from sunlight until installation is completed.

- For structures founded below the ground water table, waterstops shall be placed in the construction joints of the slabs, and at the interface between the slab and the perimeter wall, as shown on the drawings. Prior to commencement of concrete placing, the waterstops placed shall be inspected by the Engineer-in-Charge.

3.10. Wire Mesh Gabions

3.10.1. Scope

The purpose of this standard is to define the specifications to be followed for Wiremesh Gabions.

3.10.2. Types

Gabions shall consist of rectangular wire mesh formed containers filled with rock. Gabions will conform to one of the following mesh types:

Woven Mesh - Non-raveling double twisted hexagonal wire mesh, consisting of two wires twisted together in two 180 degree turns.

Gabions shall be furnished as baskets having a height of 12 inches or greater. Baskets shall be fabricated within a dimension tolerance of plus or minus 5 percent, except that the mattress height shall be within 10 percent.

3.10.3. Materials

Wire for fabrication and assembly shall be hot-dipped galvanized. The wire shall have a minimum tensile strength of 60,000 psi. Galvanized steel wire shall conform to ASTM A 641, Class 3, Soft Temper.

Ring fasteners are the standard fastener for use with wire mesh gabions, shall be formed from wire meeting the same quality and coating thickness requirements as specified for the gabions.

Prior to delivery to the site, the Contractor shall inform the Employer in writing of the source from which the materials will be purchased and provide the test data by which the material was determined by the Contractor to meet the specification.

3.10.4. Foundation Preparation

The foundation on which the gabions are to be placed shall be cut or filled and graded to the lines and grades shown on the drawings. Surface irregularities, loose material, vegetation, and all foreign matter shall be removed from foundations. When fill is required, it shall consist of materials conforming to the specified requirements. Gabions shall not be placed until the foundation preparation is completed, and the subgrade surfaces have been inspected and approved by the PMC.

3.10.5. Assembly and Placement

Unless otherwise specified in the construction plan, the assembly and placement of gabions shall be in accordance with the following procedures:

Assembly - Rotate the gabion panels into position and join the vertical edges with fasteners for gabion assembly. Where lacing wire is used, wrap the wire with alternating single and double half- hitches at intervals between four (4) to five (5) inches. Where ring type fasteners are used for basket assembly, install the fasteners at a maximum spacing of 6 inches.

Placement - Place the empty gabions on the foundation and interconnect the adjacent gabions along the top, bottom, and vertical edges using lacing wire, spiral fasteners, or ring fasteners. Wrap the wire with alternating single and double half-hitches at intervals between four (4) to six (6) inches. Ring fasteners shall not be spaced more than six (6) inches apart. Spirals are screwed down at the connecting edges, then each end of the spiral is crimped to secure it in place. Lacing wire will be used as needed to supplement the interconnection of welded mesh gabions, and the closing of lids.

Interconnect each layer of gabions to the underlying layer of gabions along the front, back, and sides. Stagger the vertical joints between the gabions of adjacent rows and layers by at least one-half of a cell length.

3.10.6. Filling Operation

After adjacent empty woven wire gabion units are set to line and grade and common sides properly connected, they shall be placed in straight line tension and stretched to remove any kinks from the mesh and to gain a uniform alignment. Staking of the gabions m ay be done to maintain the established proper alignment prior to the placement of rock.

Internal connecting cross-tie wires shall be placed in each unrestrained gabion cell greater than 18 inches in height, including gabion cells left temporarily unrestrained. Two internal connecting wires shall be placed concurrently with rock placement, at each 12-inch interval of depth.

In woven mesh gabions, these cross-ties will be placed evenly spaced along the front face and connecting to the back face. All cross-tie wires shall be looped around two mesh openings and each wire end shall be secured by a minimum of five 180 degree twists around itself after looping.

The gabions shall be carefully filled with rock, either by machine or hand methods, maintaining alignment, avoiding bulges, and providing a compact mass that minimizes voids. Machine placement will require supplementing with hand work to ensure the desired results. The cells in any row shall be filled in stages so that the depth of rock placed in any one cell does not exceed the depth of rock in any adjoining cell by more than 12 inches. Along the exposed faces, the outer layer of stone shall be carefully placed and arranged by hand to ensure a neat, compact placement with a uniform appearance.

The last layer of rock shall be uniformly overfilled 1-2 inches for gabions to allow for rock settlement. Lids shall be stretched tight over the rock fill using only approved lid closing tools. The use of crowbars or other single point leverage bars for lid closing is prohibited. The lid shall be stretched until it meets the perimeter edges of the front and end panels. The gabion lid shall then be secured to the sides, ends, and diaphragms with spiral binders or lacing wire wrapped with alternating single and double half-hitches in the mesh openings. Ring fasteners spaced not more than six (6) inches apart may be used for lid closure.

Any damage to the wire or coatings during assembly, placement and filling shall be repaired promptly in accordance with the manufacturer's recommendations or replaced with undamaged gabion baskets.

3.11. Bund Materials

3.11.1. Gannular Fill Material (Murrum)

The murrum shall be granular with fines smaller than 75 microns not exceeding 15% and shall be free from rubbish, clay and other deleterious material.

The maximum laboratory dry density (IS 2720, Part 8) shall not be less than 1.6 T/cum.

3.11.2. Rock Fill Material

This shall consist of quarry run material, free from deleterious matter, of size 100 mm to 450 mm.

3.11.3. Rock Armour

Rock armour shall comprise rock of adequate weight and quality to withstand the design wave forces and laid in two layers. The rock shall meet with the following requirements when tested in accordance with IS:2386.

- Aspect Ratio : >0.5
- Density : 2.6 T/cum
- Water Absorption : <2%
- Compressive Strength : 400 Kg/sq.cm (cylinder) : 500 Kg/sq.cm (cube)
- Abrasion Resistance : Abrasion value not to exceed 30%
- Impact Resistance : Aggregate impact value not to exceed 30%

3.12. Bricks

3.12.1. General

Bricks for masonry works shall conform to IS:1077–Specification for common burnt clay building bricks and shall be of class 7.5 (with minimum compressive strength of 7.5N/mm^2). Specific requirement for any other class of bricks shall be as shown in drawings or as described in the Contract for a particular site or type of work. Physical requirement, quality, dimensions, tolerances etc. of common burnt clay building bricks shall conform to the requirements of IS:1077.

Bricks shall be hand-moulded or machine moulded and shall be made from suitable soils. The bricks shall have smooth rectangular faces with sharp corners and shall be well burnt, sound, hard, tough and uniform in colour. These shall be free from cracks, chips, flaws, stone or humps of any kind.

3.12.2. Tests after Delivery

The Contractor shall make samples of each type of brick as directed by the Employer as per the requirements of IS: 5454 and tests shall be carried out as per IS: 3495. The cost for carrying out any or all the tests shall be borne by the Contractor. The bricks, when tested, as per IS: 3495 shall have a minimum average compressive strength, as given in the Code, for a particular class of brick. Water absorption shall not be more than 20% by its dry weight, when soaked in cold water for 24 hours.

Brick samples so approved shall be deposited with the Employer. All subsequent deliveries shall be upto the standards of the approved samples.

3.12.3. Stacking of Bricks

Bricks shall be stored at site as per the requirements given in IS:4082 and shall not be dumped at site. They shall be unloaded from trucks to a place on a levelled surface near to the work site. They shall be stacked in regular tiers even as they are unloaded, to minimise breakages and defacement of bricks. The supply of bricks shall be so arranged that as far as possible, at least two days' requirements of bricks are available at site at any time. Bricks, of different class, shall be stacked separately.

3.13. Admixtures

3.13.1. General

All concrete admixtures shall in general comply with the following Indian standards unless otherwise stipulated in this specification.

- Specification for integral cement water proofing compounds: IS:2645
- Specification for other admixtures for concrete: IS:9103

Generally, admixtures shall have ISI certification marks. However, even in case of BIS certified admixtures, Employer may require the Contractor to carry out and submit any or all the tests (as specified in relevant IS Codes), from approved laboratories, over and above the manufacturer's test certificate, before giving his final approval.

In case, admixtures certified by BIS are not available, the Contractor shall submit to the Employer the type and/or proprietary brand of the admixture from only reputed manufacturers along with necessary test certificates from recognised and approved laboratories or any other document directed by the Employer for the latter's final approval. In such cases, names of at least two manufacturers shall be submitted to the Employer for his selection. In case, both the names are rejected, the Contractor shall submit a fresh list of two manufacturers for approval by the Employer.

The Employer may direct the Contractor to submit test results as required by IS:2645 or IS:9103 for any admixture proposed to be used in the concrete in any approved laboratory at his discretion at any stage of the work. The cost of any/all tests required to satisfy compliance with this specification shall be borne by the Contractor.

In case of non-availability of any IS code for testing and acceptability criteria, relevant British, American or German Code shall be applicable in the order of preference.

Prior approval of the Employer shall be obtained while using water reducing admixtures in the concrete (PCC/RCC) or mortar. Other type of admixtures such as accelerating admixtures, retarding admixtures or air entraining admixtures, shall not be used unless prior approval taken from the Employer. Once approved, utmost care shall be taken at site by the Contractor to maintain the consistency in the quality of admixture and the concrete/mortar so produced.

The suitability and effectiveness of any admixture shall be verified by trial with the designed concrete mixes using cement, aggregates together with any other materials to be actually used in the works as per the direction of Employer. If two or more admixtures are to be used simultaneously in the same concrete mix, the Contractor must submit necessary test results from an approved simultaneously in the same concrete mix, the Contractor must submit necessary test results from an approved laboratory to show their interaction and compatibility. Any/all tests specified in IS Codes shall be carried out only with the type of material and mix design, to be actually used in the work site.

No admixture shall impair the durability of the concrete nor combine with the ingredients to form harmful compounds nor increase the risk of corrosion of reinforcement. Use of admixtures shall not reduce the dry density of concrete. Once the proportion of admixture has been established, strict check shall be maintained not to alter the proportions of ingredients and water cement ratio of the Design Mix during execution.

The chloride contents in admixtures shall not exceed 2% by mass of the admixture or 0.03% by mass of the cement.

Admixtures which do not meet the requirements stipulated in this specification shall be rejected and shall not be used.

3.13.2. Water Proofing Compounds

The permeability of the specimen with the admixture shall be less than half of the permeability with similar specimen without the use of these compounds. These compounds shall be used in such proportion as recommended by manufacturer but in no case, it shall exceed 3% by weight of cement.

The initial setting time of the cement with the use of these compounds shall not be less than 30 minutes and final setting time shall not be more than 10 hours. Test shall be carried out in accordance with IS:4031.

Compressive strength of specimen at 3 days shall not be less than 270 kg/sq.cm nor 90% of the 3 days compressive strength of mortar cubes prepared with same cement and sand only, whichever is higher. Similarly, compressive strength at 7 days shall not be less than 370 kg/sq.cm nor less than 90% of the 7 days compressive strength prepared with the same cement and sand only, whichever is higher. The test to determine the compressive strength shall conform to IS:4031.

3.14. Bitumen/Bituminous Materials

Bitumen to be used for various types of work shall meet all the requirements of relevant IS Codes as given below:

Specification of Paving Bitumen	IS:73
Specification for bitumen mastic for flooring	IS:1195

Specification for bitumen felts for water proofing and damp proofing	IS:1322
Specification for Bituminous compounds for water proofing and caulking purposes	IS:1834
Specification for preformed fillers for expansion joint in concrete pavements and structures	IS:1838
Specification for bitumen mastic for use in water proofing of roofs	IS:3037
Specification for bitumen primer for use in water proofing and damp proofing	IS:3384
Specification for Bitumen Mastic for Tanking and Damp proofing	IS:5871
Specification for Glass fibre base coal tar pitch & bitumen felts	IS:7193
Code of practice for damp proofing using bitumen mastic	IS:7198
Specification for bitumen Mastic, Anti Static and electrically conducting grade	IS:8374

The type and grade shall be as shown on the drawings or as directed by Employer. Tests and acceptable criteria shall be as per relevant IS Codes.

3.15. PVC Pipes

PVC Pipes shall conform to the requirements of IS:4985.

3.16. Wood/Timber

Timber required to be used for formwork shall be fairly dry before use. It should maintain its shape during the use and even when it comes into contact with moisture from the concrete. Storage of Wood/Timber shall be as per the requirements of IS:4082.

For proper identification and selection of suitable timber for formwork, following codes shall be referred.

- Classification of commercial timbers and their zonal distribution: IS:399
- Specification for ballies for general purposes: IS:3337
- Specification for ply wood for concrete shuttering work: IS:4990

3.17. Paint

3.17.1. General

All paints shall be of an approved quality and shall be obtained from only those suppliers and makers who have been in the market for a period of not less than 5 years. All paints shall conform to the appropriate Indian Standards for ready mixed paints where applicable. All paints, undercoats, primers and finishing paint shall be supplied in sealed container. The Employer’s Engineer may, if he so wishes, take samples for analysis at the Contractor's expense.

Wood preservative shall be of chemical type comprising copper-chrome-arsenic composition conforming to IS 401-1967.

All paints shall be stored in cool and dry conditions and clear of other stores to the satisfaction of the Employer's Engineer.

3.17.2. Painting

All structural steel work and metals including handrails, brackets & exposed surfaces of steel inserts shall be painted except if otherwise specified.

The operations, workmanship, schedules and equipment for painting shall generally comply with the requirements of IS:1477 (Parts I & II) "Code of Practice for Painting of Ferrous Metals in Buildings" except in so far as this Specification modifies it.

All surfaces shall be thoroughly cleaned of all foreign matters adhering to the steel surface to Swedish Standard specification Sa 21/2 by means of blasting with sand. Use of scraper wire brush and pig hammer is acceptable wherever blasting with sand is not possible due to lack of access. All painting shall be carried out by brushing. Spray and roller application of paint shall not be allowed without the written permission of the Employer's Engineer.

Painting shall generally be done immediately after cleaning. The cleaned surface shall not be allowed to stand overnight before painting. Where galvanised surfaces are to be painted, they shall be cleaned and washed with a solution of copper sulphate before the application of the first coat of primer.

No painting shall commence until the cleaned surfaces have been approved by the Employer's Engineer.

All steelwork unless specified otherwise, shall be painted as per the following schedule:

a) Two coats of epoxy base zinc rich primer (92% zinc on dry film) shall be applied. The dry film thickness of two coats shall be 60 microns minimum.

b) After the application of primer, all surfaces shall receive two coats of coal tar epoxy or any other high build epoxy compatible with the primer. The finish paint shall be applied to establish an endurable protection of the prime coat. It shall be resistant to atmospheric heat, reflect heat and rays and withstand mechanical stresses without crumbling. The total dry film thickness for these 2 coats shall be 200 microns minimum. The colours for the finishing coats shall be as approved by the Employer's Engineer.

c) Total dry film thickness for the system shall be 260 microns minimum.

d) For steel work intended to be painted only at Site, a primary coat of Red Oxide Zinc Chromate shall be given at the shop before dispatch.

3.18. Polysulphide Sealants

All Polysulphide Sealants shall conform to IS:12118 and be of approved made. Test conditions and requirements shall be as given in the above referred IS code.

4. USE, STORAGE AND HANDLING OF EXPLOSIVES

4.1. Scope of Work

(i) The specifications described hereunder relate to supply, transportation, handling, storage and use of explosives. All operations shall be carried out as per Indian Explosives Act.

(ii) A permit which allows purchase, store and use the explosives required for the works shall be obtained. Latest laws and regulations concerning storing, handling, safety and use of explosives shall be obtained, kept at site & followed.

(iii) All rules and regulation regarding the import, transport, storage and use of explosives issued by any public authority having jurisdiction in respect of the same shall be observed. All measures shall be taken to avoid injury to any person, or damage to any property and avoid accidents resulting from blasting in connection with the works.

(iv) Before firing, conspicuous red flags shall be hoisted in the area where blasting is to take place, and for at least 3 minutes prior to firing a loud siren shall be sounded. The times for blasting shall be fixed so as not to disturb other works unreasonably.

(v) If an electric ignition system is used, warning systems for thunder storms shall be installed at the blasting site and protective measures taken against ignition of charges by lightning.

4.2. Standards

(i) Transportation, handling, storage and use of explosives shall conform to the following Indian Standards or, where not covered by these Standards, to equivalent International Standards:

Indian Explosives Act

IS:4081-1986

IS:7526-1984

IS:7632-1975 (Reaffirmed 1984) IS:5878 (Part-II/Sec.I)-1970

(ii) In case of conflict between the above Standards and the Specifications given herein, the Specifications shall take precedence.

4.3. Supervision

Excavation by blasting shall be permitted only under the supervision of competent and trained workmen who are fully experienced in the work and who have received adequate instructions. It will be ensured that blasting crew is fully conversant with the rules and regulation concerning storing, handling and use of explosives.

4.4. Transportation and Handling

(i) Explosives shall not be transported to the site of operations except in suitable cases or containers which are so made as to prevent any spillage of explosives and any danger of sparks or other sources of ignition during conveyance. No explosive shall be removed from such cases or containers except when it is to be used forthwith for the purpose of the work.

(ii) Suitable Explosives Vans, duly approved by the competent authority, shall be used for transportation of explosives and detonators. The following rules shall be observed for use of Explosive Van:

(a) Vehicles shall have springs under the body. Tyre pressures shall be as per Indian Explosives Regulations.

(b) Detonators and ignitors shall not be carried in the same vehicle with explosives.

(c) Besides the driver, only one helper shall be accommodated in the Explosive Van. The vehicle carrying the explosives shall not be used to transport workmen or other materials to workspots although there may be enough space for men or materials.

(d) Drivers shall not leave the vehicle unattended while transporting explosives.

(e) All vehicles transporting explosives shall be marked or placarded on both sides and ends with the word 'EXPLOSIVES' in bold letters. All explosive boxes shall bear explosive's Lot No., Mfg. date, Expiry date etc. clearly on them.

(f) A motor vehicle carrying explosives shall not be refueled except in emergencies and that too only when motor is stopped and other precautions taken to prevent accidents. Such vehicles shall invariably have at least two fire extinguishers placed at convenient points.

(g) Vehicles transporting explosives shall never be taken into a garage, repair shop, parked in congested areas, or in a public garage or similar building.

(h) Explosives shall not be transported on a public highway during hours of darkness except in extreme emergency.

(i) Explosives shall not be transported in any form of trailer, nor shall any trailer be attached to a motor truck or vehicle hauling explosives.

(j) No transfer of explosives from one vehicle to another shall be made on any highway except in case of emergency.

(k) Persons employed in the transport or handling of explosives shall not carry with them or in the vehicles, matches, loaded fire arms, petrol or any flame-producing devices.

(l) All explosives shall be adequately protected against theft.

(m) Smoking shall be prohibited during handling and transport of explosives.

(n) The speed of the vehicle shall not exceed 25 km per hour on rough roads and 40 km per hour elsewhere.

(o) The interior of the body of the vehicle shall not have any exposed metal parts except those of copper, brass and other non-sparking metals and shall be preferably lined with wood.

(iii) Motor vehicles used for transporting explosives shall be carefully inspected daily to ensure that:

(a) Filled and serviceable fire extinguishers are in position;

(b) The electric wiring is well insulated and firmly secured;

(c) Chassis, engine and body are clean and free from surplus oil and grease;

(d) Fuel tank and feed lines are not leaking;

(e) Lights, brakes and steering mechanism are in good working order; and

(f) Vehicle is in proper condition in all respects for the safe transportation of explosives.

(iv) Boxes of explosives shall not be handled roughly or allowed to fall.

(v) Containers of explosives shall be opened only by means of non-sparking tools or instruments.

(vi) After the loading of a blast is completed, all excess explosives and detonators shall be removed to a safe location or returned at once to the storage magazine, observing the same rules as when being conveyed to the blasting areas.

(vii) Containers for detonators shall always be used only for storing detonators. (viii) Explosives and detonators shall be carried in separate containers.

(ix) The driver of the vehicle carrying explosives shall be trained in use of fire extinguishers on his vehicle.

(x) If any fire occurs on a vehicle carrying explosives, the driver shall take all practicable steps to ensure that all other traffic is stopped at least 300 m from the vehicle and that all persons in the vicinity are warned of the danger.

(xi) Loadings, unloading and handling of explosives shall be supervised by qualified personnel. At the time of loading or unloading of explosives, no electric switch shall be operated.

(xii) Explosives shall not be placed where these may be exposed to flame, excessive heat, sparks or impact.

(xiii) The covers of the explosive cases or packages shall be replaced every time after taking out part of the contents as long as any explosives are left in them.

(xiv) Explosives shall not be carried in the pockets or folds of clothing by any person.

(xv) Primers shall not be made up in a magazine, or near excessive quantity of explosives, or in excess of immediate needs.

(xvi) Nothing shall be inserted in the open end of a blasting cap except fuses.

(xvii) No person shall strike, tamper with, or attempt to remove or investigate the contents of a blasting cap or an electric blasting cap or attempt to pull out the crimped safety fuse out of a blasting cap.

(xviii) No attempt shall be made to soften hard set explosives by heating over a fire or by rolling the explosive on the ground.

(xix) The blasting powder, explosives, detonators, fuses, etc. shall be in good condition and not damaged due to damp moisture or any other cause. They shall be inspected before use and damaged articles shall be discarded totally and removed immediately.

(xx) No attempt shall be made to reclaim or use fuses, blasting caps electric blasting caps or any other explosives which have been water soaked, even if these have been dried out. The manufacturers shall be consulted for this.

(xxi) All necessary arrangements shall be made for the security of the explosives during transportation. However, the Owner, upon a request by the Contractor, may arrange protection by the Govt. security forces for large quantities of explosives, and the corresponding cost shall be borne by the Contractor.

4.5. Storage

(i) The Contractor shall provide a magazine of approved type for storing the explosives at a suitable and safe place.

(ii) The magazine shall, at all times, be kept scrupulously clean. High explosives like dynamite shall be stored in a dry, clean, well-ventilated, and fire-proof building constructed in accordance with Indian Explosives Act, on an isolated site. The area around the magazine for a distance of 8 m shall be kept clear of all vegetation and combustible matter. There shall be a barbed wire fencing and security lights around the magazine and security guards shall be posted for 24 hours to prevent loss or theft of explosives.

(iii) Explosives, detonators and fuse coils shall be stored separately.

(iv) A record of storage and withdrawal of all explosives shall be maintained. This record shall be made available to the Owner on request. The Owner shall be promptly notified of any loss or theft of explosives.

(v) Explosives shall be stored and used chronologically to ensure that the ones received earlier are used first. There shall be sufficient space between the stacks.

(vi) A "make up house" shall be provided at each working place in which cartridges shall be made up by experienced men as required for the work. All safety measures shall be ensured in the "make up house".

(vii) Unauthorised persons shall not be allowed at any time to enter the magazine.

(viii) The person-in-charge of the magazine shall, at all times, ensure that the magazine is well and securely locked.

(ix) The magazine, on no account, is to be opened during or on the approach of a thunderstorm and no person shall remain in the vicinity of the magazine during such storm. Sufficient number of lightning conductors shall be provided on top of the magazine.

(x) Magazine shoes, without nails, shall be kept at all times in the magazine, and a wood tub or cement trough, about 30 cms high and 45 cms in diameter, filled with water shall be fixed near the doors of the magazine.

(xi) Persons entering the magazine shall put on the magazine shoes provided for the purpose, and be careful not to allow the magazine shoes to touch the ground outside the clean floor.

(xii) Persons with bare feet shall, before entering the magazine, dip their feet in water, and then step direct from the tub over the barrier (if there is one) on to the clean floor.

(xiii) A brush or broom shall be kept in the lobby of the magazine for cleaning the magazine on each occasion it is opened for the receipt, delivery or inspection of explosives.

(xiv) No matches shall be allowed in a magazine.

(xv) No person having articles of steel or iron on him shall be allowed to enter a magazine. (xvi) Oily cotton rags, cotton waste and articles liable to spontaneous ignition, shall not be btaken into a magazine.

(xvii) No tools or implements other than those of copper, brass, gun metal or wood shall be allowed inside the magazine. Tools shall only be used with great gentleness and care.

(xviii) Boxes of explosives shall not be thrown down or dragged along the floor and shall be stacked on wooden trestles. Where there are white ants, the legs of the trestles shall rest in shallow copper, lead or brass bowls, containing water.

(xix) Packages containing explosives shall not be allowed to remain in the sun.

(xx) Empty boxes shall not be stored in the magazine nor let any packing material lie loose.

(xxi) Blasting caps and electric blasting caps shall never be stored in the same box, magazine or building with other explosives.

(xxii) The following shall be hung in the lobby of the magazine:

(a) A copy of these rules;

(b) A statement showing the stock in the magazine; and

(c) Certificate showing the last date of testing of the lightning conductor. (xxiii) Adequate fire-fighting equipment shall be provided in the magazine.

(xxiv) Signboards reading "DANGER HIGH EXPLOSIVES" "PROTECTED AREA" "NO SMOKING" etc. shall be conspicuously displayed in front of the magazine.

(xxv) If nitro-glycerine from deteriorated explosives has leaked down onto the floor of explosive magazine, the floor shall be desensitised by washing thoroughly with an agent obtained beforehand from the supplier of explosives. For this purpose, desensitising agents and the instructions for using them shall always be obtained alongwith the supply of nitroglycerine.

(xxvi) No explosives shall be stored in the tunnels, galleries or shafts.

4.6. Disposal of Deteriorated Explosives

All deteriorated explosives shall be disposed off in an approved manner.

4.7. Drilling

(i) The position of all holes to be drilled shall be marked out with paint.

(ii) All holes shall be of greater diameter than the diameter of the cartridges of explosives used.

(iii) Loading and drilling shall not be carried out at the same time in the same area when electric detonators are used. This will not apply in case of non-electric detonators.

(iv) A drill, bit, or poker shall not be inserted in butts of old holes even if examination fails to disclose explosives.

(v) Drilling shall not be resumed after blasts had been fired until a thorough examination has been made to make sure that there are no unexploded charges which the drills may strike.

(vi) Drilling shall not be started until all remaining butts of old holes are examined for unexploded charges.

(vii) Rock drillers shall be provided with approved respirators in sillicious dusty atmosphere arising out of drilling operations.

4.8. Loading/Charging

(i) The holes shall be cleared of all debris before a cartridge is inserted.

(ii) In loading the holes, tamping shall be done with a wooden mallet having no exposed metal parts.

(iii) Primed cartridges shall be seated by even steady pressure only.

(iv) All loaded holes or charges shall be checked and clearly located before firing.

(v) When holes are sprung, ample time shall be left between spring shots for the holes to cool and also between the last springing shot and the loading of the main charge.

(vi) When practicable, no more cartridges shall be primed than are required for a round of blasting.

(vii) Detonators shall be inserted only in a hole in the end of a cartridge prepared specially for that purpose.

(viii) Holes in cartridges shall be made with a sharpened wooden stick.

(ix) All charges, before being fired, shall be covered with blasting mats where blasting is done in the vicinity of structures likely to be injured by flying debris.

(x) Detonating cord shall be cut from supply reel before attaching to explosive or tamping in hole. Use of the short pieces of fuse shall be prohibited for detonation purposes.

(xi) No welding shall be done inside the tunnel/cavity at the time of loading of the face, till the blast has been taken. However, if tunnelling face is 500 m away from the point where welding is done with proper earthing this will not apply.

(xii) Naked flames and lamps shall be kept away at the time of loading of holes.

(xiii) Such of the electrical lines as could constitute danger for work of loading/charging shall be removed from the site.

(xiv) Highly insensitive caps shall be used in case parasite electric current are anticipated within the ground and if lightning is frequent.

4.9. Wiring

(i) All electric caps in a blast shall be of the same manufacture.

(ii) Each electric blasting cap shall be tested with an approved galvanometer before and after tamping in a hole to determine whether it will carry the current. All testing shall be done away from the heading face.

(iii) After testing the leg wires of electric blasting caps, they shall be short circuited by twisting the bare ends together and shall remain so twisted until ready to be connected into the circuit prior to connecting to the firing line.

(iv) Unless, the power supply is heavy, it is recommended that all electric blasting caps shall be wired in series and the firing line shall not be smaller than No. 14 B.S. guage copper wire.

(v) The number of electric blasting caps used in a circuit shall not exceed the tested capacity of the blasting machine.

(vi) The circuit, including all caps, shall be tested with a circuit tester or galvanometer, operating accurately, before being connected to the firing line.

(vii) Cartridges shall not be primed nor holes loaded during the approach of a thunderstorm or while it is in progress. If a charge has been primed or holes loaded, every person shall be ordered to a safe distance until the storm is over.

(viii) Blasting circuit wires shall never touch other wires carrying electric current.

(ix) Blasting operation control shall consist of two switches, a safety switch and a firing switch located at least 2 metres apart, the connection between the switches to be made by a 'Plug-in' jumper which may be permanently attached to the safety switch. The 'Plug-in' jumper is to be so made that it cannot be plugged into or connected to the firing switch until the firing switch is unlocked, and the jumper must be disconnected from the firing switch before the firing switch can be locked.

(x) Both the safety switch and the firing switch shall be of the locking, double pole, double throw type which, when opened and locked in downward position short circuit and ground the leading wires.

(xi) Both the switches shall be locked immediately after firing the shot and before any person is allowed to return to the area. Keys to the switches shall remain in the possession of the Blaster at all times.

4.10. Firing

(i) Shots shall, so far as practicable, be fired electrically and only apparatus especially designed for the purpose shall be used. Power lines shall not be tapped for the purpose. No shot shall be fired except by a licentiate blaster.

(ii) The charges shall be fired, successively and not simultaneously.

(iii) Prior to the firing of a shot, all persons in the blasting area shall be warned of the blast and ordered to a safe distance from the area.

(iv) Competent flagmen, equipped with red flags and whistles shall be posted to stop traffic at access points on each possible route of travel, to the vicinity of the blasting area.

(v) Open area blasting shall be done at fixed hours approved by the Chief Executive of PMC and the blasting times shall be displayed on a Notice Board.

(vi) Order to fire shall be given only by the supervisor-in-charge of the work after giving three warning signals to enable all the workmen to reach safe shelters.

(vii) Blasts shall not be fired until it is absolutely certain that every person has retreated to a safe distance.

(viii) The Person-in-Charge of blasting shall be the last one to leave the area to be blasted.

(ix) A bugle with a distinctive note shall be used to give warning signals. This bugle shall not be used for any other purpose. All the labour shall be made acquainted with the sound of the bugle and shall be strictly warned to leave their sites of work immediately for safe shelters at the first warning signal and not to leave the shelters till all clear signal has been given.

(x) An all clear signal shall be given when the blasting is over.

(xi) Definite places of shelter, natural or artificially constructed, shall be assigned to the crew. Workers shall be made to go to these shelters rather than trust each other judgement about a safe place.

(xii) Blasting for underground excavation shall be carried out without any restriction of fixed time after taking proper safety precautions.

(xiii) Supervisor-in-Charge shall be responsible for the safe custody of the firing apparatus. (xiv) For blasts in series, only detonators of the same brand and same electrical resistance shall be used. All detonators shall be checked before use.

(xv) The firing cables shall be with a proper insulating cover to avoid short circuiting due to coming in contact with water, metallic parts of rock.

(xvi) Use of earth as a return line shall not be permitted.

(xvii) The firing cable shall be connected to the source of current only when nobody is in the area of blasting.

(xviii) Mats or rubber tyres tied together with rope shall be used as protection from flying debris to cover the charges where blasting may expose persons or property to injury or damage.

(xix) Blasting shall be permitted only after adequate provisions have been made for the protection of persons, the works, and public and private property.

4.11. Inspection after Blasting (Misfire Drill)

(i) Immediately after a blast has been fired, the firing line shall be disconnected from the blasting or other source of power.

(ii) After a blast has been fired, a careful inspection shall be made by the blaster to determine if all charges have been exploded. The blaster shall count the number of the exploding shots in blasting. Misfires in fuse blasting shall not be examined for a sufficient time after its failure to explode. Electric blasting misfires shall not be examined for at least 15 minutes after failure to explode. Other persons shall not be allowed to return to the area of blast until an "All Clear" signal is given.

(iii) All wires shall be carefully traced and search made for any unexploded cartridges by the person-in-charge of the blasting operation.

(iv) Loose pieces of rock and other debris shall be scaled down from the sides of the face of excavation and the area made safe before proceeding with the work.

4.12. Misfires

(i) Misfired holes shall be placed in the charge of a competent person.

(ii) If broken wires, faulty connections, or short circuits are determined as the cause of a misfire, proper repairs shall be made, the firing line reconnected, and the charge fired. This shall be done, however, only after a careful inspection has been made of burdens remaining in such holes and no hole shall be so fired when the burden has been dangerously weakened by other shots.

(iii) The charge of explosives from a misfired hole shall not be drilled, bored or picked out.

(iv) Misfired charges tamped with solid material shall be detonated by the following method:

(a) Float out the stemming by use of a water or air jet from hose until hole has been opened to within 60 cm of charge;

(b) Water shall be siphoned off or pumped out;

(c) New charge shall be placed and detonated. Whenever this method is not practicable, then a new parallel hole, not nearer than 60 cms, shall be drilled, loaded and detonated. A careful search shall be made of unexploded material in the debris of the second stage.

(v) If misfire has been found to be due to defective detonators or dynamite, whole quantity or box from which the defective article was taken must be withdrawn from the work site.

(vi) All cases of misfire causes of the same and steps taken in connection therewith shall be recorded.

4.13. Blasting for Underground Works (Foundation Gallerys)

(i) Only electric blasting shall be adopted for tunnel & shaft.

(ii) A separate circuit, independent of power and light circuits, shall be used for blasting.

(iii) No electrically energised circuit shall be installed on the same side of the tunnel, shaft with the blasting circuits.

(iv) All electric lights or other energised circuits shall be disconnected for at least 70 metres from the point of loading.

(v) All rail tracks, airlines and vent pipes shall be kept properly grounded.

(vi) For loading purposes, the employees shall be equipped with permissible battery lamps.

(vii) Switches shall be as specified in this tender document. The safety switch and the firing switch shall be placed on opposite sides of the tunnel/cavity.

(viii) Only explosives, which produce less than 0.005 m^3 of poisonous gas - (carbon monoxide and hydrogen sulphide) per 1.25" x 8" cartridge shall be used for underground work.

(ix) No fire, flame, smoking or open lights shall be allowed within 6 metres from any explosive except for the purpose of firing a charge.

(x) Adequate warning notices shall be given to all persons employed indicating the period of danger at the time of firing and adequate shelters or screens for protection of workers exposed to risk of injury from the explosion or from flying material shall be provided.

(xi) After the blast takes place in underground works the workmen shall not be allowed to go to the face till all the toxic gases are evacuated from the face.

4.14. Underwater Blasting

i) Only water-resistant blasting caps and detonating cord shall be used in underwater blasting operations.

(ii) Loading tubes and casings of dissimilar metals shall not be permitted because of possible electrical transient current from galvanic action.

(iii) When more than one charge is placed underwater, a float device shall be attached to an element of each charge in such manner that it will be released by the firing.

(iv) No drilling, digging or excavation shall be permitted until all misfires have detonated or the explosives are removed from the missed holes.

5. WATER CONTROL

5.1. Diversion and Control of Water During Construction

5.1.1. General

(a) The Contractor shall design, construct and maintain all permanent and temporary diversion and protective works which are necessary for the prevention of surface drainage and groundwater entering the various parts of the Works and, where necessary, settling ponds and other associated works to prevent pollution in accordance with the relevant requirements of the Contract.

(b) Diversion and protective works shall comprise, but are not necessarily limited to tunnels, river diversions, temporary river crossings, coffer walls, channels, flumes, conduits, drains, pumps. The location of these works shall be such that there is no encroachment on any area required for construction of the Works.

(c) On completion of the Works all temporary diversion and protective works shall be removed and disposed of or shall be levelled in a manner to give a pre-construction appearance, and so as not to interfere in any way with the operation or usefulness of the Works. Areas affected by such works shall be reinstated, unless otherwise approved by the Employer, in accordance with the Contract.

5.1.2. Dewatering

(a) The Contractor shall design dewatering systems and shall furnish, install, maintain and operate all necessary pumping, piping and other equipment and temporary structures for dewatering and maintaining the various parts of the Works free from water during construction and, as required, for inspection, safety and installations by other contractors or the Employer.

(b) Control of water in underground excavations shall be in accordance with relevant Sections of this Technical Requirements.

5.1.3. Precautions

5.1.3.1. INTERFERENCE WITH RIVERS AND STREAMS

The Contractor shall not interfere with the natural flow of rivers or streams on the Site for any purpose without prior approval from the Employer.

5.1.3.2. RESPONSIBILITY FOR WORKS

(a) The Contractor shall be fully responsible for any damage or delay to the Works caused by failure of the diversion and protective works and/or dewatering installations and shall indemnify the Employer against claims by landholders or other persons, arising out of any such failure

(b) The Contractor shall be responsible for, and shall repair or reinstate, any damage to foundations, excavated slopes or any other parts of the Works caused by the failure of the diversion and protective works and/or dewatering installations.

6. OPEN EXCAVATION

6.1. Scope of Work

(i) The specifications described hereunder relate to the excavation work for all surface structures and shall include all labour, construction plant and equipment, materials and all of the work required for the satisfactory completion of this activity in accordance with the stated specifications and applicable standards. They also include drilling and blasting, loading and hauling and dewatering whereever necessary.

(ii) These specifications cover the performance of all open excavations required for the Works. The excavated material shall be transported and used in the works or disposed off in spoil areas identified and specified for this purpose.

6.2. Classification

(i) Open excavation shall be classified as in soil or in rock.

(ii) Open excavation in soil shall be defined as removal of material which can be efficiently excavated without the use of explosives or which does not require ripping by a bulldozer CAT-D8, or equivalent, equipped with a single tooth ripper. Removal of boulders, having a volume exceeding 1 m3, shall be considered as excavation in rock.

(iii) Open excavation of any other material where explosives and/or ripping equipment, as defined above, have to be used will be termed as excavation in rock.

6.3. General

(a) Setting out

(i) Permanent reference marks shall be established at suitable points on reference lines (e.g. centre lines), as may be necessary. Suitable bench marks shall also be established.

(ii) As the work progresses, reference line marks shall be made on pegs, inserted at convenient intervals for checking alignment, grades, levels, etc. Sufficiency and accuracy of all such bench marks and reference points shall be ensured.

(b) Accuracy of Alignment, Grades and Levels

(i) Bench marks and fixed reference points with the value of the levels and the co-ordinates, shall be fixed in the work areas. The plans showing the position, co-ordinates and the levels of the salient points shall also be prepared. Permanent points and bench marks in relation to these shall also be established.

(ii) The survey group shall take all precautions to ensure that the points are not disturbed during working and damage caused, if any, is promptly made good.

(iii) Facilities like labour, instruments and general co-operation shall be provided to the Owner to check alignments, grades and levels at any time.

(iv) Any discrepancy or error detected during the course of excavations and/or at the end of work shall be set right by the Contractor, in a satisfactory manner.

(c) General Performance

(i) All excavation shall be performed with due regard to safety requirement by approved methods to the lines and grades shown on the Drawings. The Contractor shall be solely responsible for the safety of the works.

(ii) All excavation areas shall be provided with adequate drainage arrangements for collection and disposal of water from whatever source.

(iii) Where excavated materials of specified type or quantity are to be used in the works, these shall be removed in a separate operation if overlying or bedding material is of other type or quality.

(iv) All safety procedures and requirements shall be complied with.

6.4. Clearing and removal of top soil

(i) Where shown on the Drawings or as otherwise required at site, clearing shall be carried out. Such clearing shall comprise removal and disposal of all trees, saw timber, bushes and other vegetation, as the case may be. Saw timber shall be stacked outside working areas, and other removed material shall be disposed off in dumps and, if possible, be burnt.

(ii) Top soil shall be excavated separately from the underlying material and stockpiled for landscaping purpose at a later stage.

6.5. Execution

6.5.1. General

(i) Excavation shall be made to the lines, grades and dimensions shown on the Drawings. Any additional excavation executed by the Contractor by mistake or for his own purposes shall be back filled and compacted with suitable material at no additional cost to the Owner.

(ii) The excavated slopes, drainage, trenches and prepared foundations shall be maintained as shown on the Drawings.

(iii) The area of open excavation shall, where it is considered that clearing is necessary, be cleared of all trees, bushes, rubbish and other objectionable matter and the materials so removed, shall be burnt or otherwise disposed of.

6.5.2. In Soil

(i) The dimensions of complete excavations and the suitability of foundation areas to receive fill, concrete, etc. shall be as specified in the Drawings. Unsuitable foundation materials shall either be further excavated or stabilized.

(ii) The toe of excavation slopes in soft strata shall normally not be closer than 3 m from any structure. Where slopes in soft material adjoin rock cuts there shall be a berm not less than 3 m wide.

(iii) The side slopes in excavation shall be as shown on the Drawings.

(iv) Every precaution shall be taken to prevent slips. In case slips occur, the slipped material shall be removed to the designed (modified) slope.

(v) Temporary berms shall be left at appropriate places with necessary approach ramps and sump pits for installation of dewatering pumps or other purpose, as required by the Owner. These shall be excavated and the excavation finished to lines and grades shown on the Drawings.

6.5.3. In Rock

(i) The open cut excavation shall be staged as shown on the Drawings.

(ii) The excavation of open cut rock slopes shall be carried out utilising the controlled perimeter blasting technique wherever required.

(iii) Where depth of open rock excavation is more than 10 m, the excavation shall be carried out in a descending way, from horizontal berms, by benching.

(iv) After scaling and prior to the excavation of the next bench, the rock bolts shall be installed and wiremesh, shotcrete and temporary relief holes if considered necessary as shown on the Drawings shall be provided.

(v) All blasted rock shall be removed from the bench toe before undertaking further work.

(vi) Rock surfaces exposed in excavations which slope steeply shall be adjusted by means of controlled blasting.

(vii) Where specifically indicated or considered necessary, the use of explosives shall be discontinued and excavation completed by line drilling, breaking, wedging or barring or other suitable methods.

(viii) Blasting within 30 m of concrete will be permitted only after concrete is 7-day old. Blasting within 30 m of grout will be permitted only after grout is 3-day old.

6.5.4. In Shear Zone

(i) Dental excavation shall include the removal of unsuitable material from shear zones clay seams, pockets, joints, or from spaces between boulders beyond the lines of excavation shown on the Construction Drawings or established in the field, which are too small to be excavated by common earth moving equipment.

(ii). Dental excavation, depending on its extent, will require the use of a backhoe, hand tools, or other small excavating equipment, as well as the use of a high velocity air water jet. The methods employed shall be such as to avoid fracturing of the rock adjacent to the material being removed.

(iii). Dental excavation shall be performed where directed. The extent, to which such material shall be removed, including the depth, direction, and dimensions of the work, will be determined by the Engineer-in-Charge. In general, however, excavation into cracks or seams shall be to the depth that is a minimum of three times the seam width, and such excavation shall be backfilled with concrete or shotcrete. No blasting will be permitted.

6.5.5. Drainage of Slopes

(i) Temporary drainage shall be provided at the toes of all slopes in rock. Adjoining berms shall fall to the drains and provisions shall be made to conduct all water away from the excavation.

(ii) Seepage water from springs or rain water shall be suitably collected and drained away by gravity, wherever it is possible to do so. Where, however, drainage by gravity is not feasible, pumping should be resorted to.

6.5.6. Excavation for Foundation of Structures

(i) While carrying out excavation for the foundations of the structures, if it is considered necessary for a particular work, the sides of the loose excavation shall be shored and strutted to ensure safety.

(ii) After completion of the soil excavation, the rock excavation in foundations of structures shall be carried out to the depths as shown on the Drawings. At all stages of excavation, precautions shall be taken to preserve the rock below and beyond the lines of required excavation. The quantity and strength of explosives used in the foundation excavation in rock in various locations shall be such as will neither damage nor crack the rock outside the limits of excavation.

(iii) As the excavation approaches its final lines and is within 300 mm to 600 mm of the specified foundation levels, the depth of the holes and the strength and quantity of explosives shall be progressively and suitably reduced so as to ensure that the rock profile beyond the lines and levels specified on the Drawings shall remain undisturbed. If required by site conditions, this excavation shall be carried out by line drilling.

6.5.7. Excavation Cleanup and Preparation of Foundations

(i) After completion of excavation of foundations, trimming for the final removal of all dummy rock or loosened mass, shall be done by chiselling, barring and wedging.

(ii) Any weathered or decomposed rock remaining shall be removed. Open fissures, joints, crevasses and any other doubtful areas shall be cleaned to a suitable depth and to firm rock on sides.

(iii) All rock surfaces of the excavations shall be washed.

(iv) Final washing of any section of the work prior to concreting or application of shotcrete shall be carried out only when the blasting for the excavation and removal of projections inside the neat lines has been completed.

(v) Final washing prior to concreting shall be done by directing a stream of water at a pressure of about 8 to 10 bars on the rock surfaces from a distance of 1.5 m through a nozzle of 18 mm diameter so as to remove all loose rock, fragments, dust and debris from the surfaces.

6.5.8. Backfill

(i) Backfill shall consist of approved materials and shall be placed in locations as shown on the Drawings.

(ii) Earth fill, which, on account of its nature or locations requires no compaction, shall be classified as backfill.

(iii) Backfill which shall be compacted by means of roller, mechanical or manual tampers is classified as compacted backfill.

(iv) At locations, where areas to be backfilled are too small or confined, compaction by hand or by the use of rammers may be allowed.

(v) Only suitable materials obtained from excavation shall be used for backfill and construction of such features as coffer dam, embankment, guide bunds, afflux bunds and similar structures.

(vi) Material to be used in backfill shall be free draining type.

6.5.9. Surface Treatment of Cut-slopes in Open Excavation

(i) Cut-slopes in open excavations shall be provided with surface treatment where required.

(ii) The treatment of cut-slopes in rock will depend on the quality of rock and shall normally comprise rock bolts, dowels and shotcrete or any combination thereof.

(iii) The extent of the bolting and dowelling will depend on the joint systems encountered which also will govern the need of shotcrete. The direction of bolts and dowels shall be chosen with due regard to the predominant joint system. Before decision on the required support of a specific portion is taken, geological mapping and classification shall be made. The classification of the rock shall be determined by changes in the ground conditions.

6.5.10. River Diversion Works

The purpose of the river diversion works is to temporarily divert water flow through Diversion pipe on the left Bank to enable the construction of Dam and appurtenant structures i.e. the Dam, energy dissipation arrangement, intake structure etc. in dry foundation conditions. Access to the Divrsion Pipe Inlet and Outlet have been envisaged by construction of Roads as shown in the Tender drawings.

Design discharge for river diversion works is 19.36 cumec (Minimum) which is 1 in 100-year non-monsoon flood. The complete river diversion works is envisaged in one stage. As a minimum, it is anticipated that the river diversion works shall comprise:

- Construction of upstream cofferdam as shown in the Tender drawings;
- Construction of Diversion Pipe as shown in the Tender Drawings.

7. UNDERGROUND EXCAVATION

7.1. Scope of Work

The specifications described hereinunder relate to the excavation work for the underground structures and shall include all labour, materials, construction plant and equipment, all drilling and blasting, loading, transporting and disposal of materials in spoil or stockpile areas as well as the removal of all loose material and cleaning of excavated surfaces. The work shall be done by conventional method of drill and blast or by shaft driving method or, in exceptional cases, by manual means.

7.1.1. Classifications

Underground excavation shall be classified as rock excavation in all types of rocks irrespective of their geological formation and states.

Documentation in the form of maps and / or photographs showing the pertinent geological features, as observed at the tunnel portion opened up after each blasting operation shall be prepared and recorded for reference as and when required.

The classification of rock will be as per Barton Q-System (2002)

7.1.2. Definitions

(i) Conventional Excavation

Excavation performed by conventional tunneling and shaft driving methods using drilling and blasting or by manual means.

(ii) Heading Face

The advance end or wall of a tunnel, shaft at which the work is progressing.

(iii) Heading Zone

Heading zone refers to tunnels (upstream and downstream headings) and shafts (vertical or inclined) with upward heading, excavated by conventional method (drilling and blasting) and is defined as a zone between the newly established face and the distance of 5 m behind that face, measured along the tunnel or shaft Centre- line.

(iv) Bottom Range Zone

Bottom range zone in the vertical shafts excavated by downward sinking is defined as a zone between the newly established floor and 1 m plus the length of the previous round above it, regardless of shaft diameter.

(v) Rear Zone

Rear zone is the whole length of tunnel or shaft between the heading zone and the portal.

(vi) Crown

Crown is the top arch of the tunnel up to the springing line.

7.1.3. General

(i) Excavation shall be made to the lines, grades and dimensions shown on the Drawings.

(ii) All safety procedures and requirements shall be complied with.

(iii) The excavation shall be performed by such methods, and in such a manner, as will leave stable, regular surfaces with a minimum of overbreak.

(iv) Sufficiently before the commencement of any blasting operation, the detailed drilling patterns showing the spacing and the diameter of drill-holes, as well as the type and magnitude of charges, type of ignition, etc. shall be prepared. Similarly, the plans for blasting adjacent to completed structures, outlining the measures to be taken for avoiding damage from vibration or fly-rock shall be prepared.

7.1.4. Excavation Lines and Tolerances

(i) Typical cross sections, excavation lines, and dimensions of excavations will be shown on the Drawings.

(ii) The minimum excavation, as shown on the Drawings, is the line within which no rock material will be permitted to remain.

7.1.5. Supports for Underground Excavation

(i) The provisional or permanent supports for the underground excavation shall principally consist of shotcrete (possibly with wire mesh), fibre reinforced shotcrete, individual or pattern rockbolts and dowels. Structural steel supports shall be used only when required by the rock conditions.

(ii) Support systems shall be as shown on the Drawings or necessitated by rock conditions, as approved.

(iii) The required supports shall be installed without delay during the process of excavation within the heading zones. In the rear zones additional supports shall be installed immediately after it is observed that the supporting system previously installed is not sufficient to prevent further loosening of the material surrounding the excavation.

(iv) Shotcrete, with or without steel wire mesh or fibre reinforced, shall be applied to excavated surfaces. It shall be taken into account, in the construction planning, that placing of shotcrete support may be required immediately after blasting a round in conventional method of drill and blast but before mucking is started.

(v) Structural steel supports, rockbolts, dowels and wire mesh shall be installed.

(vi) The use of timber will not be permitted for tunnel supports in any form, not even for temporary purpose.

(vii) All necessary constructional plant and equipment for installing rockbolts, dowels and shotcrete shall be kept at site, ready for operation in the excavation heading zones during the entire excavation period.

(viii) Proper and safe excavation including the provision of extra supports and special protection for the personnel when the conditions so require shall be ensured.

7.1.6. Primary Stabilisation of Underground Excavation

(i) Reinforcement of rock by means of dowels, bolts, etc. shall be performed with types, lengths and spacings as shown on the Drawings or as required, on account of the field conditions encountered.

(ii) The steel reinforcement for the shotcrete and concreting will be provided as shown on Drawings and as per site requirements mutually agreed to.

7.1.7. Probe Holes

(i) A probe hole, wherever required, shall be drilled by percussion drilling ahead of the tunnel or shaft excavation to determine, in advance, the nature of the material to be excavated and the presence of water and gases etc.

(ii) The drilling of the probe hole wherever required, shall be included in a normal pattern of drilling the blast holes. The length of the probe hole shall be at least 10 m between the tunnel face and the bottom of the probe hole.

(iii) Based on the probe hole information, assessment of the expected material to be encountered shall be made without delay.

(iv) Should the probe hole indicate the presence of excessive water ahead of the excavation face, appropriate precautions such as grouting, draining, or any other and suitable measures as necessary to facilitate excavation shall be taken. Similarly, suitable measures to deal with any gases or zones or weakened rock which may be encountered shall be taken. All measures deemed necessary shall be recorded immediately after probe hole information becomes available.

(v) The location and direction of probe holes for tunnels shall be varied to take account of the actual geological conditions.

7.1.8. Forepoling

In areas where it is deemed that the stand-up time may be limited, a method statement for stabilisation which shall include such measures as shotcreting, forepoling, spiling, etc. shall be prepared by the Contractor.

7.1.9. Support System

The primary stabilisation support system shall be on the basis of convergence measurements, rock quality and rock stress tests carried out in the tunnels during excavation. The design of the systems shall be as shown on the Drawings. However, the support system, as specified may be modified to suit local ground conditions and experience gained during tunneling works. Deformation measurements shall be carried out in order to determine when strengthening works shall be needed and to verify if the selected support system is adequate or shall be modified.

7.1.10. Execution

7.1.10.1. GENERAL

(i) Prior to the commencement of underground excavations for tunnels, or shafts, a reinforced concrete portal with steel ribs with concrete shall be constructed as per Drawings in order to provide a good abutment for the rock stress released during the initial excavations. Tunnel excavation shall not be started until the exposed rock faces in the portal area have been stabilised with rock support and drainage measures have been implemented.

(ii) All rock material projecting inside the minimum excavation line shall be removed.

(iii) All loose rock shall be scaled and disposed of in the approved dump areas.

(iv) The progress of excavation shall be checked constantly by means of Laser Survey in order to avoid any substantial rectification of the already opened profile and eventual rearranging of the installed rock supports.

(v) Where excessive inflows of water occur at the heading face, all appropriate measures shall be taken to execute the excavation work safely and properly, including provision of extra supports and protection of workmen, and deployment of any special equipment necessary for working in waterlogged conditions. Temporary spouts and drain pipes shall be installed to channel the water down to the floor of the tunnel and dispose of it.

(vi) When deemed necessary long exploratory drilling (other than probe holes) with core recovery will be carried out.

(vii) Sheared or shattered rock zones, foliation shears, thick joints with gouge or other thick discontinuities may be encountered during excavation. Wherever shear zones and poor rock bands are encountered along the tunnels or shafts, adequate methods of rock supports e.g. shotcrete combined with rock bolting and lattice girder / steel rib may be adopted at once to avoid or minimise any cavity formation.

7.1.10.2. METHOD OF EXCAVATION

The excavation of the tunnels and shafts shall be carried out by conventional method of drill and blast. Sequence of excavation to achieve the desired profile giving full details of the method, including design of the support system, shall be charted.

7.1.10.3. CONVENTIONAL EXCAVATION (DRILLING AND BLASTING)

(i) Drilling and blasting techniques which will produce a smooth final profile, a minimum of overbreak and a minimum of fracturing of the rock beyond the required excavation lines shall be established by trial blasts. The techniques used shall be tested repeatedly to substantiate the proposed methods of blasting.

(ii) During the progress of excavation, the drilling and blasting pattern, specifically the number and depth of holes, quantity, quality and distribution of explosives, shall be varied as necessary to suit the rock conditions encountered, taking into considerationthe information obtained from the probe holes, the actual drilling work (velocity, colour of rinsing water, etc.), as well as the previous blasting results.

(iii) Only wet drilling will be permitted in order to reduce dust in the underground excavations.

(iv) Perimeter drill holes shall be placed such that the over excavation beyond the minimum excavation line is minimised. The spacing of holes shall not exceed 50 cm. Utmost attention shall be paid to obtain a smooth and uniform excavated surface.

(v) Should a substantial part of “half barrels” not be visible after each round of blasting, the blasting pattern shall be adjusted and the results shall be reviewed.

(vi) The depth of a new round shall never exceed that which was determined and approved prior to commencement of blasting. The depth of the round may be reduced if the actual rock condition requires it.

(vii) No new round shall be blasted until the supports required within or behind the heading zone have been installed.

(viii) All loosened material that is likely to fall shall be removed immediately following blasting, at frequent intervals during the progress of the work, and finally during the clean-up prior to placing the final tunnel lining.

(ix) After excavating, the tunnel invert surface shall be adequately protected from damage caused by the construction traffic. Any material used for such protection shall beremoved prior to placing the tunnel lining.

7.1.10.4. INTERSECTION OF TUNNELS

(i) Special precautions shall be taken at the intersections of the tunnels with adits. The rockbolts may require specific orientation as indicated in Drawings.

(ii) At the intersection of tunnels with shafts, the roof zone of the tunnel shall be stabilised in advance by several row of closely spaced rockbolts around the perimeter of the shaft combined with mesh reinforced shotcrete. As soon as the intersection of the tunnels with shaft is excavated, rockbolts and lattice girder/steel ribs shall be installed, as required, and shotcrete placed as shown on the Drawings.

7.1.10.5. FEELER HOLES (ADVANCE PROBE HOLES)

Where required, a percussion drilled feeler hole (advance probe hole) shall be drilled ahead of the tunnel face to probe the ground conditions ahead of the advancing tunnel. The drilling shall be made to such a depth that after blasting of a new tunnel round, the distance between the tunnel face and the bottom of the feeler hole shall be at least 10 m. The location and direction of feeler holes for tunnels shall be varied to take account of the actual geological conditions.

7.1.10.6. TREATMENT OF ZONES OF UNSTABLE ROCK ADJACENT TO THE TUNNEL FACE

(i) When a zone of suspected unstable rock or major water inflow has been encountered adjacent to the tunnel face, further exploratory drilling shall be made in an attempt to establish the character and extension of the zone.

(ii) Based on the findings, a method statement shall be worked out. The method statement shall establish the procedure of excavation, assess the type and extent of primary stabilisation required and decide whether or not pre-treatment of the zone is required before tunnelling may resume.

(iii) Pre-treatment of a zone may be required primarily if major water inflow has been encountered. In such instances, drainage of the zone shall normally be carried out to release water pressure. When the water inflow abates, grouting ahead of the tunnel face may be required in order to tighten the rock.

7.1.10.7. CLEANING OF EXCAVATED SURFACES

(i) Even prior to the removal of the bulk of the material loosened by blasting the newly exposed rock surface shall be cleaned of rock fragments, dust and debris to permit, if required, the application of the first layer of shotcrete. However, geological mapping and inspection shall be carried out before the rock surface is shotcreted.

(ii) If required, cleaning may include water jets and/or compressed air. Rock which is prone to quick disintegration, swelling, heaving, or is interspersed with clay filled fissures shall be cleaned with compressed air only.

7.1.11. Controlled Blasting

7.1.11.1. GENERAL

(i) Where especially undisturbed and smooth excavation surfaces are required, controlled blasting may be performed by means of smooth blasting.

(ii) Controlled blasting can also be performed as pre-splitting. Where contour blasting is prescribed, the collaring and alignment of the drill holes shall be made with special care to ensure a good result. The deviation in collaring of the holes in relation to the bottom of holes in the previous round shall be kept at an absolute minimum and the error in alignment shall not exceed 5 percent of the depth of the holes.

(iii) Controlled blasting, carried out as smooth blasting, shall be used for excavation of tunnel roofs and walls and will normally also be required for limitation of overbreak at open cut rock walls against which concrete is to be poured.

7.1.11.2. PRE-SPLITTING

(i) Presplitting consists of drilling a single row of closely spaced holes along the final excavation perimeter. These holes are lightly charged and simultaneously detonated before the main blast, to produce a pre-split crack which limits the propagation of cracks from the subsequent main blast, and in such a way reduces damage in the rock beyond it. The blasting of the main excavation zone requires a reduced explosive charge in the line of holes nearest to the presplit line, and a limit on the distance between the presplit line and the nearest line of main blast holes. The presplit holes shall be drilled deeper than the depth of the round.

(ii) Pre-splitting implies that closely spaced contour holes are fired ahead of the rock mass which is blasted through subsequent delays.

(iii) The spacing and charging of holes shall be in accordance with established procedures.

7.1.11.3. SMOOTH BLASTING

(i) Smooth Blasting consists of drilling a number of closely spaced holes along the final excavation perimeter, placing light charges in the holes and detonating the charges simultaneously after the main blast. The outer line of drill holes for the main blast is set at an approved distance inside the final perimeter leaving an annulus of rock to be peeled off the final excavation perimeter by the smooth blast

(ii) Smooth blasting implies that the contour holes are closely spaced and lightly charged. The ratio between the spacing of contour holes and the burden holes shall be less than 0.8.

(iii) The ignition pattern shall be made in such a way that the contour holes have free breakage at the detonation, and all contour holes shall, as far as possible, be fired with the same detonator number. Charging of the stopping holes close to the contour holes must be made with care in order not to harm the result of the smooth blasting.

7.1.12. Tunnel Facilities

7.1.12.1. GENERAL

Details of systems for supply of water, compressed air, lighting, disposal of water, ventilation, etc., shall be worked out prior to starting the different tunneling works.

7.1.12.2. VENTILATION

(i) Suitable and adequate ventilation system shall be provided and maintained at each working front in the tunnels.

(ii) After installation, the ventilation ducts shall be checked at regular intervals and any damage that might decrease their efficiency shall immediately be repaired. Spare ducts and spare fans shall be available on site for this purpose. Diesel engines working underground shall be regularly checked and be kept well-adjusted so that harmful substances in the exhaust shall be kept to the minimum. Petrol engines shall not be permitted to work underground except where absolutely necessary.

(iii) Measurement of gas pollution in the tunnels shall be regularly taken in order to detect early the presence of carbon monoxide, nitrogen dioxide, methane and other harmful or flammable gases. If flammable gases are encountered, all construction work in the tunnel shall stop and all personnel shall be evacuated until all of the flammable gases have been cleared out by the ventilation system.

(iv) It will be ensured that pollution percentages are kept within limits of internationally recognised standards.

(v) Satisfactory ventilation shall be maintained as long as any work, including erection of Permanent Plant, is being carried out in the area.

7.1.12.3. COMMUNICATION SYSTEM

An efficient communication system between each heading face and entrance to the tunnel, shaft shall be installed and operated.

7.1.12.4. ELECTRICAL EQUIPMENT

All electrical equipment used underground shall be grounded to an approved installation extending throughout the underground workings and connected to ground outside the tunnel portal. All electrical fittings shall be waterproof and spark proof. Electrical equipment and systems shall conform to the applicable Indian Standards.

7.1.13. Geological Mapping

(i) Concurrently with excavation, the geological conditions along all tunnel(s), and shaft(s) shall be mapped.

(ii) Tunnel cross sections to be taken at every one-meter interval to determine the undercuts positions clearly to avoid dealys during lining.

(iii) This mapping and related information, alongwith the rock mechanics test results, will be used in design of the final lining for the tunnel(s) and shaft(s).

7.1.14. Disposal

(i) Excavated material not required for the works shall be disposed of in spoil tips within areas shown on the Drawings or elsewhere as agreed with the Owner. Excavated material to be used at a later stage for the works may be temporarily stockpiled outside the delimited spoil tips.

(ii) Any materials arising from the excavations, unless approved by the Owner shall not be sold or carted away from the site. While building up the spoil tip, it shall be graded to reasonably even surfaces with safe slopes. When a spoil tip has been filled up to its final elevation, the top surface shall be graded to a slight inclination in order to facilitate proper run off of rain water and the top edge of any slope shall be smoothly rounded off. Surfaces exposed to water level variations shall be protected against erosion by means of suitable materials. Temporary stockpile areas and dumps shall be cleaned.

(iii) All materials from underground excavation suitable for use as fill, concrete aggregates or for other purposes shall be stockpiled at approved locations if immediate use is not possible.

(iv) Excavated materials which are not suitable for construction and those in excess of the requirement for construction shall be disposed of in the waste disposal areas as shown on the Drawings. Surfaces of material so disposed of shall be trimmed to regular lines and grades. Disposal of all materials shall be such that it will not interfere with natural drainage or drains will be constructed to prevent the undesirable accumulation of water in or around the disposal area.

(vi) It shall be ensured that no excavated materials is disposed of in the streams or at locations where these materials are likely to be washed away by the floods.

8. SURFACE PREPARATION AND TREATMENT

8.1. Scope of Work

Works under this Section include all labour, materials, tests, equipment and services required to prepare excavated surface as foundation to receive the overlaying concrete, shotcrete or any other material for constructing the structure above or to render competent, safe and secured surface. This also includes any special treatment required for unfavourable geological conditions such as shear zones encountered during excavation.

8.2. Execution

(i) Machine cleaning of the invert of all excavation shall be carried out as carefully as possible using mechanized equipment. Where so required, the inverts shall be further cleaned using hand-tools, jack hammers and air or water-jets.

(ii) Scaling, involving the removal by hand tools of loose rock from excavated walls and roofs, shall be performed immediately after blasting, and at intervals thereafter, as necessary to prevent accidents. A complete final scaling of the excavation surfaces which are not to be covered up shall be carried out with hand-tools before the respective areas are taken into use.

(iii) Final scaling of rock surfaces in machinery hall and transformer hall, which will not be concrete lined, shall be completed before start of erection of electromechanical equipment.

(iv) When sufficiently large portion of rock surfaces have been cleared of loose material, a survey of the geological structures, faults, fissures, etc., shall be made. This survey shall form a basis for the planning of the dental treatment, grouting, drainage and support measures.

(v) In open excavations, pit and crevices in foundation rock shall be carefully cleaned and any over break filled with approved material.

8.3. Foundation Treatment and Rock Strengthening Works

The following items shall not be measured and paid separately and allowance for the same shall be deemed to have been made in the quoted prices.

a) Setting out work, profiles, bench works etc.

b) Cleaning up, washing and surface preparation

c) Working in wet conditions

d) Scaling over excavated surfaces if required

e) Disposal of surplus excavated material and materials not required for the work at approved dumping sites

f) Ventilation and lighting during construction

g) Care, storage and handling of all materials

h) Safety measures, protection barriers and signals

i) Telecommunication facilities covering work sites, camps and offices

j) Providing industrial gases, P.O.L. and all other consumables including their storage in accordance with standard rules and regulations

k) Providing construction power and water supply at each work location

l) Documentation for various activities

m) Providing temporary supports, scaffoldings, shoring, timbering, shuttering and all other ancillary and auxiliary enabling works

n) Dewatering

In accordance with these specifications, the Contractor shall, where shown on the drawings or an otherwise agreed with the owner, perform all foundation treatment and rock strengthening works required for the works.

With primary stabilization, shall be understood such measures which are required to support the blasted rock section until the final stabilization has been performed. It shall be carried out within a reasonable time after blasting. The Contractor shall be solely responsible for maintaining. Safe working conditions during construction.

With final stabilization shall be understood such measures which are taken to safeguard the proper performance of the permanent works, i.e. concreting or shotcreting etc. Such measures shall be carried out based upon the geological features studied jointly by the contractor and the owner and as per the approval of the Owner.

Cleaning and drainage of rock surfaces behind concrete and shotcrete structures are dealt with Concrete Works given in section Concrete Works.

9. STEEL SUPPORTS

9.1. General

This specification covers the requirement of providing fabrication and erection steel work including painting. Permanent steel supports shall be provided at the locations as per requirement and after certification from the assigned Geologist of GSI as and when required.

9.2. Materials

9.2.1. Structural Steel Sections

All structural steel shall conform to IS:2062:1992 and IS:800-1962. The steel shall be free from defects mentioned in IS:2062-1962 and shall have a smooth uniform finish. It shall be straightened if necessary, in the mill before shipment. Material shall be free from loose mill scale rust-pits or other defects affecting its strength and durability.

9.2.2. Storage

Structural steel shall be stored above surface of the ground upon platforms, Skids or other suitable supports to avoid distortion of sections is long length and shall be protected as far as practicable from surface deterioration by direct contact with harmful elements or exposure to conditions producing rust and corrosion. It should be so stored and handled that the material will not be subject to excessive stress and damage.

9.2.3. Straightening

All deformed structural material will be properly straightened by methods, which are not injurious prior to being laid of, punched otherwise worked in the shop. Sharp kinks and bends shall be cause for rejection.

9.2.4. Tests

When the steel is supplied by the Contractor, test certificate of the manufacturers shall be produced. If further tests were necessary, they will be done according to IS:2062-1969 and IS:1521-1960. The cost of such tests will be borne by the Contractor.

9.2.5. Measurement

The sections shall be supplied in specified exact length, smoothly cut to the required lines. The length of sections shall be measured correct to a centimeter and weight calculated on the basis of standard weights prescribed by ISI for each relevant section correct up to 0.10 of a Kg. Tolerances mentioned in IS:2062-1969 shall be applicable unless other tolerances are prescribed in the specifications of any particular item.

Bolts: These shall comply with IS:1148-1964 and IS:800-1962

9.3. Bolted Connections

i) Bolted connections shall be made using black bolts and/or high strength friction grip bolts. Black bolts shall be either cold forged or hot forged swaged head bolts.

ii) All holes for bolts, unless otherwise specified, shall be not more than 1.5 mm larger than the nominal diameter of bolts and drilled full size or, where permitted, punched 0.8 mm undersize and reamed to full size. Burnt holes punched full size will not b permitted under any circumstances. After assembly of the parts to be jointed, all holes shall be true throughout, perpendicular to the face of the member and aligned so as to permit the bolts to be positioned without damage to the threaded portion. Contacting surfaces of parts being jointed shall be free from distortion and all burns or ridges shall be removed.

iii) The length of each bolt shall be such that the threaded portion will project through the nut for at least one complete thread. The shanks of bolts used in bearing shall be of sufficient length to prevent a smooth bearing surfaces for the full thickness of parts being joined and no portion of the thread shall be within the thickness of the parts being joined.

iv) At least one washer shall be placed under the nut.

v) Bolts in tension, and with their axis at an angle to horizontal, and bolts subject to severe vibration, and all bolts carrying hoist loads, shall be locked in position in a manner approved by the Engineer-in-Charge.

vi) Black bolts shall be tightened so that the jointed parts shall be firmly drawn together using a standard ring spanner or a calibrated torque or pneumatic impact wrench. While black bolts shall be tightened as firmly as practicable by those means, care shall be taken not to overstress the bolts and the applied torque shall not exceed that recommended by the bolt manufacturer. In no case shall the bolt tension exceed 65% of the guaranteed yield load of the bolt.

9.4. Fabrication

Cutting, holding, assembly, riveting, bolting, machining, painting, marking and erection shall be carried out in accordance with approved plans and as directed by the Engineer from time to time and shall comply with IS:800-1962.

9.5. Welding

Welding shall be carried out in accordance with IS:816-1969 or its revisions. Following precautions shall be taken in carrying out the welding operations.

i) Welders and works shall be protected from wind and weather. viii) Welds should be made in the flat position wherever possible.

ii) Adequate steps shall be taken to maintain the correct arc length, rate of travel, current and polarity for the type of electrode and nature of work.

iii) Structural steel shall not be painted or oiled on any areas where welding is to be done and shall be well cleaned to remove any paints, scale or rust and expose original clean metal surface immediately before welding.

iv) The members shall be securely held in position by means of tack welds, service bolts, clamps or jigs before commencing welding so as to prevent any relative movement due to distortion, wind or other causes. When wind or manual handling is liable to distortion, the work shall be securely held in approved frames or jigs.

v) Freedom of movement of one member of the joint shall be allowed wherever possible. No butt joint shall be welded without allowing one component freedom of movement of the order of 2mm.

vi) The sequence of welding shall be such that when possible, the members, which offer greatest resistance to compression, are welded first.

vii) The welding of the joint shall be so arranged that resulting tensile and compressive stress produced by each portion of the weld tend to balance each other. The step back method shall be adopted for continuous runs.

viii) Fusion faces may be cut to the required shape by shearing, chipping, machining or machine gas cutting. Hand cutting by gas may be substituted for machine gas cutting only if the later is impracticable, the cutter shall be adequately guided so that the cut edge is clean and uniform. If the fusion face is rough, it shall be dressed by chipping, filling or grinding in a satisfactory manner.

ix) Welds showing slag inclusions, porosity or lack of proper penetration shall be cut-out and re-welded. Overlap of toe of the weld and undercutting of the parent metal should be avoided and where present to a serious extent shall be rectified.

x) All slag shall be removed from each run before another run is superimposed and from the final run. When cold, the final run shall be protected with clean boiled linseed oil and shall not be painted until approved by the Engineer's representative.

xi) Grinding of finished weld is permitted provided the weld is not reduced below the prescribed section.

xii) All welds, which have not been ground, shall be scrubbed with a 10 percent solution of Hydrochloric acid, which shall be satisfactorily washed off with water before the paint is applied unless alkali resisting paint is used.

9.6. Shop Painting

After the shop work been completed and accepted, all members shall be properly cleaned and shop painting carried out as per IS:800-1984 or its revision and IS:1477 Part I-1971 and IS:1477 Part II-1971 or its revisions. One priming coat of red lead shall be applied in the shop after proper cleaning of the metal surfaces. Surfaces, not accessible after assembly or erection and not in contact with field joints shall be given a second shop coat.

9.7. Erection

9.7.1. General

Provision of IS:800-1984 or its revisions shall generally apply.

The work of erection shall be considered as beginning with the receiving and unloading of all required materials at the nearest rail/road siding or point of delivery, to the work and shall include, unloading, handling, storing, erecting, bolting, adjusting and painting the complete steel structure including all facilities, tools, equipments, labour and expenses incidental thereto. Erection in the field will be by bolting, riveting, and arc welding or by any combination of these as shown in the drawings or as otherwise directed.

9.7.2. Damage to Material

Care shall be taken in handling and erecting all materials and in properly supporting them at all times so that no piece will be bent, distorted or otherwise damaged. In the event of any damage, which cannot be corrected in the field, the material shall be returned to the fabricating shop for attention or furnishing of new parts, as necessary. Where such corrections are necessary in view of negligence, on the part of Contractor, the cost of all handling, transport and repair etc. shall be on the Contractor's account.

No erection work shall be started till damaged material if any, that is otherwise to be incorporated in the work, has been satisfactorily corrected or replaced.

9.7.3. Field Verifications

Before beginning the work of erection, the location of anchor bolts, hinges and other metal embedded in concrete or masonry or rock etc. shall have been verified and it shall have been assured that all seats, foundations and masonry structures are at the proper elevation, are truly level and have the proper clearance between the steel work and masonry or concrete or rock etc., as the case may be. Also no erection work shall be started, unless otherwise permitted, until all the members and materials needed for that particular location, are correctly available at the site of the erection or in nearby storage.

All field connections shall be carried out by bolting, welding or riveting. Provision s of IS: 800-1984 or its revisions shall apply.

9.8. Painting Structural Steel

Provision of IS:1477 (Part-1)-1971 and (Part-II)-1971 or its revisions shall apply.

Painting of metal work and structural steel shall consist of a primin g coat (shop coat) of red lead or red oxide of iron as directed by Engineer's representative and two finishing coats (to be applied after completion of erection) of aluminium paint or ready mixed oil paint of approved colour and shade. Surface not accessible after assembly or erection shall be given a second shop coat.

9.9. Tolerances

All structural members shall satisfy the tolerances as follows:

a) Straightness of struts, columns, beams, chord members and latticed girders: Length of member x 0.001

b) Camber: length of span x 0.001

c) Length: + 0 mm / -3 mm

d) End of beams, out of squareness: depth x 0.025

10. ROCK DOWELS, BOLTS, CABLES AND ANHORS

10.1. General

The rock support system will consist of a combination of any or all of untensioned grouted rock dowels, rock bolts, expansion shell rock bolts, post-tensioned rock anchors and cables. The drawings show typical rock support systems consisting of 'pattern rock reinforcement' for each part of the open rock excavation and underground excavation – These rock support systems are typical for the rock conditions anticipated to exist. After the actual rock conditions exposed at the different excavated rock surfaces have been determined, the rock support shown on the drawings may be modified accordingly.

If required, 'feature rock reinforcement' shall be installed after each blast or a sequence of blast, as needed, to provide additional rock support in local areas of the excavated rock faces - 'Return rock reinforcement' may be required after both 'pattern' and 'feature rock reinforcement', if subsequent rock conditions need additional stabilization.

10.2. Scope

(i) The specifications described hereinunder relate to the work which includes all labour, material, equipment and services required for the supply, installation, testing and maintenance of rock dowels, rockbolts, cable and anchor bars as shown on the Drawings, to protect, stabilize rock faces, cuts, slopes and masses exposed in the course of the works.

(ii) Rockbolts shall be furnished complete with all accessories and other materials necessary for their installation, fixing, stressing and grouting.

(iii) Flat steel plates or rolled steel sections shall be used to connect together two or more rockbolts where required and shall conform to IS:2062.

(iv) Rock dowels, bolts, cables and anchors shall be used to strengthen and hold rock in position and where required provide necessary bond between the rock surface and concrete.

(v) The type, length, diameter, inclination and pattern of the rockbolts shall be as shown on the Drawings.

(vi) Bearing plates shall be flat or dished steel plates of minimum dimensions of 150x150x10 mm and shall conform to IS:2062. The washers to be used shall be bevel or hemispherical. The nuts shall be heavy hexagonal type. Where the above components are to be used with grouted rockbolts, they shall be hot-dip galvanised, with a coating mass not less than 0.6 kg/m^2.

(vii) All surfaces of the bearing plates, nuts, washers, wedges and threads on the projecting ends of rockbolts shall be protected and lubricated with rust preventive compound.

(viii) When rockbolts are used in conjunction with wiremesh, the mesh shall be connected firmly to the bolts by means of extra steel plates and nuts. Wiremesh shall not be placed between rock and the bearing plate of the rockbolt.

(ix) Where required, rockbolts shall be provided with devices for load and deformation measurement.

(x) The following types of reinforcing elements may be used:

a) Untensioned Rock Dowels and Grouted Anchor Bars

b) Tensioned rock bolts and anchor bolts

- Expansion shell type.

- Resin-grouted type

c) Prestressed Cables

d) Anchor bars

e) Expandable rock bolts (swellex system)

10.3. Drilling Holes and Preparation for Installation

(i) Holes for rockbolts and grouted anchor bars shall be drilled as specified herein.

(ii) The diameter of each hole shall be in accordance with manufacturer's recommendations except for grouted anchor bars where the hole diameter shall be at least 1.5 times that of the rod specified for the hole.

(iii) The length of drill hole shall be such as to receive the specified rockbolt and to provide for its satisfactory anchorage. The downward holes shall extend 15 to 20 cm beyond the length of the rockbolt.

(iv) After drilling, each hole in compact and washable rock shall be washed out with clean water and cleaned by blowing out all drill cuttings and debris with compressed air. The holes in rock which tends to swell or are interspersed with clay filled fissures shall be cleaned with compressed air only. The compressed air shall not contain any oil or other material preventing the bond.

(v) Prior to installing the rockbolts which will be stressed, the rock surface adjacent to the hole shall be prepared for the bearing plate. When the surface is not perpendicular to the hole axis, bevel washer shall be placed between the bearing plate and the nut, or dished bearing plate and hemispherical washer used to ensure uniform bearing.

(vi) If a rockbolt is not installed immediately after drilling the hole, the hole shall be washed and cleaned as stipulated above, immediately prior to installing the rockbolt.

(vii) Fresh holes, shall be drilled to substitute such holes as have been drilled out of place or alignment.

(viii) The rock surface around the drilled holes to receive the bearing plate shall be chipped smooth or be covered with a smooth quick-set cement pad.

10.4. Untensioned Rock Dowels and Grouted Anchor Bars

(i) The dowels and anchor bars shall be deformed bars of types as described and shall meet the requirement of IS:1786, IS:1139 or equivalent B.S. They shall be fabricated from deformed reinforcing bars 25 mm diameter with a yield stress of 415 Mpa or as shown on the Drawings.

(ii) Anchor bars shall be thoroughly cleaned before being placed in the drill hole. The hole shall be filled with cement grout of 3:1 cement/sandmix with 0.4 to 0.6 water cement ratio. Admixtures for fast setting and low shrinkage may also be used as required at site.

(iii) The anchor bars shall be protected against disturbance for a minimum time of 48 hours after installation.

(iv) The dowels shall be grouted in by means of the perfo method, the SN method or other equivalent methods. The methods shall comply with the manufacturer's recommendations.

(v) Dowels shall normally protrude a sufficient length outside the rock surface for load testing according to requirements mentioned in this Tender document. The protruding ends of the rock dowels shall be threaded and provided with anchor plates. Where the rock surface is provided with reinforced shotcrete, the anchor plates shall be located outside the reinforcement and covered with shotcrete.

(vi) Where protruding ends of anchor dowels are to be bent, this may be done by hot bending after the dowels have been grouted in. The dowels shall be heated over a length at least 5 times the diameter.

10.5. Tensioned Rock Bolts and Anchor Bolts.

10.5.1. Expansion Shell-type Rock Bolts.

(i) Expansion shell type rockbolt shall conform to IS:8266-1976 as shown on the Drawings.

(ii) The rockbolts to be used shall be grouted as indicated in the Drawings.

(iii) Expandable rock bolts shall conform to the swellex system. The swellex system for rock reinforcement consists of a mechanically folded steel tubular bolt, an installation rod and a high-pressure water pump. Water under a pressure of 30 MPa is injected into the bolt, causing the steel tube to expand and adapt its shape to irregularities of the borehole. Two types of bolts shall be used, the Standard Swellex bolt with a steel thickness of 2 mm and an expanded diameter of 41 mm which is installed in drill holes with a diameter of 32-39 mm, and the Super Swellex with a steel thickness of 3 mm and an expanded diameter of 54 mm which is installed in 43-52 mm drill holes. Breaking load for the standard Swellex bolt is 13 tonnes and for the Super Swellex 24 tonnes. For primary stabilisation, rock dowels, type Swellex, may be used in rock mass or as required by site conditions. The installation shall be made in accordance with the manufacturer's recommendations.

10.5.2. Resin-grouted-type Rock Bolts.

(i) Rockbolts shall consist of deformed steel bar 25 mm diameter with a yield stress of415 Mpa or as shown on the Drawings. Each bolt shall have one end chamfered and the other end threaded with a coarse thread over a length of 200 mm.

(ii) After the hole is drilled and cleaned, fast setting resin cartridges shall be placed and tamped to the bottom of the hole. The remaining hole shall then be filled with cement grout.

10.5.3. Pre-stressed Cables and Rock Anchors

Cables and bolts shall be of types as described and shall be installed in accordance with the manufacturer's instructions, particular regard being paid to corrosion. As far as possible use of prestressed cables will be avoided and only prestressed anchors will be provided.

10.5.3.1. PRE-STRESSED CABLES

i) The pre-stressed system shall be of the bonded type in accordance with an internationally well-known and tested system such as VSL or equivalent type. The tendons in the system shall be composed of a bundle of strands of high tensile steel. The load capacity is varied by varying the number of strands. The ultimate tensile strength of the steel shall be at least 1600 Mpa.

(ii) The steel of the cables shall have an ultimate strength of 200-2000 KN (20.4-204 tonnes) and the working force shall normally be = 0.6 x ultimate strength or 0.8 x yield strength whichever is less. The working force of cables used for primary stabilisation may be 0.8 x yield stress.

(iii) The wires for tendons of required quality shall conform to IS:1343-1980 and IS:6003-1970.

(iv) The hole shall be of a diameter recommended by the manufacturer for the specific cable used. The hole shall be drilled up to the required depth and pattern with alignment and tolerances as indicated in the Drawings.

(v) The wire for tendons shall be self-straightening when uncoiled. If not so, it shall be straightened mechanically before use. In this procedure, care shall be taken to avoid alteration in the properties of the wires during straightening process. Anchor parts such as spreading ring, spiral steel sheath, wire cap, clamping ring, anchor block, anchor base plate, trumpet, anchor head etc. shall be either shop fabricated or field fabricated in accordance with the approved method.

(vi) Anchor shall be free of dirt, detrimental rust, grease or any other deleterious substances. Special care shall be taken to ensure that the existing corrosion protection remains undamaged during insertion.

(vii) Anchors shall be either sheathed or unsheathed. The sheathing shall consist of plastic tubes, surrounding individual anchor elements (bar wire or strands) or a single tube surrounding the element altogether. A seal shall be provided to prevent the entry of grout into the sheath prior to stressing.

(viii) Plastic sheathing and accessories such as the end cap, fronting cap, front tube and sealing cap shall be made of hard PVC material with a minimum compressive strength of 80 Mpa and a minimum tensile strength of 40 Mpa. The material shall be free of chlorides and other ingredients which might cause corrosion or hydrogen embrittlement of steel. The plastic shall be non-reactive with the concrete and its ingredients.

(ix) Anchor shall be securely fastened in place to prevent any longitudinal movement during grouting. Grout and airvent tubes shall be checked with water or compressed air to ensure that they are clear. Considerable care shall be taken to ensure that the bond length of the anchor is centrally located in bore-hole.

(x) Anchor bearing concrete pads shall have a minimum compressive strength of 30 Mpa at the time of anchors stressing.

(xi) Centralisers shall be used and shall be capable of positioning the anchor in the drillhole such that there is no less than 30 mm of grout cover around the rock anchors. Centralisers shall be made from steel, plastic or any material which is not detrimental to high strength steel. Wood centralisers shall not be used.

10.5.3.2. PRE-STRESSED ROCK ANCHORS

(i) The bars shall be of Dywidag or equivalent type, threaded and manufactured in high tensile grade. The ultimate strength of the steel shall be at least 1000 Mpa. The ultimate load shall be at least 500 KN for 26.5 mm bars. Anchors shall be provided with anchor plates fixed by nut and washer.

(ii) The Anchors shall be prestressed and the prestressing force shall be achieved by using jacks imposing a direct pull on the Anchor. The Anchors shall be provided with rolled or cut threads for fixing of anchor plates by nut and washer and have an ultimate strength of at least 500 KN (51 tonnes).

(iii) Protruding ends shall be covered with shotcrete or concreted in, after prestressing.

10.6. Procedure

(i) The drill holes shall be washed with compressed air and water under pressure immediately prior to placing of the dowels, etc.

(ii) The dowels, etc. shall be thoroughly cleaned and free from loose rust, scale, dirt, grease or any other coating before they are inserted in the drill holes. Drill holes shall be protected from clogging or obstruction by means of cap or equivalent. Any drill holes that becomes clogged or obstructed before completion of grouting shall be thoroughly cleaned out or shall be replaced by another drill hole.

(iii) Dowels, etc. shall normally be grouted in over the entire hole lengths with a grout consisting of cement and water with or without the addition of sand. The grout may also consist of resin grout. The grouting shall be carried out in a manner preventing formations of voids or air pockets.

(iv) The composition of the grout shall be cement, water and expansion agent as finalised after trials at site. The water/cement ratio shall be between 0.38 and 0.42.

(v) Untensioned Cement-grouted Rock Dowels

After flushing and cleaning, each drill hole shall be filled with cement or cement-sand grout. The dowel shall be inserted in the hole and driven to the full depth of the drill hole. A 200 mm length shall protrude at the collar. After installation, rock dowels shall be protected against disturbance for at least 48 hours.

(vi) Expansion shell Rock Bolts

Hole corresponding to size of the shell shall be drilled to the desired depth and then the hole be flushed and cleaned. The rock bolt shall be inserted in the hole to full depth and the expansion shell opened by giving few turns to the bolt. The bolt shall then be tensioned to the designed value by giving torque to the bolt with the help of a Torque Wrench. The bolt shall then be grouted with the help of grout tube.

(vii) Tensioned Resin Grouted Rock Bolts

a) Rock Bolt

Tensioned resin grouted rock bolts shall be deformed steel bars with a 200 mm threaded portion at one end. Mechanical couplers, if needed, shall develop 125% of the minimum yield strength.

b) Resin Grout

Resin grout shall be either epoxy or polyster resin grout supplied in cartridges that can be inserted directly into the drill hole. Resin cartridges shall be stored out of direct sunlight, and at temperatures below 280 Celsius. Resin cartridges of different setting times shall be distinguishable by colour. The cartridges shall be stored in such a manner that the oldest is used first. Any resin cartridge whose shelf life has been exceeded shall be removed from storage and disposed of.

c) Installation

The Contractor shall drill holes to receive the rock bolt as specified by the manufacturer, taking into account the rock bolt diameter and resin cartridge diameter. The hole diameter for each bolt shall be uniform for the entire length of the hole, when installing uncoupled rock bolt assemblies.

Telescoping of holes will be accepted when drill site restrictions and rock conditions require coupled rock bolt assemblies to be used. For holes 6m long or longer, coupled rock bolts may be required. Telescoping permits clearance to be maintained for both drill steel and rock bolt couplings.

The drill holes shall be flushed with compressed air to remove drill cuttings, sludge and debris prior to installation of the rock bolts. The drill holes shall not be flushed with water. A 200-millimeter length of the bolt shall extend out of the hole.

When quick and slow–setting resins are used, the difference in setting time between the two resins shall not be less than fifteen minutes.

Sufficient cartridges of fast setting resin to suit the length and diameter of the holes and to develop an anchorage length adequate for the tensioning of the bolts shall be pushed to the back of the holes and, if necessary, supported in place by means of retainers.

Where a slow setting resin cartridges shall be used to bond the remaining length of the rock bolts, the slow setting cartridges shall be inserted after the fast setting cartridge have been retained in place.

The 200 millimeter threaded length of the bolt protruding from the hole shall be protected from resin contamination by means of a protective sleeve or a suitable debonding agent.

During insertion of the rock bolt into the hole, the bolt shall be rotated steadily at the rate recommended by the manufacturer by means of a pneumatic tool and a suitable coupling attached to the threaded end of the bolt. The rotation shall be continued after the bolt has been fully inserted for a further thirty seconds unless otherwise recommended by the manufacturer and the rock bolt shall be maintained in position until the fast setting resin has hardened. Excess resin flowing from the hole shall be removed.

Installation of the bearing plates, washers and nuts shall be similar to that specified for other tensioned rock bolts.

When the anchorage resin has reached its final set, the bolt shall be tensioned to a load to suit rock conditions. The bolt shall be tensioned before the slow speed resin or the cement grout have begun to set. Bolt tensioning shall be by axial or impact torque tensioning.

The Contractor shall provide calibrated tensioning equipment including hollow ram hydraulic hacks with capacities up to the ultimate strength of the bolts and pressure gauges measuring in metric units. The hydraulic jack and pressure gauge or the impact torque tensioning system used for tensioning shall be calibrated by a registered calibration agency not longer than 1 month prior to the tensioning operation.

(viii) All bolts within 10 m of a blasting operation shall be retightened to the approved torque within 4 hours after each blast. If it is found that any bolt does not take the required torque without anchorage slip, a new bolt shall be installed in the immediate vicinity of the unsatisfactory bolt.

10.7. Testing of Dowels, Bolts and Cable

(i) The reliability and performance of the procedures for grouting and fixation of dowels, bolts and cables shall be ascertained by pre-construction tests. Such testing shall be carried out in a manner and to an extent which shall define the working loads to be adopted.

(ii) Running tests on dowels, bolts and cables shall be performed.

(iii) As routine, 5% of all dowels installed shall be tested to 1.5 x working load. Dowels which fail before 1.5 x working load is achieved shall be replaced and the further dowels shall be tested.

(iv) All prestressed cables and bolts shall be tested between 7 and 10 days after installation. Where tension has not been maintained, they shall be retensioned to the working load. Cables and bolts which have lost more than 30% of their load shall be considered defective and shall be replaced. Further testing and re-tensioning may be carried out for all or any cable or bolt.

(v) Testing equipment including hydraulic jacks, fixing device, hydraulic pump with manometer, extensiometer and all necessary accessories shall be kept at site. The testing equipment shall be capable of stressing the largest diameter rockbolt to the yield stress of the bolt.

10.8. Drainage Holes and Relief Wells

(i) Drainage holes and relief wells shall be provided where shown on the Drawings. Drainage holes and relief wells shall be drilled only after final grouting of adjacent rock, except holes drilled for drainage adjacent to the tunnel face.

(ii) Drainage holes shall be drilled in rock for the release of water pressure in water-carrying zones in underground excavations and open excavations, behind concrete and shotcrete structures, and elsewhere as shown on the Drawings. The hole diameter shall be at least 35 mm, but drainage holes with a diameter of upto 100 mm may be required. The holes shall be drilled either by means of percussion drilling or rotary drilling and may be vertical or inclined in any direction. Such holes will normally be equipped with 65 mm strainer pipes of PVC or approved corrosion resistant material.

(iii) If the outlet of a drainage hole is located adjacent to a grouted zone an initial part of the hole may be first drilled and grouted and subsequently re-drilled.

(iv) Relief wells in soil shall be drilled with a minimum inner diameter of 200 mm. The holes shall be equipped with strainer pipes of PVC or approved corrosion resistant material with an inner diameter of 100 mm.

(v) Special centering devices shall be used when the strainer pipe is installed and the annular space around the strainer pipe shall be carefully filled with sand of a gradation to be approved by the Owner. In special cases, the strainer pipe may be surrounded by a filter fabric.

(vi) Adequate drainage arrangement for seepage water below machine with connecting pipes to sump well shall be provided. The adequate opening below draft tube and connection to drainage pipe shall be made for draining out the machine and draft for inspection and maintenance.

11. SHOTCRETE AND WIREMESH

11.1. Scope

(i) The specifications described hereinunder relate to the work which includes all labour, materials equipment and services required for the shotcrete work to be carried out.

(ii) Where shown on the Drawings and as required duly approved by EIC shotcrete works shall be performed.

(iii) In general, the recommended practice for shotcreting as per ACI Manual of concrete practice "Recommended practice for shotcreting committee 506" or IS:9012-1978 shall be followed. When using shotcrete for primary stabilisation of rock, these practices shall be followed but may be modified as agreed with the Owner, to suit actual conditions.

(iv) The Contractor is free to use both dry mix and wet mix shotcrete.

11.1.1. Standards

(i) The shotcrete materials, production, methods, testing and admixtures shall conform to the following Indian Standards or, where not covered by these Standards, to the equivalent International Standards:

IS:8112 or BS 12 or BS 4027

IS:456-1978

IS:1489-1976

IS:383-1970 (Reaffirmed 1980) or BS 882

IS:9012-1978 (Reaffirmed 1987) IS:9103-1979 or BS 5075: 1-3

IS:2645-1975 (Reaffirmed 1987)

IS: 1566, BS:4449, BS:4483 & BS:4461

(ii) In cases of conflict between the above Standards and the specifications given herein, the specification shall take precedence.

11.1.2. Definitions

(i) Shotcrete

Shotcrete, for the purpose of this work, is defined as cement concrete applied from a spray nozzle by means of compressed air with water being added at the nozzle in case of dry process. Shotcrete shall contain an approved admixture suitable to attain quick set and high early strengths as specified herein.

(ii) Rebound

Rebound is defined as the aggregates and cement or wet shotcrete which bounces away from a surface against which shotcrete is being projected.

11.2. Materials

(i) Shotcrete shall be composed of cement, aggregates, water and approved admixtures as specified herein.

(ii) Cement shall be ordinary Portland cement conforming to the requirements of relevant standards or IS:8112 or BS 12 or BS:4027.

(iii) Aggregate shall conform to the requirements of relevant Indian Standards of IS-456-1978 or IS-383-1980 or BS 882.

(iv) Aggregate shall be tested as per IS:2386 and ASTM C227 obtained from a source.

(v) Air used for spraying shotcrete shall be clean and free of oil and other contamination.

(vi) An admixture shall be used to develop quick set and high early strength, as approved by the Owner, conforming to the requirements of relevant Standards or IS:9103-1979, ASTM C494 & C260 or BS:5075: 1&3.

(vii) The water to be used shall be in accordance with IS:456 or BS:3148.

(viii) The methods of workmanship in application and testing of shotcrete shall be in accordance with IS: 9012:1987

(ix) An accelerating admixture may be used to develop quick setting and high early strength at such places as required. The admixture used shall have acceptable service records of at least five years use in this type of applications and the suitability and the required amounts thereof shall be established with pre-construction tests. It shall not contain water-soluble chlorides or materials corrosive to steel, and shall not entail other detrimental effects, such as cracking and spalling of applied shotcrete. The proportion of admixture shall be as recommended by the manufacturer. Exceptionally, a higher proportion may be accepted where rapid treatment of weak rock is needed. The shotcrete accelerator may be liquid as of the Stabilorapid type or in powder form such as Sigunit. Water shall conform to the requirements of Tender documents.

(x) The steel reinforcement shall consist of hot rolled, deformed bars as specified in welded steel wire fabric of mild steel, Grade 40, meeting the requirements of IS 1948, BS 4449, 4483 & 4461.

(xi) In wet mixed shotcrete, the use of steel fibres of Dramix type or equivalent as reinforcement is allowed. Steel fibres shall be cold drawn fibres crimped or having deformed ends and shall consist of high carbon steel. The fibre shall have a length/thickness ratio of 40-60 or as otherwise agreed with the Owner. The yield strength shall be at least 800 N/mm^2.

11.3. Mixing

11.3.1. Mix Design and Proportioning

(i) The type/class of shotcrete to be used in a particular location shall be as per Drawings.

(ii) The mix proportions of cement, aggregates and permitted admixtures in each class shall be as approved. The mixes shall be such as to permit placement without excessive rebound and segregation.

(iii) The admixtures shall have proven compatibility with the cement make and type so as to ensure initial and final setting time as 3 and 12 minutes respectively. The Contractor shall supply to the Owner all the necessary test results and reports to confirm compatibility.

(iv) The water content of the mixes shall be limited to prevent sloughing. The water-cement ratio of fresh shotcrete in place shall be between 0.32 and 0.45.

(v) The mixes shall be such that aggregate gradation and cement content after placing are as those obtained from samples taken from test panels produced from approved trial mixes. All constituents shall be uniformly dispersed throughout the mix.

(vi) Proportioning of aggregate and cement shall be only by weigh batching.

(vii) Moisture content of the combined aggregate at the time of mixing with cement shall not exceed 2% (two percent) by weight of the oven dry aggregate.

(viii) Mixed material shall be used within 60 minutes after adding cement.

(ix) The accelerating admixture, if in dry state, shall be added immediately after depositingthe materials in placing equipment and shall be accurately proportioned and thoroughly mixed with other ingredients. If in liquid form, the admixture shall be accurately proportioned into the water supply at the application nozzle.

(x) Mix proportions shall be varied, when required, to obtain required strength of shotcrete, to maintain rebound to the minimum and to meet all other requirements.

11.3.2. General

(i) The quantity of cement and aggregates shall be gauged by weight and be mixed dry in a mixer for during at least 2 minutes.

(ii) Proportioning by volume may be allowed in the case of mobile mixers, provided that regular checking of mix proportions is carried out.

(iii) The proportions of cement, aggregates and admixture shall be determined with pre-construction tests. The proportions of cement and dry aggregates shall be between 1:3 and 1:5 by weight.

(iv) The steel fibre content in wet mixed shotcrete shall be so adjusted as to satisfy the criteria of flexure test vide 10.5.2 below. The fibres shall be added to the mix at the concrete station and be well proportioned in the concrete.

11.4. Personnel, Placing Equipment and Application

11.4.1. Proficiency of Workmen

(i) Nozzlemen shall have had sufficient previous experience in the application of coarse aggregate shotcrete or shall work under the immediate supervision of a foreman or instructor having such experience.

(ii) The spraying shall be carried out by skilled workmen and be supervised by a foreman or an instructor with good experience in shotcrete work.

(iii) Each crew shall demonstrate acceptable proficiency in the application of shotcrete to test panels before beginning production work.

11.4.2. Surface preparation

(i) When shotcrete is to be applied to excavated surfaces immediately after blasting, the surfaces shall be prepared by scaling, as required, followed by washing with clean water. All surfaces shall be wet, clean and free of rebound, at the time of applications of shotcrete. For all other shotcrete application, the surfaces to be treated shall be thoroughly sluiced with air and water jet or cleaned by other approved means to remove all traces of dirt, mud debris, oil, loose particles, rebound or loose rock and any other deleterious material. The surfaces shall be kept moist until shotcrete is applied.

(ii) Where water flows from the rock against which shotcrete is to be placed and when water cannot be sealed off by shotcreting alone, the water shall be excluded from the area by caulking or diverted by pipes, pans or other approved means in such manner that the shotcrete will be unaffected by action of the water through percolation, by hydrostatic pressure or erosion.

(iii) A layer of shotcrete, which is to be covered by a succeeding layer, shall first be allowed to take its initial set and shall have all laitance, loose material, dirt or other deleterious material and rebound removed by brooming, sluicing or other means approved by Engineer.

(iv) At any time during surface preparation, if site conditions so require, shotcrete may be applied to isolated areas before proceeding with surface preparation.

(v) Shotcrete surface shall be kept moist until the succeeding layer of shotcrete is applied.

11.4.3. Mixing and Application

(i) Shotcrete materials shall be accurately weigh-batched before mixing. Aggregate shall be thoroughly mixed without the addition of water before being deposited in the placing equipment. Cement shall be added not more than 1-1/2 hours before application. Mixes which are not applied with 1-1/2 hours of adding cement shall be discarded. Rapid- hardening additive shall be accurately proportioned.

(ii) A sufficient number of mobile units provided with a remote-control movable nozzle mounted on an extendable boom of such length that the operator can work in safety, shall be provided. In addition to the mobile units, the Contractor shall provide an adequate number of manually held and operated nozzles.

(iii) The water shall be added in the nozzle when performing dry mix shotcrete and be supplied through regulating valve, easily and accurately controllable by the "nozzleman", in sufficient amount and at a pressure slightly above the operating air pressure recommended by the manufacturer of the spraying equipment.

(iv) Air shall be supplied at constant and sufficient pressure and volume. The air shall not be contaminated by oil.

(v) The dry mix shall be batched in special batching plants or mobile mixers to be used solely for this purpose and placed within an appropriate distance from the various places where shotcrete shall be applied. The aggregate and the cement shall be well protected against water and sunshine. The transport of the dry mix from the respective batching plant to the place of application shall be carried out with specially equipped vehicles and the dry mix shall throughout the transport be completely protected against water and sunshine.

(vi) Batching of wet mixed shotcrete shall be done by mobile mixers or at the concrete station and transported, ready to use to the place of work by transmixers. The concrete shall be well protected from sun and moisture before application.

(vii) Welded steel wire fabric shall be fixed with steel nails, length about 150 mm, driven into plastic plugs, dia about 12 mm length about 150 mm in rock and /or shotcrete, or with other appropriate methods.

(viii) Spraying shall be carried out with the nozzle at right angles to the rock surface and at a distance of about one metre. Care shall be taken that the wire fabric is well embedded.

(ix) Should the mix be too dry or too wet or of uneven quality, the spraying shall be stopped and the unsatisfactory shotcrete shall be removed.

(x) The shotcrete shall be applied in layers about 30 mm thick for the dry mix methods and about 50 mm thick when wet mix shotcrete is performed. Before the applications of the next layer, the cement of the previous layer shall have attained initial setting.

(xi) Examine rock faces following blasting and scaling. On the basis of such examination, it may be necessary to shotcrete immediately the surfaces, in which case shotcrete shall be applied within 4 hours of blasting and before drilling the next round. Where very poor rock conditions are anticipated, shotcrete equipment may need to be kept available before blasting so that shotcrete can be applied with the minimum of delay.

(xii) Shotcrete, other than that placed immediately after blasting, shall not be placed in any area until all blasting within 30 m of the area has been completed, unless otherwise approved by the Owner.

(xiii) Shotcreting in open area shall not be carried out when it cannot be placed effectively because of adverse weather conditions, unless adequate cover is provided over the working area until the shotcrete has been cured sufficiently to prevent damage.

(xiv) Operating procedures shall be developed such as to ensure:

a) Minimum rebound

b) As smooth a finished surface as possible

c) No hollow areas in the shotcrete

d) A minimum of shrinkage cracks

e) Good adherence of the shotcrete to rock or another surface.

(xv) The flow of the material at the nozzle shall be continuous and uniform and the rate of application over any given areas shall be uniform. Slugs, sand spots, wet areas or other defects shall be cut out and corrected as specified herein.

(xvi) At the start of shotcreting operations in any area, establish procedures for the application of shotcrete which will produce the best quality product with the minimum of rebound. Such establishment of procedures shall include minor variations in mixes, if required, and variations in acceptable finishes and thickness and quantities to be discharged at the nozzle to a unit area of rock or length of cavity, as required.

(xvii) In shotcreting vertical or steeply inclined surfaces, other than roofs of underground cavities, application shall begin at the lowest point and the shotcrete layer shall be built up in horizontal strips until the entire surface is covered.

(xviii) In areas against which no further shotcrete is to be placed and where required the edges of shotcrete shall be formed to regular lines and sloped at 45 degrees to the adjacent surface.

(xix) Drainage holes shall be drilled after shotcreting.

(xx) Where drain holes have been drilled and instruments have been installed into rock on which shotcrete is to be placed, take all necessary precautions to prevent such holes from being plugged or instruments from being damaged.

(xxi) When shotcreting is to be performed near existing structures, ensure that no damage results to the structures and ensure protection of surface of structures before shotcreting.

(xxii) Application of shotcrete in any area shall be considered complete when the shotcrete has been built up to the thickness specified.

(xxiii) Where shotcrete is placed over wiremesh and supporting bolts, it shall be covered with shotcrete to a depth of at least 30 mm or as specified.

(xxiv) While applying shotcrete, the nozzle shall be held steady at a predetermined distance approximately one metre from the surface to be covered and positioned so that the stream of flowing water and material shall be applied as nearly as possible at right angle to the surface to be covered. Nozzle shall be held in steady position so that the shotcrete is applied uniformly to build up the required thickness of layer. Acceptable shotcrete shall consist of dense and uniform concrete, without segregation or discernible weakness of bond between layers.

(xxv) The nozzleman shall apply shotcrete with a uniform consistency in order to maximise bonding, cohesion and density and minimise rebound and segregation, and prevent sagging of the applied shotcrete.

11.4.4. Rebound

(i) Rebound shall be removed during the spraying and shall not be re-used. After completion of the spraying, the shotcrete shall be kept moist during at least 7 days. For the curing of shotcrete underground, no special measures are required.

(ii) Every effort will be made to keep rebound to a minimum. If the rebound is excessive, it may need revision of the mix design for shotcrete or review its application procedures or take any other such other measures as may be necessary to reduce the rebound to a reasonable level.

11.4.5. Construction Joints

Construction joints or stop joints shall be provided, as required, and shall be sloped at 45 degrees to the adjacent shotcrete surface in a clean, regular edge. Before placing the adjoining work, the sloped portion and adjacent shotcrete shall be prepared as specified in para Surface Preparation thereof.

11.5. Requirement for Final Product

11.5.1. Compressive Strength

The following minimum compressive strength requirements shall be met:

(i) 12 MPa at 3 days

35 MPa at 28 days

(ii) These strength requirements refer to test cubes with an edge length of 100 mm or test cylinders with length and diameter both of 100 mm in laboratory.

(iii) The insitu strength of shotcrete shall be 22 Mpa at 28 days tested on cylinders having length and diameter both 100 mm. This value shall be worked out taking average from 3 samples. No single value shall be below 80% of the required strength.

(iv) Core test results will be statistically analysed in accordance with recommendations of IS: 456. Test results shall meet all the acceptance criteria specified in relevant IS code.

11.5.2. Flexural Strength

The flexural strength of fibre reinforced shotcrete shall be 4.2 Mpa.

This value shall correspond to average value of 3 samples. No single value shall be lower than 80% of the required value

11.6. Pre-Construction Tests

11.6.1. Preparation of Test Panels

(i) The pre-construction tests by spraying panels shall conform to the IS:9012-1978 or ACI 506.

(ii) Test cubes shall have an edge length of 100 mm and test cylinders a diameter of 100 mm. Test cylinders with length/diameter ratio, L/D, between 1.0 and 2.0 may be used. Cylinder strength shall be converted to L/D = 1.0, using factors given in BS 1881.

(iii) The flexure test shall conform to ASTM C78 standards by using simple beams with third point loading (dimensions 150 x 150 x 450 mm).

(iv) The pre-construction tests shall commence in due time before the commencement of the shotcreting. An early start of shotcreting may be permitted in case there is no doubt that the 28 days compressive strength in accordance with this tender document shall be met.

(v) In order to facilitate the decision regarding the use of accelerators, the perform tests using at least two different percentages of each type of the acceleration admixtures proposed to be used; the percentages being determined with due consideration of the recommendations given by the manufacturer. The compressive strength shall be determined at 3 hours, 8 hours, 24 hours, 3 days and 28 days in such tests and each series of specimens shall always as a control measure contain an adequate number of samples without admixture.

(vi) Three test panels of minimum size 75 cm x 75 cm and 80 mm thick shall be prepared for each mix design and for each type of plant. They shall be sprayed from each position required in the works, one downward onto a horizontal surface, one shot to an inclined surface and one shot overhead onto a horizontal surface with a layer thickness appropriate to that position and with reinforcement. Panel moulds shall be formed from plywood, at least 20 mm thick, be adequately braced and be held rigidly in position.

(vii) The pressure at which the shotcrete shall be applied to the test panels shall be same as will be used in actual works at the place of application.

(viii) Shotcrete from both the trial mix and the routine quality control test panels shall be tested as described hereunder.

11.6.2. Testing for Compressive Strength

(i) Four, 100 mm diameter cores, shall be cut from each test panel at right angles to the plane of the panel approximately 48 hours after the panel has been sprayed. Cores shall not be taken within 10 cm of the edges of the panel.

(ii) First core shall be compression tested at 3 days, second core at 7 days, and the remaining two cores at 28 days. The core capping and testing will be carried out in a laboratory.

(iii) The cores shall be stored, cured and tested in accordance with relevant standards. All cores shall be suitably labelled to identify them with the panels from which they have been taken, and the location in the works to which they relate.

(iv) The appropriate compressive strength requirement for each set of two, 28 days cores, shall be satisfied as per IS:516 & IS:9012

(v) In case any of the cores reveal defects such as lack of compaction, dry patches, voids or sand pockets. The repair/removal and replacement of shotcrete has to be done.

11.7. Running Tests

(i) For the purpose of routine quality control during the execution work, control test panels of the same size as for the trial mix testing shall be sprayed. For the first 50 m^3 of shotcete applied in each underground excavation heading, one test panel shall be prepared. Further, the test panels will be limited to one per nozzleman per week or one per 100 m3 of material placed. The test panels shall be constructed alongside the area of placement and at same angle and shall be sprayed by each nozzleman, in rotation so that the tests shall represent the quality of the shotcrete being placed by each nozzleman. The test panels shall be stored and cured alongside and under similar conditions to the shotcrete placed in the works.

(ii) The quality control of strength shall be carried out by means of coring from test panels and from completed works. One series of 3 Nos. 100 mm cores shall be extracted per 50 m3 of applied shotcrete in the early stages of execution of shotcreting work. Less frequent testing may be allowed provided that test results are consistently satisfactory.

(iii) L/D ratios between 1.0 and 2.0 may be used. The cylinder strength shall be converted to L/D = 1.0 using the factors given in BS 1881.

(iv) Two cylinders shall be tested for strength after 3 and 28 days respectively and the third one shall be kept as spare. Notwithstanding the possible use of accelerating adm ixture, at least 95 percent of the cylinders shall meet the specified strength requirements. No single cylinder, however, shall have a strength of less than 80 percent of the specified strength.

(v) Cut sets of 100 mm diameter cores from the finished shotcrete, which shall be tested using the same procedure as on cores taken from the test panels.

(vi) Core holes shall be filled by hand with well rammed dry-pack mortar of a similar mix to that used for shotcrete.

11.8. Wire Mesh

i) Wire mesh shall consist of welded wires in a fabric. Wire mesh shall be installed in surface and under excavation as reinforcement for shotcrete usually in combination with rock reinforcement. It may also be used with steel ribs, when it shall be laid over the outer flange of the rib and pinned or fixed to the excavated surface between the ribs where necessary.

ii) Wire mesh shall conform to the requirements of IS 4948 (Welded Steel Wire Fabric for general use). The wire mesh shall have a square mesh of I00 x 100mm spacing made of wires having yield strength not less than 275N/mm2. The diameter of the wires shall be 3.4mm.

iii) Where possible, the wire mesh shall be placed at the same time as the rock reinforcement is installed. It shall not be placed between the rock surface and bearing plates but shall be placed over the heads of rock reinforcement and fastened to them by separate plates and nuts. It shall be ensured that the fabric is drawn close to the excavated surface so that when shotcrete is applied subsequently, the mesh neither sag nor vibrate excessively and impair the effectiveness of the shotcrete.

iv) Usage of wooden pegs or pins for fastening of the wire mesh to the rock surface will not be permitted.

v) Wire mesh shall be firmly stretched between the rock reinforcement and other fastening attachments.

vi) Overlap of wire mesh shall be at least 3 times the mesh spacing with the clearance between parallel bars but not less than 300 mm.

12. STEEL REINFORCEMENT

12.1. General

12.1.1. Scope of Work

(i) The specifications described hereinunder relate to the work which includes all labour, materials, equipment and services required for the supply, handling, storing, cutting, bending, cleaning, placing and fastening into position all reinforcing steel, as shown on the Drawings.

(ii) The steel reinforcement shall consist of hot rolled, cold treated deformed bars in accordance with IS 1786, IS 1139. For special purposes, where indicated on the Drawings, plain bars of mild steel conforming to IS 432 or equivalent BS may be used.

(iii) The Owner shall be provided with a certified mill test report for each batch of reinforcing bars at arrival on Site of the respective consignment.

(iv) One tensile test and one bending test as per IS:1608-1972 and IS:226-1975 shall be made for each batch of reinforcing bars delivered to the site, and for each 100 tonnes of large consignments. The Owner shall be provided with certified reports for each test not later than one week after the receipt of each consignment.

(v) Reinforcent placed against surfaces in contact with acid water shall be galvanized (Hot Dip Galvanised).

12.1.2. Standards

(i) The cutting, welding, acid protection, placement and binding of reinforcing steel shall conform to following Indian Standards or, where not covered by these Standards, to their equivalent International Standards.

IS:456-1983

IS:1786-1985

IS:1139-1966

IS:2502-1963 (Reaffirmed 1990) IS:2751-1979(Reaffirmed 1987) IS:4826-1979 (Galvanization) IS:2629-1985 (Galvanization) IS:13620-1993 (Epoxy Coating

(ii) In case of conflict between the above Standards and the specifications given herein, the specifications shall take precedence.

12.2. Handling

Steel reinforcement and welded steel wire fabric shall be stored in such a manner as to avoid contact with the ground and distortion. If the steel deteriorates seriously due to rust and scale during transport and storage, it shall not be used in the Permanent Works. Bars of different sizes and quality shall be stored separately and tagged with the manufacturer's test identification number.

12.3. Cleaning

Before being positioned, steel reinforcement shall be well cleaned and free from loose rust, scale, dirt grease or any other coating that will tend to destroy or reduce the bond, and after being placed, it shall be maintained in a clean condition until completely embedded in concrete.

12.4. Bending

(i) Steel reinforcement shall be accurately formed to the lengths and shapes indicated on the Drawings and in the bending schedules. In case of over-excavations not shown on the Drawings, the number and lengths of the bars shall be increased, so that the steel reinforcement continues with unchanged spacing to the actual contour of the excavation, or otherwise be modified, as approved by the Owner.

(ii) Steel reinforcement against the theoretical rock surface shown on the Drawings shall be modified, so that the bars follow the actual contours of the excavation. The use of concrete blindings shall normally not be permitted.

(iii) Hot bending of steel reinforcement or other heat treatment will be permitted only when approved by the Owner.

(iv) All bars shall be cut and bent in accordance with the bar bending schedules.

(v) Reinforcing steel bars shall be cut and bent at the site of the works or at a fabricator's plant.

(vi) Shorter lengths of steel shall not be used in places where continuous lengths are required as per the Drawings. Shorter bars, shall be lapped or spliced to achieve continuity in accordance with the requirements of relevant Indian Standards.

(vii) Bars shall be bent cold to the shape and dimensions shown on the Drawings using a bar bender operated by hand or power to attain the proper radii of bends.

(viii) A hook at the end of the M.S. bar, if used, shall conform to IS:456 / IS:2502-1963.

12.5. Straightening

Steel reinforcement shall not be bent or straightened in a manner that will damage the material. Bars with kinks or bends, which are not shown on the Drawings or in the bending schedules shall be rejected.

12.6. Placing

(i) Steel reinforcement shall be accurately positioned in accordance with the detailed Drawings and secured against displacement by using annealed iron-wire ties or suitable clips and shall be supported by concrete or steel spacers or steel hangers. Metal support arrangements shall not be placed in contact with forms for exposed surfaces. Where steel reinforcement is supported by mortar cubes, such cubes shall be of a quality equal to the concrete into which they are to be incorporated and shall be tapered to ensure firm embedment. The steel reinforcement shall be firmly fixed in position, so that it is not displaced when workmen walk or climb on it. The ends of all tying wires shall be turned into the body of the concrete and not be allowed to project towards the surface.

(ii) Except at splices, the clear distance between parallel deformed bars in the same layer shall not be less than twice the diameter of the bar or 5 mm more than maximum size of coarse aggregate whichever is more. With two or more layers, the clear distance between the layers shall not be less than 1.5 times the diameter of the bars or 2/3 of nominal maximum size of aggregates or 15 mm whichever is greater.

(iii) Except at splices, the clear distance shall in no case be less than 30 mm between parallel bars in the same layer and less than 20 mm between different layers. Where shown on the Drawings, the steel reinforcement shall be arranged in bundles.

(iv) Binding wire and steel support shall not be carried to permanently exposed surfaces and shall be subject to the same requirements with regard to concrete cover as for the reinforcing steel.

(v) Special care shall be exercised to prevent any disturbances of the reinforcement concrete that has already been placed. The reinforcement after being placed in position shall be maintained in a clean condition until it is completely embedded in concrete.

(vi) The longitudinal bars shall be straight and fixed parallel to each other and to the sides of the form as shown on the Drawings. The ties, links and stirrups connected to the bars shall be tightly fixed so that the bars are properly braced. The inside of their curved part shall be in actual contact with the bars around which they are fixed and their position shall be exact as shown on the Drawings.

(vii) Wire for tying reinforcement shall be black annealed iron wire. The diameter of wire shall not be less than 1.6 mm.

(viii) Reinforcement for lining in underground cavities and other locations may be fixed in position by means of anchor rods or supporting and hanger rods. In difficult locations, tack welding of bars at isolated spots may be permitted to keep these bars in position.

(ix) Sufficient concrete cover, as indicated on the Drawings shall be provided to protect reinforcement from corrosion. All protruding bars from concrete to which other bars are to be attached and which shall be exposed to action of the weather for long period shall be protected from rusting by a thin coat of neat cement grout. Accurate record shall be kept al all the times of the number, sizes, lengths, and weights of bars placed in position for different parts of the work.

(x) Where reinforcement bars are bent aside at construction joints and afterwards bent back into their original positions, care shall be taken to ensure that at no time is the radius of the bend less than 4 bar diameter for plain mild steel or 6 bar diameter for deformed bars. Care shall also be taken when bending back bars, to ensure that the concrete around the bar is not damaged.

12.7. Concrete Cover

At surfaces subjected to rapid flow of water steel reinforcement shall have a minimum cover of 100 mm of concrete; at surfaces placed directly against the ground, steel reinforcement shall have a minimum cover of 75 mm of concrete. At other surfaces exposed to water or weathering conditions, or situated below ground level, the cover for steel reinforcement shall be not less than 50 mm for bars over 16 mm in diameter and not less than 40 mm for bars 16 mm or less in diameter, unless otherwise shown on the Drawings.

12.8. Splicing

(i) If it will be necessary to splice steel reinforcement at points other than those shown on the Drawings, the position and overlap of splices shall be as agreed with the Owner. Splices shall not be made at points of maximum stress and splices in adjacent bars shall be staggered and should conform to IS:2502-1963.

(ii) Lap splices shall not be used for bars larger than 36 mm diameter, which may be welded. In cases where welding is not practicable, lapping of bars larger than 36 mm may be permitted, in which case, additional spirals shall be provided around the lapped bars. Where welding is proposed, at least three samples of butt welds shall be prepared. These specimens shall be tested by in a recognised laboratory. If the results are satisfactory, the welding may be allowed in place of lap joints. The joint shall be butt welded by the electric-arc-method. The ends of the bars shall be cleaned of all loose scale, rust, grease, or other foreign materials and all welding shall conform to the relevant standard or specifications for welding of reinforcement bars used in reinforced concrete construction.

12.9. Tolerances

The tolerances in cutting, bending & fixing of reinforcement bars shall be as given hereinafter, based on the provisions of IS:456-1978, IS:2502-1963 (Reaffirmed 1990) and BSI Code of Practice CP 110: Part-1. In case of doubt, the provisions of above mentioned IS Codes shall be governing.

12.10. Bending and Cutting Tolerances:

Bars shall be bent in accordance with the appropriate dimensions shown in the schedule. Where an overall or an internal dimension of a bent bar is specified, the tolerance, unless otherwise stated, will be as given below:

	DIMENSION	TOLERANCE

	Over (cm)	Upto and Including (cm)	Plus (mm)	Minus (mm)
For Bent Bars	-	75	3	5
	75	150	5	10
	150	250	6	15
	250	-	7	25
For Straight Bars	All Lengths		25	25

The cutting length shall be specified to the next greater whole 25 mm of the sum of the bending dimensions and allowances.

12.11. Tolerances for Reinforcement between two concrete faces

Where reinforcement is to fit between two concrete faces, the dimension on the bending schedule should be determined as the nominal dimension of the concrete less the nominal cover on each face and less the deduction for tolerance on member size given here in below: -

Distance between Concrete faces (m)	Type of Bar	Deduction for Tolerance (mm)
0-1	Links and other bent bars	10
1-2	Links and other bent bars	15
Over 2	Links and other bent bars	20
Any length	Straight bars	40

12.12. Tolerance on Placing of Reinforcement

(i) Reinforcement should be secured against displacement outside the specified limits. Unless otherwise specified, reinforcement shall be placed within the following tolerances:

a) For effective depth 200 mm or less ±10mm

b) For effective depth, more than 200 mm ±15mm

(ii) The cover shall in no case be reduced by more than one-third of specified cover or 5 mm whichever is less.

13. FORM WORK

13.1. General

13.1.1. Scope of Work

The work under this section shall comprise all labour, plant and material and performance of all work necessary to be designed, fabricated, supplied, erected and its maintenance and removal to form the dimensions of finished surfaces of concrete as shown on the Drawings.

13.1.2. Common

(i) Forms or formwork shall mean the mould into which concrete is placed.

(ii) Falsework or shoring shall mean the structural supports and bracing for forms used in any part of the works.

(iii) All exposed concrete surfaces having slopes steeper than 200 to horizontal, shall be formed unless otherwise directed.

(iv) Complete calculations and Drawings of form work shall be kept on record.

(v) Safety and sufficiency of the form work will be ensured at all times.

(vi) Forms shall be such that the finished concrete conforms to the dimensions shown on the Drawings and complies with the specified tolerances. They shall be of a type, size, shape, quality and strength which will produce true, smooth lines and surfaces in accordance with the Drawings.

(vi) The forms for each pour shall be built to the full height and finished before the concreting is commenced. However, forms for concrete structures thinner than 0.75 m which may be exposed to unilateral water pressure shall be provided with slot openings at regular intervals on one side in order to facilitate compaction.

(vii) These openings shall be successively plugged in, flush with the inner formwork surfaces, as the concrete rises in the form. The plugging planks in the slots shall not be built up higher than 1.0 m above the fresh concrete. However, this shall not apply to prefabricated steel shuttering used in tunnels.

13.1.3. Materials

(i) Forms shall be of wood, matched boards, hardboard, plywood, steel or other approved material, except that the sheeting for all exposed surfaces, where form lining is not specified, shall be of tongue and groove timber of uniform width.

(ii) All materials used in formwork construction shall be of adequate strength and quality for their intended purpose.

(iii) Timber shall be sound, straight, free from warp, decay and loose knots, and shall be dressed smooth.

(iv) Where plywood is used, it shall be non-warping, non-wrinkling and manufactured with special water-proof glues. Plywood sheets shall be of uniform width and length.

(v) The surface of steel or steel lined forms shall be smooth. Forms with dents, buckled areas or other surface irregularities shall not be used.

(vi) Reuse of forms and form lumber shall be allowed only if they are thoroughly cleaned and repaired and capable of producing the finish required for the concrete. Timber of plywood forms, repaired with metal patches, shall not be used.

(vii) Damaged forms or forms which have been deteriorated through uses shall not be used.

(viii) Form oil used on surfaces of timber of plywood forms shall be a straight, paraffin base refined, pale, mineral oil. The oil used on the surface of steel forms shall be specially compounded petroleum oil and other oils of animal or vegetable origin and gums or resins which are heavier in body and frequently darker than straight petroleum oils shall be used in the case of steel lining forms.

(ix) Forms of like character shall be used for similar exposed surface in order to produce a uniform appearance.

(x) The type, size, shape, quality and strength of all materials from which forms are made, shall be selected by the Contractor, subject to the Owner's approval.

(xi) In general, forms for permanently exposed surfaces shall consist of, or shall be lined with, matched or dressed edge grain timber of appropriate thickness, free from loose or cracked knots.

(xii) Metal forms or metal-lined forms shall be permitted for permanently exposed surfaces only when an entire surface is to be built completely with such forms.

13.2. Design, Fabrication, Erection and Maintenance of Formwork

(i) Forms and false work shall be designed, fabricated, erected and removed in accordance with the applicable provisions of the Recommended Practice for Concrete formwork of IS:456-1978, and as specified herein.

(ii) All falsework shall be designed to withstand safely all live and dead loads, necessary pressures, ramming and vibrations without significant deflection from the prescribed lines, which might be applied to the falsework during all stages of construction, service and removal.

(iii) The Contractor shall be solely responsible for the design, construction and maintenance of all formwork and falsework required in the work.

(iv) Detailed Drawings of shoring and falsework shall be prepared by the Contractor. The calculations and Drawings shall show the size and specification of the falsework, including the type and grade of all materials used in the construction, design loads on falsework supports, horizontal forces imposed on the falsework and used for design purpose, and details of splices and connection, including nails, spikes and other fasteners. If mechanical equipment such as concrete buggies screening machines, etc., are to be used, this information shall be shown on the Drawings.

(v) Contractor shall ensure the adequacy of form and falsework, for the safety of persons, property, and for the successful completion of the work.

(vi) The falsework shall be constructed strictly in accordance with the approved falsework Drawings.

(vii) Forms shall be designed to permit the concrete to be deposited, as nearly aspracticable, directly in its final position, and to allow inspection, checking and clean-up of the formwork and reinforcement to be completed without delay.

(viii) Forms for concrete against which backfill is to be placed or which shall not be exposed to view may be constructed of smooth tight boards not less than 25 mm nominal thickness.

(ix) Forms for concrete exposed to flow of water or exposed to view shall be constructed of steel or plywood which is smooth and free from defects with matched and sanded jointsto give a symmetrical pattern over the entire area.

(x) The formwork for the gate groove areas shall be accurately drilled to be held with first stage anchor couplings/plates to be embedded in primary concrete. Both shall be fixed through formwork into the first stage anchors coupling/plates to ensure that the couplings/plates remain flush with primary concrete face and the couplings do not get plugged.

(xi) Where timber forms are used, the laying shall be in the direction which will blend architecturally into the lines of the structures.

(xii) Curved and special forms shall be such that these will result in smooth concrete surfaces. They shall be designed and constructed so that they will not warp or spring upduring erection or placing concrete. For double-curved surfaces the formwork shall be built up of laminated splines cut to make tight, smooth surfaces. Steel plate sheeting or steel faced sheeting shall not be used for double-curved surfaces.

(xiii) When metal sheets are used for lining forms, the sheets shall be placed and maintained the form with the minimum amount of wrinkles, humps or other imperfections. The use of sheet metal to cover imperfections in the lining of timber faced forms for surfaces that shall be permanently exposed to view, shall not be permitted.

(xiv) Where plywood or hardboard is used for form lining, the joints between the sheets shall be smooth and as perfect as practicable and no patching of the plywood or hardboard shall be permitted for permanently exposed surfaces. Minor imperfections in the plywood may be corrected by the use of plastic wood secured firmly in place and sand papered smooth.

(xv) Wire ties shall be permitted for the forms when specially approved by the Owner and shall be cut off flush with the surface of concrete, after the forms are removed. Wire tiesshall not be used when permanently exposed finished surfaces are required.

(xvi) Forms shall be so constructed that the finished concrete surfaces shall be of uniform texture in accordance with the type of finish specified for concrete surfaces in these specifications.

(xvii) For special sections/shapes, timber/steel form shall be used, as approved by the Owner. (xviii) The form work shall be strengthened or modified, whenever required.

(xix) Suitable mouldings shall be placed to level all exposed edges, at construction joints, and any other edges shown on the Drawings.

(xx) Formwork shall not be fastened to reinforcing steel bars or embedded parts. Formwork ties shall not be welded. Where existing or excavated rock surfaces are stabilised with rock support, the rock bolts, rock dowels or rock anchors shall not be used for formwork support.

(xxi) Forms shall be maintained, at all times, in good condition, particularly as to size, shape, strength, rigidity, tightness and smoothness of surface.

13.2.1. Formwork for Foundation gallerys

(i) The forms shall be fitted with ample windows at appropriate spacings and locations to allow the introduction of vibrators and to carry out inspections and any other work needed behind the form.

(ii) The formwork shall be of rigid construction, non-deformable due to working loads imposed upon it. Once installed in the position, the form shall remain in position without displacement during concrete placement.

(iii) The formwork shall be constructed in such a way that no abrupt irregularities arise at vertical construction joints. The joints in form work shall overlap the vertical construction joint by at least 50 cm and one form work element remains in contact with placed concrete while others are being stripped down and installed for following concreting stages.

(iv) The windows shall be provided in each side about the midheight at the tunnel and the crown on alternate sides of the centreline

Construction

(i) Forms shall be sufficiently tight to prevent the loss of mortar from the concrete. Forms shall be constructed sufficiently rigid by the use of ties and bracing to prevent displacement or sagging between supports and to withstand all loading, ramming and vibration. Joints in forms shall be provided with suitable devices to hold adjacent edges together in accurate alignment. All forms shall be so constructed that they can be removed without hammering or prying against the concrete.

(ii) Bolts and rods shall be used for internal ties. They shall be so arranged that when the forms and bolts are removed, no metal shall be within the distance given as the nominal cover from any concrete surface. Holes in concrete surface from removed tie bolts shall be dry-packed with mortar of the same sand/cement ratio as the concrete. Bolts and rods through concrete walls which will be exposed to unilateral water pressure shall have a remaining length of minimum 3/4 the width of the wall or if the wall is thick minimum one metre and be provided with continuously welded washer, 100 x 100 x 5 mm, arranged in such a way that they will prevent leakage along the bolts and rods.

(iii) All material to be used for formwork shall be thoroughly cleaned before use, and formswhich have been used repeatedly and are no longer accepted for further use shall be disposed off or satisfactorily repaired.

(iv) In the case of long spans, where no intermediate supports are possible, the probabledeflection in the forms due to the weight of the fresh concrete shall be allowed for, so that the finished members shall conform accurately to the required line and grade shown on the Drawings. If adequate foundation for props cannot be obtained, truss supports shall be provided.

13.3. Chamfers

All exposed corners and edges of concrete shall, if not otherwise shown on the Drawings, be rounded off or chamfered with 25 mm strips.

13.4. Oiling and Wetting

The insides of steel or wooden forms shall normally be coated with non-staining mineral oil or, if so approved by the Owner, with other materials which shall be applied before the steel reinforcement is placed. Care shall be taken that the oil or other approved material is not allowed to come into contact with the foundation or the steel reinforcement.

The coating compound applied to the interior of formwork shall not cause chemical deterioration or discoloration of concrete surfaces.

Wooden forms, when not coated as specified above, shall be thoroughly wetted well before the placement of the concrete.

13.5. Temporary Openings

Temporary openings shall be provided at the base of column and wall formwork and at other points where necessary to facilitate cleaning and inspection immediately before placing the concrete. Formwork for walls, or other thin sections of considerable height, shall be provided with openings or other devices to facilitate the placing and consolidation of the concrete.

13.5.1. Removal of Formwork

(i) Unless otherwise agreed with the Owner, the following earliest times for removal of formwork after placing Ordinary Portland Cement concrete shall be valid:

Forms	Min. period for which formwork is required to be in place (hrs)
Form work for tunnel lining	15
Form work for sides of beams	15
Form work for walls and columns	24
Form work sofits of beams & slabs with Props left under	240
Props for slabs and beams	480

(ii) All formwork shall be removed from concrete surface in such a manner that the concrete will not be damaged.

(iii) Forms shall not be struck until the concrete has reached a strength at least thrice the stress to which the concrete may be subjected at the time of removal of formwork. The strength referred to shall be that of concrete using the same cement and aggregates with the same proportions and cured under conditions of temperature and moisture similar to those existing in the works. In any case, forms shall not be struck before the minimum time indicated in the above table.

(iv) Heavy live loads shall not be permitted until after the concrete has reached its design strength.

(v) The forms shall be removed with great caution and without jarring the structure or throwing heavy forms upon the floor. In order to achieve this, wedges and clamps shall be used whenever practicable instead of nails.

(vi) In order to avoid excessive stresses in the concrete that might result from swelling of the forms, wood forms for wall opening shall be loosened as soon as this can be accomplished without damage to the concrete. Forms for the openings shall be constructed so as to facilitate such loosening.

13.6. Tolerances:

Forms shall be so constructed that the finished concrete surface shall be of uniform fixtures in accordance with the types of finish specified in section ‘Concrete’.

14. DRILLING, GROUTING AND DRAINAGE

14.1. Scope

This section covers the supply of all labour, plant, equipment and materials, and the execution of all work necessary to drill, wash and test, grout holes, drain holes and instrument holes, to supply, transport, store, mix and inject grout materials and additives for backfill, contact, consolidation and curtain grouting, and to supply drill and install temporary and permanent drains and wells in the foundations and in the excavated slopes as specified herein, as shown on the Drawings and as required by the Owner. Location, depth, pressure of all grouting shall be approved by the assigned Geologist of GSI ans and when required.

14.1.1. Description of the Work

The work shall include

a) Drilling and washing non-cored vertical or inclined consolidation grout holes, using percussion or rotary drills from shotcrete protected rock surfaces, from excavated rock surfaces and from concrete surfaces.

b) Drilling and washing non-cored vertical or inclined curtain grout holes using percussion or rotary drills from overburden surfaces through casing from shotcrete protected rock surfaces from excavated rock surfaces and from concrete surfaces.

c) Drilling and washing cored, vertical or inclined exploratory holes, using rotary drills from overburden surfaces through casing to bedrock, from shotcrete protected rock surfaces and from excavated rock surfaces.

d) Drilling and washing non-cored vertical or inclined drain holes from shotcrete protected rock surfaces from concrete surfaces and from excavated rock surfaces.

e) Supplying, embedding and washing PVC grout pipes in concrete for backfill contact consolidation and curtain grouting.

f) Water pressure testing grout and instrument holes where required.

g) Supplying and setting packer assemblies.

h) Supplying, mixing and injecting cement grout mixes, including the backfilling of grout and instrument holes.

i) Supplying and mixing sand in cement grout mixes.

j) Supplying and using grout additives.

14.1.2. Technical Supervision

The extent of drilling, grouting and drainage shown on the Drawings and specified herein is tentative and the actual work will increase or decrease the scope of any part of the drilling, grouting and drainage should the actual subsurface conditions encountered indicate that such changes to the scope are required. Drilling, water pressure testing, grouting and installing drains shall be done under the technical supervision of competent specialists. The technical supervision will include:

- Establishing the procedures to be adopted

- Locating primary secondary and tertiary grout, holes, drainage and instrument holes,
- Adjusting the length of grout holes
- Locating and establishing the length of control and check grout holes, if required
- Orientating and sequencing the drilling and washing of grout holes,
- Selecting and sequencing grout mixes, grout pressures and pumping rates,
- Grout mix control and testing, and
- Modifying and adjusting any aspect of the procedures.

Requirements for adjacent holes in any area will be determined after the grout takes of the previous sequence of holes have been evaluated. This may necessitate returning to areas that have been previously grouted.

14.2. Standards

The codes and recommended procedures shall be as per applicable Indian Standards. In case of ambiguity, these specifications shall take precedence.

14.3. Materials

All materials shall be handled, stored and protected from deterioration and contamination. Deteriorated or contaminated materials shall not be used.

14.3.1. Water

Water used for drilling and washing and as an ingredient of grout mix tures shall be fresh, clean and free from deleterious amount of oil, silts, organic matter, alkali, acids, salts and other impurities. At the time of mixing, the temperature of water used in grout mixes shall be less than 28 degrees celsius.

Adequate water storage facilities shall be provided to ensure a continuous supply of water for washing drill holes and for the grouting operations and to ensure that grouting operations will not be hindered by a temporary breakdown in the main supply line.

14.3.2. Cement

Cement used in the grout mixes shall be ordinary portland cement conforming to IS:8112.

Cement containing lumps or foreign matter detrimental to the results of the grouting program shall be removed from the site by the Contractor.

Each shipment of cement shall be stored so that it is protected from the weather and is readily distinguished from other shipments. To prevent undue ageing of cement, cement shall be used in the chronological order in which it is delivered to the site.

14.3.3. Sand

Sand added to the grout shall consist of clean, durable stone particles, shall be free from lumps of clay and foreign matter, shall have a moisture content of less than 3 percent of the dry weight and shall be well graded passing a 0.30 mm sieve. The percentage by weight passing the 0.074 mm sieve should be less than 5.

14.3.4. Admixtures

The mixing, handling, storing and rates of application of admixtures shall be in accordance with the manufacturer's recommendations.

Admixtures shall be obtained from the same manufacturer to ensure that they are compatible with each other.

The Contractor shall, if and as required, supply and use the following admixtures:

- Grout fluidizer
- Retardant
- Accelerator
- Calcium Chloride
- Colouring agent

14.3.5. Bentonite

Bentonite shall have a liquid limit of not less than 400%. Bentonite conforming to IS:12584 shall be pre-mixed with 14-15% water and aged for at least two hours before adding to the grout slurry.

14.3.6. Grout Mixes

Grout to be injected at each location shall consist of the mixture of cement, sand, and water plus admixtures in the proportions required. The proportions of materials in the grout mixes will be varied as shown on the Drawings to suit the particular conditions encountered.

Not less than 60 days prior to the start of grouting the Contractor shall perform the tests laboratory on the range of the grout mixes proposed for use in the works and using the actual materials to establish the consistencies of mixes, practical mixing ratios, initial and final setting times, the optimum quantities of sand and other admixtures, compatibility of admixtures with grout mix ingredients and such other properties as may affect the quality of the grout.

The results of the laboratory testing shall be submitted to the Owner for review not less than 40 days prior to the start of grouting.

14.4. Equipment

14.4.1. Drilling Equipment

All drilling equipment used shall be of a type, capacity and mechanical condition capable of performing the drilling and shall be subject to the approval of Engineer-in-Charge. Contractor shall provide a list of equipment to Engineer-in-Charge for approval.

Standard drilling equipment of the rotary and percussion type shall be used to perform the drilling as specified herein. Percussion drilling equipment shall be equipped with a water swivel for continuous flushing of the holes during drilling. Drills shall be capable of drilling holes of 50mm minimum diameter to a maximum depth of 55m in the rock or concrete.

The Engineer-in-Charge may require some of the grout holes and pressure relief holes to be drilled using rotary type drills with core recovery. The rotary type machines shall be capable of drilling NX size holes utilizing double tube core barrels equivalent and capable of recovering soft or friable materials with maximum possible core recovery. The equipment and crew shall be available at site when Engineer-in-Charge requires exploratory holes to be drilled.

The drilling units shall be mobile and of size suitable to the dimensions of the galleries.

14.4.2. Percussion Drilling

The holes shall be drilled at locations, in the sequence, orientation, inclination and to the depths shown on the Drawings or as required by Engineer-in-Charge.

Most of the holes for consolidation, curtain or contact grouting and pressure relief will be drilled with drill of the percussion type which must be equipped for constant water flushing at the far end of the drilling rod.

No drilling water additives of any kind shall be used without the written permission of Engineer-in-Charge.

All holes shall be established to within 0.25m of the specified location. All orientation shall be within 1 degree of the orientation specified. If for any reason the drill hole deviates in inclination or orientation in such a way that it does not satisfy the purpose for which it was intended, Contractor shall correct the deviation or shall drill another hole to the satisfaction of Engineer-in-Charge without any additional cost to Corporation.

All holes for consolidation, curtain and contact grouting shall be 50mm minimum in diameter whereas the pressure relief holes shall be minimum 75mm diameter.

Whenever the drill water is lost or artesian flow is encountered, drilling operations may be stopped by Engineer-in-Charge, who may require the hole to be grouted before drilling operations are resumed. Contractor is required to record the location, the flow and pressure of any artesian conditions encountered in any drill holes.

On completion of drilling and washing of any grout or pressure relief holes drilled through the floor of the galleries. Contractor shall immediately cap the holes with proper removable plugs (wooden or plastic) and shall protect them from entry of direct or other foreign material. Any grout or pressure relief hole that gets obstructed prior to grouting or installation of elbow, shall be cleaned out or another hole shall be drilled at the expense of Contractor.

Grout or pressure relief holes shall not be drilled within 12m of another hole which is being grouted or which has been grouted within the previous 24 hours.

No hole shall be drilled through concrete before 5 days after the placement of the concrete.

14.4.3. Rotary Drilling

Rotary drilling shall be carried out with or without coring.

For rotary drilling with coring, double core barrels giving core diameters of at least 52mm shall be used. The equipment shall be capable of drilling holes in any direction to a depth of at least 300m.

The radial deviation of boreholes shall not exceed 5% of the borehole depth.

Where necessary, and as approved by the Owner, drill holes shall be provided with casings through overburden and in rock of poor quality. The length through over burden may be drill without coring. Filling of part of the hole with grout and subsequent re-drilling shall be carried out as necessary in zones of poor rock quality.

In specific cases, as approved by the Owner, drill holes shall remain open. In those cases the upper end of the hole, and the part of the hole extending through the overburden, shall be provided with a pipe closed by a cap.

During drilling with coring, the rotation speed, feeding pressure and amount of flushing water shall be adapted to the rock properties, so as to obtain cores of the best possible quality.

Cores shall be placed in core boxes of wood or metal. The depth of each run shall be noted in the box and core losses marked by pieces of wood of corresponding length. The core boxes shall be transported to and kept in a core store. The water levels in the drill holes shall be measured when first encountered at the beginning and end of each shift. An electrical device, including spares, shall always be available for this purpose.

Records of core drillings shall be submitted on daily basis within 24 hours and shall comprise:

- Core recovery per run, as well as all core losses, RQD and fracture spacing
- Depth at each run
- Water level in the drill hole when encountered and at the beginning and end of the shift.
- Length of casing, lengths grouted and re-drilled

The form of the records shall be as agreed with the Owner.

14.4.4. Exploratory Drilling

Contractor shall perform exploratory drilling with NX size holes through concrete, rock and hardened grout at any inclination as directed by Engineer-in-Charge. The amount of and the requirement for exploratory drilling will be as directed by Engineer-in-Charge and no change will be made in the unit price for this work by reason of any variation in the amount of work required.

The use of mud or any other drilling fluids besides water is not permitted when coring. Exploratory holes shall be water pressure tested and grouted under pressure, if required by Engineer-in-Charge.

Contractor shall give Engineer-in-Charge all the necessary assistance and facilities to perform insitu tests or examination using borehole camera, or geophysical tests in the selected exploratory holes.

14.5. Preparation of Drill Holes

14.5.1. General

All works in this section shall be carried out by fully qualified and experienced personnel.

14.5.2. Washing of Drill Holes

All holes drilled for grouting and drainage, as well as for rock dowels, bolts, anchors, etc. shall be washed after completion of drilling and prior to water pressure tests during drilling, whenever such tests are to be performed.

Washing of holes shall be carried out by flushing, alternately with compressed air and water under pressure, through pipes or stiff hoses equipped with swivel nozzle reaching the bottom of the holes. Normally, flushing shall commence at the bottom and proceed towards the mouth of the drill hole. Finished drill holes shall be properly plugged.

14.5.3. Pressure Testing of Drill Holes

Water pressure testing of drill holes for investigation purposes, and in special cases for placing of dowels, bolts, anchors, etc. shall be performed during drilling or after completion thereof. The minimum inner diameter of the water conduit shall be 12mm. Testing shall be made by means of single or double type packers, spaced up to 5m apart. Suitable packers for testing of holes of all occurring diameters shall be available at all times. Packers, which are used in weak rock, shall be inflatable and have a length of at least 500mm.

During testing, the water pressure shall be kept constant over three consecutive two minute periods and the water leakage shall be measured during each of those periods. Testing for investigation purposes will be required at four different pressure levels comprising 50, 100, 150, and 200% of the total overburden pressure. Normally, testing of grouting holes shall be performed in one stage at a pressure level of 10 kg/cm^2. All gauges used should be such that the pressures adopted are around the middle of the measuring range of the gauge.

14.6. Grouting

14.6.1. General

The Contractor shall submit to the Owner a method statement, giving full details of the grouting systems, the Contractor proposes to use.

All grouting operations shall be carried out by fully qualified and experienced personals and shall take account of the grouting trials in terms of pressures, mix design, hole spacing and depths.

All equipment for mixing and injecting grout shall be furnished by the Contractor. The equipment shall be maintained in good operating conditions at all times and comprise:

- Double acting slush capable of operating at a discharge pressure of at least 2.5 MPa (25 kg/cm^2)
- High speed mixers, capable of preparing a colloidal form grout.
- Mechanically agitated sumps with arrangements for screening and removal of particles not passing a 1.2 U.S. Standard sieve, and with a capacity corresponding to not less than three batches of grout, each of minimum 50 litres.
- Necessary valves, scales, pressure gauges and meters, packers, pipes, hoses, fittings, spares etc.
- Adequate supply of air and water at a pressure of 0.6 MPa (6 kg/cm^2) for washing of holes and crevices, pressure testing and grouting.

The grouting material and equipment shall be adequately protected against rain and sunshine. Grout supply conduits shall have an inner diameter of about 12mm.

14.6.2. Grouting Requirements and Methods

Grouting may be required as area grouting to seal and consolidate shallow parts of foundation rocks, to produce a screen of tight rock to create a barrier and as contact grouting to seal joints in structures or areas between structures and foundations.

Grouting may normally be required, of complete drill holes in one operation, or if special circumstances so require of portions of drill holes down to two metres in length. Grouting of portions of holes may be required in ascending or descending steps or stages.

Where grouting in descending stages is prescribed, the grout holes shall be drilled down to indicated depth, washed and pressure tested and grouted by means of a suitable packer placed at the upper end of the portion to be grouted. The suitable time for re-drilling or water flushing of the drill holes after grouting will be determined on the basis of experience gained on the setting time of the grout mix used. Water flushing of drill holes in lieu of re-drilling may be used subject to the approval of the Owner.

Where grouting in ascending stages or of complete holes is prescribed, the holes shall be drilled to full depth, washed, pressure tested and grouted by means of a suitable packer, placed at levels as approved by the Owner. On grouting of the final stage, the packer shall remain in place for a period of time to be approved by the Owner.

Normally, grouting in ascending stages will be required whereas grouting in descending stages will be applicable in rock with high water losses.

Contact grouting shall normally be carried out by means of pipes for grouting and for release of air. The pipes shall be installed before concreting.

14.6.3. Materials

Cement grout shall be composed of the following ingredients, which may be used in varying combination:

Portland cement type 1 meeting the requirement of Indian Standard or other Standard approved by the Owner. The cement shall be free from lumps.

- Clean water, according to Concrete Works
- Well-graded sand passing a 0.30mm sieve, the percentage by dry weight passing the 0.074mm sieve should by less than 5.
- Additives in accordance with the manufacturer’s instructions.

- Bentonite with a liquid limit not less than 400%. Bentonite shall be pre-mixed with 14- 15% of water and aged for at least two hours before adding to the grout slurry.

Tests to establish the composition of the grout shall be carried out by the Contractor as approved by the Owner before the grouting operations start. Different grout mixed shall be prepared in full scale using the grout mixes, and samples shall be extracted for checking of segregation, hardening etc. Similarly, samples shall also be extracted from time to time during the grouting works, as agreed with the Owner.

14.6.4. Procedure

Grouting shall normally be preceded by a few minutes of pumping water into the holes. Where pressure tests give small water losses, grouting shall commence with a thin mix. In holes with large water losses, a thicker mix shall be used. The water content of the mix shall be adjusted so that the grouting pump is operating at normal and practically constant speed, irrespective of the permeability of the grouted rock. The water-cement ratio shall be decreased, if necessary, to reach the required pressure. If, however, the pressure tends to rise excessively, the water cement ratio shall be increased; and periodic injection of water under pressure as approved by the Owner may be carried out to counteract premature stoppage. Under no conditions shall the grouting pressure or the rate of pumping be allowed to increase suddenly. Sudden increase in rate of pumping may indicate a heaving of the ground under the influence of the grout pressure.

Grouting in a given hole shall normally continue until either no grout is taken at 75% of the maximum pressure permitted by the Owner or less than 10 litres of grout is taken per 5 minute period at the maximum pressure. The water cement ratio by weight of the grout shall normally not exceed 5. Holes, which do not take grout, shall be filled with mortar.

If so required for the performance of continued grouting, open fissures through which grout percolates to the ground surface shall be caulked using lead wool, mortar or other approved packing.

Grout waste and loose material shall be removed from foundation surfaces, which are to receive concrete.

14.6.5. Records

Records, the format of which shall be as agreed with the Owner, shall be submitted daily to the Owner and shall give all relevant data such as:

- Location and depth of holes and stages
- Water losses measured during drilling and Lugeon values determined water pressure tests
- Grout composition used, pressure and grout intakes for each stage
- Possible rock heaving recorded.

The sufficiency of the records shall be acknowledged by the Owner 24 hours at the latest after receipt of the same.

14.6.6. Consolidation Grouting for Dam

Consolidation grout holes will be drilled from the top of the concrete lifts.

Generally, the holes will be drilled a minimum 10m into the rock foundation and spaced 6m on a staggered pattern in such a way to cover all the surface of the dam foundations.

The holes shall be drilled, subjected to water pressure testing, if required, then grouted in stages of 6m each or as determined by Engineer-in-Charge. Additional holes must be drilled and grouted when the absorption in 6m stage, which is not caused by leakage at the surface, exceed 0.15 cum of cement.

For the treatment of certain geological features, the pattern, orientation and depth of grout holes may be modified as required by Engineer-in-Charge. The actual pressure to be used at each hole shall be determined by Engineer-in-Charge.

Consolidation grouting should be started only in areas over which at least 2.5m of concrete has been placed.

14.6.7. Curtain Grouting for Dam

The drilling and grouting of the curtain holes will be done from the longitudinal galleries in the dam and abutments. The method of split spacing shall be used.

Primary holes shall be drilled 6m centre to centre, washed, subjected to water pressure testing when required by Engineer-in-Charge and grouted before proceeding to execute the secondary holes. The primary and secondary holes shall be drilled upto a maximum depth of 50m into the bed rock. The spacing between primary and secondary hole shall be 3m.

Unless otherwise specified by Engineer-in-Charge, the curtain grouting shall be done in stages of 5m each.

If absorption in any 5m stage, which is not caused by leakage at the surface exceeds 0.15 cum of cement in adjacent primary and secondary holes, the Engineer-in-Charge may ask Contractor to drill and grout additional holes between the primary and secondary holes.

In general, the depth of grout curtain from any reference point along the foundations of the dam shall be two-third of the maximum hydraulic head acting at that point, subject to a minimum of 10m at the abutments, as shown on the Drawings or as directed by Engineer-in- Charge.

Curtain grouting shall not be started until consolidation grouting has been completed within a12m radius zone around the curtain hole to be grouted.

14.6.8. Contact Grouting for Dam

Contact grouting will be required over all the surface of the dam foundation. Along the curtain holes line, the contact grouting will be performed from the curtain holes by adding a packer setting above the rock concrete contact.

The grouting should be done in such a manner as to ensure that all voids between concrete and rock are completely filled with grout. The actual pressure to be used at each hole shall be determined by Engineer-in-Charge.

14.6.9. Contact Grouting for Underground Works

Contact grouting and void filling shall be carried out to fill voids between all concrete and rock, concrete and shotcrete in tunnels and shafts and to provide bond at the concrete / steel interface of steel liners and turbines.

The grouting pressure for grouting rock / concrete interfaces will be decided by the Contractor in consultation with the Engineer-in-Charge.

The grouting pressure used to contact grout the turbine embedded parts and draft tube liner and for grouting the steel / concrete interface in the steel lined areas, pressure shall be as required by Engineer-in-Charge and will be closely controlled by the Contractor. Strain monitoring instruments will be installed by the Contractor for the above purpose.

Grouting procedure shall be varied by Engineer-in-Charge, according to the conditions encountered, so that all voids between concrete and rock are completely filled with grout.

All holes drilled through concrete and all pipes embedded in concrete for the purpose of grouting shall be backfilled with non-shrinking sand/cement mortar.

14.6.10. Drainage Holes / Pressure Relief Holes

(i) Drainage Holes/Pressure relief holes shall consist of 75 mm minimum diameter holes as shown on the Drawings, as specified herein or as required by the Owner. The length of Drainage Hole / pressure relief hole may vary between 5 m and 7 m depending upon the area.

(ii) As rock excavation progresses, install all Drainage holes/ pressure relief holes required as shown onthe Drawings.

(iii) All water emanating from the Drainage holes/ pressure relief holes shall be directed to a collection system acceptable to the Owner and water subsequently removed from the excavated area.

(iv) Continuously protect and maintain the Drainage holes/ pressure relief holes in working order.

15. CONCRETE WORKS (CVC)

15.1. General

15.1.1. Scope

The Work covered by this Specification considers all plant, material, equipment and labor required for the manufacturing, transporting, placing, compacting and curing of conventional concrete. The Specifications described hereunder cover all labour, materials, equipment and services related to the concrete work to be carried out. Shotcrete, Reinforcement and Formwork shall be covered under respective Sections.

15.1.2. Site Laboratory

(i) A well-equipped laboratory shall be established on site and shall be provided, equipped, maintained and staffed under an engineer in charge thereof. The personnel working with the testing of the concrete shall be well trained for their tasks.

(ii) Well before the commencement of the concreting of any Permanent Works structures, related pre-construction and others requisite tests will be performed.

(iii) All testing of concrete materials and works shall be carried out in accordance with the appropriate "Bureau of Indian Standard" or “British Standard Institution” or ASTM Standard Specifications and methods, except where otherwise agreed with the Owner.

(iv) Following equipment shall be provided and installed in the concrete laboratory.

Test	No. of Equipment	Description
General	1	Concrete mixer
	1	Saw for cutting of concrete cores
Compression strength	54	Steel moulds for strength test cubes 150 x 1 50 x 150 mm
	1	Hydraulic press for testing materials capacity 200 tonnes
	1	Weighing machine of 50 kg. capacity. Sensitive to 10 g.
	1	Dynamometer for testing the hydraulic press.
	1	Device for checking planeness of cubes and cores.
	1	Equipment for extraction of concrete and shotcrete cores for testing of strength, core dia 100 mm extension rods.
	1	Concrete test hammer.
Consistency	3	Moulds for slump test
Flexural Strength	1	V.B. Consistometer
Acid Resistance	1	Equipment for testing Aadmixes and Coating materials for Concrete Waterproofing and Acid Resistance

(v) Any other equipment not included here but necessary for testing and quality control shall also be provided from time to time.

(vi) The laboratory equipment shall be calibrated and checked periodically.

15.2. Submittals

Submittals listed herein are to be made by the Contractor before the appropriate work may proceed.

The Contractor shall submit a layout and schematic drawing with a narrative description of his planned aggregate production and equipment, locations and sizes of stockpiles, transportation methods and storage procedures. The anticipated peak production capacity, estimated amounts of any waste material, normal operational rates, anticipated hours of production, storage areas and storage volumes plotted against date shall also be provided. This submittal shall be provided at least 90 days prior to the start of aggregate production.

The Contractor shall submit 120 days prior to the placement of CVC all manufacturer's certifications of compliance, mill test reports, and other required information relating to the constituent materials of the CVC.

The Contractor shall submit 60 days prior to the first placement of CVC a layout and schematic drawings with a narrative description of his planned CVC production and placement which includes all required information for site layout, equipment, crew composition, plant, processes, and procedures to produce and place CVC, produce and place all other cementitious materials, and any other related or required process.

The Contractor shall submit a detailed equipment layout, flow diagram, and proposed procedures for CVC temperature control, if required. The submittal shall include the capacity of the pre-cooling facilities and computations used to determine the capacity of cooling facilities.

Not later than 35 days prior to any CVC placement in permanent structures the Contractor shall submit to the Employer conclusive test results of the CVC mixes to be used.

Depending upon the CVC work program, CVC lift drawings may be submitted partially for designated elevations. First submittal shall be submitted 30 days in advance of CVC test section construction. CVC lift drawings shall show elevations of lifts and shall include embedded items, anchors, or other features contained or to be installed in the CVC section.

The Contractor shall submit formwork drawings 30 days prior to the placement of CVC for the test section and shall include the formwork for the upstream face, downstream face, gallery, and interfaces.

These hot-weather protection procedures will require adequate resources to assure complete coverage of the entire surface areas to prevent unacceptable damage to the conventional concrete. The Contractor shall submit a description of the materials and methods proposed for protection of the concrete, when concrete is to be placed under hot-weather conditions, to the Employer for review and approval.

The Contractor shall not later than 14 days prior to concreting operations submit to the Employer various information concerning his CVC construction activities, i.a. the following:

a) names and qualification of the foremen for batching, mixing and placing of CVC

b) proposed material for repair and method of application.

The Contractor shall apply in writing to the Employer for issue of a " CVC placement clearance" not less than 24 h prior to placing of a CVC lift. All formwork, reinforcement, embedded items and preparations for placement of the CVC lift must be completed before the clearance is issued. The CVC placement clearance, shall give account of:

a) date and hour of scheduled commencement and finish of placing,

b) location of placement,

c) type of CVC ,

d) estimated volume of CVC to be placed,

e) reinforcement (if any) placed,

f) expected temperature of air and concrete,

g) placement and compacting equipment,

h) proposed methods for protecting concrete lift surface in case of heavy rain,

i) curing methods including i.a. heat control of CVC , e.g. pre-cooling methods, CVC temperature measurements, joint maturity control, expected strength development of CVC , removal of forms and prevention of premature drying of concrete surfaces.

During the performance of the CVC placement work, the Contractor shall keep a diary where he shall record the construction procedures related to CVC placement. This diary shall be made available to the Employer upon request. The records shall contain at least the following:

a) Commencement and termination of concreting of various parts of the structures

b) Quantities and quality of aggregates and cement provided, and the storage from which they were drawn

c) Temperature of air, water, cement, aggregates, and concrete

d) Meteorological conditions and humidity of air

e) Sampling and testing performed and summary of results

f) Personnel employed during various stages of the concrete placement operation and name of the responsible inspector or foreman

g) Equipment used

h) Requests received from the Employer

Any special material or procedures employed

15.2.1. Reporting

(i) Before the casting of each concrete block, prepare a checklist to ensure adequacy of preparations for the casting and forward a signed copy of the same to the Owner for approval.

(ii) Temperatures, amounts and types of admixtures, consignment of cement, name of the Contractor's supervisor, and any other important information affecting the quality of the concrete, as well as the results of the running tests, shall be recorded on the checklists which shall be kept available for inspection by inspecting officer. W hen all running tests have been completed and the results inserted on the checklist, one copy thereof shall be submitted to the Owner.

(iii) A report shall be submitted within one week to the Owner on the receipt of each new consignment of cement and carry out distinguish marks thereof.

15.2.2. Practice and Standards

(i) In general, the applicable Indian Standards shall be adhered to in executing concrete works.

(ii) Wherever the standards for the materials used and works performed are not specified, the relevant latest edition of Indian Standards and/ or BS shall be followed. In general, the standards & recommendations of ACI Manual of concrete practice 1983 shall be adhered to.

(iii) The following Indian Standard shall apply:

(a)	IS:383-1970 (Reaffirmed 1980)	Specification for coarse and fine aggregate from natural source for concrete.
(b)	IS:2386-1963 (Part 1 to 8)	Method of Test for Aggregates for concrete
(c)	IS:269-1989	Specification for 33 Grade OPC (Fourth edition)
(d)	IS:8112-1989	Specification for 33 Grade PPC (First revision)
(e)	IS:1489-1991	Specification for PPC.
(f)	IS:8112-1989	Specification for 43 grade OPC (First revision)
(g)	IS:12269-1987	Specification for 53 grade OPC.
(h)	IS;12600-1989	Specification for Low heat Portland Cement.
(i)	IS:12330-1988	Specification for Sulphate Resisting Portland Cement.

(j)	IS:3024-1967 IS:3025-1964	Method of Sampling and test (physical and chemical) for water used in Industry.
(k)	IS:456-1978	Code of Practice for Plain and Reinforced Concrete.
(l)	IS:457-1957	Code of Practice for General Construction of Plain and Reinforced Concrete for Dams and other Massive Structures.
(m)	SP:23-1982	Hand Book on Concrete Mixes.
(n)	IS:10262-1982	Recommended Guidelines for Concrete Mix Design.
(o)	IS:1199-1959	Methods of Sampling and Analysis of Concrete.
(p)	IS:516-1959	Methods of Tests for Strength of Concrete.
(q)	IS:5816-1970	Method of Test for Splitting Tensile Strength of Concrete cylinder.
(r)	IS:4031-1988 (Part 1 to 15)	Method of Physical Tests for Hydraulic Cements.
(s)	IS:9103-1979	Specification for Admixture for Concrete.

15.2.3. Tolerances

Tolerances indicated in the relevant Indian Standards and/or ACI 117 shall apply. Tolerances required on surfaces connecting to mechanical and electrical installations, exposed to high velocity water flow, etc., shall be indicated on the relevant construction Drawings in form of finishing type.

15.2.4. Time Before Use

The earliest time for allowing rapid water flow over concrete surfaces or allowing water pressure on concrete structures shall be one month after concreting. In specific cases, in order to deal with particular hydrological conditions, shorter times may be allowed. The earliest time for allowing loads on concrete structures shall be as indicated in the Drawings.

15.3. Materials for Concrete

15.3.1. Cement and Admixtures

(i) The cement to be used shall meet the requirement of IS 269 -1976, IS1489-1976, IS:8112-1989, IS: 12600 – 1989 and/or IS:12269-1987.

(ii) For all cement used certified mill tests in accordance with the relevant standard shall be carried out. No cement shall be used until the satisfactory test results are available.

(iii) Test the cement, together with fine and coarse aggregates obtained from the actual borrow areas on site, to determine alkali reactivity in accordance with the relevant Indian Standards and/or ASTM C 227. The tests shall be completed at the same time as the full scale pre-construction tests of the concrete.

(iv) Concrete admixtures, such as air entrainment agent, plasticizer, water reducer, super-plasticizer, accelerator and retarder shall meet the requirements of relevant Indian Standards/ ASTM.

(v) For mass concrete, in dam and power dam, a combination of air entrainers and chemical plasticizer will be preferentially utilized in order to lower as much as possible the cement content.

(vi) Admixtures shall meet the requirement of IS:9103-1979 or BS: 5075:1-3. The range of their content shall be as recommended by the manufacturer. The precise rate of admixtures shall be determined by performing tests with various concrete mixes.

(vii) Cement to be used for various works shall be of different types such as Ordinary Portland Cement (OPC) or Portland Pozzolana Cement (PPC) or Sulphate Resistant Cement (SRC) as required and shall conform to the relevant standards at the time of its use.

(viii) For Concrete production non-acid water shall be used from upstream and downstream of Dam axis.

15.3.2. Aggregates

(i) Information regarding suitable sources for aggregates will be collected sufficiently in advance to establish necessary site installations to produce suitable grades of aggregates for concrete. The quality of the aggregates shall conform to the relevant Indian Standards.

(ii) Fine aggregate (less than 4.75 mm) shall conform to IS:383-1970 (Reaffirmed 1980) and shall consist of hard, dense, durable, un-coated fragments of sand or crushed rock. For obtaining concrete with good workability and water tightness, depending on the cement content, 10-30 percent by dry weight of the fine aggregate should pass sieve No. 50.

(iii) Coarse aggregate shall conform to IS:383-1970 (latest edition) and shall consist of hard, strong, durable particles of gravel or crushed rock free from adherent coatings.

(iv) The maximum aggregate size shall not be larger than 1/4 of the narrowest dimension between forms of the member for which the concrete is to be used, nor larger than 3/4 of the minimum clear space between the reinforcing bars.

15.3.3. Mixing Water

Water for concrete shall be clean and free from harmful quantities of oil, acid, alkali, organic matter, silt or other deleterious substances. Should there be any doubt about the suitability/durability of any water for concrete work, the influence thereof on the strength and the time of setting of cement mortar cubes shall be examined by making comparable tests in accordance with IS:3025-1964. The tests shall be made with water from the source to be tested and pure, drinkable water to the approval of the which, later water shall be considered as a reference source. The water from the source to be tested may be used if it produces 7- and 28-day strengths which are equal to at least 90 percent of the strength obtained with water from the reference source, and a setting time which does not deviate by more than one hour from the reference source. Acidity influence on durability over time shall be addressed separately.

Mixing water for mass concrete will be cooled prior to batch plant or used along with ice flakes during concrete processing.

15.4. Transport, Storage and Cooling of Materials

15.4.1. Cement

The cement shall be transported from the factory to the site in such a manner that it will be properly protected from exposure to moisture and sunshine. Immediately upon arrival on site, the cement shall be placed in dry, shadowed stores or in aluminum painted cement bins. Cement of different types shall be stored separately. Storage facilities shall be such as will permit easy access for inspection and identification. Cement shall be used in the sequence in which it is delivered to the site, and any cement older than four months shall not be used, except with the specific approval of the Owner. Cement in sacks shall be stacked not higher than fourteen sacks for periods up to 30 days and not higher than seven sacks for longer periods. Cement in sacks damaged during transport to the site shall not be used.

15.4.2. Aggregates

(i) Aggregates of different sizes shall be stored separately in stockpiles or bins in such a manner as to avoid separation of the material and inclusion of dirt and other foreign material. Stockpiling shall be made on a hard-standing laid to fall. Aggregates shall be unloaded in such a manner that the even grading of sizes is maintained.

(ii) As far as practicable, the storage bins and stockpiles at the batching plant shall be protected from sunshine and rain.

(iii) The coarse aggregates shall be stacked in five stock piles, designated 150 mm to 80 mm, 80 mm to 40mm, 40 mm to 20 mm, 20 mm to 10 mm and 10 mm to 4.75 mm nominal size aggregates.

(iv) The fine aggregate, having the required grading, shall ordinarily be stacked in two piles, one of which is washed and drained and the other freshly washed, to minimise the variation in the moisture content.

15.4.3. Mixing Water

The water shall be cooled before mixing if required. Pipes, storage tanks, etc. for mixing water shall be insulated and protected against sunshine.

15.5. Proportion and Testing of Concrete

15.5.1. General

(i) The cement content, the water-cement ratio, the quantity and type of admixtures and the most suitable proportions of fine to coarse aggregates to attain the required water-tightness, strength and other properties of the various concrete mixes shall be determined by laboratory tests.

(ii) During the tests, special regard shall be paid to the requirement that the concrete mass shall be smooth and easily workable. The slump of the concrete shall normally be around 50 mm, corresponding to a stiff, plastic consistency. In case of pumped concrete, a higher slump may be accepted by using plasticizer.

15.5.2. Concrete Mix

(i). Denomination of concrete classes is based on the nominal cube compressive strength (in Newton per square mm) and maximum aggregate size.

(ii). The cube compressive strength is defined as the strength as measured at 28 days. The strength shall comply with the requirements of IS: 456.

(iii). The following table shows, in general, the anticipated classes of concrete required in various sections of work. The specific class of concrete to be used in each area will be shown on the Construction Drawings or designated by Owner.

Class	Specified Strength N/mm^2 tested on cubes 150x150x150 mm 28 days	Water cement ratio, maximum
Class A Concrete in structures exposed to unilateral water pressure or in the range of a fluctuating water surface or spray: - A 35 A 30 A 25	 35 30 25	 0.45 0.50 0.50
Class B Concrete in structures submerged in water, covered with earth or outdoors. B 35 B 30 B 25	 35 30 25	 0.55 0.55 0.60
Class C Concrete in other structures indoor area: - C 35 C 30 C 25	 35 30 25	 0.65 0.65 0.65
Class D Concrete for simple unreinforced structures, backfill or similar D 20 D 15	 20 15	 ------- -------

(iv) The following table shows in general the specific class of concrete required in various sections of work. The of concrete to be used in each area shall be shown on the Construction Drawings

S.No	Concrete Grade	Cement Type	Characteristic compressive strength at 28 days (N/mm²)	Max. Aggregate size (mm)	Description
1	M15	PPC	15 N/mm²	150	Mass concrete in interior of Dam body/Leveling Concrete
2	M20	PPC	20 N/mm²	80	Mass concrete near foundation level.
3	M20	PPC	20 N/mm²	40	0.5m thick First lift of concrete in contact with rock.
4	M25	OPC	25 N/mm²	40	2.0m all around, openings, Piers, Bridge, Breast wall, U/s & D/s face and Foundation level.
5	M50	OPC	50 N/mm²	20	Silica fume concrete 0.5m thick on spillway glacis and along piers to accommodate high rate velocities.
6	M45	OPC	45 N/mm²	20	Prestressed concrete around trunnion beam and passive anchorage
7	M30	OPC	30 N/mm²	20	Second stage concrete for HM Blockouts
8	M50	HPC	50 N/mm²		Spillway glacis and other wearing surfaces

Proper mix designs will be carried out in respect of the following mixes or any other mix required to be used. "The mix design shall be approved by Owner/Engineer-in-Charge before use".

Concrete Grade	Aggregate size (mm)	Cement
M1	15	PP
M2	8	PP
M2	4	OP
M3	2	OP
M4	2	OP
M5	2	OP

In case of failure in meeting the above requirements, a thorough investigation shall be made to find out the cause of the failure. Test cylinders, or other approved test, shall be taken out from the finished structure in places agreed with the Owner to find out if the failing concrete cubes are significant for the relevant concrete block. Remedial measures, as agreed with the Owner, shall be taken.

15.5.3. Technical Specifications for High Performance Concrete

(i) The top layer of the spillway glacis and bucket concrete shall be terminated approximately 500 mm (or as shown on drawings) below the final surface to provide room for placing the special concrete to increase the abrasion resistance of the structure.

(ii) This high-performance concrete shall be obtained by adding silica fume and/or steel fibres in the concrete. Depending on the mix, design quantity of silica fume will be approximately 40 kg per cubic meter and/or steel fibres of 60 kg per cubic meters. Mix proportions to be used will be determined by trial mix design. Test samples shall be made in accordance with IS: 1199, tested as per IS: 516 and analysed as per IS : 456. Source of aggregate for high performance concrete shall meet the requirement of wearing surface and shall be as identified by Engineer-in-Charge.

(iii) Silica fume shall comply with SABS CAN/CSA-A23.5-M86 or equivalent international standards. In addition, it shall meet the following requirements.

Particle size Average not more than 0.2 micron, max 0.4 micron

SiO content Not less than

85% Carbon content Not greater

than 5%

Total alkali content Na_2O + 0.658 K_2O not greater than 1.5% and

when combined with OPC not greater than 0.6%

In addition to the standard requirements for individual materials, the blended cement and silica fume for high strength concrete shall comply with the following requirements (IS : 4031 (3), (5), (6) and (10) – 1988 and IS : 4032 – 1988) :

Min. compressive strength at 28 days 50

Mpa Min. initial setting time 90

minutes Max. mortar shrinkage 0.07%

At 28 days

Max. sulphate content (SO_4) 5%

Max. auoclave expansion 0.5%

Max. CaO content 45%

The Contractor shall present the results of quality control tests carried on a representative sample by the supplier. Once approved, the silica fume shall only be supplied from the same production plant. Deliveries shall be in impervious sacks weighting about 40 kg and shall be accompanied by manufactures quality assurance certificates.

(iv) Steel fibers shall be hook bends bundled fibers with normal dissolving. The fibers shall be clean and free from rust, oil and deleterious materials. The method of storage shall be such as to prevent oxidation. Rusted fibers shall be refused.

15.6. Testing and Quality Control

15.6.1. Testing

(i) At least 4 months prior to commencement of any concreting of Permanent Works, the Contractor shall start the testing of materials, propose the composition of concrete mixes and prepare trial mix of each of the proposed concrete class. The Contractor shall prepare the trial mixes using the cement, water, aggregates and admixtures intended for the work and which conform to the requirements specified in this Section.

(ii) Contractor shall determine, in accordance with IS standards, the mix proportions for the designated classes of concrete. The contractor shall submit the test reports to the Owner for approval. This preliminary test program shall include the determination of following parameters.

a. Cement properties

b. Characteristics of aggregates

c. Mix water properties

d. Admixture and coating properties

e. Proportion of aggregate ranges in the mix

f. Proportion of uncrushed to crushed aggregates g. Cement content

h. Water-cement ratio (W/C)

i. Workability of concrete mixes

j. Compressive and tensile strength k. Entrained air

l. Density

m. Water-tightness

(iii) These test shall be carried out until the concrete mixes show appropriate strength, workability, density and water tightness without the use of excessive cement and water.

(iv) To carry out these preconstruction tests, full scale machine-mixed test batches shall be made and test samples taken therefrom. Tests shall be made in ample time so that complete and acceptable results are available before concreting of structures.

(v) Test samples shall be made in accordance with IS : 1199 and tested in accordance with IS : 516. The test results shall be analysed in accordance with IS : 456.

(vi) The mixes for different classes of concrete shall be selected jointly by the Owner and the Contractor.

(vii) Water to be added to the mix shall be adjusted to compensate for any variation in the free moisture content of the aggregate as they enter the batch plant. Water beyond the specified water cement ratio shall not be added without the written permission of the Owner.

(viii) The types and quantities of admixtures shall be tested and used as specified in this tender document.

(ix) For every type of concrete intended to be used in the Works, pre-construction tests shall be carried out for at least three different mixing operations. For each operation, 6 test cubes shall be made giving a total of 18 tests cubes. The specimens from each operation shall be tested as follows:

- 1 concrete cube to be tested for strength after 7 days. (Class A-D) and for other mixes too
- 1 concrete cube to be tested for strength after 14 days. (Class A-D) for other mixes too
- 3 concrete cubes to be tested for strength after 28 days. (Class A-D) and for other mixes too
- 1 concrete cube to be tested for strength after 91 days. (Class A-D) and for other mixes too

(x) For each type of concrete, the consistency, bleeding and air content shall be measured.

(xi) For continual check of the quality of the concrete, running tests shall be carried out.

For these tests, three series of samples shall be taken from different batches of concrete, each series consisting of:

- 2 concrete cubes to be tested for strength after 7 days (Class A-D)
- 2 concrete cubes to be tested for strength after 28 days. (Class A-D)
- 1 concrete cube to be tested for strength after 91 days or be kept as spare. (Class A-D)

(xii) For testing, one sample for each test shall be taken from each of the three series.

(xiii) During the initial period of the concreted works, running tests each including 15 cubes as specified above, shall be carried out for each concrete block and on each 100 m^3 of concrete and the sampling of the concrete shall be spread evenly over the concreting period.

(xiv) When sufficient experience has been gained the running tests shall be carried out on each 200 m^3 of concrete of respective class, as agreed with the Owner.

(xv) If satisfactory results are consistently obtained, the running tests shall be carried out on each 400 m^3 of concrete or more of respective class, as agreed with the Owner.

(xvi) At every test, the consistency of the concrete mass shall be determined. Tests on bleeding shall be performed when so required by the Owner. In case an air entraining agent is used, the air content shall also be established.

(xvii) If the Contractor proposes to modify the source, type or quality of any concrete materials for the selected concrete mix designs, additional testing shall be carried out using concrete mixed and batched in the batch plant that will be used for concrete production for the works. The additional testing shall be in accordance with these specifications except that the testing shall be to the 28 day test results only.

(xviii) The tests to obtain modulus of elasticity of placed concrete for 90 & 365 days shall be made. Necessary modifications in mixes shall be made if average modulus of elasticity varies considerably (>15%) than the value assumed in the design.

15.6.2. Quality Control

(i) The Contractor shall be completely responsible for performing detailed quality control program during the execution of the work. This quality assurance program shall be subject to inspection and checking by the Owner.

(ii) The Contractor shall keep records of test results which shall be presented to the Owner upon request.

(iii) Should the Contractor wish to reduce his approved testing program he shall notify the Owner of these changes 2 weeks in advance.

(iv) Besides Contractor's testing program the Owner will make control test to the extent as he deems necessary. The Contractor shall give all required assistance in sampling and provide for the proper storage and transport of the specimens to be tested by the Owner.

(v) The Contractor shall make such arrangements or purchase a new equipment should the test results prove that changes in the aggregates or concrete plant are necessary to obtain required concrete quality.

15.6.3. Air Content of Concrete

When an air entraining admixture is used, the entrained air in freshly mixed concrete shall not be less than 3.5 percent or more than 6 percent by volume of the concrete material when aggregate larger than 32 mm has been removed. Air content shall be determined by tests conforming to relevant Indian Standards.

15.6.4. Consistency

Consistency tests shall be carried out by means of the cone slump test in accordance with relevant Indian Standards.

15.6.5. Bleeding

Bleeding tests shall be carried out in accordance with relevant Indian Standards or ASTM C 232.

15.6.6. Test Specimens for Compressive Strength

Test specimens for compressive strength shall be cubes 150 x 150 x 150 mm molded in steel forms. When molding, aggregates larger than 32 mm shall be removed. The cubes shall be made according to IS:1199-1959 (latest adition).

15.7. Batching and mixing of Concrete

15.7.1. Plant

(i) Automatically controlled batch and mixing plant with sufficient spare parts of adequate size shall be provided. The batching equipment shall provide adequate facilities for the accurate measurement and control of each of the materials forming part of the concrete. The mixing equipment shall ensure a uniform distribution of the material throughout the concrete mass. The equipment, or applicable parts thereof, shall be placed in dry, properly ventilated and shaded, closed rooms.

(ii) The plant shall be capable of determining accurately, by direct weighing, the prescribed amount of the various ingredients including water, cement, admixtures, pozzolona, etc. and each individual size of aggregate entering the concrete and combining them to give a uniform mix within the prescribed time and discharging the mix without segregation.

(iii) The quantities of all materials, except water and fluid admixtures, shall be gauged separately by weighing. The apparatus provided for weighing shall be suitably gauged by volume/weight. Approved automatic equipment for dosage of admixtures shall be installed in the mixing plant.

(iv) An adequate number of mixers shall be available, so that concreting can continue in case of breakdown of one of the mixers in operation.

15.7.2. Mixing

(i) All concrete shall be thoroughly mixed in the batch and mixing plant. This will include a tilt batch mixer of an approved type, size and design so as to positively ensure uniform distribution of the components throughout the mass during the mixing operations.

(ii) The mixing time shall be increased when, in the opinion of the Owner, the charging and mixing operations fail to result in the uniformity of composition and consistency within the batch and from batch to batch.

(iii) Separation of coarse aggregate from mortar shall be avoided by proper arrangement of the discharge so that the concrete falls vertically and not diagonally into whatever container is to receive it.

(iv) Should the last fraction of the batch contain an excessive amount of coarse aggregate, this portion shall be retained and mixed with the succeeding batch.

(v) Discharge pipes of all water batches shall be of such a size and so arranged that the flow into the mixer is completed within the first 25% of the mixing time and delivered well inside the mixer where it is mixed quickly with the entire batch.

(vi) Over mixing requiring additions of water to preserve the required consistency shall not be permitted.

(vii) The volume of the mixed material per batch shall not exceed the manufacture's rated capacity of the mixer. The mixing speed shall be that specified by the manufacturer. The mixing of each batch shall continue for the periods indicated hereunder. The mixing periods shall be measured from the time when all the solid materials are in the mixing drum, provided that all the mixing water has been introduced before one-fourth of the mixing time has elapsed.

(viii) The minimum mixing time shall be as recommended by the manufacturer of the mixing plant. If a uniform concrete cannot be obtained by mixing according to the manufacturer's recommendation performance test according to IS:4634-1968 or BS 3963 may be executed and the mixing time shall be decided on the basis of the test results.

(ix) Subject to the approval of the Owner, a reduced mixing time may be allowed, provided that the Contractor can prove that a satisfactory degree of mixing can be achieved.

(x) The mixing shall be checked by ampere or wattmeters coupled to the feeders of the mixer motors. Every mixer shall be equipped with an ampere or wattmeter having a larger visible hand from which the operator can judge the consistency of the concrete mass before discharging from the mixer.

(xi) No water may be added to the concreted mix once it has left the mixer. Retampering of concrete is not allowed.

The mixer shall be examined at regular intervals to ensure that wear on the blades and liners does not allow dead spots or agglomerations of mortar around the sides of the mixer.

Transit mixers shall not be used for primary mixing of concrete.

15.8. Transport of Concrete

15.8.1. General

(i) Concrete shall be conveyed from the mixer to the place of deposit as rapidly as practicable by approved methods to prevent segregation or loss of ingredients, undue rise of its temperature or undue loss in moisture content.

(ii) Alternative equipment shall be provided for immediate use to prevent delays causing unintentional construction joints in case of breakdowns.

(iii) The concrete shall be delivered to the place of deposit in a thoroughly mixed and uniform mass and be discharged with a satisfactory degree of uniformity. The slump of concrete discharged at the place of deposit shall not differ by more than 25 mm from values specified in this tender document.

(iv) Concrete without retarder, not placed within 30 minutes after first adding water to the mix, shall only be used with the approval of the Owner.

(v) Plant, such as buckets, cars, conveyors, and pumping equipment, which may be used for conveying concrete shall be of such size, design and condition as to ensure an even and adequate supply of concrete at the placement area.

(vi) Particular attention shall be paid to prevent segregation at the ends of chutes, at hopper gates and at all other points of discharge.

(vii) Concrete shall be deposited in the formwork as near as possible to its final position, so as to avoid re-handling. The free fall of the concrete shall be adapted to the circumstances and shall in no case be more than 1.5 meters. Methods of conveying concrete to any part of the structure wherein the concrete is loaded into chutes, belt conveyor or other similar equipment and carried in a thin continuously exposed flow to the forms shall not be permitted except for very limited or isolated sections of the work.

(viii) Where chutes are used, they shall be so constructed and arranged as to permit continuous flow of the concrete without separation of the ingredients. Chutes shall not have a slope steeper than 1 V : 2 H.

(ix) Concrete may be dropped through flexible elephant-trunk chutes, provided the flow of concrete from the feeder is controlled and segregation is prevented.

(x) Buckets for transporting concrete shall be manufactured as low-slump concrete buckets.

(xi) The conveying plant shall be kept free from hardened concrete and foreign materials and shall be cleaned at frequent intervals.

(xii) During hot or cold weather, concrete shall be transported in deep containers as such containers, on account of their lower ratio of areas to mass, reduce the rate of loss of water by evaporation during hot weather and loss of heat in cold weather.

(xiii) All conveying plant shall be supported independently of the forms, except as specifically permitted by the Owner.

15.8.2. Pumping

(i) Pumping of concrete may be used.

(ii) The pump and all appurtenant equipments shall be so designed and arranged that the specified concrete mix can be transported and placed in the form work without segregation. The pump shall be capable of developing a working pressure of at least 20 atmospheres and the pipeline and fittings shall be designed to withstand twice the working pressure. Aluminum pipes shall not be used in pipelines for pumping of concrete, unless approved by the Owner. Concrete pumps and liners shall be washed with water after each pumping operation.

15.8.3. Transport by Truck

(i) The volume of any batch being transported in truck agitator shall not exceed 80% of the gross volume of the drum. When a truck agitator is used for transportation of concrete, agitation during transportation shall be kept to the minimum required for homogeneity at delivery. Before being discharged, the concrete shall be agitated in the transit mixer by a sufficient number of revolutions of the drum in order to obtain a uniform concrete mass.

(ii) Central-mixed concrete, which has been proportioned for the purpose, may be transported in a suitable non-agitating vessel, consisting of a smooth, watertight, metal container equipped with gates that will permit control of the discharge of the concrete. If required, covers shall be provided for protection against the weather.

(iii) Drums, containers, etc., used for transportation of concrete, shall be painted white.

15.9. Placing of Concrete

15.9.1. General

(i) Before any concrete is placed, all debris shall have been removed from inside the form work and any mortar splashed on the steel reinforcement and surfaces of the forms shall have been removed.

(ii) Before concrete is placed on a rock foundation, all loose rock, clay, mud, debris, etc. shall be removed from the surface of the rock. On other rock surfaces, against which concrete shall be placed, the cleaning shall be carried out by means of a high velocity air-water jet having a pressure of at least 3 atmospheres at the nozzle; care being taken, however that the rock shall not be unduly split up. Water shall be removed from the framework or excavation before the concrete is placed. Any flow of water into excavations shall be diverted by proper drains or be removed by other approved methods in order to prevent scouring of fresh concrete during or after placement. Fissures and seams in the rock shall be cleaned out to adequate depth and if necessary packed with cement mortar of an approved mix. If required water and vent pipes and drains shall be filled by grouting or by other approved means after the concrete has thoroughly hardened.

(iii) Concrete for filling of the void, resulting from over break outside the theoretical profile shown on the Drawings, shall be of the same quality as the concrete in the adjacent structural members.

(iv) Such concrete filling shall be placed during the progress of the normal concreting work or as a separate operation before the ordinary concreting if specifically agreed.

(v) No concreting may commence before the formwork and the rock and concrete surfaces against which the concrete shall be poured and the steel reinforcement have been inspected by the Owner. After such inspections, no work of any kind, except the actual concreting, shall take place either in or over the formwork until the concreting is completed, except in the case of progressive building up of forms.

(vi) At every place where concreting is in progress, one of the supervisors, well experienced in concrete works, shall be present and responsible for the work. All concreting shall be carried out by skilled workmen under the supervision of foremen with sound technical knowledge and experience. During concreting, sufficient number of workmen shall be present to handle the concrete supervision, an adequate number of steel fixers and carpenters shall keep the steel reinforcement and formwork under surveillance.

(vii) If and when concreting is carried out in the dark, ample lighting shall be provided at the mixing station and at every place where concrete is being placed.

(viii) A communication system shall be provided linking the Owner's and the project offices, the concrete laboratory, the mixing station, and the places where concrete is being placed.

15.10. Handling and Placing

15.10.1. Preparation for Placing of Concrete

(i) All surfaces on which or against which concrete is to be placed, including surfaces of construction joints between successive concrete placement, reinforcing steel and embedded parts, shall be thoroughly cleaned of standing water, dirt, mud, debris, grease, oil, dried mortar or grout, laitance, loose particles or other deleterious matter.

(ii) Surface seepage and other water shall be so controlled, that at no time during the placement or hardening of the concrete will it wash, mix with, or seep into the concrete.

15.10.2. Concrete Placement

(i) Concreting shall be placed continuously and at a rate which will give the prescribed rise of the fresh concrete in the form work, while a block of concrete is being completed.

(ii) The concrete shall be handled and placed in such a manner that it will have an approximately horizontal, plastic surface throughout the casting. The rise of concrete in the form work shall not be less than 100 mm per hour nor exceed the following rates, unless otherwise approved by the Owner.

(a) for concrete structure which can be subjected to unilateral water pressure and which is concreted against shuttering on one side and against rock on the other: 300 mm per hour.

(b) for concrete structure which can be subjected to unilateral water pressure and which is concreted against shuttering on both sides: 400 mm per hour.

(c) for concreting structure which can not be subjected to unilateral water pressure and which is concreted against shuttering on one side and against rock on the other 500 mm per hour.

(d) for concrete structure which cannot be subjected to unilateral water pressure and which is concreted against shuttering on both sides: 750 mm per hour.

(iii) Tunnel concrete lining shall in context be considered as a concrete structure under(d). The maximum permitted rise of concrete in the formwork shall thus not exceed 750 mm per hour.

(iv) Thin slabs and shallow beams may be concreted to the full height in one operation, but the concrete shall not be allowed to flow in the slope of fresh concrete.

(v) Concrete shall be protected against damage from sunshine and rainfall. Concrete may not be placed in or through water, unless specifically indicated on the Drawings or approved by the Owner. All water encountered during concreting operations shall be dealt in such a manner that the water is prevented from flowing over or exerting pressure against the concrete for four hours or such time after depositing as agreed.

(vi) Where placing of concrete under water is permitted, tremie concrete or pumped concrete shall be used. A detailed description of procedure of placing using and surface finighing of concrete under water will be submitted to the Owner.

(vii) Water and slurry shall be removed from the concrete surface during concreting.

(viii) The method and equipment used for placing concrete shall be such as shall permit the delivery of concrete of the required consistency into the work without objectionable delay, segregation, porosity or loss of workability.

(ix) All surfaces of forms and metal work including reinforcement bars that have become encrusted with dried mortar or grout from concrete previously placed, shall be cleaned of all such matter or grout before the surrounding or adjacent concrete is placed.

(x) Concrete shall be placed in lifts as shown on the Drawings or as directed by the Owner.

(xi) In all cases, concrete shall be deposited as nearly as practicable directly in its final position and shall not be caused to flow by vibrators or otherwise in a manner which shall permit or cause segregation.

(xii) The maximum time interval between placing successive layers within a lift shall notexceed the initial setting time of cement being used. However, depending upon job requirements and climatic conditions, this time interval can be increased, with the Owner’s approval, using appropriate methods of vibration/agitation.

(xiii) Concrete shall not be piled up in the forms in a manner that causes movement of the unconsolidated concrete or permits mortar to escape from the coarse aggregate.

(xiv) Concrete vibrators shall not be used for moving concrete. No concrete shall be placed until the concrete in the previously placed layer has been thoroughly and systematically vibrated. Vibrators confirming to relevant Indian Standard Code or BS Code shall be operated as nearly as practicable in a vertical position. The vibrating head shall be allowed to penetrate under its own weight until it can re-vibrate the top layer of the underlying concrete. Vibrators shall be inserted at uniform spacing over the entire area of placement. The distance between insertions shall be approximately 1.5 times the radius of action of the vibrator. Vibrators shall be held stationary until the concrete is consolidated and then withdrawn slowly. The concrete ingredients shall not be allowed to segregate and no laitance shall be allowed to appear on the surface. Vibrators shall not come in contact with or disturb embedded parts, reinforcing steel and formwork.

15.10.3. Rate of Placing of Concrete.

(i) Concreting shall be done as a continuous operation until the structure or section is completed or until a satisfactory construction joint can be made. All arrangements necessary to maintain continuity of concrete placing in any particular pour during meal periods, shift changes, or any other such interruptions shall be made.

(ii) Concrete shall not be placed faster than the placing crew can compact it properly.

(iii) Placing concrete in thin members and columns, precaution shall be taken against too rapid placement which may result in movement or failure of the form due to excessive lateral pressure. An interval of at least 24 hours, unless otherwise approved or directed by the Owner, shall elapse between the completion of columns and walls and the placing of slabs, beams or girders supported by them.

(iv) The rate of placing shall be such as to have no objectionable effect on placement of concrete, particularly near the forms and in and around embedded equipment where the rate shall not exceed the limit placed by the Owner.

15.11. Concreting in Underground and Open Works

15.11.1. Tunnel Concrete Lining (Concrete Lining in foundation gallerys if Any)

(i) Concrete to be used for the tunnel concrete lining shall be as specified on the Drawings.

(ii) The tunnel lining shall either be poured in sections or by continuous pouring. If it is proposed to use the latter method, ensure that the concrete production, transport and placing equipment to be used has sufficient capacity to produce and handle the quantity of concrete necessary for continuous pouring of the lining sections. In addition, sort out details of the steps to be taken in the event of an interruption in the concrete supply.

(iii) The steel reinforcement required in the concrete lining, based on the results of the rock mechanics tests performed in the excavated tunnel, shall be as shown on the Drawings.

(iv) Openings for communication with the drainage trench (where executed) shall be left in the concrete lining to serve as cleaning and control pits at intervals not exceeding100 m. After fill grouting of the entire system of temporary invert drains, theseopenings shall be filled with concrete of specified grade containing a non-shrink agent.

15.11.2. Backfill Concrete behind Steel Liners

(i) No windows for introduction of vibrators shall be provided in the steel liners. Working space shall be provided at the crown of the tunnel and the shaft to permit access for the necessary vibration of the backfill concrete. Special care shall be taken to ensure compaction of concrete and complete filling of the space beneath the steel lining and filling of the crown.

(ii) Concrete used for backfilling behind the steel liner shall be of the grade as specified on the Drawings.

(iii) Concreting shall be coordinated and carried out in conjunction with the installation of the permanent steel liner according to the following sequence:

1st Concreting of the invert, including casting in of rails.

2nd Installation of the permanent steel liners. A maximum of 3 units, may be installed before the surrounding backfill concrete is placed.

3rd Placing of the surrounding concrete.

15.11.3. Concrete in R.C.C. Frames / Walls, Slabs

(i) Concrete shall be placed in lifts of heights as shown on the Drawings. Within each lift, concrete shall be deposited in approximately horizontal layers about 40 cm in thickness.

(ii) At locations where lift heights are not shown on the Drawings, details of the placing procedure shall be approved by the Owner. No concrete shall be placed at such locations without the prior approval of the Owner.

(iii) Slabs shall be placed in one lift unless otherwise indicated or directed by the Owner.

(iv) In walls, lifts shall terminate at such levels as will conform to the structural requirements.

(v) The placement of concrete shall be carried out at such a rate and in such a m anner that the formation of cold joints is prevented.

15.11.4. Concrete for Block-outs

(i) Block-outs for gate guides, seals, or track assemblies of the like shall be provided as indicated on the Drawings.

(ii) After the assemblies have been installed and adjusted, the blockout recesses shall be filled with concrete as specified on the Drawings.

(iii) Before installing the components to be embedded in block-out concrete and before depositing mortar or concrete, the concrete surfaces of the block-out shall be cleaned in the manner specified for cleaning construction joints.

(iv) Exceptional care shall be taken in placing mortar or concrete in the block-outs to ensure satisfactory bond with the concrete previously placed and to secure complete contact with all components embedded in the block-outs.

15.11.5. Concrete Deposited in Water

(i) Concrete shall be deposited in water only with the prior approval of the Owner.

(ii) Concrete placed underwater shall be deposited by a tremie or by a valved tremie.

(iii) The methods and equipment used shall be subject to the prior approval of the Owner.

(iv) Concrete buckets shall not be permitted for underwater placement of concrete.

(v) The tremie seal shall be operated in a manner which will not produce undue turbulence in water around the pipe. The discharge end shall be kept submerged continuously in the concrete and the concrete pumped in without interruption until the concrete has been brought to the required height.

(vi) The tremie shall not be moved horizontally during a placing operation and a sufficient number of trmies shall be provided so that concrete does not have to flow horizontally a distance of more than 3 m.

15.11.6. Forms for Concrete lining in foundation gallerys if any

(i) Forms for concreting shall be used where it is considered necessary.

(ii) Equipment for form concreting (Inside the foundation gallerys) shall be operated by experienced staff. A suspended platform shall be arranged and used for surface treatment and curing, etc. Protection of workmen against falling objects, etc. shall be satisfactorily arranged.

(iii) Form concreting (Inside the foundation gallerys) shall be executed without interruptions between levels indicated on the Drawings.

(iv) Reasonable amounts of stand-by equipment shall be available. Placing of steel reinforcement and concreting shall follow the specifications for the ordinary concrete works.

(v) Suitable instruments shall be installed to check alignment/verticality during slip forming. Proper procedures shall be adopted to correct any misalignment or deviation from verticality.

15.11.7. Concreting in Open Works

(i) While placing concrete, the exposed area of fresh concrete shall be kept as the minimum possible by first building up the concrete in successive and approximately horizontal layers to full width of a block and to full height of the lift over a restricted area at the downstream end of the block and then continuing upstream in similar progressive layers of concrete shall also be kept as steep as practicable in order to keep its area minimum. Concrete along these edges shall not be vibrated until the adjacent concrete in the layer is placed. However, it shall be vibrated immediately if the weather conditions are such that the concrete will harden to the extent that any vibration done later on, will fully consolidate and integrate it with more recently placed adjacent concrete. Clusters of large aggregate shall be scattered before new concrete shall be vibrated completely before another deposit of concrete is placed over it.

(ii) Mass concrete shall not be placed during rains, if sufficiently heavy or prolonged, as this may result in washing away of mortar from coarse aggregate on the forward slopes of placement.

(iii) Once placement of mass concrete has commenced in a block, placement shall not be interrupted (by diverting, placing equipment to other places) till completion of such block.

(iv) Concrete shall be placed, as nearly as practicable, in its final position and shall not be piled up in large masses at any point and then pushed, shoveled, or vibrated into empty spaces for long distance. However, full capacity of concrete bucket may be deposited in one operation where this has no objectionable effects on placing of concrete, but near forms in and around embedded metal work and elsewhere, the contents of the bucket shall be discharged in such quantities which can be compacted and vibrated properly.

(v) Concrete buckets shall be capable of promptly discharging low slump mass concrete mixes specified and dumping mechanism shall be so designed as to permit discharge of as little as 0.5 m^3 portion of concrete in one place. Bucket shall be suitable for attachment to and use of drop chutes where required in confined locations.

(vi) At such location where freezing conditions are expected, richer concrete mix (higher in cement contents) shall be placed on the exposed surfaces of the mass concrete than in the interior with the approval of the Owner.

(vii) The minimum allowable period between successive lifts of concrete in any one block shall generally be 72 hours, or as shown on the Drawings.

(viii) The height of a lift shall vary from 1.5 m to 2.25 m or as shown on the Drawings or as directed by the Owner.

(ix) During placement, the concrete shall fall vertically and shall be discharged fast enough to form a cohesive, bulging and growing mass without separation as the concrete is discharged by the concrete placing buckets.

(x) Since the mass concrete is placed with a relatively dry consistency of low slump it shall be adequately and thoroughly vibrated into place.

(xi) Areas adjoining embedded materials shall be consolidated with manual vibrators.

(xii) The maximum size of aggregate for mass concrete shall be 150 mm.

(xiii) Placing temperature of mass concrete shall be maintained as specified in the construction Drawings.

(xiv) Special measures shall be taken at the time of allowing river flows over the concrete which is still in the process of generating heat.

15.11.8. Concrete Placement in Dam (conventional concrete)

The placing of concrete in the dam shall be regulated as under:

(i) Height of each lift shall be as specified in the approved lift drawing.

(ii) Minimum time interval between successive lifts shall be as specified on the approved Drawings/stated in technical specification.

(iii) Placement of concrete shall start from the deepest block or those adjacent thereto. However, concreting may start in dam sections close to the embankments, if so required by river diversion sequences.

(iv) The difference in height between adjacent monoliths shall not in general exceed four lifts.

(v) The difference in height between the lowest and highest monoliths shall not in general exceed eight lifts.

(vi) Mass concrete of low cement content will be placed at a temperature not more than 12^0 C.

15.11.9. Compacting

(i) During, and immediately after placing, concrete shall be thoroughly compacted by means of suitable high-frequency vibrators. The consistency of the concrete and the period of vibration shall be such that segregation, honeycombing, accumulations of water or surface laitance are avoided.

(ii) For thin walls or inaccessible portions of the forms, the concrete shall be worked into place manually or tapping or hammering the formwork opposite the freshly placed concrete. The concrete shall be thoroughly worked around the steel reinforcement, embedded fixtures and into corners of the formwork.

15.12. Placement Temperature of Concrete in Hot and Cold Weather

15.12.1. General

Concrete shall always be placed at the minimum possible temperature. The placement temperature, the lift height, the interval between successive lifts and necessity to resort to pre cooling and post cooling shall be determined by thermal studies on placement of concrete which shall be approved by the owner. The Contractor shall be required to strictly follow the placement criteria approved by the Owner.

The Contractor shall furnish at his cost all plants, labour and materials and perform all works required to precool the concrete, including cooling of the aggregate and using ice flakes and/ or chilled water as per recommendations of USBR manual or the temperatures specified by the Engineer-in-charge at the point of placement. To counteract the heat gained by the concrete during conveyance from the mixing plant to the placement point, the concrete shall be cooled to a suitable lower temperature than the specified placement temperature. However, the placement temperature of mass concrete for dam and power dam shall be 12 ^{0C}.

15.12.2. Placement Temperature of Concrete in Hot Weather

i) The maximum permitted temperature rise in concrete and temperature distribution after placement will be determined by the Engineer-in-Charge based on the laboratory test performed prior to the start of concrete work using the actual cement, concrete mix proportions, and infusibility for the concrete under consideration, or by actual field monitoring.

ii) The temperature of concrete when being placed in hot weather shall be as follows, unless otherwise permitted by the Engineer-in-Charge;

a. Mass concrete including 40-150 mm aggregate in dam and spillway and plugs in tunnel/galleries, not more than 12^{0}C

b. Structural concrete lining not more than 20^{0}C

c. All other concrete, not more than 30^{0}C

iii) The Contractor shall supply and install temperature meters in the fresh concrete in Dam, and perform temperature measurement as detailed in the section “Instrumentation”.

15.12.3. Hot Weather Precautions

(i) The Contractor shall furnish, install, operate, and maintain equipment and make the necessary provisions in order to maintain the temperature of concrete, when being placed, below the maximum temperatures specified above.

(ii) Following means shall be employed to attain the specified concrete temperatures:

- Pre-cooling of coarse aggregate by sprinkling, immersion in cold water or with cold air blast,
- Refrigerating the mixing water or adding the chip or flake ice as a portion of the mixing water,
- Insulating the water tanks and water supply lines, cement silos, mix drums, exposed pipelines for pumped concrete and sheltering the aggregates,
- Mixing and placing the concrete at night.

(iii) Ice, when used for mixing water, shall be completely melted before mixing is completed.

(iv) The temperature of concrete at the mixing plant shall be 20 C lower than the placing temperature specified above.

(v) The contractor's concreting operations shall be in accordance with the recommendations contained in IS: 7861 (Part-1).

15.12.4. Temperature Control for Mass Concrete in Dam and Spillway

- For mass concrete in spillway and dam, the maximum lift height shall be 2.1 m in 300mm layers.
- The temperature gradient and the lift height shall be controlled as per thermal studies calculations.
- Before placing second lift, the existing concrete surface should be properly treated as per Engineer's instruction.

15.13. Bonding

To ensure bonding between previously concreted blocks and new concrete, all construction joints shall be treated as prescribed in this tender document.

15.14. Curing of Concrete

15.14.1. Wet Curing

(i) All concrete surfaces, when not protected by steel forms or membrane-forming curing compounds, shall be kept constantly wet for a continuous period of not less than 14 days after the concrete has been placed. For the purpose of wet curing, the Contractor shall install and maintain a pipe system by which concrete undergoing curing can be sprayed with water. When wooden forms are left in place during the curing period, they shall be kept sufficiently damp at all times to prevent drying out of the concrete.

(ii) Moist curing with wet burlaps, watered hessian or similar material shall include covering with transparent polyethylene sheets.

15.14.2. Curing with Membrane-forming Compounds

(i) Curing by means of membrane-forming compounds with or without preliminary wet curing, may substitute wet-curing when approved by the Owner.

(ii) The membrane-forming compounds shall be sprayed on the finished surfaces, as soon as the surface water has disappeared. Spraying equipment shall be of the pressure-tank type with provision for continual agitation of the contents during application. If forms are removed during the curing period, the compound shall then immediately be sprayed or brushed on the concrete surface.

(iii) The rate of application shall be 1 l/m2 or as recommended by manufacturer for smooth surface. On rough surfaces this rate shall be increased to obtain the required continuous membrane. Membrane curing compounds shall be applied before concrete repairs are started. Each repair to concrete cured by compound shall made moisture for not less than 24 hours and then coated with membrane curing compound.

(iv) The continuity of the coating must be maintained until the 28th day after the concrete has been placed. When required, possible remainders of the compound shall be removed by means of steel brushing or sand blasting.

15.15. Finishing of Surfaces

15.15.1. General

(i) The requirement for finishing of concrete surfaces shall be as specified herein, and in accordance with the symbols shown on the Drawing and defined in Clauses Formed Surfaces and Unformed Surfaces. Finishing of concrete surfaces shall be performed only by skilled labour.

(ii) Offsets, caused by displaced or misplaced forms or form sections or by defective form material, will be considered as abrupt irregularities and will be tested by direct measurement. All other irregularities will be tested by use of a template, consisting of a straight edge or the equivalent thereof for curved surfaces.

15.15.2. Formed Surfaces

Except as otherwise specified or directed all permanently exposed concrete surfaces and other waterway surfaces requiring durability under water shall be finished in the following manner:

(i) Any damage to finished concrete resulting from the action of removing formwork or from any other cause shall be repaired. Immediately on removal of the form, the surface shall be examined and all porous honeycombed or defective concrete removed and repaired as specified herein.

(ii) All imperfections or ridges due to joints in the formwork, shall be removed by light chipping or grinding down if necessary, to produce a smooth surface.

(iii) When the treatment of a surface has been completed, the surface shall be cured.

(iv) All patches and mortar filled pits on exposed surfaces shall be neat and of the same colour and texture as the adjoining concrete.

(v) The finished surfaces of concrete shall be true, sound, smooth and free from fins, offsets, pits, depressions, voids, blemishes and other defective concrete and surface irregularities and shall be in accordance with the requirements for the particular class of finish specified herein or as shown on the Drawings.

(vi) Finishing work shall be done only by skilled workman within 4 weeks of placing.

(vii) The classes of finish for formed concrete surfaces are designated by use of the symbols F1, F2, F3 and F4. Except for surfaces to be painted and F4 finish surfaces, sack rubbing or sand blasting will not be required on formed surfaces.

(viii) No grinding or rubbing will be required on formed surfaces, except as necessary for the repair of surface imperfections. Recesses resulting from the removal of form ties shall be filled with dry pack, except that filling of recesses in finish F1 surfaces will be required only if the recesses are deeper than 25 mm in walls less than 0.3 m thick or if unfilled recesses would reduce the required concrete cover of steel. The classes of concrete finishes for formed surfaces and their applications shall be as follows:

a) F1 - Finish F1 generally applies to formed surfaces upon or against which backfill for concrete is to be placed. These surfaces require no treatment after form dismantling except removal and repair of defective concrete. Correction of surface irregularities will be required for depressions only, and only for those which, when measured as described above, exceed the allowed tolerances according to Clause Tolerances.

b) F2 - Finish F2 generally applies to all formed surfaces not permanently concealed by backfill or concrete, and not requiring F3 or higher surface finish. Surfaces with finish F2 will need no filling of pits or sack rubbing and no grinding other than that needed for repair of surface imperfections. Surface irregularities, measured as described above, shall not exceed the allowed tolerances according to Tolerances.

c) F3 - Finish F3 generally applied to formed surfaces of structures prominently exposed to public view where appearance is of special importance. There shall be no visible offsets, fins, bulges, misalignment of concrete between chamfered joints, and no stains or discoloration, other abrupt and gradual irregularities such as depressions or bubble holes and misalignment of concrete across chamfered joints shall not exceed the allowed tolerances according to Clause Tolerances.

(d) F4 - Finish F4 generally applied to formed surfaces that could be subjected to rapid water flow velocities. Abrupt surface irregularities shall not exceed 3 mm for irregularities not parallel to the direction of flow and shall not exceed 6 mm for irregularities parallel to the direction of flow.

(ix) Abrupt irregularities exceeding these limits shall be treated as follows:

- Abrupt irregularities parallel to the direction of flow shall be reduced to the specified limit by grinding to a bevel not steeper than 1 to 20 ratio of height to length.

- Abrupt irregularities not parallel to the direction of flow shall be eliminated completely by grinding to a bevel not steeper than 1 to 50 ratio of height to length when the offset is into the flow, and by grinding to a bevel not steeper than 1 to 20 for offsets away from the flow.

15.15.3. Unformed Surfaces

Unformed surfaces shall be finished by one or more methods of screeding, floating and troweling and working of the surfaces shall be done at the proper time employing experienced labor and shall be just sufficient to produce the desired finish.

(i) Screeding

(a) It gives the surfaces its approximate shape by striking off surplus concrete immediately after completion and shall be accomplished by moving a straight edge or template with a swing motion across wood or metal strips which have been established as guides.

(b) Where the surfaces is curved, a special screed shall be used.

(ii) Floating

Shortly after the concrete is screeded, the surfaces shall be brought true to form and grade by working it sparingly with a wooden float. If a coarse textured finish is specified or if the surface is to be steel troweled, a second or final floating shall be performed after some stiffening has occurred and the surface moisture film or shine has disappeared.

(iii) Troweling

(a) If a smooth dense finish is desired, floating shall be followed by steel troweling some time after moisture film or shine has disappeared from the floated surfaces and when the concrete has hardened sufficiently to prevent fine material and water from being brought up to the surface. Excessive troweling at an early stage as would tend to produce cracking or result in a surface that is too hard to finish properly shall be avoided.

(b) Troweling shall, therefore, be done at the appropriate time and shall have the surface smooth, even and free of trowel marks and ripples. A fine textured surface that is not slick shall be obtained by troweling lightly over the surface with a circular motion keeping the trowel flat on the surface of the concrete. Where a hard steel troweled finish is required, troweling shall be continued until it no longer produces noticeable compaction and the surface has a glossy appearance, troweling pressure being increased gradually as the operation progresses.

(c) The use of any finishing tool in areas where water has accumulated shall be prohibited. Operation on such areas shall be delayed until the water has been absorbed or has evaporated or has been removed by draining, mopping or other means.

(d) Where separate floor finish is specified or directed, the concrete shall be struck off sufficiently below grade to allow for the subsequent placing of a finished floor. The surface of such concrete shall be left rough.

(e) As soon as the condition of the base permits and before it has hardened fully, all dirt, laitance and loose aggregate shall be removed from the surface, by means of water jets and wire brooms leaving the coarse aggregate slightly exposed and the surface made suitable for taking further concrete.

(iv) The classes of finish for unformed concrete surfaces are designated by use of the symbols U1, U2 and U3. The classes of finishes for unformed surfaces and their applications shall be as follows:

(a) U1 - Finish U1 (screeded finishing) generally applies to unformed surfaces for which U1 is shown on the Drawings and unformed surfaces that will be covered by backfill or by concrete. Finish U1 is also used as the first stage of finish U2. Finishing operations shall consist of sufficient levelling and screening to produce even, uniform surfaces meeting the tolerances requirements of Clause Tolerances.

(b) U2 - Finish U2 (floated and broomed finishing) generally applies to all unformed surfaces not permanently concealed by backfill or concrete, or for which finish U1 is not shown on the Drawings. Finish U2, brooming excluded, is also used as the second stage of finish U3. Floating shall be started as soon as the screeded surface has stiffened sufficiently, and shall be the minimum necessary to produce a surface that is free from screed marks and is uniform in texture.

(c) U3 - Finish U3 (troweled finishing) generally applies to tops of parapets exposed to public view, inverts of tunnels and spillways subject to high velocity flow and indoor floor, except floors requiring a bonded concrete finish. When the floated surface has hardened sufficiently to prevent excess of fine material from being drawn to the surface, steel troweling shall be started. Steel troweling shall be done with sufficient pressure to flatten the sandy texture of the floated surface and produce a dense uniform surface, free from blemishes and trowel marks.

15.15.4. Form Surfaces for Concrete Lining in Foundation Galleries (If Any)

The surfaces of formed concrete shall, if not otherwise agreed with the Owner, be equivalent in evenness, smoothness, and freedom from rock pockets and surface voids to that attainable by the effective use of long - handled steel trowel. Light surface pitting and light trowel marks will not be considered objectionable. Surface irregularities shall not exceed the allowed tolerances according to Clause Tolerances.

15.15.5. Tolerance for Concrete Construction

(i) General

(a) All concrete structures shall be constructed to the exact lines, grades and dimensions established. However, inadvertent variations from the established lines, grades and dimensions shall be permitted to the extent set forth herein.

(b) Where the tolerance are not stated in the specifications or on the Drawings for any individual structure of features thereof, permissible deviations shall be interpreted in conformity with these provisions.

(ii) Tolerance for Concrete in Underground Cavities / Tunnels / Shafts, etc.

The concrete in underground cavities, tunnels and shafts shall conform to the tolerances as per Indian Standards or equivalent international Standards.

(a) The inclination of tunnel invert can differ only by 0.1 % (10 cm per 10 m) from the design inclination, the accumulated vertical deviation of the springline from the theoretical line shall not exceed 20 cm in total. The horizontal deviation shall be within a limit of ± 20 cm

(b) Gradual variations measured with 1.5 m template shall be 12 mm.

(c) Abrupt variation in the direction of flow shall be 6 mm and that across the flow shall be 3 mm.

(iii) Tolerance for Surface Finishes

(a) Surface finishes shall generally conform to the types and tolerances indicated in the table given below, unless otherwise specified on the Drawings.

(b) No negative variation in thickness of concrete lining for underground works, i.e cavities / tunnel / shafts shall be allowed.

(c) Positive tolerance shall be measured outside and negative inside the lines and grades defining the structure on the Drawings.

Type of Finish	General Area of application and Method of Forming	Tolerance (in mm) in any 3.00m
F1	Formed surfaces of construction Joints and other Surfaces which shall not be permanently exposed. The Surface shall require no treatment after form removal, other than repair of defective concrete and specified curing, or treatment as specified for construction joints.	+ 10 - 10
F2	All permanently exposed formed Surfaces for which F3 finish is not specified. Form sheathing or lining shall be placed so that joint marks on the concrete surface shall be in general alignment, both horizontally and vertically and conform to a standard pattern. Immediately on the removal of forms, all unsightly ridges or fins shall be removed; all holes left by removal of ends of form rods shall be neatly filled with mortar and surfaces treated to meet the required tolerance by tooling and rubbing.	+ 5 - 5
F3	Formed surfaces which shall be exposed to flowing water shall be hard, smooth and dense, free from offsets, pits, voids, air holes and irregularities, and shall be chipped, grouted and thoroughly cleaned as necessary to conform to the required tolerances.	+ 5 - 5
U1	Unformed screeded surface which shall be covered by fill materials static water or concrete. Type U1 finish shall be used as the first stage of type U2 and U3 Finishes. Finishing shall consist of sufficient levelling and screeded to produce an even uniform surface meeting the required tolerance.	+ 10 - 10
U2	Unformed surfaces not permanently concealed by fill or concrete or not required to receive Type U3 finish. (Type U2 finish shall be used as the second stage of U3 finish). Floating by means of hand or power driven equipment shall be started as soon as the screeded surfaces has stiffened sufficiently and shall be the minimum necessary to produce a surface that is free from screed marks and uniform in texture if type U3 finish is to be applied, floating shall be continued until a small amount of mortar without excess water is brought to the surface so as to permit effective troweling.	+ 5 - 5
U3	Unformed, screeded surfaces which shall be exposed to flowing water. This finish shall be applied by steel troweling after the concrete has hardened enough to prevent excess of fine materials and water from being brought to the surface free from blemishes, ripples and trowel marks. After the surface has nearly hardened it shall be troweled once more until the surface is hard and glossy in appearance.	+ 3 - 3

15.16. Joints

15.16.1. Location of Joints

(i) Construction surfaces which become so rigid, by reason of limitations in the rate of placing of concrete imposed by these specifications or by reason of delays in construction progress, that new concrete cannot be integrally incorporated with that previously placed shall be defined as construction joints.

(ii) Construction joints shall be located in the positions shown on the Drawings or as directed by Owner.

(iii) A proposal for location of construction joints and concreting sequence shall be made and submitted to the Owner for his approval.

(iv) Locations and types of joints are shown on the Drawings. In all structures, the concreting of each concrete block between surfaces and joints shown on the Drawings shall be carried out in one continuous operation without interruption.

(v) Should for any reason an interruption in the concreting of a block occur, and last so long that on resumption of concreting the new concrete mass cannot be effectively incorporated with the previously placed concrete mass, then the resulting unintentional joint shall be considered as a construction joint and treated in the same way as the ordinary construction joints shown on the Drawings.

(vi) Construction joints not shown on the Drawings shall be permitted only when, in the opinion of the Owner, they are unavoidable. Such construction joints shall be located in such a manner that they are easily accessible for cleaning before concreting is continued.

(vii) Joints at exposed surfaces of concrete shall be straight and continuous, as shown on the Drawings or otherwise directed.

(viii) Horizontal construction joints shall be arranged wherever possible to coincide with joints in the formwork.

(ix) To prevent feather edges, the construction joints at the tops of horizontal lifts near sloping exposed concrete surfaces shall be inclined near the exposed surface so that the angle between such inclined surface and the exposed concrete surface shall not be less than 50 degrees.

15.16.2. Preparation of Vertical and Steeply Sloping Construction Joints

(i) Joint surfaces shall be treated as described in this tender document For this purpose, the end shuttering for the joint between form sides may be removed while the concrete is at an early age.

(ii) All the joints shall be thoroughly cleaned. All intersections of construction joints with concrete faces, which will be exposed to view shall be made straight, level and plumb.

15.16.3. Preparation of Horizontal and Slightly Sloping Construction Joints

(i) While the concrete is at an early age, the surface of the joint shall be prepared for the subsequent placement of fresh concrete by the application of high velocity air- water jets with a pressure of at least 3 atmospheres at the nozzle. The jets shall be applied so that laitance and foreign matter are removed and the clean aggregate exposed, but not so that the edges of the larger particles of the aggregate are undercut.

(ii) Should, however, the concrete has become fully set and the above treatment cannot be carried out satisfactorily, joints shall be pick-hammered and thereafter scrubbed with a wire brush. The indentations shall not in any case be taken nearer than 50 mm to exposed edges of the concrete to water stops. In addition, after the scrubbing the whole area shall be thoroughly scoured using a high velocity air-water jet, until all loose and foreign matter and surface laitance have been removed.

(iii) In case the joint surface is left to dry it shall be kept continuously wet for twelve hours prior to placing adjacent concrete.

15.16.4. Preparation of Contraction and Expansion Joints

(i) Expansion and contraction joints shall be constructed at such points and of such dimensions as indicated on the Drawings. The method and material used shall be subject to the approval of the Owner.

(ii) Standard bitumen sheets, impregnated with saw dust or any other filler material and sealing compounds, required to be placed in the expansion joints, shall be fixed in position as shown on the Drawings or as directed by the Owner.

(iii) The surface of the joint shall be carefully cleaned from dirt and foreign matter by means of water hosing.

(iv) Where shown on the Drawings, a 3 mm thick bituminous sheeting shall be placed in contraction joints exposed to water pressure. The sheeting shall be pasted on to the hardened concrete surface using warm bitumen in accordance with relevant Indian Standards. The method of fixing the bituminous sheeting shall be tested before the commencement of the concrete works. In other contraction joints, the hardened concrete surface shall be painted twice with plastic paint.

(v) Expansion joints shall be provided with a separating strip of preformed, durable, resilient joint filler which shall be continuous through the joint and sealed at surfaces with a sealing compound.

(vi) Well in advance of purchases, samples of the bituminous sheeting, the plastic paint,the joint filler and the sealing compound, as well as documentation of the characteristics thereof shall be obtained and approved by the Owner.

15.16.5. Embedding of Items

(i) Where shown on the drawing or when agreed with the Owner, the Contractor shall supply, fix and embed in concrete (first stage as well as second stage in block-outs) and where required further grout, such items as steel linings, pipes, edge-protecting angles, steel grooves, anchorages for steel structures, etc.

(ii) Before placing of the concrete, the items to be embedded shall be firmly fixed in place and they shall be cleaned from oil, rust and other foreign matter. Care shall be taken not to disturb or displace embedded parts during concrete placement.

(iii) Where plant and machinery have been supplied and erected under another contract, carry out embedding and grouting as required. Such embedding shall be performed so that the erection work is not unduly hindered.

(iv) For second stage concrete and grout, when agreed with the Owner, rapid hardening cement shall be used and non-shrink ingredients of approved type be added.

(v) Forms shall be built where necessary. Care shall be taken to ensure that the concrete fills the whole space under and around the embedded items and, where required, grout shall be inserted under pressure. The requirements with regard to strength and water tightness in respect of the second stage concrete shall be no less than for the first stage concrete.

15.16.6. Water stops

(i) Construction and expansion joints which will be exposed to unilateral water pressure shall be provided with water stops of stainless steel, copper or PVC, as shown on the Drawings.

(ii) Water stops of stainless steel shall be straight or Z-shaped and be at least 1 mm thick. Stainless steel shall be of type 316 according IS:6911-1992 have a molybdenum content of minimum 2.70 % and a carbon content of minimum 0.05 %. Joints shall be argon welded, pickled and passivated. Bends shall be as shown on the Drawings and carried out with care so that the plates are not damaged.

(iii) PVC water stops shall comply with specification IS:12200-1987.

1. Tensile strength - The tensile strength shall not be less than 13 MPa (132Kg/cm2) when tested in accordance with IS:8543.
2. Ultimate elongation - Ultimate elongation shall be not less than 280 percent when tested in accordance with IS:8543.
3. Low temperature brittleness - The material shall not crack when tested in accordance with IS:8543.
4. Accelerated extraction test - The tensile strength shall not be less than 10MPa (102 Kg/cm^2) and the ultimate elongation shall not be less than 280 percent.
5. Stability during alkali tests - The material shall have an increase in weight of not more than 0.25 percent at seven (7) days and not more than 0.40 percent at thirty (30) days, or a decrease in weight of not more than 0.10 percent at seven (7) days and not more than 0.30 percent at thirty (30) or a dimensional changes not in excess of 1 percent at thirty days (30) or a Shore durometer (type A) reading at seven (7) days differing by not more than plus or minus five (5) from the reading on the original sample.

(iv) The wings of the PVC water stops shall be provided with corrugations or bulbs to achieve good bond. PVC water stops in expansion joints shall be provided with hollow centre bulb. Jointing shall be carried out in accordance with the manufacturer's instructions.

(v) Neoprene water stops shall be made of suitable synthetic rubber. Neoprene water stops shall conform to the applicable requirements of the Indian Standards.

(vi) Samples and the supplier's specifications of water stop proposed to be used shall be submitted to the Owner well before the purchases.

(vii) Since unintentional construction joints may result from machinery breakdowns or from other accidental occurrences, adequate stocks of water stops shall be maintained in store on site for immediate use during the concreting of such parts of all Works as will be exposed to unilateral water pressure.

(viii) The water stops shall be well braced and securely fastened in the positions shown on the Drawings. The concrete shall be particularly carefully packed around horizontal or slightly inclined water stops. The edges of horizontally placed water stops shall be bent slightly upwards to facilitate concreting underneath them and to prevent the formation of air pockets. The concreting shall be carried out so that the flow of concrete as much as possible will be directed parallel to the waterstops and in one direction only.

(ix) Free sections of built-in waterstops shall be protected from shocks and wherever exposed, from direct sunshine.

15.16.7. Concrete Repairs

(i) All irregularities on concrete surfaces shall be repaired where necessary to produce smooth, uniform surfaces that conform to the tolerances specified.

(ii) The surface irregularities shall be repaired either by cutting out the concrete to a required depth beyond the reinforcing bars, and filling the cavity with cement mortar or concrete, or by cutting out to a shallower depth and the cavity filled or patched with cement mortar or dry pack mortar or epoxy polysulphide sand mortar, or an alternative mortar approved by the Owner.

(iii) Surface irregularities above the surface shall be removed by chipping, bush hammering and grinding. Surface irregularities below the surface shall be cut out by bush hammering or sawing and chipping to remove defective concrete and to provide a cavity of sufficient depth for filling or patching. Then the cavity shall be shaped as required, cleaned, prepared and filled or patched.

(iv) Sawing shall be done with a diamond or carborundum saw around the edge of the area to be cut out. Saw lines shall be plumb and parallel and shall form the shape required. The saw cuts shall be a minimum of 25 millimeters in depth and shall not penetrate closer than 5 millimeters to reinforcing steel bars. The remainder of the defective concrete shall be chipped out to the required depth and in such a manner that the concrete outside of the sawn lines does not spall.

(v) The inside surface of the cavity to be filled or patched shall be cleaned by sand blasting, by high-pressure water jet or with a power wire brush as required.

(vi) The area to be repaired and a space at least 150 mm wide surrounding it, shall be wetted to prevent absorption of water from the patching mortar or concrete. The prepared area shall be brush coated with a neat cement grout after dampening and filled with cement mortar or batched and mixed concrete or dry pack mortar. Alternatively, if epoxy-polysulphide sand mortar is to be used, the prepared area shall be brush coated with an approved epoxy resin as recommended by the manufacturer.

(vii) The cement mortar and concrete shall be made of the same materials and of the same proportions as used for the concrete being repaired except that the coarse aggregate shall be omitted from the mortar. The quantity of mixing water shall be as small as is consistent with the requirements for handling and placing. Cement mortar shall be retemperd without the addition of water by allowing it to stand for a period of one hour during which time it shall be mixed with a trowel to prevent setting.

(viii) The cement mortar and concrete shall be compacted into place to its maximum density and screened off so as to leave the patch slightly higher than the surrounding surface. It shall then be left undisturbed for one to two hours to permit a partial set to take place before being finally finished. The patch shall be finished in such a manner as to match the adjoining surface.

(ix) The resin for epoxy polysulfide sand mortar shall be of a type approved by the Owner. The contractor shall demonstrate the adequacy of the proposed materials under actual field conditions to the satisfaction of the Owner. The mortar mix will be approximately one part resin to 2.5 plaster sand by volume or as recommended by the manufacturer. Patching with epoxy-polysulphide mortar shall only be done when both the ambient air temperature and the surface temperature of the concrete are not more than 15 degrees celsius apart.

16. FILL WORKS

16.1. General

16.1.1. Scope

(i) The specifications described hereunder relates to supply of all labour, materials, plant and equipment required for processing, placing and compaction of filters, rock fill and backfill material and amongst other things:

(a) Prepare the foundation surface to receive fill material

(b) Extract, transport and, as required, process and/or stockpile fill material

(c) Place, spread, compact and, as required, surface treat fill material

(d) Test fill materials

(e) Carry out all other work required for, or incident to, the filling all in accordance with this specification and as shown on the Drawings.

16.1.2. Standards

(i) Specifications and method of testing of various types of fill shall be as per the relevant Indian Standards.

(ii) The guide lines and directions of the most recent edition of the following publications shall also apply for the construction and testing of fill:

- U.S. Bureau of Reclamation Earth manual
- ASTM Specification and Tests
- AASHTO Specifications and Test

16.1.3. Preparation

(i) The Contractor shall prepare and submit to the Owner, for review, not less than 40 days prior to the scheduled commencement of fill placement, a method statement comprising descriptions of intended methods for extraction, transport, processing, placing and compaction of fill. This method statement shall include the location of any required haul roads.

(ii) The method of exploitation intended to be used in the approved borrows and quarries as well as in excavations required for the works, where the material is intended to be used as fill shall also be prepared and submitted to the Owner.

16.2. Materials

16.2.1. General

Fill material may be obtained from excavations required for the Works and from borrow areas or quarries, proposed to and agreed with the Owner, provided always that the various fill materials shall meet the respective requirements of this specification. Gradation of the material shall be determined based on laboratory and field testing.

16.2.2. Backfill Material

(i) Backfill material shall consist of soil, having such granulometric characteristics, consistency and water content as will permit handling, spreading and compaction as mentioned in this tender document. The material shall have a maximum stone size of 75% of the layer thickness.

(ii) Material for back fill shall be obtained from approved borrow areas. Alternatively, approved back fill material resulting from excavation can also be used.

16.2.3. Filters

(i) The filters shall consist of hard and durable grains, the fines shall be non-plastic, and the granulometric requirements of accepted filter rules shall be fulfilled. Filters shall consist of processed riverbed material, terrace material or tunnel rock. The gradation of the filters shall be governed by results from testing of samples extracted from the foundation materials.

(ii) Material for filters shall be obtained by screening material from borrow areas of granular fill shown on the Drawings.

16.2.4. Rock Fill Revetment

(i) Rock fill revetment shall consist of hard, durable and essentially unweathered stones. The material can be obtained from the tunnelling work, a rock quarry or from processed terrace or river bed material. The shape of the stones shall normally be such that the ratio of maximum dimensions in perpendicular directions is less than two.

(ii) Rock fill revetment shall be used as bottom protection upstream and downstream of the dam. In connection to the dam, the revetment shall consist of stones of the following gradation:

Weight heavier than kg.	**Percentage %**
115	50-80
25	90-100

16.3. Execution

16.3.1. General

16.3.2. Borrow and Quarries

(i) Clearing and stripping shall first be made. In borrows and quarries, the cleared and stripped area shall at any time extend to at least 10 m outside the limits of excavations

(ii) Wasted material shall be placed in spoil tips.

(iii) If necessary, borrow areas shall be drained to prevent the wetting of fill materials by precipitation or by surface or sub-surface runoff.

16.3.3. Personnel

Wherever fill is being placed, one of the superintendents, well experienced in works of this nature, shall be present and responsible for the work.

16.3.4. Preparation of Foundation

Fill shall be placed only when the foundation area has been approved to receive the fill. Excavation and treatment of excavated surfaces shall be carried out in accordance with technical specifications mentioned in this tender document. Where foundation treatment consists of stripping, all top soil and organic matter shall be removed.

Foundation areas shall be scarified and air-dried as necessary, so that they can be compacted in accordance with specified technical specifications.

16.3.5. Layer Thickness

The layer thickness shall be the compacted layer thickness perpendicular to the surface of the underlying layer of fill.

16.3.6. Rejection of Fill

(i) Another fill shall not be placed until previously placed layers have been satisfactorily compacted and tested.

(ii) If the soil material does not meet the specifications, it shall be removed and disposed off.

16.3.7. Documentation of all Fill Works

The Contractor shall keep a record on the progress of fill works, the location and results of the tests performed etc. The format of the record shall be agreed with the Owner and a copy of the same forwarded to the Owner for information.

16.4. Processing

16.4.1. Filters

If required, filters shall be produced by processing so that the granulometric requirements specified in technical specifications are fulfilled.

16.4.2. Rock Fill Revetment

Rockfill revetment shall be produced by processing of rock from the tunnelling work, terrace materials or riverbed material so that the granulometric requirements specified in technical specifications are fulfilled.

16.5. Placing and Compaction

16.5.1. General

(i) All fill material shall be handled in such a way that the fill material shall be free from segregation of particles, lumps, pockets and layers of materials which are substantially different in gradation or texture from the surrounding material in the same zone. Material which is placed directly on top of a previously compacted layer shall be of such gradation that only an insignificant portion could penetrate into the underlying fill.

(ii) Fill material shall be placed and spread in continuous and approximately horizontal layers of uniform thickness for the full width and length of the zone by routing the hauling and spreading equipment in a direction parallel to the main axis of the fill. Placement shall commence at the lowest elevation of the foundation. Once the local depressions are filled the placement shall continue in regular horizontal layers until completion. Fill material shall not be end-dumped into depressions or bladed down slopes. Water shall not be allowed to pond on the surface of fill layers.

(iii) Compaction of backfill material and filters shall be by means of a vibratory roller with a static weight of not less than 9 tonnes and equipped with a smooth drum, travelling with a speed not exceeding 3 km/hour.

(iv) Compaction of rock fill revetment shall be by means of a bulldozer D8 or equivalent travelling with a speed not exceeding 8 km/hour.

(v) In places where space restriction prevents the use of the compaction equipment mentioned above, the compaction shall be carried out by means of small-size equipment. The thickness of the layers shall then be reduced in order to achieve the same degree of compaction as with the normal equipment.

(vi) Compaction of each layer of fill material shall proceed in a systematic, orderly and continuous manner, such as to ensure that each portion of the layer receives the compaction specified. The compaction shall be carried out by routing the compaction equipment parallel to the axis of the fill.

A compaction pass shall mean one traverse of a compactor across the surface of a layer in one direction only, and a coverage shall mean the operation by which all parts of any area on the surface of a layer of fill have been traversed at least once by the compacting surfaces of a compactor.

For compaction by a vibratory roller, one coverage shall consist of one pass of the roller. An overlap of 200 millimeters shall be maintained between the surfaces traversed by adjacent passes of the roller.

Should the surface of the fill become rutted or uneven subsequent to compaction, it shall be re-levelled and recompacted before the next layer of fill is placed.

Each layer of fill material in roller turning areas shall be rolled perpendicular to the normal pattern to obtain compaction equal to the remainder of the fill in the zone.

Materials which cannot be compacted by the vibratory roller because of the location of such materials, shall be compacted with special compactors. Such locations shall include:

- Portions of required fills adjacent to structures and required embankment foundations, and
- Portions of required fills at steep and irregular abutments.

Precaution shall be taken when operating compaction equipment to avoid damage to adjacent structures and instruments and their leads and to avoid disturbing the prepared foundation. Any such damage or disturbance shall be repaired by the Contractor at no cost to the Owner.

(vii) The layer thickness for each material shall be determined based on field trials.

16.5.2. Backfill Material

Backfill material shall have such water content as will permit handling and compaction and shall normally be spread in horizontal or nearly horizontal layers with a maximum thickness of 0.6 m after compaction.

Each layer shall be compacted by four passes of a smooth drum vibratory roller as specified in technical specifications.

16.5.3. Filters

(i) Filters shall have such water content as will permit handling and compaction and shall normally be spread in horizontal or nearly horizontal layers with a maximum thickness of 0.6 m after compaction.

(ii) Each layer shall be compacted by four passes of a smooth drum vibratory roller as specified in technical specifications.

16.6. Rock Fill Revetment

(i) Rock fill revetment shall be placed in one layer so that the bigger stones will reasonably and evenly distributed over the surface with smaller stones filling the interstices. Projections of individual stones above the surface shall not normally be more than 0.3 m.

(ii) Rock fill revetment shall be spread and compacted by means of a bulldozer as specified in technical specifications.

16.7. Testing

16.7.1. Scope

(i) Routine tests in the field and in the laboratory to control that the quality requirements of fill material and filters shall be carried out.

(ii) Testing shall comprise determination of:

- grain size distribution, including hydrometer testing
- moisture content
- field dry density
- Standard and Modified Proctor compaction characteristics
- Atterberg limits
- permeability

16.7.2. Laboratory

(i) Fully equipped, furnished and manned laboratory shall be established on site to carry out all requisite tests on soil foundation and fill materials.

(ii) A well experienced soils engineer shall be in charge of the testing; other staff shall be available in sufficient number and shall be adequately trained to perform their respective tasks.

(iii) Use of laboratory equipment and assistance by personnel to carry out independent testing shall be available to the Owner, if so desired.

(iv) The laboratory equipment shall be calibrated and checked periodically.

16.7.3. Sampling and Field Testing

Sampling and field testing shall be performed by the Contractor. The location for sampling and testing in the fill areas and the extent and selection of samples in borrows, processing plants and stockpiles normally shall be decided in consultation with the Owner.

16.7.4. Recording

Particulars of each test shall be recorded and submitted for information.

16.7.5. Routine Testing of Backfill Material

Tests of the grain size distribution of filters shall be performed. Additional testing, as regards the compaction result or the water content of the material shall also be carried out, if required.

17. MISCELLANEOUS METAL WORKS AND PIPES

17.1. General

The work to be done under this item shall comprise the supply of all labour construction plant and equipment, materials and performance of all work necessary for furnishing and installing of miscellaneous metal works, primary embedments, M.S. Pipes, grout and air vent pipes and porous concrete pipes.

17.2. Standards

All materials and methods used in the fabrication of miscellaneous steel works, pipes and concrete porous pipes shall conform to the relevant Indian Standards.

i. IS : 458-1971 : Specification for concrete pipes (with and without reinforcing).

ii. IS : 4350-1967 : Specification for concrete porous pipes

iii. IS:1172-1983 : Code of basic requirements for water supply drainage and sanitation

iv. IS:783-1959 : Code of practice for laying concrete pipes.

v. IS:5822-1970 Code of practice for laying of welded steel pipes for water supply.

vi. IS:800-1984 Code of practice for General Construction in steel.

vii. IS:2062-1975 Steel for General Structural Purposes.

viii. IS:226-1975 Structural steel (Standard Quality)

ix. IS:816-1969 Code of practice for use of Metal Arc Welding for General Construction in Mild Steel.

17.3. Fabrication

i. Porous concrete pipes shall be precast or cast in situ as indicated in the Drawings. Materials for concrete and method of mixing, transporting and placing shall be as fully described in Section 6.15 "Concrete Works". Form work in precast porous concrete pipes or cast in situ shall conform to specifications given in detail under "Form Work".

ii. Specifications in respect of fabrication of miscellaneous metal works shall be in conformity to specifications for fabrication of Hydro-Mechanical parts as illustrated in these Technical Specifications

17.4. Installation and Embedding

i. All piping shall be transported, handled in such a manner that no damage will be done to the materials or the structures.

ii. All embedded piping shall be placed to the lines, grades and locations as indicated in the Drawings, special care shall be taken so that all piping and accessories are installed as required. Prior to installing of piping, it shall be ensured that all pipes are in satisfactory condition for installation. Inside of all piping shall be thoroughly cleaned of all loose, foreign materials such as sand, scale or weld spatter. The piping shall be blown out with air and the inside surface inspected for cleanliness before assembly.

iii. All piping shall be supported in such a way as to withstand all forces including those caused by embedment in concrete. Supports for embedded pipe shall be made of material which will not deteriorate, weaken or cause damage to concrete. All lugs, brackets and other supports welded directly to the piping shall be of material compatible with the material of the pipe.

iv. Proper support and sealing of joints for precast concrete and porous concrete pipes shall be provided. Protection of the joints between sections of the concrete pipes will be such as to prevent leakage of cement past into the piping. The exterior surface of concrete pipe shall be carefully cleaned in order to ensure proper bond to the concrete placed around them.

v. Where a portion of an embedded pipe crosses a contraction joint, an expansion pipe-coupling shall be used regardless of whether the area of contraction joint is to be grouted or not. For larger size aeration pipes installation of expansion couplings may be replaced by coating of joint filler as shown on Drawings. The length and thickness of coating shall be as shown on Drawings.

vi. Where the embedded pipe terminates beyond the limit of concrete placement, a length of at least 100 mm shall be left at the end of the pipe and shall be sealed prior to placement of concrete. All piping, pipe sleeves, precast concrete and porous concrete pipes and large size aeration pipes shall be securely capped and sealed at all exposed ends during concrete placement. All plugs and seals shall be removed following embedment and setting of concrete.

vii. Before placing of embedded metal work, it shall be thoroughly cleaned of all rust, grease, paint or other coating that may reduce bond. All embedded metal work shall be carefully set in the locations and to the dimensions shown on Drawings and shall be rigidly held in place during the placement of concrete. Care shall be taken during placing and vibration of concrete to prevent moving of embedded metal work and to ensure they are thoroughly embedded in well consolidated concrete.

viii. All pipe lines shall be tested in accordance with procedure outlined in the applicable Indian Standards, Codes and regulations, Aeration pipes and precast concrete and porous concrete pipes shall be subject to air flow tests or visual examination.

18. MASONRY

18.1. General

Construction of masonry walls shall be carried out in accordance with the Drawings.

18.2. Standards

All materials and methods used in the construction of masonry shall conform to the relevant Indian Standards.

(i) IS:2250-1981 : Code of Practice for Preparation and use of masonry mortars.

(ii) IS:1597-1967 Part - I : Code of Practice for Construction of Stone Masonry: Part I: Rubble Stone Masonry.

(iii) IS:2116-1980 : Specification for sand for Masonry Mortars.

(iv) IS:269-1989 : Specification for 33 Grade OPC.

18.3. Construction

All stones used on the works shall be of sound hard, durable and tough quality conforming to the relevant Indian Standards. Stones shall be hammer dressed to secure close joint so that the stones when laid will come into close proximity. Stones shall be fairly equal in size and no stone shall be less than 15 cm in size.

Face stone shall be comparatively larger and uniform in size. Face stone should laid into wall to a sufficient depth to bond well. Stones shall be laid with broader face downward to give a good bedding. Face joints shall be broken and face of wall shall be truly in plumb except as otherwise shown on Drawings. Corner stone should be a good stone dressed to correct angle and laid as headers and stretches.

Mortar shall be as per mix proportion specified in Drawings with cement mortar conforming to Standard specifications. Mortar shall be mechanically mixed with portable mixers or manually mixed. If manually mixed, mortar shall be dry mixed first to have the required proportion and then mixed with water by adding water slowly and gradually and mixed thoroughly to get a uniform mortar of workable consistency. Fresh mixed mortar shall be used.

Joints shall not be thicker than 2 cm, face joints shall be thinner. Interstices shall be filled with spalls of stones embedded in mortar. Not more than 60 cm height of masonry shall be constructed at a time.

Through bond stones shall be provided one for every 0.5 m2 of face and shall extend to the full thickness of wall. For walls thicker than 75 cm, bond stones may be of two pieces placed side by side overlapping at least 15 cm. Breadth of bond stones shall not be less than 1.5 times the height.

All stones shall be thoroughly wetted before laying. The masonry shall be kept moist or cured.

19. INSTRUMENTATION

19.1. General

19.1.1. Requirements

Number and locations of various instruments shall be in accordance with bid coduments. The Contractor shall all in accordance with this technical specifications:

- supply, install, calibrate, test and survey, as required, and maintain instrumentation
- supply and install all ancillary measuring equipment;
- construct protective surrounds for instruments, tubes and cables;
- supply and install conduit and concrete cable pits for permanent power supply and protective pipe for cables;
- construct cable risers and shafts;
- drill holes for groundwater observation holes and borehole standpipe piezometers; and
- excavate pits and trenches.

The extent, type, location of the individual instruments shall be determined by the Contractor and approved by the Employer. The number and location of the instruments may be altered by the Employer during the construction period according to site requirements.

19.1.2. Instruments and Ancillary Items

The instrumentation to be supplied, installed, calibrated, tested and surveyed, as required, and maintained includes:

- Electrical instrumentation for pore pressure gauges, borehole extensometers, stress meters, strain meters, no stress-strain meter, temperature monitoring devices and joint meters;
- Surface settlement points;
- Borehole standpipe piezometers;
- Uplift measuring devices;
- Water level measuring gauges;
- Strong motion equipment.

19.1.3. Climate and Power Rating

a. All instruments and associated equipment shall be suitable for operation in the Himalayan region.

b. All electrical equipment shall operate on 220 V to 240 V single phase 50 Hz power supply

c. All steel parts shall be furnished hot dip galvanised, provided with a long term corrosion protection coating or of stainless steel of first quality.

19.1.4. Extent of Instrumentation, Testing and Storage on Delivery

The Contractor shall supply the type and number of instruments (including spares) as indicated in the Technical Requirements.

All instrumentation operating on electrical or hydraulic systems shall be accompanied by certified test certificates for each such instruments. These instruments shall also be tested in the presence of the Employer before installation. All instrumentation shall be stored on site, before installation, in a secure, weatherproof and lockable building and fitted with facilities for testing and partial assembling of the instrumentation.

19.1.5. Approval of Instrumentation and Construction Procedures

The Contractor shall, not less than 90 days before installation of instrumentation, submit for approval details of the instruments proposed for installation. These will be consistent with the general information on the instrumentation submitted by the Contractor with his Bid as well as any modifications agreed to by the Employer and the Contractor and shall include :

- detailed description of the instrumentation including the ancillary measuring equipment the Contractor proposes to install;
- evidence of the successful performance of the instrumentation the Contractor proposes to install, which have been installed and operated for a period of at least 5 years in other excavations;
- procedures prepared by the manufacturers of the instrumentation for the installation, testing and operation of the instruments;
- details of the layout of all the equipment and accessories to be installed in each switchbox and observation room;
- details of protective surrounds, recesses in concrete structures, cable shafts, etc. proposed for the installation of instrumentation and switchboxes; and
- the experience of the supervisor and technicians who will install the instruments.

During the execution of the Works, the Contractor shall submit to the Employer for approval any further details regarding the instrumentation that the Employer may require. The Contractor shall prepare surveys and as-built drawings of all installed instruments.

The installation of instruments may interfere with the overall construction progress. The contractor shall make provision for such interferences in his construction planning. The Contractor will not be entitled to any compensation or extension of th e Time to Completion by reason of any such delays, including repair and replacement of damaged instruments.

No materials shall be purchased prior to the Employer's approval. However, approval by the Employer of the Contractor's proposals and drawings or da ta shall not relieve the Contractor from his sole responsibility to meet all the requirements of the Contract.

19.1.6. Skilled Personnel

The whole of the instrumentation work shall be under the direct supervision of a senior supervisor, approved by the Employer, and employed by the Contractor who is well experienced in the installation of the instruments and who have a sufficient knowledge of the purpose and function of the particular instruments being installed.

Installation and calibration shall be carried out by skilled technicians, acceptable to theEmployer, well experienced in the installation of the instruments and who have a sufficient knowledge of the purpose and function of the particular instruments being installed.

19.1.7. Installation

The Contractor shall:

- install and calibrate instrumentation in the presence of the Employer;
- carry out all survey work required to locate such instruments before and after instrument installation;
- tag all cables, tubes and movement gauges with identification tags at intervals of approximately 15 m horizontally or at such closer intervals as necessary to provide continuous identification;
- install cables and tubes without joints, in the maximum lengths practicable;
- where permitted, splice and couple cables and tubes in accordance with the manufacturer’s recommendations as approved by the Employer;
- keep plugged or sealed the open ends of all incomplete lines of tubing and casing;
- at all times during installation keep the insides of casing and tubes free from foreign matter; and
- protect all cables, tubes etc. from degradation due to ultraviolet light by storing in an adequate building or, during construction, by covering with suitable material.

The Contractor shall install all instrumentation in accordance with the manufacturer’s instructions.

The instrumentation shall be put into operation at the earliest practical time during construction in order to obtain information relating to the performance of the structure, its foundation and abutments.

19.1.8. Care of instrumentation

The Contractor shall protect all instruments from damage and displacement during the progress of the work and for the duration of the contract period. If, as determined by the Employer, there has been any damage to, or displacement of the instruments and connections during the progress of the work, they shall be repaired or the instrument replaced immediately to the satisfaction of the Employer by and at the expense of the Contractor.

19.1.9. Reading instruments

a. An initial set of readings on all instruments installed at any particular elevation will be taken immediately by the Contractor after the Contractor has completed their installation and prior to embedment in concrete.

b. The Contractor shall program his work to allow the reading of the instruments as soon as possible after their installation.

c. The Contractor shall read the instruments at regular intervals. The Contractor shall inform the Employer when reading of the instruments will take place.

d. The Contractor shall retain a qualified and experienced engineer to monitor all instrumentation from the time of their installation until the Taking Over of the Works.

e. The Contractor's engineer shall read all instrumentation at intervals no greater than those stated in Table 19.1-1. When abnormal readings are observed the reading shall be repeated and both results shall be recorded together with an explanation. All data will be recorded in a Surveillance Manual which shall be submitted to the Employer on a weekly basis and any abnormal readings shall be reported immediately to the Employer.

f. All other instruments shall be monitored and recorded as required for the safety of the Works and to obtain the information necessary for design purposes. The frequency shall be agreed with the Employer. The records of all such monitoring shall be submitted to the Employer on a weekly basis when such monitoring is in progress and any abnormal readings shall be reported to the Employer immediately.

Table 19.1-1 : Frequency of Instrumentation Readings

Instrumentation	Reading Interval
Crest and surface settlement points	monthly
Thermometers	daily
Borehole standpipes	weekly
Groundwater observation holes	weekly
Seepage measuring weirs	daily
Strain meters	weekly
No stress strain meters	weekly
Joint meters	weekly
Strong motion accelerographs	continuously
River levels	daily

19.1.10. Operation and Maintenance Manual

a. The Contractor shall furnish an operation and maintenance manual for all the instrumentation installed in the Works.

b. The manual shall include the as-built for all instrumentation installed in the Works.

c. The manual shall include all necessary reference data furnished by the manufacturer of each item of instrumentation.

19.2. Electrical Instruments

19.2.1. General

a. Electrical instruments shall be of vibrating wire type or approved equivalent.

b. The instruments shall be provided with over voltage surge arrester to protect the gauges against damage.

c. Where applicable, a suitable thermistor shall also be incorporated in the sensor for temperature sensing and for temperature - zero reading correlation.

d. Electrical instruments shall have stainless steel outer casings and hermetically sealed by welding with a vacuum or insert gas inside it.

19.2.2. Pore pressure gauges

The pore pressure gauges shall have the following characteristic

Measuring range	0-1 MPa
Accuracy	+ / - 2 kPa
Resolution	0.1 % of Full Scale
(FS) Over range capacity	150%
Temperature range	-25°C to 60°C
Thermal effect on Zero	less than 0.05% of FS per °C

a. The cells shall be installed as shown on the Construction Drawings or elsewhere as directed by the Employer.

b. For installations in boreholes, the following procedures shall apply:

- After the hole has been prepared, the lowest cell shall be placed and embedded in an approximately 1 m thick sand layer.
- This layer shall be sealed off from the other water bearing areas with bentonite palettes in a thickness of 1-2 m.
- In the same manner, the cell located at higher levels shall be successively installed.

c. The end of the cable shall be kept during constriction in protective boxes and later permanently installed in the terminal structures or switchboxes.

19.2.3. Pressure Cells (stress meters)

(a) The cells shall have the following characteristics:

Measuring range	5 MPa
Over Load Capacity	150% of FS
Accuracy	±0.5 % of FS
Operating temperature	-25°C to 60°C

19.2.4. Borehole extensometers

Borehole extensometers are single and multipoint borehole extensometers which are securely anchored at locations along the lengths of the borehole. The relative movement, between the individual anchors and the excavated surface in the surface excavations will be measured during and after completion of the excavation operation.

The Contractor shall supply and install borehole extensometers in the surface excavations in the locations shown on the Construction Drawings or as directed. The extensometers shall be installed in accordance with the manufacturer's recommendations and the surface excavation shall be not lower than 2 m below the required level of the extensometer at the time of installation. It is anticipated that boreholes extensometers up to 40 m long will be installed.

Borehole extensometers shall be designed, manufactured and installed to:

- yield an accuracy of readings to within 0.1 mm;
- provide a measuring range of 150 mm ;
- provide a resolution of 0.1% of FS
- Operate within a temperature range of -25°C to 60°C.

Each borehole extensometer shall consist of a down-hole assembly of one or three individual anchors, each attached to a non-corrosive stainless steel rod with protective casing, all assembled into a single bundle, and a mechanical readout head. Borehole extensometers will be grouted to the excavation surface and set in a galvanised steel pipe fitted with a galvanised steel waterproof protective cover. All extensometers shall first be prepared for mechanical reading. Later readings will be made via a portable electrical read out unit.

Cement grout and use of an expansion agent, shall be according to the borehole extensometer manufacturer's recommendations to produce a permanent non-shrink grout. Grout used shall be neat cement.

The diameter of the boreholes shall be as recommended by the manufacturer of the extensometers. The use of drilling mud, oil, rod dope or any other material in the hole that will adversely affect the bond between the rock, grout and extensometer anchors will not be permitted. Recovery of drill core will not be required unless otherwise directed by the Employer.

Once grouting of an extensometer has begun it shall not be interrupted until completed. Should grouting be interrupted the work will be deemed unsatisfactory and the Contractor shall replace the hole and anchor assembly at no additional expense to the Employer.

If any extensometer fails to work correctly, then it will be replaced by the Contractor at a location determined by the Employer.

19.2.5. Strain Meters

The strain meters shall be used to measure the internal strain in concrete and shall be fitted on a rosette to measure strain in different directions in one plane at an inclination of 0°,45°,90°, and 135° (with the horizontal) and for installing the fifth strain meter perpendicular to the common plane of the four stain meters.

The strain meter shall be provided with protective housing. It shall also be provided with two “o” rings root prevent leakage of water through the holes for the setscrews. The gauge shall be completely waterproof.

The strain meters shall also measure temperature in the concrete. The strain meter shall be a Carlson type strain meter or approved equivalent.

Each strain meter shall be adjusted to half the total extension of the strain meter so that equal tensile and compressive strains can be measured.

The strain meters shall have the following characteristics:

- Minimum gauge length (mm) 250
- Range (x10-6) in Tension (mm) 400
- Range (x10-6) in Compression (mm) 800
- Least Reading, Strain (x10-6) 5
- Temperature range (°C) -25°C to +70°C
- Linearity and Hysteresis (full scale) +/-2%
- Least reading, temperature (°C) +/-1

19.2.6. No-stress Strain Meter

The no-stress strain meters shall provide data on strain due to thermal stress and autogenous growth in the concrete face.

The general arrangement of the no-stress strain meters shall be as approved. They shall consist of strain meters of the same make and type as used elsewhere in the concrete face embedded in a case to keep the specimen concrete under no stress, but under the same temperature and humidity as that for the surrounding concrete.

The strain meters shall be adjusted to fifty (50) percent of their range during installation.

19.2.7. Thermocouples and thermometers

a. The thermocouples measuring device shall be capable of measuring across the range of -25ºC to 60ºC to an accuracy of 0.5ºC.

b. Each thermocouple shall be connected to its appropriate length of cable and shall be calibrated before being embedded in the concrete. A table and graph of the calibration data for each thermocouple shall be submitted to the Employer.

c. The thermocouples shall be embedded in the fresh concrete during construction of the dam and headrace intake structure, together with the necessary lengths of cable connecting to the face of the formwork

d. After concrete temperatures have stabilised the thermocouple leads shall be cut and the surface of the concrete shall be repaired.

e. Temperature gauges are required to monitor the temperatures in concrete structures.

These gauges are in addition to those the contractor may need to control the placement temperature of the concrete.

19.2.8. Load Cells

a. Local cells are required to measure and monitor loads of bolts and anchors.

b. The capacities of the load cells shall be 300 and 600 KN and they shall be suitable for 25 mm rock bolts or 32 mm grouted bars.

c. The cells shall have the following characteristics:

- Over load Capacity 150% of FS
- Accuracy ±.05% of FS
- Resolution 0.1% of FS

19.2.9. Joint Meters

a. Electrical, one directional joint meters are required to measure movements normal or parallel to joints in the concrete structures.

b. The joint meters shall also measure temperature.

c. The general arrangement of the joint meters shall be as approved. Adequate provision must be made to avoid shear on the joint meter due to movement normal to its axis.

d. Measurement of movement of the joint shall be made by Carlson type joint meter or approved equivalent.

e. The joint meter and its housing shall be installed in the first pour to be cast at the vertical contraction joint.

f. The extension rod target and associated items shall be installed in conjunction with the next pour at the vertical contraction joint.

g. The joint meter shall be adjusted to twenty (20) percent of its range during installation.

The joint meters shall have the following characteristics:

Minimum range 50mm

- Accuracy ±0.1 mm
- Resolution 0.01 mm

19.2.10. Cables

(a) All cabled instruments, except borehole extensometers, shall be supplied complete with the required length of cable. Splicing of cables on the site shall be avoided wherever possible. No splicing of cables on site may be performed without the prior approval of the Employer.

(b) The general cable routes shall be shown on the Drawings.

(c) All instrument cables shall be of the heavy duty insulated type suitable for direct placing in concrete and shall have the following characteristics:

- Cables shall be of dual windings composed of one layer of chloroprene or neoprene cabtyre covered with rubber and metallic tubes for protection. The cables shall have distinctly coloured cores.

No. of core: 4

- Conductor nominal section 0.5 mm^2
  - Compositio 20/0.18 mm
  - outer diameter 1.0 mm

- Strand diameter approx 5.1 mm

Thickness of
- separator 0.5 mm
- rubber 0.5 mm
- chloroprene sheath 1.3 mm
- armouring steel 0.3 mm
- anti-corrosive vinyl 2.5 mm

- Finished outer diameter approx. 19.7 mm
- Conductor resistance at 20°C 39.8 ohm/km
- Test voltage 1 000 V/min
- Insulation resistance, at 20°C 400 M ohm/km
- Approx. weight 435 kg/km

(d) No solder shall be applied to the conductor joints without the approval of the Employer.

(e) At joints the insulating layers shall be joined by vulcanising unless the use of self-adhering synthetic rubber tape is approved. A polysulphide or urethane adhesive compound shall be applied to the connecting part of conductor and the connecting part shall be covered with protecting tape.

(f) The tapes for connecting parts shall satisfy the following specifications:

	Self-adhering Tape	Protecting Tape
Thickness	More than 0.5 mm	More than 0.2 mm
Width	More than 15 mm	More than 19 mm
gth	More than 2 kV/1 min	More than 5 kV/1 min
Volume inherent resistance	More than 1 x 1015 ohm/cm	More than 2 x 1012 ohm/cm

Tensile strength	More than 0.07 kg/cm^2	More than 0.7 kg/cm^2
Elongation	More than 200%	More than 100%
Bond strength	-	More than 3.0 kg

(g) All earth wires shall consist of 19/1.53 mm bare hard drawn copper conductors.

(h) The Contractor shall supply samples of all cables and earthwires to the Employer for approval.

19.2.11. Switchboxes

(a) Switchboxes shall be monitored in recesses in concrete structures, in instrument houses or at temporary read out points.

(b) They shall be of weather proof and dust proof construction and all metal parts including terminals shall be of rust proof material.

(c) Each switchbox shall permit the installation of 12 cables.

19.2.12. Portable Readout Units

(a) The Contractor shall supply sets of portable readout units suitable to readout all cabled instruments.

(b) The readout unit shall be capable of being set to a resolution of up to two decimal points.

(c) The readout unit shall be capable of storing the calibration coefficients of around 100 vibrating wire transducers.

(d) The readout shall be capable of displaying the temperature of the transducer directly in °C from the thermistor incorporated in the sensor

(e) The readout units shall have the following provisions:

- Digital reading
- Storage of last reading
- RS-232 interface to transmit readings to a computer.

(f) The readout units shall be powered by DC batteries and be light, robust and durable.

19.3. Uplift Pressure Gauges

19.3.1. Requirement

(a) Uplift measuring devices shall be installed on top of boreholes or piezometers.

(b) They shall consist of tubes connected to the borehole or piezometers, a value to release toe pressure and to measure the discharge and a readout manometer. The manometer shall permit readings up to 10 bar with an accuracy of 0.05 bar.

19.4. Surface Movement Points

19.4.1. General

The Contractor shall supply, install and survey all surface movement points including pipes, pipe fittings, survey pins, and concrete. The Contractor shall also supply six approved survey targets for temporary mounting on the survey pins.

19.4.2. Material and installations

Pipe and fittings for surfaces movement points shall be galvanised mild steel in accordance with this Technical Requirements. The survey pins shall be stainless steel.

The Contractor shall carry out all work necessary for the installation of surface movement and points within 0.5 m of the required position and shall complete the installations as soon as practicable after completion of the excavation support at the locations at which surface movement points are required.

Immediately after installation of any point, its position and level shall be precisely surveyed and co-ordinates calculated to the nearest 5 mm and this data reported to Employer in writing.

19.5. Groundwater Observation Holes

19.5.1. General

The Contractor shall drill 75 mm diameter groundwater observation holes and install slotted PVC casing in, and galvanised steel covers over the holes as directed by the Employer. The Contractor shall supply an electrical-signal type measuring device for measuring water levels in these holes.

19.5.2. Materials

The PVC casing shall be an approved type which is capable of being installed without deformation. The external diameter of the casing shall be of size such that will occupy the full diameter of the hole but allow sufficient clearance for installation. The size, location and spacing of the slots in the casing shall be as approved by the Employer.

The covers over the top of the groundwater observation holes shall be constructed from 100 mm diameter galvanised steel pipe and fitted with lockable caps.

19.5.3. Installation

The groundwater observation holes shall be drilled to the full length using bits and methods adapted to the material being drilled so that caving of holes is minimised. Immediately after each hole has been drilled, the slotted PVC casing shall be installed for the full length of the drilled hole. The lower end of the casing shall be pointed or shaped to assist installation and prevent any material from entering.

Immediately following installation of the slotted casing in all holes, the Contractor shall grout in the covers and after the grout has set, survey the covers.

19.6. Borehole Standpipe Piezometers

19.6.1. General

The Contractor shall supply, install, test and survey borehole standpipe piezometers and ancillary measuring equipment in the locations as shown on the ConstructionDrawings.

The borehole standpipe piezometers shall measure the groundwater level at various locations as shown on the Construction Drawings or as directed by the Employer.

19.6.2. Instrument specification

The borehole standpipe piezometers shall consist of an approved PVC standpipe tube with a Cassagrande ceramic piezometer tip or equivalent.

The Cassagrande piezometer tips shall be fitted with fine grained porous ceramic elements having:

- a soil contact surface area not less than 30 000 mm^2
- a maximum overall diameter of 60 mm.

The piezometers shall be connected to the ancillary measuring equipment at the top of the borehole by tubing meeting the specified requirements.

The ancillary measuring equipment will consist of a Dip-meter or approved equivalent. The Dip-meter shall be portable and be operated by d.c. battery.

19.6.3. Installation and testing

Borehole standpipe piezometers are to be installed in drill holes and the Contractor shall drill and case, where necessary, holes of 100 mm minimum diameter into the excavation for the installation of the piezometers.

After installation of the borehole standpipe piezometers in the boreholes, the Contractor shall withdraw any required casing, taking all precautions against damaging the piezometer installations. The Contractor shall backfill grout around the standpipe in accordance with the details shown on the Construction Drawings.

19.7. Water Level Measuring Gauge - Electronic

19.7.1. Requirement

(a) The Contractor shall supply and install water level measuring gauges near upstream of the dam.

(b) The gauges shall be enamelled ironware with melamine resin coating, and shall be subject to the approval of the Employer. The principal division shall be in meters above see level which will be further divided into centimetres. The lettering shall be every 10 cm with large, clearly legible letters.

(c) The Contractor shall set the gauges by accurately levelling from a designated benchmark. The gauges shall be fixed propoerly.

19.8. Seismograph

19.8.1. Requirement

Seismographs are required to be placed at suitable locations for recording data such as acceleration time, earthquake location and magnitude.

19.9. Data Acquision system and web-based data monitoring services shall be installed to log the data received from various instruments installed in the dam.

20. ARCHITECTURAL

20.1. General

Architectural finishing of the following project structures shall be carried out:

Dam Area Dam control room, Staircase tower, Gate Control structures, Dam top roadway and railing etc.

Intake Area, Intake control room, Intake top roadway and railing etc.

The specifications of finishing works shall be of very good quality meeting the National/International Standards befitting the prestigious project, the exact details of which shall be provided after the detailed designs are finalised.

20.2. Designs, Specifications and Execution

(i) The work shall be executed in a careful manner by engaging the services of specialised and reputed agencies in the field.

(ii) Detailed specifications in respect of each structure for the following items shall be prepared in consultation with the specialised and reputed agencies in the respective field/items:

(a) Specification for flooring and floor tiles.

(b) Specifications for wall finish, external and internal.

(c) Specifications for painting and colour.

(d) Specifications for masonry works.

(e) Specifications for delivery and installation of kitchen type storage units and office type storage units.

(f) Specifications for false ceiling.

(g) Specifications for doors and windows which include standard steel doors, gates, aluminium doors, windows and partitions. Details of hardware and glass and glazing shall also be provided.

(h) Specifications for metal locks.

(i) Specifications for toilet and bathroom accessories.

(j) Specifications for electrical fittings.

(iii) Approval of the Owner shall be obtained for samples of various items & installations submitted according to the specifications as finalised above in consultation with agencies of repute, before proceeding with the execution.

20.3. Permanent Drinking Water Supply and Treatment of Waste Water

20.3.1. Permanent Drinking Water Supply and Disposal of Waste Water

(i) Permanent drinking water supply and disposal of waste water scheme shall be installed & commissioned at various major project structures upon completion.

(ii) A complete scheme indicating the source of raw water, water treatment plant, transportation and storage of drinking water shall be designed and submitted for various project structures as under:

Dam Area, Itake area, Dam control room, Gate Control structures etc.

(iii) Specifications in respect of piping, treatment plant, water pumps for pumping etc. shall be prepared in consultation with agencies of repute.

20.3.2. Designs, Specifications and Execution

Approval of the Owner shall be obtained for the Designs and Specifications for permanent drinking water supply and treatment of waste water schemes before proceeding with execution.

20.4. Landscaping Of Dam Area Area

20.4.1. General

Upon completion of all civil works landscaping treatment shall be provided at the identified locations in Dam area and spoil tips to render aesthetic & pleasant look.

20.4.2. Scheme for Landscaping

The detailed scheme for landscaping shall be finalised in consultation with the Engineer.

(i) development of lawns, parks, rock gardens and horticultural treatment.

(ii) development of water falls, musical fountains etc.

(iii) providing necessary and suitable lighting arrangement.

20.4.3. Execution

Approval of Owner shall be obtained for the landscaping features and shall be developed by engaging the services of experienced and reputed landscaping and horticulture agencies before proceeding with execution.

20.5. Architectural Finishing

For architectural finishing schedules for floors, walls and ceilings refer to relevant architectural drawings.

20.6. Architectural Aspects of Building Construction

20.6.1. General

All building construction and finishing work shall be performed by experienced tradesmen or accredited specialists. The Employer may require the Contractor to supply proof of competency of any tradesman or specialist employed on the work.

20.6.2. Obvious work

(a) If the Employer's Requirements do not contain particulars of materials and works which are obviously necessary for the proper completion of the work and the intention to include which is nevertheless to be inferred, all such materials and works shall be supplied and executed by the Contractor.

(b) Similarly, the Contractor shall supply, place and attach to the structure all timber, metal or other accessories necessary for the proper completion of the work as shown on the Drawings or as specified.

(c) The Contractor shall provide and fix all incidental flashings, damp proofing, weather seals or other approved materials necessary to render the building completely watertight and weatherproof.

20.6.3. Samples

In accordance with the requirements for Contractor's Documents to allow for the initial review period of not less than sixty (60) days prior to the date the Contractor wishes to place or confirm orders, the Contractor shall submit, for approval, samples of all materials with specimens of workmanship, color and finish for all items described in this Section of Technical Requirements.

20.6.4. Nominal sizes

The Contractor shall allow for variations between nominal sizes and actual sizes where such variation is within the required tolerances or is normal trade practice.

20.7. Finishing Work

Finishing Work shall not commence until each or all of the following conditions have been met to the satisfaction of the Employer:

- The area concerned and such adjacent areas which may affect the finishing work have been weatherproofed.
- Unless otherwise specified, all construction including installation of permanent plant, fittings and equipment has been completed.
- The concrete or other materials have dried out sufficiently.

20.8. Cement, Water and Fine Aggregate for Finishing Work

(a) Cement, water and fine aggregate for plaster, mortar and grout shall conform to the requirements of this Technical Requirements except that the grading of fine aggregate shall conform to the following limits:

Sieve Size	Percentage by Mass Passing
2.36 mm	100
1.19 mm	70 - 100
0.6 mm	40 - 80
0.30 mm	5 - 40
0.15 mm	0 - 10

20.8.1. Provision for Services

In all wall and ceiling finishing, the Contractor shall make necessary provision for the installation of pipes, metal frames, electrical conduit, electrical wiring, lighting fittings, and other fixtures, and shall neatly finish the surfaces around them to conform to the surrounding wall or ceiling finishes. Permanent openings shall be finished neatly, and the Contractor shall furnish and cut as required such special shapes of materials as are required for neat finishing at edges. Where required in suspended ceilings, access openings neatly finished at edges shall be formed by the Contractor and panels with surfaces corresponding to the ceiling finish shall be fabricated by the Contractor and fitted into the openings in such a manner as to blend with the ceilings.

20.9. Trial Panels

Where walls, floors or ceilings are to receive a plastered, tiled or painted finish, the Employer may direct that trial panels, approximately one metre square, be erected in the locations where the particular types of finish are required. The trial panels will be required to demonstrate the final appearance of the alternative types of finish which may be required at a particular location.

20.10. Tiles and Sheets

All required floor and wall tiles and sheets of a particular color or type shall be purchased by the Contractor from the one source and at the one time.

20.11. Protection

It is anticipated that during installation of permanent plant, damage may be caused to concrete or blockwork in walls, floors, columns and ceilings, to fittings and fixtures, and to building finishes, including aluminium and other metalwork, glass and paintwork. The Contractor shall provide and maintain adequate protection from such damage to such work carried out under the Contract.

20.12. Keying System

(a) The Contractor shall provide a keying system for all doors at the Facility to the extent required by the Employer. The number or numbers of construction key, master key, grand master key and great grand master key shall be submitted to the Employer for approval.

20.13. Metal Roofing, Cladding and Insulation

20.13.1. General

The Contractor shall furnish and install weatherproof protected metal roofing, ceiling lining and external and internal wall cladding systems as shown on the Drawings or as approved including all box gutters, cappings, flashings,corrugation closers, ridges and other necessary accessories and trim.

The systems shall be designed and manufactured by the manufacturer of the protected metal material to suit the building and shall be installed under the supervision of the manufacturer and in accordance with its recommendations.

20.13.2. Shop Drawings

In accordance with the requirements for Contractor's Documents to allow for the initial review period of not less than ninety (90) days before proceeding with fabrication, the Contractor shall submit copies of shop drawings of all of the work covered by this Clause and showing details of profiles, fabrication, jointing, fixing, anticorrosion separation, flashings, penetrations, expansion allowance, weatherproofing, and other information as may be required.

20.13.3. Installation and Fabrication Generally

(a) The installation of all work covered by this Clause shall be carried out by experienced tradesmen approved of by the supplier if a patent system is used.

(b) Purpose-made profiles including cappings, flashings, accessories and trim shall be factory-fabricated with all folds mechanically formed.

(c) The work shall include all necessary items and operations for the satisfactory performance of weatherproof systems including cutting, trimming, flashing and sealing, at junctions and penetrations.

(d) Corrosion shall be prevented by separating incompatible materials.

(e) Allowance shall be made for thermal expansion where necessary.

(f) On completion, roofing shall be left clear and free of debris. No debris shall be allowed to enter the downpipes.

20.13.4. Fixing

(a) Roofing shall be fixed to withstand a minimum negative pressure of 0.8 kPa generally and 1.1 kPa at the ridge.

(b) Wall cladding and lining above building roof level shall be fixed to withstand a minimum negative pressure of 0.65 kPa.

(c) Roofing and wall cladding shall be fixed through the valley of the profile into steel framing at each crossing generally and in the case of intermediate roof purlins at alternate valleys.

(d) Roof sheeting shall be fixed with side laps facing away from the prevailing weather.

(e) Fascia and transom panels shall be fixed with broad pan prominent with small screws or rivets at each valley into support members at each crossing. Associated cappings and other visible trim shall be fixed in a similar manner.

(f) Flashings, cappings, and other accessories shall generally be fixed with fastenings at each edge in accordance with manufacturer's recomendations.

(g) Sill flashings and cappings shall be fixed to concrete structure with 50 mm wide by 2.5 mm galvanised steel straps at 450 mm centres screwed to approved plugs in top of concrete

(h) Galvanised wire netting for supporting ceiling insulation shall be fixed above the purlins, tightly stretched, screw fixed with approved metal clips and the insulation laid over the wire. Wall insulation shall be supported by the fasteners according to the manufacturer's recommendations. Insulation shall be installed such that the reflective insulation faces the inside of the building.

(i) Ventilation mesh shall be fixed in an aluminium angle frame with an insect screen.

20.13.5. Painting

(a) The protected metal roofing, cladding and lining shall be touched up with a painting system recommended for the purpose, by the manufacturer of the protected metal material.

(b) Touching up shall be carried out in the following cases to colour the respective items or areas to match the protected metal generally, to form a fully corrosion-resistant coating:

- Fastenings and other items not fabricated from protected metal.
- Where permitted, areas of minor damage or small areas of site fabrication.
- The framing for louvred wall cladding and box gutters shall where visible from within the building, be painted as specified to match the adjacent protected metal in colour.

20.14. Aluminium Windows, Screens, Doors and Louvres

20.14.1. General

(a) The Contractor shall furnish and install aluminium windows, screens, doors and louvres including all glazing, flashing, fixings, and other trims as specified in this Clause and as approved.

(b) The whole of the aluminium work shall be fabricated from extruded sections by an approved aluminium fabricator.

(c) The manufacture and installation of aluminium windows, screens, doors and louvres shall be carried out by a firm or firms approved by the Employer.

20.14.2. Materials

Unless otherwise specified or indicated on the Employer's Concept Drawings, aluminium sections shall be of commercial grade with the base alloy and surface suitable for the required final treatment.

20.14.3. Performance

(a) Aluminium windows, screens and doors shall be designed to withstand a minimum wind design load of 2.5 kPa.

(b) Window and door members on the external faces of the building shall not deflect more than 1/240 of their unsupported span under the maximum wind or static load. Deflection due to such loads shall not adversely affect the strength or appearance of members or result in permanent deformation.

(c) No water shall penetrate beyond the interior face of the frame under the design wind load, whether between members or between the window and the structural opening.

(d) The frame and its members shall be free to move in response to thermal changes. Provision for movement shall be made by locating slotted fixing holes in brackets in such a way as to allow sliding movement between brackets and frame. Brackets shall be rigidly fixed to the building structure. Allowance for movement shall not be less than 1/750 of the clear span of any member.

20.15. Fabrication and Assembly

(a) Aluminium frames shall be accurately set out and assembled square and true. All necessary accessories and fixings for the proper completion of the Works shall be provided. Joints shall be made by welding or by concealed mechanical connections sealed where necessary with an approved mastic sealant. No corner fixings such as pins, screws, bolts or pressure indentations shall be visible on exposed faces. Where cut outs, mortising or milling is required, it shall be accurately made and reinforced with backing plates where necessary for strength or fixings. Moving parts shall operate freely and smoothly without binding or striking, and at correct tensions or pressures.

(b) Visible welds shall be made employing parent metal or other approved filler rod. Filler rods containing not more than five (5) percent silicon may be employed for hidden components. Welds shall be mechanically sound with adequate penetration and the weld bead uniform and well formed. The dimension and strength of the weld shall be adequate to fulfil its normal service function.

(c) All fixings shall be of aluminium or non aggregate stainless steel or other approved compatible metal.

(d) All weather seals shall be extruded neoprene sections in continuous lengths, profiled to fabricator's specifications. All dust seals shall be of approved metal backed, siliconised wool pile of size specified by the fabricator.

(e) Frames shall be plumb, square and level and firmly fixed by approved devices. Fixings shall be at no more than 450 mm centres unless otherwise specified or noted and shall be fully concealed.

(f) Where frames are to be mastic caulked, sealed or pointed, the mastic shall be a non hardening polysulphide based material, and shall be applied in accordance with the manufacturer's written instructions. Samples shall be submitted for approval. Generally, where frames are mastic caulked sealed or pointed mastic shall be backed up with an approved closed cell polyurethane rod encased in polythene.

(g) Flashings shall be aluminium coated with a non staining compound. The non staining property shall be included in any guarantee required of the assembly.

(h) Aluminium surfaces coming in contact with incompatible materials shall be coated with two coats of heavy bodied bituminous paint.

20.16. Surface Treatment

(a) Aluminium to be anodised shall be given a matt surface finish being equivalent to a two minutes immersion in a bath of ten (10) percent by mass of caustic soda solution at 60°C. After etching the surface shall present an appearance free from stains, smudges, 'smuts', scratches and other blemishes.

(b) The colour anodic coating shall be given a complete seal. Colour range samples for colours shall be submitted for approval before proceeding with manufacture.

(c) The aluminium fabricator shall apply a temporary protective coating to the anodised surfaces. The protective coating shall be removed at the completion of the Works, or before the installation of glazing, the application of sealing compounds or the fixing of weather or dust seals.

(d) Allowance shall be made for the special protection of aluminium works during erection to prevent damage during building operations.

20.17. Aluminium Windows

(a) The Contractor shall obtain from the window manufacturer test certificates of compliance to verify the operating force for the windows, the structural performance under static pressure and dead load, and water penetration under static pressure and shall submit such certificates to the Employer.

(b) Frames and sashes shall be constructed from extruded sections of aluminium alloys, as specified. They shall have morticed and screwed joints and shall be sealed internally with approved nondrying elastomer suitable for tropical conditions. Sash sections shall have integral glazing rebate or glazing beads. Glazing shall be snap in beads with keyed in vinyl extruded gaskets. Generally, sashes must be capable of being reglazed without removal from the frame. Friction stays and catches shall be provided on awning windows. Allowance shall be made for colour anodised finish as specified. Glass shall be 6 mm thick minimum, grey float glass or 6 mm thick minimum unless required to be thicker by the applicable IS Standard.

20.17.1. Aluminium Screens and Doors

(a) Aluminium screens and doors shall be finished in colour anodised finish.

(b) Door furniture including latches, locks, handles, bolts, plates, closers and hooks, shall be installed to doors as shown on the Drawings and as approved. Dust seals shall be provided in stiles and in meeting stiles. Concealed flush bolts shall be fitted to door pairs. Locks shall be approved mortice cylinder narrow deadlock type suitable for use with interchangeable six tumbler cylinders.

(c) Doors shall be snap in bead glazed with keyed in vinyl extruded gaskets. Glass shall be 6 mm thick minimum, toughened grey float glass.

20.17.2. Insect Screens

The insect screen frames shall be fabricated from extruded aluminium flyscreen sections. The corners shall be mitred, and the frame constructed square and true to plane.

20.17.3. Fire Rated Door Frames

(a) Metal door frames shall be provided for all fire rated doors. The door frames shall be hour fire rated.

(b) Door frames shall be built into concrete, blockwork and brickwork as specified.

(c) Frames shall be modified where required to take door closers and allowance made for fixing on Site.

(d) At the completion of fabrication, all scratches, dents and other surface imperfections shall be cut back to base metal and repaired with approved body filler where necessary.

20.17.4. Door Furniture

Door furniture including latches, locks, handles, bolts, plates, closers and hooks shall be installed to all doors as approved by the Employer. Such furniture shall generally be stainless steel of first class standard best suited to each particular application. A master locking system shall be provided for different features and structures of the Facility.

20.18. Floor Finish

20.18.1. General

(a) The Contractor shall furnish and install the various floor finishes, as specified in this Clause, or as approved.

(b) The Contractor shall be responsible for ensuring that the background or sub base to which the specified finish is to be applied, has properly cured, has the correct moisture content, is properly finished and is completely adequate to receive the specified finish. Any faulty work resulting from non compliance with the above shall be replaced and such replacement may be extended at the Employer's sole discretion to include the whole of the room or area affected.

20.18.2. Preparation of sub-base

(a) The sub bases of all concrete floors specified to receive a finish shall be constructed to the approved lines and grades.

(b) The Contractor shall maintain the prepared sub base in a satisfactory condition until the time of application of the specified finish, and will ensure that:

- All materials likely to reduce adhesion of the finish, including curing compounds and surface retarders, shall be removed prior to the application of the specified finish and the surface left dust free and clean and the surface shall be protected from contamination until time of laying finish.
- Surfaces to receive adhesives and fixatives shall be thoroughly dry.
- All traffic and loads shall be kept off completed work at least until bonding has set.
- Surfaces that are to receive cement mortars shall be roughened and dampened prior to the application of an approved mortar.
- If possible, areas shall be locked up on completion of finishing work.
- The finished floors shall be protected by taping down building paper over finished surfaces, lifting and relaying as required for cleaning, sealing and polishing and removing immediately prior to handing over.

20.18.3. Ceramic Tiling

(a) The Contractor shall submit for approval, loose samples of each type of tile or other unit finish specified. Samples shall be sufficient in number of illustrate the extremes and average of the ranges of colour, size and texture.

(b) The Contractor shall prepare in suitable positions, or where approved, sample 2 panels of sufficient area, ie not less than 2 m of each type of finish specified. Examples of specified junction details and trim shall be included. Each panel shall be preserved until all work of its type is complete. Approved panels may form part of the completed work.

(c) Tiles shall be approved and selected plain colour, glazed ceramic tiles, 200 mm x 100 mm x 9 mm or other approved sizes of local manufacture.

(d) Tiles shall be bedded on a cement mortar composed of 4 parts sand : 1 part cement and water proofing agent added in accordance with manufacturer's instructions. The bed shall be 25 mm minimum thickness layed to the required falls. At junctions with adjoining finishes, the finished surfaces shall be flush. Tiles shall be soaked in water for one hour then drained for 15 minutes before laying. Tiles shall be laid on the mortar bed and tamped into place. Closure tiles, and tiles around upstands, pipes, etc. shall be neatly cut and set in. Joint width shall be a uniform width of 2 mm throughout. A 20 mm x 5 mm brass strip embedded flush with finished floor level shall be provided at junctions with adjoining finishes. Where changes in finish occur at doorways, the change shall be located directly beneath the closed door. Tiles shall be cured a minimum of 24 hours before grouting.

(e) Control joints shall be provided to full perimeter of each area and at 4.5 m maximum centres and so as to divide tiles into 10 square metre maximum panels. Control joints shall be 5 mm wide, extending through the bed, filled with polythene encased polyurethane foam strips and pointed up with silicone rubber or polysulphide sealant.

(f) After the specified curing time all joints in tiles, except control joints shall be grouted up with cement grout coloured to match tiles.

20.18.4. Spare Materials

The Contractor shall furnish additional spare materials of the same type, quality and colour, equal to two (2) percent of the quantity of each type laid. These sheets and tiles shall be packed and labelled suitable for storage.

20.19. Flooring Systems

20.19.1. Access Floor System

(a) The Contractor shall furnish and install cable access flooring as shown on the Drawings or as approved.

(b) The sub base of surfaces with access floor system shall be prepared as specified.

(c) The floor system shall be installed in accordance with the manufacturer's recommendations. Allowance shall be made for forming around columns and for make up panels at edges.

20.20. Wall Finishes

20.20.1. General

(a) The Contractor shall furnish and install the various wall finishes in areas as required and approved.

(b) The Contractor shall be responsible for ensuring that the background or sub base to which the specified finish is to be applied has properly cured, has the correct moisture content, is properly finished and is completely adequate to receive the specified finish. Any faulty work resulting from non compliance with the above shall be replaced and such replacement may be extended at the Employer's sole discretion to include the whole of the wall or area affected.

20.20.2. Ceramic Tiling

(a) The Contractor shall submit for approval, loose samples of each type of tile or other unit finish specified. Samples shall be sufficient in number to illustrate the extremes and average of the ranges of colour, size and texture.

(b) The Contractor shall prepare in suitable positions, or where approved, sample 2 panels of sufficient area, ie not less than 2 m of each type of finish specified. Examples of specified junction details and trim shall be included. Each panel shall be preserved until all work of its type is complete. Approved panels may form part of the completed work.

(c) Tiles shall be set out to use only whole tiles where practicable or to give equal margins of cut tiles larger than half a tile.

(d) Tiles shall be 200 mm by 200 mm by 9 mm selected plain matt colour with glazed edges. Adhesive shall be an approved rubber based two component adhesive and shall be waterproof and flexible. Grout shall be mixed in the proportions of 1 part white cement to 4 parts whiting or proprietary grout, coloured to approval.

(e) Joints in all tiled wall panels shall be 2 mm wide in both directions set out to approval and to the manufacturer's recommendations. All joints and edges shall be grouted not less than 24 hours after tiles have been fixed.

(f) Adhesive shall be cleaned off tiles during laying. Grout shall not be cleaned off tile faces before 24 hours after last application.

20.20.3. Spare materials

The Contractor shall furnish additional spare materials of the same type, quality and colour equal to two (2) percent of quantity of each type laid. These tiles and skirtings shall be packed and labelled suitable for storage.

20.21. Ceiling Systems

20.21.1. General

(a) The Contractor shall furnish and install the various ceiling systems as specified.

20.21.2. Aluminium Ceilings

(a) The Contractor shall furnish and install aluminium panel ceilings where required and approved.

(b) The aluminium panels shall be lightweight building panels as approved. Panels shall be nominally 1 200 mm x 600 mm x 50 mm thick with 19 mm x 25 mm deep rebates all round, with edges and faces machine cut square and true. Panels shall be set out evenly with equal length panels to each bay and opposite bay ends, equal bay panel widths with equal opposite bay widths to each side, all in a staggered stretcher bond pattern.

(c) The suspended ceiling suspension system shall be capable of fully supporting the ceiling panels, fire detectors and luminaires without movement or deflection. The grid members shall be extruded aluminium tee bar sections with matching wall angles which shall support each slab on all sides and suit the slab pattern previously specified. The system shall be adjustable and shall be braced as necessary. The individual panels shall be removable without disturbance to the adjoining panels.

(d) The aluminium panels, supporting tee bars and wall angles shall be prepainted in accordance with Section 15 of this Technical Requirements on all exposed edges and faces before delivery to a colour as approved.

20.21.3. Fire Rated Ceilings

(a) The Contractor shall furnish and install 2 hour fire rated ceilings as approved.

(b) The system shall consist of four layers of approved 16 mm thick plasterboard arranged as two strata each of two layers. The ceiling shall be installed in accordance with the manufacturer's instructions.

(c) The ceiling suspension system shall be capable of fully supporting the ceiling, fire detectors and luminaires without movement or deflection.

20.21.4. Bench Cupboards

Bench cupboards shall be constructed as follows:

- Bench tops shall be plywood with 50 mm by 25 mm soft wood front edge with laminated plastic sheet on top and exposed edges.
- Bottom shelves shall be 20 mm plywood with 10 mm edge strip on front edge, set behind doors.
- Intermediate frames shall be 50 mm by 30 mm ladder frames set back behind doors.
- Free ends shall be plywood with laminated plastic sheet on exposed face and edges.
- Doors shall be 12 mm plywood.
- Drawers shall have false fronts of plywood with plastic laminate sheet on the front and edges. The front shall be fixed to drawers of 19 mm thick softwood front, sides and back. The drawers shall be fitted with hardwood runners and 100 mm chromium plated handle, all as approved.
- Sinks shall be built in where required.
- Cupboards shall be set up on 100 mm high concrete plinths set back 50 mm from the face of doors and with plinth front finished skirting in accordance with this Technical Requirements.

20.22. Seals

20.22.1. General

The Contractor shall furnish and install seals to contraction and expansion joints in the structures where required and approved.

20.23. Brickwork

20.23.1. General

The Contractor shall furnish and install clay brickwork as required and approved.

20.23.2. Materials

(a) Bricks shall be sound, sharp, well-burnt clay common bricks of good, even, rectangular shape.

(b) In accordance with the requirements for Contractor's Documents to allow for the initial review period of at least ninety (90) days before ordering bricks, the Contractor shall submit to the Employer for approval samples of the bricks to be used and the name and address of the brickworks.

(c) Mortar shall consist of 1 part cement, 1/10 part hydrated lime or approved plasticiser and 5 parts of fine aggregate, by volume. Mortar shall be used within one hour of initial mixing.

20.24. Reinforcement

(a) Joint reinforcement

Hot-dip galvanised woven wire brick reinforcement, 75 mm wide, shall be laid in every fifth joint, lapped full thickness of the wall at intersections and 300 at splices. Reinforcement shall not continue across control joints.

(b) Column straps

Column straps shall be provided at all abutments of brickwork with steel or concrete columns or walls. Straps shall be 25 mm by 1.6 mm galvanised steel

400 mm long overall, crimped and forked, with 75 mm turn up. One strap to each half brick thickness of wall every five courses, fixed by bolts or masonry anchors to the structure and built into bed joints.

(c) Lintels

Unless otherwise approved, reinforced beams or mild steel lintels shall be built in to support brickwork over openings, one to each half brick thickness of wall.

21. STEEL PRESSURE CONDUIT (PENSTOCK)

21.1. Scope

21.1.1. Work to be carried out

(a) The Contractor shall:

design all steel penstock liners and associated works

- supply all necessary materials;
- develop and test suitable weld procedures;
- prepare all workshop drawings necessary for fabrication and installation of the penstock steel liners;
- fabricate penstock steel liners, including the inspection and repair at the place of manufacture;
- furnish and install bracing and supports to prevent damage or distortion to the penstock steel liners during manufacture, transport, storage and installation;
- deliver penstock steel liners to the site of the Works;
- supply and apply corrosion and protection coatings to the internal and external surfaces of penstock steel liners;
- install penstock steel liners in the location and to the lines and grades shown on the Drawings;
- weld together the separate liners;
- carry out non-destructive inspection of welds; and
- inspect and repair all defects in the welds or coatings and any damage to coating.
- The penstock steel liners components include all straight liners, bends, tapers, seep rings and grout plugs.

21.1.2. Employer's Review

(a) The Contractor shall submit drawings for review by the Employer at least 90 calendar days prior to performing any fabrication or installation required for the Works. The Contractor shall certify that these drawings have been checked before submission.

(b) Any fabrication commenced prior to the approval of the drawings shall be at the Contractor's risk.

(c) Approval of the drawings by the Employer will not waive or modify this Technical Requirements Technical Requirements, nor will it relieve the Contractor of any part of his responsibility under the Contract for the correctness of all his drawings.

(d) The Employer may require the Contractor to make changes to the Contractor's drawings necessary to ensure that the Works conform to the Technical Requirements of the Contract and the Contractor shall make such alterations withoutcost to the Employer.

(e) All shop work including the application of the protective coatings shall be performed under cover in a building which has a concrete or other approved floor.

(f) The Contractor's proposal for handling, storing, transporting and installing the penstock steel liner shall be subject to review by the Employer.

21.1.3. Terms used

(a) The terms 'Upstream' and 'Downstream' are considered, for the purpose of this Technical Requirements, to correspond with the direction of flow for water supply.

(b) The term 'pipe-shell' shall, for the purposes of this Technical Requirements, include all curved shell plates in penstock steel liners.

21.2. General Technical Specification – Penstocks

21.2.1. General

This technical specification presents general information and gives principal guideline regarding criteria for hydraulic and structural design of steel penstocks for hydroelectric power plant taking into account the current development in the high strength low alloy steel plates, advancement in welding technique and in inspection and testing of welds. The following provisions shall be applicable to all the detailed technical specification.

21.2.2. Introduction

A steel penstock is the pressure conduit installed to convey water directly from Dam Intake to Outlet. Penstocks should be as hydraulically efficient as practical to conserve available head, and structurally safe to prevent failure which would result in loss of life and property. Penstocks can be fabricated out of many materials, but strength and flexibility of steel make it best suited for large range of pressure fluctuations met in water supply operation. The design and construction of pressure vessels such as penstocks are governed by appropriate codes which prescribe safe rules and practice to be followed.

21.2.3. Layout

The layout and arrangement of penstock depends upon the type of development, site conditions, topography and relative location of dam and Outlet points. In this project, the water is conveyed from dam across river by surface steel pressure conduit (Penstock) supported on concrete saddles, anchorblocks and steel bridges wherever required according to site condition to outlet point.

Penstocks installed in trenches backfilled with combination of concrete and Compacted backfill may be designed to transmit some of the radial thrust due to internal water pressure to the surrounding concrete. More generally, such penstocks are designed to withstand the full internal pressure. In either case, the shell should be of sufficient thickness to provide the rigidity required during fabrication and handling, and to serve as a form for the concrete. Embedded or buried penstock shells also should be provided with adequate stiffeners or otherwise designed to withstand any anticipated external hydrostatic or grouting pressures.

Proper location of the penstock intake is important. Regardless of arrangement, the intake should be placed at an elevation sufficiently below low reservoir level and above the anticipated sill level to allow an uninterrupted flow of water under all conditions. Each intake opening is protected against floating matter by means of a trash rack structure and is controlled by suitable gates.

To prevent the development of a partial vacuum during certain operating conditions, penstock profiles from intake to outlet should, whenever possible, be laid on a continuous slope.

21.2.4. Head Losses

A penstock is designed to carry water to a turbine with the least possible loss of head consistent with the overall economy of installations. Hydraulic losses in a penstock reduce the effective head in proportion to the length of the penstock and approximately as square of the water velocity. An economic study will size a penstock from a monetary standpoint, but the final diameter should be determined from combined engineering and monetary considerations. The various head losses are as follows:

- Trash rack losses
- Entrance losses
- Losses due to pipe friction
- Bend losses
- Losses in valve and fittings

The magnitude of entrance losses depends upon the shape of the intake opening. Head losses in pipes because of friction vary considerably, depending upon velocity of flow, and condition of the inside surface of the pipe. Bend losses vary according to the shape of the bend and condition of the inside surface. Mit ered bends constructed from plate steel no doubt cause greater losses than smooth curvature bends formed in concrete, however, there is no way to evaluate such effects. As the fabrication cost of a bend increases with increasing radius and the length, there appears to be no economic advantage in using R/D ratios greater than 5. Head losses in gates and valves vary according to their design. As gates or valves placed in penstocks are not throttled, only the loss which occurs at the full open conditions to be considered.

Rapid opening or closing of the valves produce a pressure wave in the penstock called water hammer, the Intensity of which is proportional to the speed of propagation ofthe pressure wave produced and the velocity of flow destroyed. As the investment in penstocks is often considerable, they must be safeguarded against surges, accidental or otherwise.

Adjustments in the profile of a penstock may be necessary to prevent the development of a vacuum and water column separation during negative pressure surges. As water-hammer surges occurring under emergency conditions could jeopardize the safety of a penstock if they are not considered in the design, their magnitude should be determined and the shell thickness designed for the resultant total head. Stresses approaching yield-point values may be allowed. By using ductile materials in the penstock, excessive surge stresses may be absorbed by yielding without rupture of plates or welds.

21.2.5. Pipe Shell

Penstock steel liner means "pipe shells" of steel penstocks. Attachment referred to in this specification mean those listed below:

21.2.5.1. MANHOLE

Manhole shall be designed considering the clauses in IS 11639 (Part-3). Manholes are provided in the course of the penstock length to provide access to the pipe interior for inspection, maintenance and repair.

The normal diameter of manholes is 600 mm. As per IS 11639 (Part -3), Manholes are generally located at intervals of 120 to 150 metres, but however the location of Manholes may be decided mutually by Employer and Contractor depending upon the location and suitability . For convenient entrance, exit manholes on the penstock may be located on the top surface or lower left or right surface along the circumference of the penstock.

The manhole, in general, consists of a circular nozzle head, or wall, at the opening of the pipe, with a cover plate fitted to it by bolts.

Sealing gaskets are provided between nozzle head and cover plate to prevent leakage. The nozzle head, cover plates and bolts should be designed to withstand the internal water pressure head in the penstock at the position of the manhole.

The pipe should be reinforced around the manhole by providing extra reinforcing plate adjacent to nozzle head. Sectional area of reinforcement should be at least 5 percent to 10 percent greater than the sectional area of the pipe shell.

21.2.5.2. EXPANSION JOINT

Manhole shall be designed considering the clauses in IS 11639 (Part-3). Expansion joints are installed in exposed penstocks between fixed point or anchors to permit longitudinal expansion, or contraction. When changes in temperature occur and to permit slight rotation when conduits pass through two structures where differential settlement or deflection is anticipated. The expansion joints are located in between two anchor blocks generally downstream of uphill anchor block. This facilitates easy erection ofpipes on steep slopes.

Expansion joints should have sufficient strength and water tightness and should be constructed so as to satisfactorily perform their function against longitudinal expansion and contraction. The range of variations to be used for calculation of expanded or contracted length of penstocks should be determined keeping in consideration the maximum and minimum temperature of the erection sites.

Depending upon the internal pressure, diameter of pipe and magnitude of movement expected, Sleeve type expansion joint are proposed for Surface penstocks:

21.2.5.3. AIR PIPE AND AIR VALVE

These shall be designed considering the clauses in IS 11639 (Part-3). These are provided on the immediate downstream side of the control gate or valve to facilitate connection with the atmosphere. Air inlets serve the purpose of admitting air into the pipes when the control gate or valve is closed and the penstock is drained, thus avoiding collapse of the pipe due to vacuum excessive negative pressure. Similarly, whenthe penstock is being filled up, these vents allow proper escape of air from the pipes.

The factors governing the size of the vents are length, diameter, thickness, head of water,

and discharge in the penstock and strength of the penstock under external pressure.

Size of the air vent may be determined by the following formula:

$$F = \frac{Q\sqrt{S}}{750\ 000\ C}\left(\frac{d}{t}\right)^{3/2}$$

where

F = area of air inlet in m^2,

Q = flow of air through inlet in m^3/s,

S = factor of safety against collapse of pipe,

C = co-efficient of discharge through airvent (generally 0.6),

d = diameter of steel pipe in mm, and

t = thickness of steel pipe in mm.

Air valves are subject to great impact during closing or opening. Therefore, their construction should be capable of withstanding such impact.

The minimum sectional area of the air valve may be determined by the following equation

$$A = \frac{Q}{C\sqrt{2g\frac{\Delta_P}{\lambda_a}}}$$

where

A = maximum flow sectional area in m^2,

Q = maximum water flow in pipe in m^3/s,

P = difference between allowance pressure in t/m^3,

a = air density in t/m^3 (generally 0.001 226 t/m^3),

g = acceleration due to gravity in m/s^2, and

C = flow co-efficient (generally 0.6).

In order to avoid risk in the event of failure of air valves, it is desirable to provide two or more redudant air valves, so that minor malfunction of air valve will not cause serious damage.

21.2.5.4. PIEZOMETRIC CONNECTIONS

Piezometric connections shall be designed considering the clauses in IS 11639 (Part-3). Piezometric connections are provided in the penstock pipes to facilitate connections to pressure gauges located in the control room. Normally these piezometric connections are provided in the straight length of penstock away from bends. They are provided in groups of four, equally spaced around the periphery of the pipe section. From each group of these connections the piezometric line is connected to a pressure gauge.

21.2.5.5. DRAINAGE CONNECTIONS

Drainage connections shall be designed considering the clauses in IS 11639 (Part-3). Drainage connections are required to be provided for draining of the penstock whenever the penstock is to be inspected for maintenance and repairs. Drainage nozzles are located at the bottom most reach of the penstock at the lowest point of the pipe with proper grating, flush with the inner surface of the pipe.

A longitudinal joint means an axial joint subjected to circumferential forces.A circumferential joint means a joint in a circular direction subjected to axial forces. Penstock should be designed to resist the total head consisting of static and water hammer heads. Working stresses which will assure safety under all expected operating conditions should be used. However, stresses approaching the yield point may be used in designing for emergency conditions. The plate thickness should be proportional on the basis of an allowable equivalent stress, which varies with the type of steel used.

The hoop tension (σ) In a thin shell pipe, due to Internal pressure is expressed as:

$\sigma = D*p / 2*t*e$

Where,

σ =hoop tensile stress (i.e. circumferential stress) developed in steel liner due to internal pressure (p) in N/m^2

p - internal pressure (static head + dynamic head) In N/m^2

D - internal diameter of penstock shell in m

t - thickness of penstock shell in m

e - weld joint efficiency

With pressure determined, the steel plate thickness is

$$t= \frac{D * p}{2 * \sigma * e}$$

σ = allowable stress, for design consideration.

Regardless of pressure, a minimum plate thickness is recommended for all large steel pipes (D >2.5 m) to provide the rigidity required during fabrication and handling (transportation/ installation). For penstocks the desired minimum thickness (in mm) for diameter D, may be computed from the formula.

$$tmin = \frac{D+500}{400}$$

Note: This is a minimum shell thickness when a penstock has no circumferential stiffener and also excluding corrosion allowance of 1.5 mm. A thinner shell may in some cases be used if the penstock is provided with adequate stiffeners to pr event deformation during fabrication, handling, and installation.

Joint efficiencies for arc-welded pipe depend on the type of weld joint and the degree of examination of the longitudinal and circumferential joints. The ASME code stipulates a maximum allowable joint efficiency of 100% for double welded butt joints

Specifications issued by the Bureau of Reclamation for construction of penstocks usually require that they be welded by a rigidly controlled procedure using automatic welding machines, that the longitudinal and circumferential joints be rad iographed, and that either the individual pipes sections or the entire installation be tested hydrostatically,

Since the head varies along the profile of a penstock in accordance with its elevation and pressure wave diagram, it is customary to plot the heads and stresses. The total head at each point along the profile can then be scaled off and the plate thickness computed accordingly.

21.2.6. Bends & Reducer

Changes in direction of flow are accomplished by curved sections commonly called bends. Plate steel bends are made up of short segments of pipe with mitered ends (miter -a corner joint formed by cutting bevels of equal angles at the ends of each piece of material). To conserve as much of the available head as possible, bends for penstocks should be made with large radii and small deflections between successive segments. The general practice is to provide the radius of bend 3 to 5 times the pipe diameter (D) and deflection angle of 5° to 10° between segments. The most recommended value of successive deflection angle is however 5° to 6°.

Consider the total deflection angle is θ

Recommended deflection of successive segment = $\Delta\theta$ = 5° to 10° Total segments=

$\theta / \Delta\theta = n$

When the change of alignment is only in vertical plane, the bend is called "simple bend" and the deflection angle is the deviation in the direction of alignment. Sometimes the penstock alignment will be deflected both in horizontal and vertical plane to align with the contour. This is called “compound bend" and it is required to determine true or developed bend angle. Bends may be designed with a constant diameter or with a different diameter at each end.

A reducer is the component in a pipe line that reduces t he pipe size from a larger (D1) to a smaller inner diameter (D2). This reducer piece is a frustum of a cone. Normally the angle of divergence shall be kept between 5° to 10° so as to minimize the hydraulic loss at the junction where the diameter is reduced.

Consider the angle of convergence is θ.

Change in radius= D1/2 - D2/2 =AB Length of reducer pipe L

$$L = \frac{D_1 - D_2}{2 * \tan 6}$$

21.2.7. Penstock Accessories

Besides the main components of the penstock system, several accessories will also have to be provided for in a pipe line to facilitate fabrication, installation, testing, safe operation, and inspection and maintenance. Among the penstock accessories which should be given consideration in design are the following for installation and testing:

a) Temporary supports are generally required for penstocks embedded in dams or tunnels. They should be designed to carry only the empty pipe and to anchor the pipe to prevent flotation during placement of concrete. These supports remain in place and are concreted in with the pipe.

b) Standard dished test heads are used in hydrostatic pressure tests of the installed penstocks.

c) Closing pipes or make-up pieces for final field adjustments to obtain perfect assembly of the pipe line system.

Proper maintenance of penstocks requires the following accessories:

a) Air inlets located downstream of gate admit air into the penstocks and prevent negative pressures during draining and admit air during emergency gate closure. In addition, air pipes or air valves should be installed at summits in the penstocks to release air during filling and admit air during draining.

b) Drains at the upstream and downstream ends of penstock to handle any water leaking past the gate.

c) Manholes for inspection and maintenance work shall be located to facilitate ventilation and entry of men and materials during inspection and maintenance work.

d) The reinforcement of all openings in a penstock such as manholes, connections for drains, filling lines, and air vents shall be designed with the ASME code.

e) Gate and valve is provided to control the flow into the penstock for operations inspection and repairs.

21.2.8. Materials

21.2.8.1. GENERAL

The steel plates to be used for fabrication of penstock shall be of pressure vessel quality. Low carbon steels are considered to be most satisfactory because of their favourable fabrication and welding characteristics and their high ductility. The steel plate with high yield point stress is developed to provide economy and facility of fabrication. These are low alloy steel plates. The properties of steels are governed by their chemical composition, by the process used to transform the base metal into the shape, and by their heat treatment.

Steel plate is manufactured to two standards, i.e. for structural use and for pressure vessels. The physical and chemical properties of steel produced to these two standards can be very similar, particularly when "supplement requirements• are specified. They differ, however, in the amount of testing required to assure uniform quality. The individual ASTM standards for plates give the design engineer a wide range of properties from which to select the economical material for a particular application.

Structural steel (A-6) is suitable for ring girders, stiffener rings, thrust rings, lugs, and support systems and for the pipe shell in many of the less critical penstocks where design stress does not exceed 145 MPa (21000 psi).

Pressure vessel quality plates (A-20) are normally used in the fabrication of the pipe shell for higher pressure, large diameter penstocks. They may also be used for crotch plates, ring girders or other structural parts if desired.

For selection of suitable type of steel, apart from chemical and physical properties of steel plates, its commercial availability and combined costs of material, fabrication, transportation, erection, shop and field tests shall be known. A number of low alloy steels suitable for pressure vessel construction are available and approved by the code. Some of the steels commonly used in the manufacture of welded steel penstocks are:

Steel shall conform to the latest edition and revision of the American Society of Testing and Materials (ASTM) and Indian Standards (IS) with the following minimum certified mechanical characteristics:

IS 2002 (Grade 2)

- Minimum Tensile strength TS = 410 MPa

- Minimum Yield Strength Fy = 250 MPa

ASTM A 285 Grade C

- Minimum Tensile strength TS = 410 MPa

- Minimum Yield Strength Fy = 250 Mpa

Other Requirements

Steel Plates for penstock fabrication material shall confirm to IS 2002 or ASTM A – 285 Grade C. Saddle Plate Material shall confirm to IS 2062.

All materials used for the fabrication of the equipment shall be new. Before starting fabrication, Contractor shall submit to Employer for their approval, mill test certificates for all type of steel to be used in the fabrication.

All materials for the equipment shall conform to the Standards specified in this Specification or to similar standards proposed by Contractor and approved by Employer.

Employer's approval of materials proposed by Contractor for the fabrication of the penstock, in no way relieves Contractor from the obligation to satisfy all requirements of this Specification and does not preclude subsequent rejection byEmployer of materials judged defective. This requirement shall also apply to the approval of welding procedures.

The contractor shall submit to Employer, all mill test certificates for the material supplied. A mill test certificate shall be submitted for each different mill heat, which shall be positively correlated to the steel plates to be supplied. If the contractor fails to produce such certificates, or if correlation between the certificates and the steel plates to be supplied is in doubt according to Employer, the contractor shall have similar test made, at its own expense, in a laboratory approved by Employer. In this case, the tests shall conform to supplementary requirement of S2 of Standard ASTM A20M. All ultrasonic tests, physical, chemical and metallurgical tests shall be conducted by a third party inspection agency to be approved by Employer.

Ultrasonic Examination: 100% Ultrasonic examination shall be carried out as per supplementary requirements S12 of Standard ASTM A 20 M. Acceptance standards corresponding to level I as specified in the standard specification A-578/A578-M shall apply for the purposes of Ultrasonic examination.

21.2.8.2. INDIAN STANDARDS

The following Indian Standards shall be applicable for penstock designs fabrication and installation:

- IS 2002 – IS Steel Plates for Pressure Vessels for Intermediate and High temperature Service Including Boilers – Specification
- IS 2062 – IS Steel for General Structural Purposes – Specification
- IS:2825 – IS code for unfired pressure vessels
- IS:11625 – IS criteria for Hydraulic design of Penstock.
- IS:11639 – IS criteria for structural design of penstocks – Part 1 – Surface penstocks
- IS:11639 – IS criteria for structural design of penstocks – Part 2 – Burried penstocks
- IS:11639 – IS criteria for structural design of penstocks – Part 3 – Specials for penstocks
- IS:14209 – Epoxy Enamel, two component, glossary
- IS:14506 – Epoxy red-oxide Zinc Phosphate Weldable Primer, two component.

And other relevent standards of the BUREAU OF INDIAN STANDARDS and American Society for Testing and Materials (ASTM). Any substitute for the materials specified herein, shall be proven, by tests made at Contractor's expense and to Employer's satisfaction, to have characteristics identical or superior to those of standardized materials.

21.2.8.3. ASTM SPECIFICATION

A285 - popular, moderate strength steel for stationary service vessels and boilers;

Note: Plates subjected to ultrasonic examination ensures the absence of any serious internal defects in the plates, hence recommended.

21.2.9. Fabrication

Penstocks may be fabricated in the manufacturer's shops or in a field fabrication plant, depending on the size of the pipe. Fabrication of penstocks requires a variety of special machines and equipment, such as rolls, presses, flame-cutting tolls, welding machines, testing, radiographic, and handling equipment. Steel mills publish information concerning the availability of sheared plates of various thicknesses, widths, and lengths and the sections of plates conforming to mill limitations will provide an economic advantage. Fabrication includes cutting the plates to exact dimensions, preparing the edges for welding, pressing and rolling the plates to the required radius, and welding the plates together. The type of edge preparation required depends on the welding procedure to be used. Shop joints are usually welded with semi automatic or automatic welding machines, while field joints are manually welded. In shop welding, after the plates have been rolled, they are tack-welded into pipe courses and then welded by automatic machines. With the submerged arc- welding process, the joints are either machine welded on either side, and the opposite side welded manually, or arc welded by one pass of the machine on both side and outside. If multi-pass machine is used, the weld metal Is deposited in successive layers, the number of layers depending on the thickness of the plates being welded. In the installation of a penstock in a tunnel, there may not be sufficient clearance between penstock and tunnel walls to back-weld field girth joints from the outside. In such cases, it will be necessary to complete the weld from the inside using an outside backing strip.

Stiffener rings may be formed from bars or flame-cut from plates. The segments so produced are butt-welded into full rings, then welded to the pipe with fillet welds either manually or by machine.

Special rounding-out spiders are often used to aid fit-up and welding work and to prevent distortions in the pipe. Makeup sections with excess laying lengths are provided for long tangents to provide for discrepancies in length between anchors. They are also useful between penstocks and turbines or control valves for the same purpose.

21.2.10. Non-destructive Inspection of Welds

After completion, butt-welded joints are usually radiographed to detect defects in the welds. The same standards of inspection are applied to longitudinal and circumferential joints. Weld defects may consist of slag inclusions, cracks, gas pockets, porosity, incomplete fusion, and undercutting. Cracks, incomplete fusion, and undercuts are not acceptable but a certain amount of porosity, slag inclusions, and cavities may be acceptable if their size and distribution is such as not to impair the strength of the weld. Criteria for judging and acceptability of defects are given in the ASME code. Unacceptable defects are removed by chipping, machining, or flame gouging. After a defective area has been re-welded the repair is re-radiographed to check its quality. Radiographic inspection always precedes post weld heat treatment and hydrostatic testing.

The inspection may be performed by using either X-ray or gamma rays. The most frequently used radioactive isotopes are iridium 192 and cobalt 60. The practical thickness range of steel for iridium 192 and cobalt 60. The practical thickness range of steel for iridium is from 10 to 60 mm and for cobalt from 50 to 150mm. Equipment for radiographic inspection is usually portable. Radium and radioactive isotopes are contained in metal capsules, which are stored and transported in portable lead containers. Proper care must be taken to protect personnel from the dangerous effects of X-rays and gamma rays.

Films 4.5-inch x 17 inches in size is generally used which permit a 15 inch length of effective exposure, assuming an overlap of 1 inch at each end. All films should be marked with identification numbers in accordance with a marking diagram of the penstock so that defects appearing on the radiographs may be accurately located. A complete set of radiographs for each job should be retained and kept on file for a period of 5 years.

For welds that cannot be satisfactorily inspected by radiography, other non-destructive methods of inspection can be used. Methods available are: magnetic particle inspection, ultrasonic inspection, and various methods using dye penetrants. Of these, magnetic particle inspection will only disclose defects close to or extending to the surface. The fillet joints are subjected to magnetic particle testing. The ultrasonic method requires considerable experience on the part of the inspector but it is suitable for detecting internal defects. Dye penetrants are suitable only for locating surface discontinuities.

21.2.11. Installation & Hydrostatic test

Upon delivery of penstock sections at the specified delivery point, they are usually transported to the place of installation by truck or trailer and lifted in place by cableway, or mobile crane. For installations in tunnels, special handling equipment consisting of trolleys and hoists is required. The installation work becomes complicated by limited clearances and ventilation requirements. As has been stated, the length and weight of penstock sections are often dependent on the capacity of the transportation and handling equipment available.

After being set to line and grade on temporary supports, several pipe sections are first tack- welded together, and then the joints are completed. If the specification requires radiographic inspection, portable X-ray machines are used. Penstock sections which are to be installed in tunnels are placed in position on temporary structural steel supports and welded into the line. Supports are anchored to the concrete to prevent displacement or flotation of the pipe during concrete placement. When penstocks are installed in tunnels excavated through unstable rock, the space around the penstock should be backfilled with concrete.

A proof hydrostatic test on the penstock after installation is most desirable. Hydrostatic tests should be performed at a pressure sufficient to prove the adequacy of all plates and welds with the required margin of safety. The following formula as per IS 2825 may be used to determine the test pressure to be applied.

$P = 3 * \sigma * t / D$

P = test pressure in N/mm2

t = minimum thickness of penstock (excluding corrosion allowance) in mm

D = internal diameter of penstock in mm

σ = allowable hoop stress in N/mm2

The test pressure so determined will produce in the pipe a hoop stress approximately 1.5 times the allowable stress. The pressure should be applied 3 times, being increased and decreased slowly at a uniform rate. The test pressure should be held for a length of time sufficient for inspection of all plates, joints, and connections to detect leaks or signs of failure. The penstock should be vented at high points during filling to prevent the formation of air pockets. Objectionable defects disclosed during the pressure test should be repaired by welding, the section radiographed again, and retested.

21.2.12. Particular Technical Specifications

The particular technical specifications for fabrication and installation of penstocks shall be provided for the requirements as discussed in the above paragraphs. Specifications should be accompanied by drawings showing the general layout of the penstocks with sufficient design details to enable bidders to prepare estimates and shop drawings. In addition, the specifications should include fabrication, material, test, and erection requirements, and other essential information.

21.2.13. Welding Control & Weld Test

To insure compliance with specifications, it is necessary that all welding operations in shop and field be subjected to rigid inspection by qualified welding inspectors. Before commencement of welding, qualification of welding procedures and operator's performance is usually required in accordance with applicable codes. For penstocks the Bureau stipulates qualification tests required by ASME code. Repetition of tests is mandatory whenever essential variables in materials or procedures are made. The welding test plates and the testing of specimens should be done in the presence of welding inspectors representing the Employer. The test plates are welded in the same manner and with the same technique and electrodes as used in production welding.

A number of different tests are specified in the ASME code for qualification of procedures and welders. For groove welds, tests in direct tension are required in the procedure qualification to measure the tensile strength of the joints. Guided bend tests are used in both procedure and performance qualification tests to check for degree of soundness and ductility. For fillet welds, fracture tests are used to detect cracks, incomplete fusion, slag inclusions and gas pockets. Etch tests are also required for fillet welds and are sometimes used on butt welds to give a clear definition of the structure of the weld.

21.2.14. Corrosion Control

Steel penstocks should be protected against corrosion by coating appropriate to the exposure. Coal-tar enamel, with an estimated service life in excess of 50 years, stands out among current protective coatings with long, well established service records. When suitable, such a material should therefore be specified.

The exterior of burled penstocks may also be protected by coal-tar enamel. The enamel, which protects the metal from corrosive soil constituents, must in turn be protected against soil stresses and backfill damage by a bonded felt wrapping, or by an embedded glass mat reinforcement plus the felt wrapping.

Preparation of surfaces to receive the preceding coatings must remove all contaminations and should provide a somewhat roughened surface. Sandblasting to base metal is the only practical method known to insure this result for coatings to be in immersion or buried exposure.

21.2.15. Design and Drawings

The scope under this contract shall also include submission of the following documents:

a) Hard copies- 2 sets of approved design document and 4 sets of all approved drawings properly bound condition.

b) As Built drawings -2 sets properly bound condition.

c) Soft (PDF) copies-2 sets of approved design & drawings on good quality DVD.

21.3. Design Criteria

21.3.1. Final Liner Design

The design of the steel liner required a balance of many issues:

a) The constructability of the selected alignment,

b) Confinement/stiffness/ load sharing of rock and backfill,

c) Buckling due to external ground water pressure,

d) Handling loads,

e) Corrosion considerations,

f) Design life,

g) Welding issues,

h) Seismic design issues, and

i) System hydraulics including maximum velocity, and static and transient internal hydraulic pressure.

21.3.2. Structural Design Criteria

The structural design of penstock involves determination of various forces and stresses in pipe shell for various operating conditions by the methods generally adopted by penstock designers. These are discussed in the following paragraphs. The working stresses and joint efficiency to be adopted for the design depends upon the type of material used, method of fabrication and testing.

21.3.3. Forces and Stresses in Shell

Penstocks which are laid on Surface supported by saddles and Anchor Blocks, shall be designed to withstand the stresses as mentioned in Clause no 4,5,6 of IS 11639 (Part -I).

Penstocks which are embedded with combination of concrete & compacted soil backfill shall be designed to withstand the stress developed due to full internal water pressure plus water hammer pressure.

Penstocks which are embedded and backfilled with combination of concrete & compacted soil backfill shall be designed to withstand the external pressure due to ground water and grout pressure (if any). The critical buckling pressure (for various R/t ratios) for unstiffened shell may be computed using formulaes given in clause 6.2 of IS 11639 (Part 2):1995.

21.3.4. Operating Condition

As per IS 11639- Part -I&Part -II& Part -III, the Following operating Conditions shall be considered.

a) Normal operating conditions

The design criteria for dynamic pressure rise or drop due to water hammer under normal operating condition shall be due to full load rejection or acceptance.

b) Intermittent operating condition

Intermittent condition includes those during filling and draining of penstocks and maximum surge in combination with pressure rise during normal operation.

c) Emergency operating condition

For emergency condition of operation, the dynamic pressure rise is due to sudden load rejection.

21.3.5. Calculation of stresses in a pipe shell

21.3.5.1. EMBEDDED PENSTOCK

i) Hoop stress due to internal pressure

The hoop stress developed due to internal pressure is given by

$\sigma = D*p / 2*t*e$

ii) For embedded penstock, the design pressure shall be equal to internal pressure 'p' due to static and dynamic head.

iii) Stress due to restraint

Pipe shells which are provided with stiffener rings are restrained due to relative radial deformation between the shell and stiffener under internal pressure, the secondary bending stress due to restraint is given by

$$f = \frac{1.82*(Ar-bt)}{A_r+1.56*t*\sqrt{rt}} * \frac{p+R}{t}$$

Where

Ar	-	area of stiffener ring
B	-	Width of the stiffener ring
t	-	thickness of pipe shell
R	-	radius of pipe shell
P	-	internal pressure

This stress is local, and the effect shall be taken for a distance of 3/q where 'q'=1.285/ SQRT (rt) on either side of ring and pipe thickness shall be increased if required in this zone.

iv) Critical external pressure for unstiffened steel liner

Buckling stresses are caused in embedded steel pipe due to ground water and grouting pressure, on the assumption that there would be a radial gap between steel and surrounding concrete, the critical stress in the liner is given by the solution of the following equations:

E. Amustuz's Analysis (EM 1110-2-2901 May 1997)

$$\left(\frac{f_N}{E'}+\frac{Yo}{R}\right)\left(1+\frac{3K^2 f_N}{E'}\right)^{3/2} = 1.68K\left(\frac{f'_y-f_N}{E'}\right)x\left[1-\frac{K}{4}x\left(\frac{f'_y-f_N}{E'}\right)\right]$$

$$1-\frac{P_{cr}K}{2f_N} = 0.175\frac{K}{E'}x(f'_y-f_N)$$

A value of 3 x 10 - 4 for inttial gap (Yo/R) is recommended.

The thickness of steel liner calculated based on internal pressure is checked for critical buckling stresses with a load factor of 1.5.

v) Check for external pressure for stiffened steel line

If it is not safe, either the thickness can be increased or alternatively, external stiffeners can be provided. The stiffener rings provided at the spacing of L shall have a moment of inertia given by the following formula to resist the external pressure,

$$I = \frac{0.5 * P * R^3 * L}{E_s}$$

Where

I	-minimum moment of inertia of stiffener ring (in cm4)
P	-external pressure (corresponding to FRL with pressure shaft empty) (in kg/cm^2) R -distance of centroid of the stiffener ring from CL of penstock (in cm)
L	-spacing of stiffener rings (in cm)
E	-modulus of elasticity of steel (in kg/cm2)

The section is checked from strength consideration as given in USBR manual. Minimum required area Ac= 1.5PLR/Fy

Where

Ac – area of combined ring and part of shall acting with the right (in cm2)

Fy – Yield stress of material

21.3.5.2. SURFACE STEEL PRESSURE CONDUIT (SURFACE PENSTOCK)

Stresses in Penstock Shell

As per Clause 6 of IS: 11639 (Part-1), the following stresses are considered in the design of Surface Penstocks.

i. Hoop (Circumferential) stress due to internal water pressure:

Under working condition, the steel liner is subjected to circumferential stresses due to internal water pressure corresponding to the sum of static head due to full supply level at Dam Reservoir plus the dynamic pressure rise due to water hammer.

$$S = \frac{Pr}{t}$$

Where

S = Hoop Stress in Pipe

P = Internal Water Pressure (Static Head + Dynamic Head)

r = Radius of pipe shell, m3

t = Thichickness

ii. Longitudinal Stress due to Beam Action

The stress developed due to self weight and weight of water pipe spanning over supports (between saddles) due to beam action is calculated by the following formula:

$$f = \frac{M}{Z}$$

Where,

f = Bending Stress

M = Bending moment caused due to self-weight and weight of water

Z = Section modulus of pipe shell, m^3

iii. Longitudinal Stress developed due to radial strain caused by internal pressure adopted as 0.303 times of the hoop tension

iv. Longitudinal Stress developed due to seismic forces in the pipe spanning over the support due to beam action.

v. Longitudinal Stress developed due to temperature variation:

vi. Longitudinal stress developed due to wind or snow load actiong on the pipe spanning over the support.

vii. Longitudinal stress due to sliding friction

viii. Longitudinal stresses developed due to expansion or contraction of pipe shell and is calculated by the following formula.

Pipe shell with expansion joint, = $\mu_1 P A_C / A$

where,

μ_1 = Coefficient of friction between packing material and pipe shell, and

P = Internal pressure due to static head + dynamic head

A_C = Contact area between shell and packing material

A = Cross sectional area of pipe shell material

ix. Circumferential bending stress at supports:
Circumferential stresses at supports due to bending caused by internal pressure is calculated by the following formula:
$M = C\ P_1 r$
where,

M	=	Moment,
C	=	A value for different angles of support,
P1	=	Total reaction of support, and
r	=	radius of the shell

x. Longitudinal bending stress due to restraint by ring girders or stiffener rings at the supports:

As per CWC manual on “Design fabrication erection and maintenance of steel” ring girders are not required for the penstock of diameter less than 2.5m. Therefore, this stress is not considered in the design.

Stress may be +ve (tensile) or -ve (compressive) due to expansion and contraction, +ve value is considered to get maximum value of equivalent Stress.

xi. Equivalent stress:

The steel liner is designed to withstand longitudinal and circumferential stresses. Equivalent stress is then calculated as per IS: 11639 Part-I.

$$S_e = \sqrt{S_x^2 + S_y^2 \pm S_x S_y}$$

$$S_x, S_y = \frac{f_x + f_y}{2} \pm \sqrt{\frac{(f_x - f_y)^2}{2} + q^2}$$

Where,

S_e = Equivalent Stress

S_x S_y = Principal Stress

fy = Total of circumferential stress

fx = Total of longitudinal Stress

q = Shear Stress

Water Hammer Pressure

Water hammer is calculated using the computer program ‘WHAMO’ (Water Hammer and Mass Oscillation), developed by US army Corps of Engineers or any commercially acceptable software like Hammer, Hytran or approved by Employer. Increase in pressure head due to water hammer effect is calculated.

21.3.5.3. DESIGN OF ANCHOR BLOCK

Anchor blocks represent the fixed supports of the penstock and are located at either vertical or horizontal bends in the length. Where the distance between any two bends exceeds 150m, intermediate anchors are also provided. The design of anchors shall be carried out as per the clauses mentioned in IS 5330 and shall be designed to withstand the following loads and forces:

i) prevent the penstock sliding down the hill,

ii) control the direction of expansion,

iii) resist the unbalanced hydrostatic forces at a change of direction of the penstock length, and

iv) prevent movement of the penstock on account of vibration or water hammer pressures within permissible limits.

21.3.5.4. DESIGN LOADS

The following loads are considered in the design of anchors:

- Hydrostatic force acting along axis of penstock on each side bend
- Dynamic force acting against out-side of bend
- Force due to dead weight of penstock from anchor uphill to expansion joint, tending to slide downhill over pier
- Force due to dead weight of penstock from anchor downhill to expansion joint, tending to slide downhill over pier
- sliding friction of penstock on piers due to expansion or contraction uphill from anchor
- sliding friction of penstock on piers due to expansion or contraction downhill from anchor
- sliding friction of uphill expansion joint
- sliding friction of downhill expansion joint
- Hydrostatic pressure on exposed end of pipe in uphill expansion joint
- Hydrostatic pressure on exposed end of pipe in downhill expansion joint

In addition, inertia forces due to earthquake have also been considered in the design

The loads and forces mentioned above for the design are considered for both expansion and contraction conditions.

21.3.5.5. DESIGN CRITERIA

- Maximum pressure developed on the anchor block foundation is limited to allowable bearing pressure, or foundation on soil and rock. Permissible bearing capacity is increased upto 50% more for seismic conditions.
- Anchor blocks are designed safe against sliding on foundations. The sliding friction factor is computed by dividing the total horizontal forces by total vertical forces and is within the permissible limit.
- Anchor blocks are designed such a way that the resultant of all the forces falls within the kern of the base.
- Under seismic conditions, tension is being permitted as per the ISCode 5330.

Anchor blocks shall be checked for the above said loads and forces and shall be stable against all de-stabilizing forces. Sliding factors and bearing pressures should be within permissible limits.

21.3.5.6. DESIGN OF SADDLE SUPPORTS

The exposed or above grade penstock is usually supported by either concrete saddles or ring girders. Concrete anchor blocks support the steel penstock pipe line at points of horizontal and vertical bends. When it is installed on concrete piers placed relatively close together, the top of the pier is formed into a saddle support whose contact angle generally is 120 degrees. It has a rubberised polyster fabric pad or a steel plate placed between pipe and concrete surface of the saddle or one plate embedded with saddle and one plate welded with penstock and inbetween steel strips with opening for grease for removing friction between these two plates when span increase, ring girders or support rings are provided to prevent excess deflection of the pipe cross section over the pier.

The piers are designed for vertical reactions at support, longitudinal forces resulting from frictional resistance due to longitudinal strain and temperature movements, and lateral forces caused by earth quakes.

21.3.6. Allowable Stresses

In case of structural steel, it is logical to take the yield as the basis for calculating the working stress because here a considerable permanent set may occur, which is not permissible in engineering structures. For brittle materials such as cast iron, concrete, the ultimate strength is usually taken as a basis for determining the working stress. The magnitude of the factor of safety depends very much upon the accuracy with which the external forces acting upon a structure are known. Knowing the limits of proportionality, the yield point and the ultimate strength of the material, it is possible to establish for each particular engineering problem the magnitude of the stress which may considered as a safe working stress. In order to eliminate difficulty one takes usually the yield point of the material, as a basis for determining the magnitude of working stress. Denoting by and respectively the working stress and yield point stress of the material, the magnitude of the working stress will be determined by the following equation:

$$\sigma_w = \frac{\sigma_{yp}}{n}$$

Here 'n' is called factor of safety.

The use of a factor of safety does not imply that an item, structure, or design is safe. Many quality assurance, engineering design, manufacturing, installation, and end- use factors may influence whether or not something is safe in any particular situation.

For the Traditional design, normal operating condition is defined as the maximum static head plus the water hammer and surge for a plant load rejection when all units are operating with normal governor closure time. Intermittent condition is defined as condition during filling and draining and earthquake during normal operation.

21.3.6.1. DESIGN STRESSES FOR INTERNAL & EXTERNAL PRESSURE

21.3.6.2. INTERNAL PRESSURE

i.Normal condition

It is recommended that under normal operating condition, the design stress is no case shall exceed minimum of 0.333 times ultimate tensile stress and 0.666 times the minimum yield point stress of the specified steel.

ii.Intermittent condition

Stresses caused during filing and draining, or earthquake shall not exceed 0.66 yp or 40% of UTS, whichever is less.

iii. Emergency condition

Stresses caused during dynamic pressure rise due to sudden load rejection (partial turbine gate closure, cushioning stroke inoperative in one unit) shall not exceed 0.9 yp or 2/3 UTS, whichever is less.

iv. Exceptional condition

Stresses developed due to malfunctioning of control equipment in the most adverse manner in odd situation shall not exceed minimum yield point stress of steel.

21.3.6.3. EXTERNAL PRESSURE

Whenever a penstock is embedded, shall be designed to resist external water pressure head (either the difference between the ground water level vertically above the penstock and the profile center line or the maximum level from which the water is likely to find its way around steel lining, whichever is less), it is recommended not to exceed 2/3 times the critical external pressure calculated according to Amstutz's formulae.

If the maximum external pressure exceeds 2/3 times critical external pressure for unstiffened shell, stiffeners shall be provided to prevent buckling.

Longitudinal stresses caused by radial stress

Radial expansion of pipe shell due to internal pressure tends to cause longitudinal contraction with corresponding tensile stress equal to 0.3 times the hoop tension in the circular lining.

21.3.7. Joint Efficiency

All the penstock welded joints shall be radiographically or ultrasonically tested. Depending on type of examination the following joint efficiency shall be adopted over and above the allowable stresses.

Table 21.3-1 : Joint Efficiency

Sl. No.	Type of joint	Fully radiographed	Spot radiographed
1	Double welded butt joint with single V & without backing strip	1	0.85
2	Double welded butt joint with double V	1	0.85
3	Single welded butt joint with backing strip (butt weld with plate offset for circumferential joints)	0.90	0.80

21.3.8. Change in Shell Thickness

The difference in adjoining shell thickness should not be more than 3 mm. If two plates having more than 3 mm difference in thickness are butt-welded, thicker plate shall be tapered off to thickness of thinner plate with less than a quarter slope and then welded. For a steel penstock, the internal surface should be fit smoothly with each other with one-side taper because water flows in the pipes.

21.3.9. Backfill Concrete

In embedded penstocks(trenches), the backfill concrete lining around the penstock and the rock supports, if required, should be designed according to provisions of IS 4880 (Part 4 & Part 5).

21.3.10. Design Loads

21.3.10.1. EMBEDDED PENSTOCK

Steel liners are often are required to prevent the migration of water leakage due to unfavourable geologic conditions in the surrounding rock/soil mass. When a steel liner is installed in a trench, it must be analyzed to determine that it can resist internal operating pressures as well as resisting buckling from external water pressures when the tunnel is dewatered infrequently for inspection and maintenance. The following shall be considered for analysis and design of steel liners:

a) Internal pressure

b) External pressure (steel tunnel liners without stiffeners)

c) External pressure (shell between stiffeners when stiffeners are used)

d) External pressure (stiffener and contributing contiguous portion of shell)

21.3.10.2. DESIGN OF STEEL LINERS FOR INTERNAL PRESSURE

Steel liner shall be designed for internal water pressure corresponding to static head in combination with transient water hammer pressure as applicable at turbine main inlet valve.

21.3.10.3. DESIGN OF STEEL LINERS FOR EXTERNAL PRESSURE

Experience has shown that buckling occurs in a single lobe. Both E. Amstutz and S. Jacobsen developed their analysis in a very similar manner based on the theory that a single lobe is formed. The critical external pressure for an unstiffened shell is determined considering a gap between the shell and the concrete backfill surround due to concrete shrinkage and a temperature difference. The gap can realistically vary from 0 to 0.001 times the radius of shell.

The radial temperature gap results from concrete shrinkage plus the temperature differences between the temperature reached by materials during construction including the effects of the temperature rise during hydration of cement and the rise in ambient temperatures due to forced ventilation into the tunnel using warmer air over a long period during construction. The steel liner is the form for the concrete backfill. Under certain conditions the steel liner might reach temperatures near 80° F when the concrete sets, due to a combination of ambient air temperature and hydration effects. If the tunnel is later dewatered during winter when the water temperature is 34° F, a maximum 46° F temperature difference could exist for a short duration. A 46° F temperature difference produces a gap equal to 0.0003 x R.

Permissible tolerances during fabrication and erection allow an out of roundness creating an elliptical shape with a 1% difference between the measured maximum and minimm diameters. This difference should not be considered in arriving at the critical radial design gap. The development of a lobe in an unstiffened liner usually involves a sector of the shell subtended by an angle less than 80 degrees. The indented lobe would be expected to develop at the weakest point, which would be the flattest curvature produced by the ellipticity of the penstock shell.

During concrete placement, the concrete backfill is introduced behind the steel liner from a steel pumpline at the top of the tunnel. The concrete flows down around the steel liner. Due to a combination of frictional drag along the lower external surface of the liner, poor venting, and settlement occuring during consolidation, a void can be created under the bottom invert of the steel liner. This void can subtend an angle of approximately 40 to 60 degrees (0.70 to 1.05 radians). The void is usually shallow and very little grout is needed to fill it. When correctly executed, contact grouting between the steel liner and the concrete backfill eliminates these voids. The determination of the critical radial gap can assume that contact grouting has been properly executed when careful inspection and quality control has been exercised during construction. Therefore, temperature and shrinkage effects alone should govern the selection of an appropriate radial gap for purposes of analysis and design.

21.3.10.4. SURFACE PENSTOCK

As per the IS 11639 (Part – I), the following shall be considered for analysis and design of steel liners:

i. Internal pressure
ii. Self Weight and Water Weight of pipe
iii. Seismic forces
iv. Snow or Wind Load
v. Temperature Load

21.4. Fabrication

The fabrication of penstocks involves straight pipe shells, miter bends, reducer piece, stiffener/seepage rings, thrust collars, etc. The fabrication procedure of these items depends upon the available facilities at workshop. The fabricator shall adopt suitable welding process and electrodes for the specified steel. In order to obtain quality as laid down in the specification, the fabricator shall take care that they are complied with by proper inspection,

21.4.1. General

The pocess of fabrication involves visual inspection of steel plates, verification of quality of steel with mill certificate (ultasonically checked for laminations, heat number, size}, marking, cutting & bevelling using straight line PUG machine, rolling using three roll double pinch plate bending machine (hydraulic type), welding and testing & inspection of welds.

21.4.2. Cutting & Edge preparation

The size of the plate shall be determined by multiplying internal diameter plus thickness by ‘π’ (pi). Consider pre-pinching allowance for higher thickness steel plates. The plate length as far as possible shall be close to the required size. However, if more than one plate is required for the shell, the minimum number of plates shall be used. The cutting of plates shall be planned in such a way so as to minimize the wastage of steel plates.

The plates are laid out and trimmed to true rectangular shape and check for equal diagonal distances. Cutting and bevelling are generally prepared by flame cutting. Further heat input in case of flame cutting shall need to be controlled as per the recommendations of the steel manufacturer so as not to affect basic properties and strength of quenched and tempered steel.

Plate edges shall be made in conformity with the specification drawings to suit 'V' or 'U' welds as applicable to various thicknesses for all longitudinal and circumferential welds in shop. Edge preparation for all circumferential joints in field shall be to suit single V or 'U' joint with backing strip. The following broad guidelines shall be adopted for edge preparation of plates:

Marking shall be made using suitable ruler and template etc. Punch and chisel shall not normally be used. However, where the use of punch is unavoidable, punch with blunt point can be used and whenever possible, plate shall be marked on the side which shall be inside the pipe after bending. Edge preparation of steel conforming to above shall preferably be done by planning. In the event of flame cutting followed by chipping and necessary grinding, oxy-acetylene torche may be employed such that basic properties of steel are not affected. In the gas cut edge preparation, 2mm to 4mm of metal shall be removed from gas cut surface by grinding. The bevels which are not satisfactory after flame cutting particularly shall be ground. The shape of bevel depend upon the thickness of plate and type of weld joint.

21.4.3. Rolling

The final edge prepared plates shall be rolled to true curvature by cold bending process in a Pre-pinch cum pyramid type plate bending machine (hydraulic type). Curvature of bent shells shall be checked with the help of template. Correction of curvature neither by blows nor by hot forming shall not be permitted.

The acceptable tolerances for shape and appearance of longitudinal and circumferential joint shall be as per the applicable codes/ specification.

21.4.4. Alignment & Tolerances

Alignment for longitudinal and circumferential joints in shop and circumferential joints in field for shells shall preferably be avoided as far as possible to ensure that no inadvertent damage occurs to parent plate due to welding or removal of cleats later on. The fabricator, therefore, shall be required to develop a mandrill fitted with screwed pipe jacks/hydraulic jacks which shall provide perfect alignment of one circular shell with another as well as control the gap between them without necessitating welding of fit up cleat.

Before any welding is commenced, it shall be ensured that the chamfered edges are in alignment.

Weld preparations whose cross-sectional dimensions vary from those shown on the approved workshop drawings by more than the following tolerances, shall be corrected prior to welding.

a) Root opening of joints ± 1.5mm.

b) Groove angle ±5 degrees.

c) Size and location of root face ±1.Smm.

d) Radius of 'J'/'U' grooves ±2mm.

The maximum offset (or other defect in alignment) between abutting external surfaces at any position along a butt joint shall not exceed 2mm for both the longitudinal joints as well as circumferential joints.

The following limit shall apply to the fit up of joints to be fillet welded and to the fit up of stiffener rings (as well as anti-percolation rings) to pipe shells. Gap at joint -2 mm maximum.

This provision is subject the condition that effective throat thickness of the weld shall be not less than that specified in the approved drawings.

21.5. Welding

Welding of steel penstocks is critical to the success of Water hydroelectric projects and drinking water scheme projects. Application of weldlng codes to penstock installation provides a measure of quality assurance by requiring qualified welders, welding specification, and welding Inspection.

21.5.1. General

Welding is used extensively in both shop and field fabrication of penstocks, and applicable provisions of the welding codes must be used in design and fabrication of penstocks. Welds that connects penstocks sections must be designed to resist forces imposed on them. The full strength of the adjoining steel plate can be attained by using complete joint penetration (CJP) butt joint welds. If lesser strength is acceptable, then the more economical fillet welds are often used. Weld strength values can be determined by applying code recommendations.

Welding materials (such as electrodes, fluxes, and shield gases) used for penstocks must comply with the requirements of the ASME (2010a), ASME(2010b), and applicable welding procedure specification (WPS). Field welding requirements and welder's qualification must be consistent with those for the shop fabrication process.

Weld tests are necessary to confirm the choice of filler material and welding process for defined base material (steel plate) and to make sure that final features of the weld joint have achieved the required standards. Production weld test plate of size 900 mm x 400 mm consisting of two strips, shall be welded edge to edge in longitudinal direction. During production, test plates shall be prepared at regular specified intervals and shall be treated in the same manner. Various tests such as radiographic examination, tensile test, bend test, chemical analysis, diffusible hydrogen test shall be conducted to monitor the soundness and properties of welds on routine basis.

21.5.2. Submissions

Procedure for welding and NDE must be submitted before the start of the work. Copies of the following should be submitted:

- Procedure qualification record (PQR)

- Welding procedure specification (WPS)
- Welder's performance qualification (WPQ)
- Welding sequence, repair procedures, and welding rod control processes.
- Welding procedures must be qualified in accordance with ASME (2010) or AWS (2010).

The PQR document the welding parameters and coordinations that occurred during welding of the test coupon and the results of testing the coupon.

The WPS is a witten document that provides direction to the welder or welding operator for making production welds in accordance with code requirements. The WPS provides the welding parameters ranges within which the welder or welding operator is allowed to operate. The purpose for qualification of WPS is to determine that the weldment proposed for construction is capable of providing the required properties for its intended application. A WPS establishes the intended properties of the weldment, not the skill of the welder or welding operator.

The WPQ establishes the basic criteria to determine the welder's ability to deposit sound weld metal, according to a WPS. The purpose of the performance qualification test for the welding operator is to determine the welding operator's mechanical ability to operate the welding equipment.

21.5.3. Welding Codes

Welding of shells and assemblies classified as pressure parts must be in accordance with ASME (2010a)/ AWS(2010). No production welding can be undertaken until the welding procedures have been qualified or are prequalified by AWS (2010). Only welder's and welding operator's who have been qualified in accordance with ASME (201 Ob) or AWS(2010) can be used in production and installation.

21.5.4. Joint type and Configuration

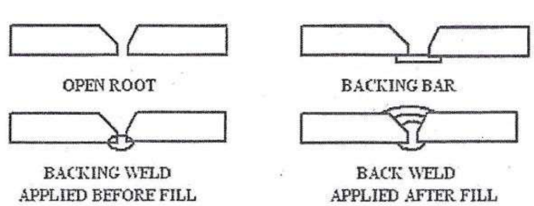
The engineer must evaluate the joint type that meets the project design requirement with consideration to the associated cost impact. There is a wide and varied list of possible joints to fabricate structural shapes. When two pieces of structural steel are to be connected by welding, the way they are prepared for welding and placed together is known as the Weld Joint.

The edge preparations are arranged to make the weld joint. The pieces to be welded may be connected or a gap between the pieces to ensure penetration may be used. On most joints the gap is at the bottom of the joint and is referred to as the root of the joint.

The term root opening or open root is used to describe this condition. For example; Open root V groove, or V groove with an open root.

When the joint design allows, a backing strip or insert may be used for easier welding.

Some joints may have a backing weld, or back weld applied. A back weld is applied after the groove is filled. A backing weld is applied before the groove is filled. See examples below.



A butt joint is formed when the pieces to be welded are laid side by side and it is one of the most widely used types of joint.

The V groove and bevel grooves are easier to prepare and are used more than the J or Ugroves.

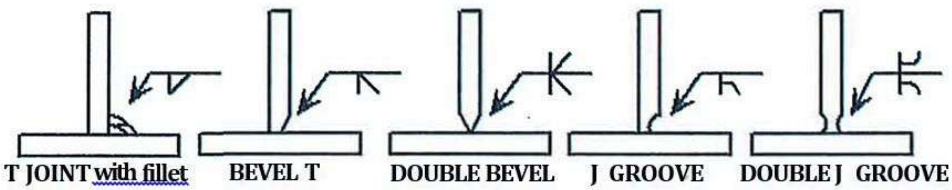
A T joint is formed when one piece of metal to be welded is placed vertically on another piece lying horizontally, to form the shape of an inverted T.

The vertical member is usually placed at 90 deg to the horizontal member.

One of the most widely used types of weld applied to a T joint is the fillet weld. When a single pass or multiple passes are made against the joint, the weld resembles a Triangle when viewed from the side.

The T joint and fillet weld are the most frequently used joint and type of weld.

In the same way the edges of the butt joint may be prepared for welding, the tee joint's vertical piece may be prepared using a Bevel, or J shape. The preparation allows the Welder to penetrate into the root of the joint See examples below:



21.5.5. Welding Processes

Welding of penstock sections is commonly performed using manual shield arc welding (SMAW), semi-automated flux cored arc welding (FCAW) or submerged arc welding (SAW) processes.

In submerged, arc welding, penetration is relatively great and the chemical composition of the deposited metal varies widely with dilution of the base metal. For this reason, mechanical properties of crack sensitivity of the deposit metal are easily affected by the speed of cooling, Therefore, in the selection of wire, fluxes, sufficient consideration shall be given to the type of joint, built up method of preheat temperature, interpass temperature welding heat input etc.

When manually welded, the arc length shall be held as short as possible consistent with maintaining satisfactory operation. Weaving shall be permissible if a steady arc length is maintained. But, the width of the weave shall not exceed three times the diameter of the electrode used in the vertical position and twice the diameter of the electrode used in the down flat position (diameter of core wire). When welding is performed in the vertical position. all beads shall progress from bottom to top, except that the first pass shall be uphill or downhill and the finish or wash beads shall be run from top to bottom using 3.2mm or 4mm dia electrodes using either 2 or 3 stringer beads to cover the uphill passes. The tack welding of jigs shall also be carried out under the same conditions as for regular welding (welding of the main body). The bead length shall be 80mm minimum.

In periods of high wind, the operator and joint shall be protected to prevent the protective gas blanket of the welding arc from being blown away. No welding shall be performed when water is falling/dropping on the surface to be welded unless the work is properly protected.

21.5.6. Assembly

During assembly and welding, attention must be given to minimizing distortion caused by welding. When welding circumferential joints of a large-diameter penstock, adequate stiffening must be provided to avoid weld cracking.

a) Butt straps

Butt straps are proposed for the steel liner to facilitate making the circumferential joints in-situ. Each complete butt strap should be arranged in two halves, the bottom half being welded in the shop to the erection section to be erected first, the other half of the butt strap being welded in the shop to the following erection section.

This arrangement facilitates placing the adjoining erection sections at the field. When adjoining sections are in their final positions the butt straps should fit closely to the adjoining shell thereby enabling a satifactory welded joint to be obtained. All in-situ welding must be carried out from inside.

b) Thrust rings

Thrust rings shall be welded to the steel liner where necessary and shall have the strength sufficient for transferring axial thrust to surrounding concrete.

21.5.7. Shop Weld Joints

All welding shall be carried out by experienced and qualified welders. All welding electrodes and welding material shall be furnished by the Bidder for approval. The electrodes shall be stored and protected in accordance with manufacturer's instructions to prevent moisture ingress. Internal surface of joints shall be smooth and convexity shall not exceed 2 mm. Internal convexity shall be rounded to avoid sharp edges.

a) Cleaning before welding

The surfaces of plates to be welded shall be cleaned of all scale, rust for a distance of not less than 25 mm from the welding edge. Welding grooves shall similarly be cleaned.

b) Core wires, fluxex and welding rods

The materials of core wires, fluxes and welding rods shall be most suitable for the base metals and shall be kept in sufficient dry conditon. Welding rods withdrawn from the oven and not used immediately after two hours shall be rebaked. Rebaking is allowed only for a time. Storage of flux overnight in supply lines and hoppers of welding machines, re-use of fused flux, mixing of fluxes or batches of fluxes shall not be permitted.

c) Back chipping

Back chipping for weld joint shall be performed by arc air gouging. Dye penerant or magnetic flux inspection shall be applied to check cracks in welding joints after gouging.

d) Tack welding

Tack welding on the pipe shells shall be avoided as much as possible. If the tack welding is made, the welding portion shall be preheated prior to tack welding at more than 100° C for a distance of not less than 50 mm from the welding line to reduce residual stress.

e.) Preheating

When preheating is the part of approved welding procedure, weld joints shall be preheated in accordance with the kind of steel material and plate thickness. Maximum interpass temperature of preheating shall be 200□ C and preheating area shall be over a distance of more than 4 times of plate thickness for each side from the welding joints.

If welding work is made under the condition of ambient temperature less than 5° C, steel materials on weld joints shall also be preheated even though application of preheating is not required due to the kind and thickness of the steel materials under normal welding condition.

The relations between the carbon equivalent and the preheating temperature in cases of manual welding, shall be as follows:

Table 21.5-1 : Details of Preheating temperature

Carbon equivalent (CE)%	Plate Thickness (mm)	Preheating temperature for low hydrogen welding
0.38 to 0.48	0 to 25	40 to 60° C
0.38 to 0.48	25 to 100	80 to 100° C
More than 0.48	0 to 100	100 to 150° C

f) Stiffener/Seepage/Thrust rings

Stiffener rings, seepage rings, thrust rings and backing plate for grout plugs shall be welded on the pipe shells as specified in the drawings at the Bidder's workshop, and shall be made of the same plate material as the pipe shell. The circumferential welding joints of stiffeners with the pipe shall be checked by "Magnetic Particle Inspection" and specified number of joints between two stiffeners by ultrasonic testing.

g. Lugs, Saddles or Brackets

All lugs, saddles or brackets which are to be welded to the steel liner and form part of the permanent or temporary support shall be made of the same plate material as the steel liner and the welding shall meet with all the requirements as set herein.

21.5.8. Field Weld Joints

Common field welded joints are typically CJP butt-joints.

Double welded butt joints, which results in the highest weld strength, require welder access from both sides of the joint. The first pass (root pass) of an open butt weld generally does not provide proper shielding from the atmosphere and frequently results in a unaccetable weld quality. However, having access to both sides of the joint allows the welder to gouge out the root pass from opposite side and apply sound weld metal. Weld passes after the root weld are shielded and therefore do not have the same weld quality issues.

Avoid longitudinal weld joint at erection site to maintain weld joint quality. Single welded butt joints are often used where welder’s access is limited to only one side for example, in steel tunnel liners/ Trenches. This joint configuration is generally provided with a backing bar to improve the quality of the finished weld assist in assembly.

In the installation of a penstock in a trench, there may not be sufficient clearance between penstock and trench walls to back·weld field girth joints from the outside. In such cases, it will be necessary to complete the weld from the inside using an outside backing strip. Stiffener rings may be formed from bars or flame-cut from plates. The segments so produced are butt welded into full rings, then welded to the pipe with fillet welds either manually or by machine.

Special rounding-out spiders are often used to aid fitup and welding work and to prevent distortions in the pipe.

21.5.9. Selecting the proper low alloy electrodes

Factors you should consider when selecting a stick electrode include base metal type, joint fit- up and welding positions.

When welding low alloy steels, the tensile strength, yield strength, elongation, and impact properties of the weld metal should match those of the material being welded as closely as possible. The chemical composition of the weld metal should match that of the steel also, although this may not always be possible. The mechanical properties and chemical compositions published in the electrode manufacturer's literature are based on undiluted weld metal. Welds made on the job will be diluted with the base metal, and composition and strength level may be somewhat different than the published data. In most cases, however, matching strength and composition as closely as possible works out well.

The wide variety of low alloy steels available today can make electrode selection a complex problem. In some cases, low alloy steels of the same chemical composition will have different mechanical properties depending on whether they have been rolled, hot or cold worked, cast or forged. For this reason, the American Society for testing materials (ASTM) has published several volumes of standards and classifications for the various forms of ferrous metal products. Electrode manufacturers usually provide a list of some of the more common ASTM specifications for which their electrodes are suited.

21.5.10. Welder's qualification

All welders assigned to manual welding shall have successfully passed the test conducted by the bidder as prescribed for welder qualification in IS:2825 or section IX of ASME Boiler and Pressure Vessel Code. If in the opinion of the Engineer, the work of any welder becomes or appears questionable at any time, such welder shall be required to pass another qualification test.

21.5.11. Workmanship

All steel liner assemblies and specials shall be manufactured and finished in a thorough workman like manner equal to the best modern engineering practice in the manufacture and fabrication of steel liner components notwithstanding omissions, if any, in the specifications and the approved drawings. Dimensions shown on the drawings shall be adhered to closely limiting to the maximum tolerance specified in the relevant Standards.

Where finished surfaces are specified or required for parts or materials, they shall be smooth as specified and almost free from tool marks.

Wherein average surface is required, smooth surface shall be produced but slight tool marks shall be allowed.

21.5.12. Repair to welds

Defects in weld such as cracks, pinholes, incomplete fusion penetration or porosity detected as a result of radiographic/ultrasonic inspection shall be removed by chipping or any other mechanical means or by oxygen grooving, gouging, until sound metal is reached on all sides of the weld. The resulting cavity shall than be filled solidly with weld metal deposit strictly as per the welding procedure specified in para 6.9 of IS:2825. Portions of welds that have been repaired shall be radiographed/ultrasonic tested and repaired till the defects are removed.

All areas of welds on which repairs have been made shall be examined 100 percent by the method specified for the original weld.

When a weld has been examined for 100 percent of its length and the examination shows many unacceptable defects distributed over its length or when the defects envisage need for rectification of more than 25 percent of the weld length, the entire weld length may be rejected and the weld cut out and re-welded and shall be re- examined by the method specified for the original weld.

21.5.13. Recommendations from steel manufacturer

The steel supplier may recommend certain procedures/precautions in respect of fabrication and erection of steel liner, which shall be followed. If special type of electrodes and special processes such as preheating and post heating etc are recommended, such electrodes shall be procured and shall be used strictly according to the instructions of the manufacturer of the steel plates.

The latest practices of welding shall be followed even if the manufacturer of steel plates does not furnish any assistance contemplated in above plan.

21.6. Testing & Inspection Methods

Penstocks for water supply schemes & hydro power plants are mostly fabricated as pressure water steel pipelines. In addition, there are a several approaches for mechanical design and further installation practice, as well for quality insurance activities. American standards fully cover all related activities (ASCE M79, AWWA M11, and AWWA C206). Particularly, for designers it is of special concern, how to define appropriate methods and amount of non-destructive testing, especially while considering long and large diameter penstocks (over 2.5 m) as well as relatively high working pressures. This section will provide some basic approaches and welding quality insurance, related to design and manufacture of welded steel penstocks, as well as suggestion for methods and amount of non-destructive testing related to design inputs. American codes for penstock design are more consolidated. The most general are ASCE steel penstock manual No.79, and AWWA M11 (Steel water pipe- A guide for design and installation) while particularly field welding work for steel water pipe is specified in AWWAC206.

21.6.1. Test & Inspection

Tests must be made to qualify the process (es) and the operators.

Inspection usually involves the examination of completed welds to establish their quality and their confirmation to specifications. Thus, testing and inspection determines whether or not the quality standards of materials and workmanship are being met.

A number of different tests are specified in the ASME code for the qualification of procedures and welders. For groove welds, tests in direct tension are required in the procedure qualification to measure the tensile strength of the joints. Guided bend tests are used in both procedure and performance qualification tests to check for the degree of soundness and ductility.

Mechanical tests are used to qualify welding procedures, welders, and welding processes, and to determine if electrodes and filler metals meet the requirements of the specification. Welds in weldments are often tested for soundness, strength, and toughness by mechanical tests. Mechanical tests are destructive tests since the weld joint is destroyed in making the test. The test specimen (coupon) may be taken from a completed joint in a welded structure or from a test piece welded at the same conditions.

Destructive tests – tension test and bend test

a) Weld tension test

The tension testing of welds is somewhat more involved than for base metal because the weld test section is heterogeneous in nature, composed of the deposit weld metal, the HAZ and the unaffected basemetal. Tensile test specimen can be either transverse or longitudinal depends on the loading on the welded joint. In tension test, strength, elongation and reduction area are of primary importance.

b) Weld bend test

Various types of bend tests are used to evaluate the ductility and soundness of welded joints. Bend specimens may be longitudinal or transverse to the weld axis and may be bent in simple three- or four-point bending (free bend) or around a mandrel of specified diameter (guided bend).

The top and bottom surfaces of a welded plate frequently designated as the face and root surfaces, respectively. Face bends have the weld face on the tension side of the bend specimen; with root bends, the weld root is on the convex side.

Transverse bend tests are useful in qualifying welders and welding operators because they quite often reveal the presence of defects (lack of root fusion or penetration) that are not detected in tension tests.

The transverse bend test is sensitive to the relative strengths of the weld metal, the HAZ, and the base metal.

c) Visual Inspection

It is the most widely used non-destructive testing technique. It is extremely effective and is the least expensive inspection method. The welding inspector can utilize visual inspection throughout the entire production cycle of a weldment.

It is an effective quality control method that will ensure procedure conformity and will catch errors at early visual inspection methods can be divided into three subgroups:

Visual examinations prior to welding: drawings, material specifications, edge preparation, dimensions, cleanliness of the welding joint etc.

Visual examination during welding: welding process, electrode selection, operating conditions, preheat requirements, welder performance etc.

Visual examinations of the finished weldment: weld size (using weld gauges), defects (surface cracks, creator cracks, surface porosity, incomplete root penetration, undercut, underfill), warpage, base metal stages, defects etc.

21.6.2. Non-destructive examination (NDE)

Non-destructive testing is also known as non-destructive examinations of evaluation (NDE). To provide quality assurance of fabricated welded steel penstocks, it is common practice to perform sufficient type and amount of NDT of welds, as well as to perform hydro-test. For NDT testing, a radiographic testing (RT) is most reliable. RT is normally applied only to butt welds. For welds that can not be satisfactorily inspected by RT, as for example some of the welds on branch outlets and wyes, or fillet welds, other NDT methods of inspection can be used.

These techniques use the application of physical principles from the detection of flaws or discontinuities in materials without impairing their usefulness. In the field of welding, three nondestructive tests are widely used:

a) Dye-penetrant testing and Fluorescent-penetrant testing

Liquid-penetrant examination is a highly sensitive, nondestructive method for detecting minute discontinuities (flaws) such as cracks, pores, and porosity, which are open to the surface of the material being inspected.

The applied surface must be cleaned from dirt and film. So, discontinuities must be free from dirt, rust, grease, or paint to enable the penetrant to enter the surface opening.

A liquid penetrant is applied to the surface of the part to be inspected. The penterant remains on the surface and seeps into any surface opening. The penetrant is drawn into the surface opening by capilary action. The parts may be in any position when tested. After sufficient penetration time elapsed, the surface is cleaned and excess penetrant is removed.

The penetrant is usually a red color; therefore, the indication shows up brilliantly against the white background. Even small defects may be located.

Applications:

Liquid-penetrant examination is used to detect surface defects. It is very usefull for locating leaks in all types of welds. Welds in pressure and storage vessels and in piping for the petroleum industry are examined for surface cracks and for porosity.

Fluorescent Penetrant Examination:

The penetrant is fluorescent and when it is exposed to ultraviolet or black light it shows a glowing fluorescent type of read-out. It provides a greater contrast than the visible dye penetrants. Used for leak detection in magnetic and nonmagnetic weldments.

A florescent penetrant is applied to one side of the joint and a portable ultraviolet light is then used on the reverse side of the joint to examine the weld for leaks.

Inspect the root pass of highly critical pipe welds.

b) Radiographic examinations (RT)

Radiography is a nondestructive examination method that uses invisible X-ray, or Gamma radiation to examine the interior of materlals. It gives a permanent film record of defects that is relatively easy to interpret.

Although this is a slow and expensive method of nondestructive examination, it is a positive method for detecting porosity, inclusions, cracks, and voids in the interior of castings, welds, other structures.

X-ray generated by electron bombardment of tungsten, and gamma rays emitted by radioactive elements are penetrating radiation whose intensity is modified by passage through a material.

The amount of enegry absorbed by a material depends on its thickness and density. Energy not absorbed by the material will cause exposure of the radiographic film. Those area will be dark when the film is developed.

Areas of material where the thickness has been changed by discontinuities.such as porosity or cracks, will appear as dark outlines on the film. All discontinuities are detected by viewing shape and variations in the density of the processed film.

Radiography shall be performed in accordance with ASME Boiler and Pressure vessel code Section-V Article-2. The image quality indicator shall be of wire type and the sensitivity shall be atleast 1.5 percent or better. All radiography shall be conducted using lead intensification screens.

All radiography shall be performed and supervised by the experienced personnel qualified or trained for the job from the institutes such as Bhabha Atomic Research Institute or other reputed Institute of Nondestructive examination.

Radiographs shall not be taken until 24 hours after welding have been completed.

c) Ultrasonic examinations (UT)

It is a nondestructive examination method that employs mechanical vibrations similar to sound waves but of a higher frequency. A beam of ultrasonic energy is directed into the specimen to be examined. This beam travels through a material with only a small loss, except when it is intercepted and reflected by a discontinuity or by a change in material.

Ultrasonic examination is capable of finding surface and subsurface discontinuities. The system uses a transducer, which changes electrical energy into mechanical energy. The transducer is excited by a high-frequency voltage that causes a crystal to vibrate mechanically. The crystal probe becomes the source of ultrasonic mechanical vibrations.

These vibrations are transmitted into the test piece through a coupling fluid, usually a film of oil, called a couplant, when the pulse of ultrasonic waves strikes a discontinuity in the test piece, it is reflected back to its point of origin.

The transducer serves as a receiver for the reflected energy,

The initial signal or main bang, the returned echoes from the discontinuities, and the echo of the rear surface of the test material are all displayed by a trace on the screen of a cathode-ray oscilloscope.

Ultrasonic examination shall be performed in accordance with Article-5 of ASME Boiler and pressure vessels code Section V. The relevant references from ASTM specification E-164-74 shall be also taken.

The ultrasonic examination shall be performed and supervised by experienced and qualified personnel. If necessary special type of transducers and/or higher test frequency etc shall be adopted to improve the reliability of the examination. The equipment with recording facility shall be used for ultrasonic examination.

d) Quantum of RT/UT

Radiographic/ultrasonic tests shall be conducted as per table given below:

Table 21.6-1 : Quantum of NDT

Sl. No.	Type of weld joint	Shop welding	Field welding

1.	All longitudinal joints in straight pipes, and all longitudinal & circumferential joints in segmental bends, reducers, bifurcations / wye pieces	100% RT + random UT	100% UT
2	Circumferential joints of straight pipes	100% RT + random UT	100% UT
3.	All T joints (i.e. between longitudinal and circumferential joints)	100% RT	100% ultrasonic testing with two different angle probes 45 & 60 degree

Butt joints in seepage rings and stiffener rings shall be examined ultrasonically. Atleast one joint shall be examined for each ring.

21.6.3. Hydrostatic Testing

Entire quantity of straight ferrules shall be hydrostaticfally tested at shop to check the water tightness at joints.

However, if desired the hydrostatic field test shall also be done to determine if the field joints are water tight or not.

Hydrostatic tests should be performed at a pressure sufficient to prove the adequacy of all pipes and welds with the required margin of safety. Specification of hydro-test pressure is of particular demand. Generally, hydro-test pressure should be between 1.1 to 1.5 of maximum allowable working pressure but never such high to produce hoop stress more than 80% of the penstock material yield stress.

The pressure should be applied 3 times, being increased and decreased slowly at a uniform rate. The test pressure should be held for a length of time sufficient for the inspection of all plates, joints, and connections to detect leakes or signs of failure. It is desirable that the pressure test be performed when the pipe and water have a temperature of not less than 15° C. Before applying pressure, the equipment shall be inspected to see that all joints are leak proof and to ensure that all low pressure filling lines and other appurtenances that shall not be subjected to the test pressure, are disconnected.

After being completely filled with water, the pressure in steel liner assembly to be tested shall be increased slowly and uniformly until the specified test pressure is reached.

All defective welded seams and all defects in steel plates discovered during the hydrostatic pressure test shall be marked and after draining out the water they shall be satisfactorily repaired.

After repair and radiography, all such sections shall again be subjected to a hydrostatic pressure test. This procedure shall be repeated till satisfactory results are obtained.

21.6.4. Acceptance test

On completion of penstock erection, before handling over to the employer, the penstock is filled with water and checked for stability and tightness. The filling of penstock shall be done at a slow rate and during filing, the closing and tightness of all the valves, Inspection openings and other accessories shall be checked and the penstock shall be properly vented at high points to prevent formation of air pockets.

For field hydrostatic test, the penstock shall be filled to full reservoir level i.e. to static head or to a higher pressure. The water in the penstock shall be maintained to the required head for such a time as is considered necessary for inspection of all joints. Any leakage shall be repaired and ensured for soundness.

21.7. Painting

Good painting on the interior of a penstock will reduce the frequency of water supply shut downs and consequent loss of revenue during maintenance. It will also withstand high water velocities, impact and shock; with a smooth glossy finish, friction loss in the penstock will be minimized.

21.7.1. General

All steel liner assemblies shall be cleaned and painted as hereinafter specified. Completed coatings shall, in all respects, conform to the detailed requirements of these specifications. The sequence of various operations involved in painting for interior surfaces is i) preparation of surface, b) priming, c) finish painting and d) inspection.

21.7.2. Cleaning and preparation of surface

Weld spatters; burrs or any other objectionable irregularities shall be carefully removed or repaired by suitable means before cleaning.

Any grit or dust remaining from the cleaning operation shall be completely removed from the surfaces by brushing, air blowing, suction or other effective means before the surfaces are accepted for painting.

In the event of rust formation or when the surfaces become otherwise contaminated in the interval between cleaning and painting, re-cleaning shall be required to be done.

Surface preparation shall be in accordance with the method given below:

The surface to be painted shall be cleaned to base metal (near-white metal) to remove all rust, mill scale and other tightly adhering objectionable foreign materials by sand/grit/shot blasting after fabrication prior to painting. A clean, dry, gypsum and salt free quartz sand having grain size 0.7 to 1.5 mm shall be used for sand blasting. Blast cleaning shall be accomplished with abrasives of such particle shape, hardness and gradation as to effectively clean the metal and have roughened surface suitable for tenacious adhesion of subsequent coating. The average surface roughness after sand blasting should not exceed 40 microns.

The pre-requisites for good adhension of the coating are cleanliness, roughness and dryness of the surface. Unless these are ensured by proper surface preparation, a successful performance is not possible, Rust left on the surface will loosen the coating whereas mill scale, if not completely removed, will accelerate corrosion. The most expensive and technologically advanced coating system will fail if the surface is not prepared properly.

By far the most effective method for removal of mill scale, rust and old coatings is "Abrasive blast cleaning" The substrate should be degreased and all weld spatters removed prior to blasting, This is because contaminants like grease or oil are not completely removed by this method and they tend to impair the adhesion of the paint film. In this method, an abrasive (sand grit or shot) is injected into a rapid moving air stream and propelled at high velocity through a nozzle against the surface. The profile of the substrate after blasting will depend on the following: (a) abrasive used; (b) air pressure employed and (c) technique of blasting. Too low a profile may not provide a sufficient key for a coating while too high a profile may result in uneven coverage with high sharp peaks which may lead to the failure of a coating in the long run. The following Table 21.7-1 gives a brief guide of typical roughness profiles obtained by using various types of abrasives.

Table 21.7-1 : Typical roughness practices

Type of abrasive	Mesh size	Maximum height of profile in microns
Very fine sand	80	37
Coarse sand	12	70
Iron shot S390	14	90

Blast cleaning shall be performed in accordance with the following standards

Table 21.7-2 : List of Blast Cleaning Standard

Sl. No.	Description	Near white metal
1	Indian standard IS 1477 (Part 1):1971	Class B
2	Swedish standard SIS 05-5900:1967	Sa 2 ½
3	British standard BS 4232: 1967	Second quality
4	Steel structures painting council (USA)	SSPC-SP10-3T
5	National Association of corrosion engineers (USA)	NACE No.2

21.7.3. Primer and Finish painting (Airless Spray)

Proper application of protective coating is an important criterion in giving the paint system its required life. Airless spray is by far the fastest and most versatile method because it enables application at variable thicknesses. The equipment utilizes a motor and high-pressure fluid pump to compress the coating to extreme pressures. The paint is then made to pass through a special tip which atomizes it and controls the application properties. The main advantages of this method are:

a. High build coatings can be applied without thinning

b. Very fast rate of application

As already indicated, the special tips in the spray gun and the pressure control enables one to monitor application of very low to very high viscosity products. The general indication of orifice sizes given below in Table 21.7-3 to help in choosing the proper orifice size for a paint.

Table 21.7-3 : Orifice size

Sl. No.	Wet film thickness in microns	Orifice size in mm
1	Upto 50	0.02 to 0.03
2	100 to 200	0.03 to 0.04
3	>200	0.04 to 0.07

There are several designs of tips available, the choice of which depends upon the finish required, the ease of application and ease of cleaning blockage from tips.

Paint and coating materials shall be thoroughly mixed at the time of application and shall not be thinned except where hereinafter specifically provided.

Paint shall not be applied when temperature of the steel surface is less than 3°C above the dew point or when the weather is foggy or when the relative humidity is enough to cause condensation on the surfaces.

Surface preparation leaves the surface in vulnerable condition. It is therefore essential that immediately after surface preparation but not later than a time gap of 6 hours, the prepared surface of the steel should be covered with primer coat. A primer coat cannot be expected to last for an extensive period.

Paint shall be applied by airless spraying preferably without thinning. However, up to 5% thinner may be added if absolutely essential depending on condition using standard equipment. It is absolutely necessary to measure wet and dry film thickness of painting coats using "Wet Film thickness gauge" and "Magnetic coating thickness gauge”. It is better to use separate "Airless Spray Equipment" for primer and finish paint. It is recommended to do DFT measurements in accordance with SSPC PA 2. All edges, weld joints to be stripe coated. Inaccessible areas for spray application should be painted by brush.

Each coat of paint shall cover completely and uniformly the surface being painted and shall be free from runs, sags and blisters.

Newly painted surface should remain in a covered shop protected from moisture, condensation, contamination until the paint is thoroughly cured. Except as otherwise specifically provided, each coat shall be allowed to dry or harden sufficiently before a succeeding coat is applied. Coating should be done by qualified workers experienced in applying the specific coating materials.

The first and second finishing coat should be applied at shop after primer and the third finish coat at field after installation and prior to commissioning.

a) Zinc Rich Epoxy High Build Primer

Zinc rich epoxy high build primer shall be applied in two coats by Airless-spray over abrasive blasted surface. Stir the base thoroughly and then mix catalyst in recommended proportions to uniform consistency. Allow it to mature for 30 minutes and stir again before use and during application. Primer should be applied to give a dry film thickness of 50 ± 5 microns for each coat and the total DFT should not be less than 100 microns. Thinning of zinc paste shall be permitted but only with compatible with the paint and shall not exceed 5 percent by volume. The second coat of primer shall not be applied earlier than 24 hours after the application of first coat.

b) Cold Applied Coal Tar Epoxy High Build Paint

Cold applied coal tar epoxy high build finish paint (solvent less) shall be applied in two coats by Airless-spray over the primer coats. Finish coat should give a minimum dry film thickness of 175 ± 5 microns (approximate theoretical spreading rate will be 4 sq.m·per liter) and the total dry film thickness of both the coats including primer coating should not be less than 450 microns.

The penstock outer surfaces which are to come in contact with concrete should be abrasive blasted to class D classification as per IS 14177. Under this class at least 65% of surface of steel penstock be cleaned to bare metal except some tightly bonded residue in the form of mill scale and should be given a coating of cement latex to prevent rusting.

The bidder shall specifically furnish brand, name of paint and the details of the relevant specifications and accepted standard practice for application procedure. Primer drying time, before first coat of epoxy paint can be given, shall be indicated. Similarly, drying time between each successive coat of epoxy paint and its final curing time for a well bonded film as recommended by the manufacturer of paint shall be indicated. Quality/life of this paint after application shall not deteriorate at any ambient temperature from 5° C to 75° c.

21.7.4. Painting Schedule

Cleaning and painting of steel liner shall be done in accordance with following schedule

(Approval of the Brand by the Employer is Mandatory):

Table 21.7-4 : Painting Schedule

Sl. No.	Surface to be painted	Paint material	Number of coats	Dry film thickness in
1	External surface (i.e. embedded in concrete)	Cement solution mixed with 5% potassium dichoromate	1 (one)	
2	Exposed surface	Zinc rich epoxy high build primer (two pack)	2 (two)	Minimum 50 per coat but total not less than 100.
		Cold applied coal tar epoxy high build paint (two pack)	2 (two)	Minimum 175 per coat but total not less than 350.
3	Interior surface	Zinc rich epoxy high build primer (two pack)	2 (two)	Minimum 50 per coat but total not less than 100.
		Cold applied coal tar epoxy high build paint (two pack)	2 (two)	Minimum 175 per coat but total not less than 350.

21.7.5. Repair of Shop Painting

Before proceeding with the regular painting or coating operation all areas of shop coat which are defective or damaged shall be cleaned and repaired. Areas on which the part is loose, weakly bonded, blistered, abraded, rusted or otherwise defective shall be removed to clean metal by scraping, chipping, power wire brushing or other effective means. Areas, thus prepared shall be cleaned of all dust, dirt and other contamination using clean rug and clean solvent. These surfaces shall then be repainted in accordance with the painting schedule and shall be required to pass acceptance tests as specified.

21.7.6. Field Painting

After erection, concrete back filling and grouting, all temporary fixtures/appurtenances, debris etc. inside the steel liner shall be carefully removed. The circumferential field weld joints approximately 300 mm wide and grout plug weld joints approximately 300 mm x 300 mm shall be thoroughly cleaned by grinding/buffing. The same treatment shall be required at the spots where bars or other temporary steel pieces were installed to facilitate erection of steel liners. The entire interior surfaces of steel liner shall be cleaned after completion of entire erection work. After ensuring proper cleaning, primer and paint shall be applied (in 2+ 2 coats} as per approved procedure adopted in the workshop.

While applying primer and painting on the weld joints and grout plug welding inside the pressure shaft, due to confined site conditions and elevation difference, high fumes may be formed. These fumes may cause eye irritation, vomiting and severe headaches to the labours engaged in the painting work. A part from causing serious environmental conditions and health hazard quality and speed of work may also be affected. Hence it is important to review the painting scheme for the field joints. As surface preparation for joints inside the shaft was not possible by sand / shot blasting. It is to be decided to achieve higher thickness in one coat, produce less fumes and have life long durability against water passing in the inclined shaft with high velocity. Keeping in view of the above, paint system most suitable for pipe joints and grout plug joints in inclined shaft shall be selected and to be achievable for DFT 450 microns (In 3 coats).

The rollers and other rods meant for movement of trolley should be removed and ground to match with the inner surface of the steel liner. Damaged areas shall also be repainted with primer and epoxy paint to get the desired thickness.

21.7.7. Paint Losses

It is extremely complicated to estimate accurately the quantity of paint required for a particular job since the theoretical spreading rate does not take into account the various "losses" involved during application. Experienced contractors, having knowledge of application conditions, are best able to produce more or less accurate estimates. These notes are intended to supplement this experience by highlighting the major areas of “losses". Usually two types of losses are considered: "Apparent losses" where the paint on the surface does not contribute to the required thickness, and •Actual losses" where the paint is lost or wasted.

The loss factor is usually expressed as the difference between the theoretical and practical spreading rates expressed as a percentage of theoretical spreading rate. In each data sheet a special section is devoted to thinner consumption which should be strictly adhered to. Adding a small percentage of extra thinner does not necessarily impair the film properties, but excess thinning increases the quantity of liquid paint without contributing to the solid content.

21.8. Health and Safety

The majority of paints, coatings and thinners do not present special hazards in storage or use provided that good standards of industrial hygiene are maintained. However, it must be remembered that these materials can introduce two potential hazards- health and fire. The following is a guide to the potential hazards and recommended safe practices.

a) Food and drink should not be brought into, stored, prepared or consumed in areas where paints are stored, handled or used. Smoking in such areas should be prohibited.

b) The inhalation of paints, dust or fumes should be avoided by the use of local ventilation or extraction. Where fumes or dust are unavoidable, suitable approved respirators or face masks should be worn.

c) Normally harmless chemicals can cause irritation by repeated or prolonged contact with the skin. All personnel who handle and use paints should wear appropriate protective clothing (as a minimum; gloves, eye protection and overalls).

d) It is recommended that operators should wear suitable eye protectors when there is a risk of paint splashing into the eyes.

e) Personnel should be encouraged to wash especially before eating food.

f) Adequate fire prevention and firefighting equipment should be provided and maintained.

Do not attempt to fight fire with water this will cause the fire to spread. g) Spilage of pairs should be cleaned up as soon as they occur.

21.9. Transportation & Erection

The penstock pipe will usually be shipped directly to the jobsite on flatbed trucks. This one- time handling between project site workshop and actual erection site avoids damage sometimes encountered by multiple handling and is therefore the first choice. In no case shall the pipe be handled with unpadded chains or cables or other equipment that might damage the coating. Upon arrival at the jobsite, the pipe shall be unloaded and placed in storage area.

21.9.1. Erection

In case of steel lining concreted in a shaft, the pipes are pre-assembled in sections of 5 to 7.5 m length and carried on trolley into shaft with the help of power winches. Enough clearance of about 300 mm all around the liner shall be maintained for welding and inspection before backfill concreting. Suitable internal bracings shall be provided to withstand the external pressure caused during concreting or grouting pressure.

21.9.2. Erection Procedure

The enginner will usually furnish a plan and profile of the pipe line indicating critical vertical and horizontal points. From this plan and profile, the pipe manufacturer will produce a pipe laying schedule with reference to elevation. When the starting point elevation is fixed, the penstock pipe shall be layed and aligned.

The welding procedure at field is similar to shop welding and fabricator shall observe the similar manufacturing control as those carried out in the shop. When welding inside the pipe, provisions for adequate ventilation must be considered.

Inspection of the field welded joints should be comparable to that specified for the pipe. i.e. magnetic particle test of fillet welds, and ultrasonic examination of butt joints.

21.9.3. Field Coating of Joints

Befor backfilling, the field joint should be coated with material compatible with the shop applied coating. The interior lining at the field joint may be completed at any time prior to the field hydrostatic test.

21.10. Completion of Work

On completion of work, unpainted portions (welded joints} shall be prepared and painted with specified paints as a protective measure

Before putting into service, all the internal spiders shall be removed and penstock cleaned from inside all the unwanted materials and final field coating wherever shall be applied as specified and ensured for dry fllm thickness.

On completion of erection, finishing of protective measures, the penstock shall be subjected to field hydrostatic test and acceptance test as specified.

21.11. Materials

21.11.1. Steel plate

(a) Steel plate for penstock steel liners and welded attachments shall comply with standards listed in these technical specifications.

(b) The following information forms part of the Technical Requirements:

Purchaser steel works inspection is required.

Test certificates are required and the Contractor shall make copies available to the Employer before steel covered by the Certificates is accepted for payment as liners and pipes.

- Ladle analysis is required.
- Product analysis is required.
- The material is to be supplied with a maximum carbon-equivalence in accordance with standards listed in the specification of this section.
- Impact tests carried out at temperature of 0°C shall give an energy not less than 27 Joule.
- Ultrasonic examination of each steel plate is required.

(c) The Contractor shall transport steel plate to his place of manufacture and shall stockpile it in a manner in accordance with best industry practice to avoid any damages to the steel plates. Plates shall be marked with paint to maintain their identity and shall have the heat number recorded.

(d) The Contractor shall submit copies of his steel orders and the steelworks test certificates to the Employer for information within 7 days of receipt of steel at his manufacture site.

(e) All materials stored prior to fabrication and all fabricated items stored prior to application of corrosion protection or transport shall be supported above the ground in a manner which will not cause damage, distortion or high stresses, shall be prevented from rusting and shall be kept free from dirt, grease, oil and other foreign matter.

21.11.2. Welding electrodes, fluxes and wires

(a) All welding consumables used for the Works shall be of the highest quality and shall be capable, with the welding processes and procedures used for the Works, of producing weldments to the requirements of this Requirements.

(b) Submerged arc consumable shall comply with standards listed in the specification of this section.

(c) Gas shielded or self-shielded consumable shall comply with standards listed in the specification of this section.

(d) Manual metal arc electrodes shall be low hydrogen electrodes complying with standards listed in the specification of this section.

(e) The characteristics of welding electrodes shall be superior to the base metal in ultimate tensile strength, yield point, and elongation.

(f) Welding consumables will not be approved by the Employer until it has been demonstrated, by weld procedure tests, that they will produce welds of the specified standard. Welding consumables supplied for the Works shall be equal in all respects to those used for the weld procedure tests and shall be certified to this effect by the material manufacturer.

(g) The Contractor shall supply to the Employer for information the manufacturer's certificates certifying that each batch of electrodes and each batch of flux complies with the specifications listed in the approved welding procedures, before they are used in production.

(h) The Contractor shall supply to the Employer for information the manufacturer's certificates certifying that each batch of welding wire complies with the specification listed in the approved welding procedures. The certificates shall list the check chemical analyses of the wire.

(i) The Contractor shall weld a production test plate in accordance with the specified technical specifications to confirm that new batches of consumables provide welds with mechanical properties and soundness in accordance with this Technical Requirements and shall submit to the Employer the results of the tests at least 1 week before use of the new batch of consumables in production.

(j) All electrodes shall be baked at a temperature recommended by the electrode manufacturer but not less than 2500 for 4 hours prior to use. After baking, electrodes shall be stored in an oven at a temperature of at least 1000 and shall be withdrawn singly from this oven and if not used immediately shall be re-baked or rejected.

(k) Flux for submerged arc welding shall be dried and stored as recommended by the manufacturer. Storage of flux overnight in supply lines and hoppers of welding machines will not be permitted. The flux shall be clean and dry at all times. Re-use of fused flux will not be permitted. Mixing of fluxes or batches of fluxes will not be permitted.

(l) Wire for submerged arc welding shall be clean and dry.

21.11.3. Miscellaneous materials

(a) Bolts, nuts and washers shall comply with standards listed in the specification of this section.

(b) Material for internal and external corrosion protection shall be sampled and tested.

21.12. General Requirements for Manufacture

21.12.1. Supervision

(a) The Contractor shall ensure that all work is carried under the direction of qualified and experienced engineering personnel and is supervised by persons with training and experience in the construction of large welded plate steel structure.

(b) The Contractor shall employ or retain a qualified metallurgist or welding engineer, who shall be available to advise on metallurgical problems associated with materials and welding.

21.12.2. Quality control

(a) The Contractor shall be responsible for quality control, supervision and testing during manufacture and installation and shall ensure that all checking of materials, dimensions, tolerances and all inspection of fabrication, welding and transport is carried out. As part of the quality control supervision, the Contractor shall make regular checks of the operation of all cutting and welding equipment and instruments, of the fit-up, pre-heat and inter-pass heat actually achieved, and of the compliance of welding operators with the details of automatic and manual welding procedure.

(b) The Contractor shall maintain quality control records of his operations and these shall be available for inspection by the Employer. The Contractor shall nominate a quality control supervisor to liaise with the Employer on matters of quality.

(c) If the Contractor's quality control supervisor determines that any part of the manufacture is not in accordance with the detailed workshop drawings or this Technical Requirements, he shall immediately advise the Employer of the deficiency and the proposed method of rectification. The Contractor shall effect the rectification at no cost to the Employer.

(d) The Employer will carry out spot checks to assess the standard of welding and quality control. These checks will include random inspection together with suitable regular inspection at pre-arranged stages. The Contractor shall give reasonable notice of when any fabrication weld will reach a stage at which inspection is required.

21.12.3. Inspection

(a) The Contractor shall ensure that all welding or inspection of fabrication work which forms part of or is attached to the penstock steel liners is carried out by personnel individually qualified for the work they perform.

(b) The Contractor shall maintain a current list of qualified personnel employed on the Works which shall be available at all times to the Employer or his representative.

21.13. Plate Preparation

21.13.1. General

(a) Cutting and trimming of plates shall be performed by machining or machine flame cutting.

(b) Hand flame cutting shall be limited to those locations where machining or machine flame cutting are not practicable.

(c) The finish of edge surfaces which will not form part of a welded joint shall be as defined in American Society of Welding (AWS).

(d) The finish of edge surfaces which form part of a welded joint shall be as defined in AWS in the above mentioned Note.

(e) All notches whether rounded or sharp, shall be removed from flame cut surfaces by grinding to merge smoothly with adjacent plate surface. All burnt metal, slag and scale shall be removed by grinding except that removal by grit blasting will be permitted provided the specified finish is obtained. Slight discoloration of machine flame cut surfaces will be accepted. Repair of flame cut surfaces by welding shall be subject to approval by the Employer.

(f) All burring of edges shall be removed. All exposed edges shall be rounded or chamfered.

(g) The edge surfaces shall not contain flaws, cracks, laminations, slag inclusions or other defects.

(h) All plates shall be accurately prepared and trimmed so that the specified tolerances of fit-up at welded joints and of all fabrications are obtained.

(i) All lugs, brackets, and reinforcements around openings and other members shall conform to the shape of the surface to which they are attached. This shall be accomplished by machining, grinding, or by pressing the attachment, but not by hammering.

(j) Openings in the pipe-shell shall be ground to fit the nozzle fabricated for the particular opening.

(k) Rings shall be fabricated into not more than 2 segments prior to attachment to the pipe-shell. The inside surfaces of the ring halves shall be machined or ground to fit the pipe-shell to which they will be attached. The final preparation of the closing butt joints for the rings shall be performed after matching the inside surfaces with the pipe-shell.

(l) Where a butt weld is required between plates of different thickness, the thicker plate shall be trimmed to a smooth taper of 4 in 1 measured as a ratio of the distance along the centreline of the pipe to the distance perpendicular to the centreline of the pipe, including the width of the weld.

21.13.2. Curvature

Forming to curvature of pipe-shell plates shall be in accordance with standards listed in the specification of this section.

21.14. Fabrication Tolerances

21.14.1. General

(a) Weld preparations whose cross-sectional dimensions vary from those shown on the approved workshop drawings by more than the following tolerances, shall be corrected prior to welding:

- Size and location of land +2 mm
- Root opening of joints +2 mm
- Groove angle +5°
- Radius of J and U grooves +2 mm

(b) The following limit shall apply to the fit-up of joints to be fillet welded and to the fit-up of rings to the pipe-shell:

- Gap at point 2 mm maximum

(c) The maximum offset between abutting external surfaces at any position along a butt joint shall not exceed 2 mm for longitudinal joints and 3 mm for circumferential joints.

21.14.2. Pipe-shells

(a) The following tolerances shall apply to fabrication of pipe-shells:

- There shall be no flats or peaks at welded seams and any local departure from circularity shall be gradual.
- The external surface of the completed pipe-shell shall not depart from the calculated circumference based on the nominal outside diameter by more than 0.05 percent.
- The difference between the maximum and the minimum internal diameters of the pipe-shell measured at any one cross-section, other than at rings, shall not exceed 0.4 percent of the mean diameter of the pipe-shell.
- The profile, measured outside or inside of the pipe-shell by means of a gauge of the designed form of the pipe-shell and having a length equal to 0.25 of the internal diameter, shall not depart from the designed form by more than 0.2 percent of the mean diameter of the pipe-shell.

(b) The maximum deviation from a straight-line parallel to the axis of the pipe-shell, as measured by a straight edge along the outside of the pipe, shall not exceed the following:

- 5 mm in 6 m length
- 10 mm in 12 m length

(c) The pipe ends shall be square or at the designed angle to the pipe axis within a tolerance of + 2 mm measured at the circumference.

(d) The length of steel liners shall not depart from the designed length by more than 5mm.

(e) The lengths of steel cans which make-up individual liners and pipes may be varied provided that the overall length of the completed steel lined conduit is achieved.

21.14.3. Other items

(a) The following tolerances shall apply to fabrication of parts other than pipe shells:

Length of members	+ 5mm
Depth of rings	+4mm
Location of attachments	+10mm
Deviation of rings from a plane normal to pipe axis	+ 4mm

(b) The difference between the maximum and the minimum internal diameters of rings shall not exceed 0.2 percent of the mean internal diameter of the ring.

(c) The fabricated parts shall be adequately match-marked as shown on the approved workshop drawings. Each part shall be identified with a number and a mark indicating the direction of flow and its top and bottom vertical centreline. The location of the plane of the bend shall be marked on all mitre sections as well as the top and bottom match points. The location of all match points shall be carried out as accurately as possible with the pipe-shell circular. The marked vertical plane through the centrelines of all components and the marked planes of bends shall be within 3 mm of the true position of the plane.

(d) Marking shall be performed with paint wherever practicable. Punch or die marks, if essential, shall be light so as to not damage the plate and shall not be located on or immediately adjacent to edge preparations. Marking may be performed during or after fabrication and shall be completed prior to delivery from the factory.

21.15. Welded Attachments

21.15.1. General

(a) No attachments of any kind shall be welded to any part of the liners or pipes after they have been inspected by the Employer at the fabrication shop.

(b) Permanent attachments are defined as those which are essential for the operation or maintenance of the steel lined conduit and pressure pipes.

(c) The Contractor shall show all temporary attachments required for installation, handling and joint alignments on his drawings.

(d) Temporary attachments shall be welded to the steel liners and pipes in the shop but shall not be welded all round in connecting them to the pipe-shell.

(e) All temporary attachments which may adversely affect the performance of the finished Works shall be cut off and ground flush as soon as they have fulfilled their function. Flush shall mean level with the adjacent plate surface within a tolerance of + 1 mm, this tolerance to be achieved by a smooth transition with a maximum angular deflection not exceeding 10° between tangents to the cross-section at the adjacent points. Flame cutting will not be permitted within 3 mm of the pipe-shell.

21.16. Welding

21.16.1. General

(a) All welding including tack welds and welds for temporary attachments shall be carried out strictly in accordance with the Contractor's welding procedures. All welders and welding machine operators shall be individually qualified.

(b) The welding process, welding consumables, weld procedures and weld preparation shall be selected by the Contractor subject to the requirements that the weldments performance is in accordance with this Technical Requirements.

(c) All welding shall be performed by the electric arc method and automatic welding equipment shall be used wherever practicable.

(d) All surfaces to be welded and the adjacent plate surfaces shall be thoroughly cleaned of scale, rust, oil or other foreign matter down to a clean surface for a distance of at least 15 mm from the welding edge. Each run of weld metal shall be thoroughly cleaned and all slag removed before the next run is deposited.

(e) Plates shall be assembled and retained in position for welding by suitable methods.Tack welds, where used, shall be laid in accordance with an approved weld procedure. Where tack welds are not removed and form part of the completed weld, then the test welds shall include tack welds as proposed for production; provided the test weld meets the requirements, the tack welds will be permitted to remain in the weldment. Correction of major irregularities in fit-up shall not be carried out by hammering but minor adjustments are permissible provided care is taken to avoid damaging the plate. Where a root gap is specified, the edges of butt welds shall be held so that the correct gap is maintained within the permitted tolerances during welding.

21.16.2. Preheating

When pre-heating is part of the weld procedure, it shall be performed prior to and during tack welding and shall be maintained as a minimum temperature during welding. Pre-heating of joints shall be carried out using fixed gas burners or electric blankets wherever possible. The use of hand-held gas pre-heating torches shall be restricted. The Contractor shall provide any temperature indicators necessary tosatisfy the requirement that minimum pre-heat is being maintained over a width of 75 mm on each side of the weld. The necessity for pre-heat and control of inter- pass temperature will be nominated by the Contractor with the weld procedures on the basis of the run size, joint thickness, steel composition and type, the welding process and the type of electrode. Notwithstanding satisfactory results in weld procedures tests, the Employer may require, for some welds, a higher pre-heat to compensate for lack of accurate fit-up, for variations in plate composition and for additional restraint.

21.16.3. Sequence of welding

(a) The sequence of welding and tack welding shall be marked on the Contractor’s drawings.

(b) The sequence of tack welding and welding shall be selected by the Contractor and shall be such as to reduce distortion and minimise shrinkage stresses. In general,all welds shall be deposited in a sequence that balances the applied heat of welding on various sides as much as possible while the welding progresses. The direction of the general progression in welding on a member shall be from points where the parts are relatively fixed in position with respect to each other towards points where they have a greater relative freedom of movement, and points expected to have lesser shrinkage and with as little restraint as possible. After commencement of the welding of any restrained joint, welding shall be continued to completion or to a point that will ensure freedom from cracking before the joint is allowed to cool below the minimum approved pre-heat and inter-pass temperature.

21.16.4. Welding practice

(a) Butt welds shall be welded from both sides of the plate.

(b) The metal at the bottom of the first side welded shall be removed by grinding, chipping, arc-air gouging or other approved methods so as to provide clean sound metal on which to deposit the subsequent welds. When arc-air gouging is used, the gouging head shall be mechanically driven. The Employer will examine preparations after back gouging of welds and prior to any repairs. Any welder or welding machine operator to be approved for manual back gouging of welds shall demonstrate his gouging ability to the Employer by completing the appropriate gouging test as per standards listed in the specification of this section. Any such demonstration shall be carried out at the Contractor's expense.

(c) Welding shall, wherever practicable, be carried out in the down-hand position.

(d) After welding has been stopped for any reason, care shall be taken in restarting to ensure proper fusion and penetration between the plates, the weld metal and the previously deposited weld metal, which shall be thoroughly clean and free from slag.

(e) Run-on and run-off plates shall be provided for all longitudinal butt welds.

(f) Suitable allowances shall be made for distortion and shrinkage.

(g) Plates which will fom part of a T-weld shall be ultrasonically checked for laminations prior to welding.

(h) Fillet welds shall be made so as to ensure proper fusion and penetration of the weld metal at the root of the fillet.

(i) The arc shall be struck only on those part of parent metal or of the weld metal where metal is to be applied. Accidental arc strikes on surfaces where weld metal is not to be applied shall be repaired.

(j) Unacceptable surfaces imperfections in the pipe-shell shall be removed by grinding, provided that the ground surface merges smoothly with the plate surfaces and that the final plate thickness meets the requirements of standards listed in the specification of this section.

21.16.5. Weld finish requirements

All butt welds in penstock steel liners shall be ground flush, or to + 1 mm, to ensure that non-destructive inspection by ultrasonic methods is not hindered. The grinding requirements for these welds shall be as determined from the procedure plates.

21.17. Welding Procedures

21.17.1. General

(a) The Contractor shall develop the welding procedures for the Works for all welded joints in or attached to conduit liners and pressure pipes. The developed procedures shall be described in a written submission to the Employer of all details of welding procedures which shall be submitted for review by the Employer a clear 90 days before initial welding on any permanent steelwork. The Employer may require the Contractor to carry out additional development work or provide additional details of welding procedures, if the submitted information is incomplete or the development work does define the working limits of the procedure.

(b) At least the following information shall be provided for all welding procedures:

- Welding process, such as manual metal arc welding and automatic submerged arc welding.
- Material specification and the range of thickness to which the procedure specification applies.
- Joint design, such as angle of bevel and size of land, root opening, backing strips and tolerance limits on fit-up.
- The makes and brands of electrodes and fluxes, and the nominal composition of filler metal and shielding gases and the heating and protection procedures for electrodes to prevent hydrogen embrittlement.
- Conditioning procedures for manual metal arc electrodes and submerged arc flux.
- Size and type of electrodes, approximate number of runs, size of electrodes used for each run, sequence of runs and run-out length for each electrode sizes.
- Electrical characteristics, i.e. current and polarity, and the range of voltage, current and welding speed.
- Welding position.
- Pre- and post-welding heat treatment, i.e. method of heating, temperature range and methods of control.

21.17.2. Test plates

(a) The Contractor shall weld the weld procedure test plates nominated in this Clause. The test plates shall be of the identical material to the plate to be used for manufacture of conduit liners and pressure pipes and shall be set with the worst fit-up conditions permitted by the Contractor's welding procedures.

(b) The test plates shall be subjected to the pre-heat and post-heat treatments specified in the welding procedures.

(c) The test plates shall be visually inspected and inspected by non-destructive methods over the full length and butt welds shall be submitted to mechanical testing only if the extent of rectification required for any cause is less than 5 percent of the length. Test plates which require repair to more than 5 percent of the length shall be rejected.

(d) The test plates shall be sectioned for mechanical tests without regard to the location of known discontinuities in the weld.

(e) Each welding procedures will be reviewed by the Employer individually on completion of:

- satisfactory written submission of procedures details;
- satisfactory visual and non-destructive examination of the test plate or plates directed by the Employer; and
- satisfactory results in the nominated mechanical tests.

(f) The Contractor shall weld at least the following test plates for conduit liners and pressure pipes using test plates equal in thickness to plates to be used for the Works:

- longitudinal butt weld, automatic submerged arc;
- circumferential butt weld, automatic submerged arc;
- circumferential butt weld, semi-automatic or manual arc welding;
- circumferential fillet weld for backing strips and seep rings;
- butt joints for backing strips and seep rings; and
- manual weld repair of automatic weld procedure.

(g) Test plates for butt welds shall be 1.5 m long with the weld centrally located in a strip 0.75 m wide. The test plates shall be subject to the same restraints as will apply to production welds and test plates which are excessively distorted after welding will be rejected.

(h) Test plates for longitudinal automatic butt welds shall be welded in the down-hand position.

(i) Test plates for circumferential automatic butt welds shall be welded in the down-hand position.

(j) Test for circumferential, semi-automatic or manual, butt welds shall consist of 3 test plates. One test plate shall be welded in the overhead position, the second in the down-hand position, and the third test plate shall be welded in the vertical position.

(k) Test plates shall be identified by steel stamps with details of the test procedure number and the welding procedure.

21.17.3. Mechanical testing of procedure test welds

(a) Mechanical tests on the weld test plates shall be made in accordance with standards listed in the specification of this section.

(b) The following test specimens shall be prepared from each butt weld test plate:

- Transverse joint tensile specimen, 2 off, both shall achieve an ultimate tensile strength of at least 550 MPa in accordance with ASTM 537.
- Macro sections for soundness examination and hardness traverse, 2 off.
- Side bend test over a former radius of three times the specimen thickness, 2 off.

(c) Charpy impact test shall be taken in accordance with standards listed in the specification of this section and shall give an energy not less than 27 Joule at 0ºC.

(d) Mechanical tests on the procedure test plate for manual weld repairs are not required.

(e) The Contractor shall be responsible for carrying out all mechanical tests on procedure test welds and shall retain for this purpose a laboratory.

21.18. Production Welding Test

21.18.1. Requirement

(a) During production, the Contractor shall, carry out production tests on welded joints to:

- monitor the soundness and properties of welds on a routine basis;
- verify existing procedures and welding variables when there is a change in plate thickness; and
- confirm that new batches of welding consumables produce welds with mechanical properties and soundness in accordance with the Specification.

(b) The test welds may be run-on or run-off tabs or separate test plates which simulate as closely as practicable the production weld being checked. Production test plates shall be of sufficient size to accommodate the test specimens listed.

21.18.2. Frequency of test plates

(a) Production test weld shall be welded at approximately the following frequency:

- test weld per 100 m of longitudinal welds in the pipe-shell welded by automatic processes.
- test weld per 300 m of circumferential welds in pipe-shells welded by automatic processes.
- 1 test weld per 100 m of butt welds welded by manual or semi-automatic processes.

(b) In general, the frequency will be greater than average at the commencement of each welding procedure and will be arranged to test new supplies of consumables, welding wire and flux, as their use is commenced in production welding.

21.18.3. Testing of production test plates

(a) The production test weld plates shall be radiographically examined to ensure that the standard of welding is at least equal to that required in production. The test plate shall be rejected if rectification is required for more than 5 percent of the weld length. Production weld test plates shall be sectioned for mechanical testing in the same manner as procedure test plates. Production weld test shall provide a minimum of 900 mm effective weld test length with the weld centrally placed in a 400-mm wide plate. If the mechanical tests or radiographic examination of a production test weld shows that the weld does not comply with the minimum standard required for the procedure weld, then that welding procedures shall be disqualified and further welding with that procedure shall not be permitted. The procedure shall be resubmitted for approval when the cause of the failure of the production weld has been determined by the Contractor. The failure of the test weld to comply shall not in itself be grounds for the rejection of production welds performed in accordance with the approved weld procedures prior to the failure of the test weld.

(b) The Contractor shall carry out the mechanical tests on production test welds in accordance with the provisions of this Technical Requirements.

(c) The Contractor shall be responsible for carrying out all mechanical tests on production test welds and shall retain for this purpose a laboratory approved by the Employer.

21.19. Welder and Operator Performance Qualification Tests

21.19.1. General

(a) All welders and welding machine operators engaged on welding in accordance with this Section of the Technical Requirements shall pass the welder performance tests which are designed to demonstrate their competence to make sound welds of the types on which each is to be employed.

(b) A welder who welds successfully all the test plates required for a welding procedure test or the test plates for a production welding test may be considered as qualified for the particular welding process, welding position, and type of steel.

(c) The Employer, may, at his discretion, require a qualified welder to re-pass the whole or part of the qualification test if there is any reason to doubt the welder's ability to make satisfactory production welds or if the welder, after qualification, has not been engaged on fabrication using the process and equipment appropriate to the procedure for an extended period.

(d) Welder performance tests shall be carried out in accordance with the approved procedure. Change in the procedure which require re-qualification shall require new welder performance tests. A change in the make of electrodes, fluxes or filler material shall not be a cause for re-qualification providing that there is not significant change in welding and running characteristics. The details of the welder performance test shall be recorded by the Contractor, and shall be included with the test results. Welders who weld successfully test plates in the flat, vertical and overhead position shall be qualified for all positions.

(e) If one or more tests fail to meet prescribed requirements, the welder may take two further test welds of each type rejected, both of which shall pass all test requirements. If any of the retests fail, the welder shall undergo further training before resubmission of further test welds.

(f) The welder performance test plates shall comprise at least 300 mm of welding for manual welds and 600 mm for automatic welds. All test plates shall demonstrate the welder's ability to follow the procedure. After welding, they shall be visually examined and radiographed to ensure that the standard of quality is at least equal to the minimum required in production. If the requisite standard has been attained, the test plate will then be sectioned without regard to any indication on the radiographs. The specimens shall be prepared and tested in accordance with the specified requirements.

(g) Manual welders qualifying for circumferential joints in standards listed in the specification of this section steel will be required to perform two test series of doubled sided welds, one in which the test weld has been welded in the vertical position and on which one side has been welded in the overhead position and the other in the down-hand position.

(h) Welding machine operators qualifying for longitudinal and circumferential automatic welds in standards listed in the specification of this section will be required to perform one test series.

(i) Welding machine operators qualifying for semi-automatic welds in standards listed in the specification of this section will be required to perform one test series.

(j) Welders qualifying for repairs to automatic or semi-automatic welds will be required to perform one test series.

(k) The Contractor shall provide all materials and equipment required for welder and operator performance qualification tests and shall perform all work, fabrication and machining necessary to prepare the test specimens.

21.20. Welding Inspection

21.20.1. Requirement

(a) Longitudinal butt welds in the penstock steel liners shall be radiographically examined for 100 percent of their length.

(b) Circumferential butt welds in penstock steel liners shall be radiographically examined on a spot basis. The welds and the position to be radiographed will be determined daily by the Contractor and will include radiograph of welds carried out by each welding operator. The minimum length of a spot radiograph shall be 300 mm. The extent of spot radiography shall be 10 percent of the length of the circumferential butt welds.

(c) Butt joints in backing strips and seep rings shall be examined ultrasonically. At least one joint shall be examined for each backing strip or seep ring.

(d) Welds at Tee joints and fillet welds to pipe-shells will be examined by method listed in Sub-Clause of this Clause.

(e) All areas of welds on which repairs have been made shall be radiographically or ultrasonically examined after repairs have been carried out. This examination shall be at the Contractor's expense.

21.20.2. Radiographic Examination.

(a) Radiographic techniques shall comply with standards listed in technical specifications of this section. The image quality indicator shall be of the wire type and the sensitivity shall be 1.5 percent or better. The minimum film density in the thinner of two plates shall be 2.5 and the maximum 3.0 and shall be checked on at least one film length from each exposure. The assessment of radiographs shall comply with standards listed in the specification of this section.

(b) The Contractor shall provide all materials and radiographic equipment and shall perform all radiographic examination in accordance with the requirements of this Clause and shall submit all films to the Employer within 8 working hours after taking exposure. The films will then become the property of the Employer. Markers shall be placed on the fabricated sections as directed.

(c) The Employer will interpret the radiograph, and will decide the extent and location of all weld repairs. The Contractor shall not perform weld repairs prior to the Employer's decision as to their extent and location. The Employer will provide interpretations within 8 working hours of the receipt of the radiographic film.

21.20.3. Unacceptable defects and repair

(a) The defects described in relevant Section of standards listed in technical specifications of this section are unacceptable and will require repair.

(b) When a weld has been examined for 100 percent of its length and the examination shows many unacceptable defects distributed over its length, the weld shall be gouged out and re-welded. The re-welded joint shall be examined in the same manner as the original weld.

(c) If any weld has been examined over the full length and rectification is required over more than 25 percent of the weld length, the entire weld length may be rejected and the weld cut out and re -welded as directed. The entire weld shall be re - examined after re-welding.

21.20.4. Additional examination

(a) The Contractor may make use of visual, dye-penetrant, magnetic flux and ultrasonic methods and equipment to supplement radiographic examination. These additional methods will be used to ensure that welds do not contain unacceptable defects.

(b) Ultrasonic examination shall be used to check that the welds and heat affected zones of pipe-shell are generally free from cracks and crack-like defects and to locate radiographic indications for repair.

(c) The Contractor shall make available continuously throughout the Contract a technician and equipment for ultrasonic examination of the welds. Ultrasonic techniques shall comply with standards listed in the specification of this section.

(d) Defects which have been detected by ultrasonic examination shall be repaired. Any defect which produces an ultrasonic echo that fails to reveal the nature of the defect shall be radiographically examined.

(e) The Contractor shall submit procedures for the non-destructive testing of welds using dye-penetrant method or magnetic particle method. Dye-penetrant method shall comply with standards listed in the specification of this section and magnetic flux method to standards listed in the specification of this section or approved equivalent in each case.

21.21. Delivery

21.21.1. General

(a) The Contractor shall deliver the penstock steel liners to the installation areas according to his installation program.

(b) The lifting and loading equipment and procedures, the transport equipment and the unloading equipment and procedures shall be designed and constructed by the Contractor to carry safely the loads to be supported and to ensure that liners are not overstressed, distorted or damaged. The Contractor's drawings and proposals for the equipment and procedures listed in this sub-Clause shall be submitted to the Employer at least 30 days before any liners or pipes are to be transported. In the event of any damage occurring, the Contractor shall, at his expense repair the damage.

(c) All slings used in lifting or holding liners shall be padded with or constructed from suitable materials and all supports for liners and pipes shall be curved and constructed of wood and rubber sheeting or other suitable materials.

(d) Bracing shall be used to prevent distortion and shall not be welded to the metalwork of the liners.

21.22. Installation

21.22.1. General

(a) Penstock steel liners shall be installed in the position and to the lines and levels shown on the Drawings and in accordance with the match and flow marks positioned during fabrication.

(b) The Contractor shall prepare drawings and details of his methods of installation, installation equipment and any temporary work and shall submit them for review by the Employer at least 30 days before any installation is to begin. All installation equipment and temporary work shall be designed and constructed by the Contractor to carry safely the loads to be supported.

(c) All fabricated items stored prior to handling and erection shall be supported above the ground in a manner which will not cause damage, distortion or high stresses, shall be prevented from rusting and shall be kept free from dirt, grease, oil and other foreign matter.

(d) Steel liners installed on staging shall be supported on suitable packings to ensure they will be at the correct elevation and alignment when completed. Field joints shall be securely held in position by approved means to ensure accurate alignment, curvature and elevation before welding is commenced.

(e) The Contractor shall ensure that the liners are installed so that the longitudinal joints on either side of a field circumferential weld are as shown on the Drawings.

21.22.2. Field welding

(a) Field welding of liners shall be limited to circumferential and other welds designated as field welds on the Drawings.

(b) Where required, all field welding shall be performed under suitable portable shelters to ensure protection from wind, draught and moisture.

(c) Positioning of liner sections and tack welding shall be performed at times when the temperature difference over each cross-section is small.

(d) Completion of welding at each joint shall follow the tack welding as closely as possible.

21.22.3. Over-stressing

Penstock steel liners shall not be over-stressed. Any error in the work which prevents proper assembling and fitting of the separable parts shall be reported immediately to the Employer.

21.22.4. Bolted connections

All bolted connections shall be secured in close contact by erection bolts prior to the tightening of the permanent bolts. All high tensile bolts shall be tightened to a predetermined load.

21.22.5. Installation tolerances

The following tolerances shall apply to the installation of penstock steel liner:

The maximum offset between abutting external surfaces at any position along a butt joint shall not exceed 3 mm for circumferential joints.

The difference between the maximum and minimum internal diameters of the pipe-shell measured at any one cross-section, other than at rings, shall not exceed 0.4 percent of the mean diameter of the pipe-shell.

The profile, measured on the outside or inside of the pipe-shell by means of gauge of the designed form of the steel shell and having a length equal to 0.25 of the internal diameter, shall not depart from the designed form by more than 0.2 percent of the mean diameter of the pipe-shell.

- The maximum deviation from a straight line parallel to the axis of the pipe- shell edge shall not exceed the following:

- 5 mm in 6 m length
- 10 mm in 12 m length
- The centreline of each component shall not deviate by more than 12 mm from the theoretical centreline.

21.22.6. Grout plugs

Grout plugs shall be coated with bond breaking deoxaluminate grease and screwed home before concrete placement. After concrete placement, the grout plugs shall be removed and grouting carried out in accordance with this Technical Requirements. After completion of grouting, the grout plugs and the backing plate face shall be degreased and cleaned, a flat metal washer installed and the plug screwed tightly into position. The circumference of the plug shall be welded to the pipe.

21.22.7. Protective coating

The Contractor shall complete the application of the protective coatings to the surfaces of penstock liners and shall repair all damaged areas of the coatings.

22. CLEANING, CORROSION PROTECTION AND PAINTING

22.1. General

22.1.1. Requirement

The Contractor shall furnish, prepare and apply all material for cleaning, corrosion protection and painting of all surfaces as hereinafter specified.

22.1.2. Surfaces Not Requiring Corrosion Protection

- The following surfaces and materials shall not be painted:
- Concrete surfaces except where required to be painted for architectural reasons or for protection from chemicals as specified herein.
- Hot-dip galvanised steel components except where required as part of total protection system or for decorative reasons as specified herein.
- Stainless steel, copper, PVC, glass, vinyl and aluminium surfaces.
- Steel surfaces to be covered by insulation and lagging.
- Machined surfaces.
- Prefinished panels for ceilings, walls and fixtures.
- Steel surfaces subject to temperatures above 100°C.

22.1.3. Embedded Metalwork

Surfaces of metalwork completely embedded in concrete, unless otherwise specified or approved, shall be treated in accordance with Table 22.1-1.

Table 22.1-1 : Treatment of Embedded Metal Work

Metalwork	**Surface Preparation**	**Treatment**
External surfaces of steel tunnel liners, and pressure pipes, excluding return length of internal corrosion protection specified in Table 22.12-1.	SSPC SP7	Portland cement wash coating containing approved inhibiter.
All external metal surfaces except steel tunnel liners, bifurcates and pressure pipes and galvanised surfaces	SSPC SP7	None required

22.1.4. Welding Margins

Where the protective coating is applied prior to field assembly involving welding, the surface coating shall end not closer than 150 mm to, nor further than 200 mm from the proposed weld. Field weld preparations and the adjacent blast cleaned surfaces shall be protected with one primer coat of a paint as a corrosion inhibitor. This paint shall be of a type which is readily removable for the restoration of the specified coating system after the assembly is complete or a type which may be welded through without any detrimental effects as certified by the manufacturer.

22.1.5. Metal to Metal and Metal to Concrete Contact

Except as otherwise specified, surfaces of metalwork that will be in contact with other metalwork or concrete shall receive three coats of priming paint. The type of priming paint and the method of surface preparation shall be consistent with the requirement for other surfaces of the same metalwork.

22.1.6. Temporary Corrosion Inhibitor

Items of metalwork to be shipped from overseas, welding margins, and all machined surfaces shall be painted with one coat of a temporary corrosion inhibitor on all internal and external surfaces prior to being transported from the place of manufacture.

22.1.7. Care of Coated Metalwork

Metalwork that has been coated shall be handled with care so as to preserve the coating in the best practicable condition and shall be protected from the harmful effects of heat and weather conditions.

22.1.8. Colour Schedule

The final colour schedule will be advised by the Employer. Paint colours shall be in accordance with relevant IS.

22.2. Supply of Materials

22.2.1. Qualification of Materials for Painting

(a) In accordance with the requirements for Contractor's Documents to allow for the initial review period of not less than ninety (90) days prior to the proposed date of commencement of painting, the Contractor shall submit the following for each paint type to be used:

- A certificate from the manufacturer giving details for each different product including:
- the composition, including proportions of each major constituent
- the proportion of volatile material in the product
- the proportion of any constituent considered hazardous, and the nature of the hazard
- the physical characteristics claimed for the paint as supplied and as a film.

(b) The manufacturer's recommendation as to storage, handling and application, including:

- The maximum and minimum temperatures and humidities at which it can be satisfactorily applied.
- The time which must elapse after application until:
- the surface first hardens (touch time)
- the surface will bear normal working loads (hard dry time)
- a further coat can be applied (minimum recoat time)
- a further coat cannot be applied without special precautions (maximum recoat time)
- the system is fully cured, and can be put into service (service availability time).
- The types of equipment with which it is recommended to be used, including, for spray equipment, nozzle sizes and air pressures, instruction for cleaning equipment, and any other special instructions of a similar nature.
- Recommended procedures for application in a factory or workshop adjacent to the work site.
- Recommended procedures for making good assembly joints and damaged areas, where the age of the paint film exceeds the maximum recoat time.

(c) Reference test plates of each paint type to be used inclusive of surface preparation (metal surfaces only).

(d) The Contractor's detailed proposals as to equipment, work place, and procedures for application of the paint, consistent with the above instructions.

(e) If requested, the Contractor shall also supply samples of any paint or surface protection coatings proposed for use in the Works.

22.2.2. Supply of Materials

(a) All paint materials shall be delivered to the Site, or other approved location where painting shall be applied, in unopened containers bearing the manufacturer's label and instructions. Each container of coating material shall be identified with the name of the paint system, component of paint system and batch number of that component.

(b) Each batch of the coating materials supplied for the Works shall be accompanied by a certificate from the manufacturer certifying that the coating material has been manufactured in accordance with the standard formulation and that it conforms in all respects to the manufacturer's quality assurance control. All such certificates shall be submitted to the Employer.

22.2.3. Paint Manufacturer

All paints constituting one paint system including primer, intermediate coat and finishing coats shall be supplied by one manufacturer unless otherwise approved.

22.3. Surface Preparation

22.3.1. Metalwork

a) All cleaning and surface preparation of metalwork shall be performed by skilled personnel under the supervision of staff experienced in the surface preparation of metalwork.

b) Weld spatter, burrs and any other objectionable surface irregularities on metalwork shall be carefully removed or repaired before cleaning. Edges of steel plate including holes which are to be painted shall be rounded off to a radius of 3 mm with a smooth transition to the plate surface.

c) Steel surfaces to be coated shall be cleaned of all detrimental foreign matter such as oil, grease, soil, welding slag or other contaminants in accordance with relevant IS.

d) Material which shows pitting, due to rust, will not be accepted.

e) The Contractor shall use clean, sharp steel or cast iron grit which is free from corrosion producing contaminants, dust and also free of oil, grease or other deleterious contaminants to obtain the surface preparation and the surface profile specified in Table 22.12-1 for the particular coating.

f) Blast-cleaned surfaces showing plate surface defects such as scabs or sharp gouges shall be repaired before applying the coating systems.

g) For blast-cleaned surfaces, the surface profile as defined in relevant IS, shall be not less than the figures specified for the appropriate coating system in Table 22.8-1.

h) Before being coated, the blast-cleaned surface shall be fibre-brushed and vacuum-cleaned to remove all blast products and abrasives from the entire surface including pockets and corners. Final blast-cleaning operations shall not be conducted on surfaces that will become wetted after blast-cleaning and before painting, or on surfaces the temperature of which is less than 3°C above the dew point of the surrounding air, or when the relative humidity of the surrounding air is greater than 85 percent unless otherwise recommended by the coating manufacturer.

i) Wet-blasting methods shall not be used.

j) Cleaned surfaces shall be kept free from any contamination and shall not be touched by bare hands. The operators shall wear fabric gloves whilst carrying out cleaning and coating duties, and any areas inadvertently touched by hands or bare parts of the body shall be solvent-cleaned immediately.

k) The cleaned surface shall be tested for soluble and insoluble residues in accordance with Table 22.3-1:

Table 22.3-1 : Testing Cleaned Surfaces for Residue

Soluble Iron Salts	DIN 55928: Part 4
Grease, oil and epoxy residues	DIN 55928: Part 4
Millscale, rust and dust	BS 5493 Appendix F

22.3.2. Concrete and Concrete Blockwork Surfaces

a) Concrete surfaces to be painted shall be water cured.

b) Concrete surfaces shall not be painted within twenty-one (21) days after pouring and blockwork surfaces shall not be painted within twenty-one (21) days after laying or rendering.

c) Concrete and concrete blockwork surfaces to be painted shall be rubbed with a carborundum block and shall be free from dirt, rust stains, encrustations or other contaminants and shall have a smooth uniform surface. Any grinding or buffing to achieve such a surface shall be carried out using flexible cloth backed carborundum discs. Grinding stones and wheels shall not be used for general clean off of concrete surfaces. Surfaces containing blow holes shall be stopped up either individually or generally using a cement mortar compatible with the paint. Any excess mortar shall be scraped or sanded from the wall to present a smooth surface for painting.

d) Concrete surfaces shall be prepared by cleaning with a high-pressure water jet of 27 to 35 Mpa, as appropriate for the class of concrete, and allowed to dry for at least seven (7) days and until the moisture is less than eight (8) percent as measured by a moisture meter before coating.

22.3.3. Timber

Sap or gum exudations shall be scraped off and the areas solvent-cleaned. Dirt and mortar shall be removed using scraper, abrasive paper or steel wool as necessary. All excessive roughness, loose edges, slivers and splinters shall be removed with abrasive paper. Surface defects, cracks and nail holes shall be stopped up after application of primer, with linseed oil putty.

22.4. Application of Coating Materials - General

22.4.1. Personnel

The application of all coating materials shall be carried out in a neat, workmanlike manner by skilled personnel under the supervision of staff experienced in the application of the particular system and in accordance with the manufacturer's written application instruction.

22.4.2. Equipment

All equipment used in the application of coating materials shall be as recommended by the manufacturer. The equipment shall be in first class order and, where power driven equipment is used, shall deliver the coating materials at the rate specified in the manufacturer's application instruction.

22.4.3. Temperature and Humidity

Coatings shall only be applied within the temperature and humidity ranges recommended by the paint manufacturer, but in no case shall coatings be applied to surfaces upon which there is any moisture, or during rain or misty weather without suitable protection. Application shall not be carried out when the temperature of the metal surface at the time of application or the temperature anticipated during the subsequent four hours is less than 3°C above the dew point of the surrounding air, or when the ambient temperature falls below 7°C or rises above 38°C or when the relative humidity of the surrounding air is greater than eighty five (85) percent unless otherwise recommended by the coating manufacturer. Each coat shall be protected during the initial curing period against the possibility of moisture condensation or contamination with foreign matter.

22.4.4. Priming

a) Cleaned surfaces shall be primed or treated as specified for the appropriate coating system as soon as practicable and in any case within 4 hours after cleaning or as specified by the coating manufacturer. Blast cleaned surfaces must not be allowed to stand overnight without having received the first coat of paint. Should rust form or the surface become otherwise contaminated in the interval between cleaning and coating, reblasting shall be carried out.

b) The application of a prime coat in the shop followed by the application of the finishing coats in the field will not be accepted.

22.4.5. Spraying

When the coating material is applied by spraying, suitable means shall be provided to prevent segregation during the coating operation. Free oil and moisture shall be removed from the air supply lines of all spraying equipment. Each coat shall be uniform and free from runs, sags and other imperfections. The time between successive coats shall be not less than minimum nor more than the maximum re- coating time specified by the manufacturer.

22.4.6. Film Thickness

The paint shall be applied so that the thickness at any point is that required for the particular coating material within the specified range of thickness specified in Table 22.8-1 both for the individual coat and the complete system as required. Unless otherwise specified the dry film thickness shall not be less than the specified thickness and shall not exceed this value by more than:

- fifty (50) percent for coats up to 100 micron in required thickness; and
- fifty micron for coats exceeding 100 micron in required thickness.

22.4.7. Tinting

To facilitate application and inspection successive coats shall, where required, be tinted distinctively.

22.4.8. Inaccessible Surfaces

Surfaces that will be inaccessible after installation shall be completely coated as required prior to installation.

22.4.9. Protection of Surfaces

a) Surfaces not required to be coated, but adjacent to metal work which is to be cleaned and coated, shall be adequately protected during cleaning and coating.

b) Metalwork that has been coated shall be handled with care to preserve the coating in the best practicable condition and be protected from mechanical damage and the harmful effects of heat and weather conditions. Supports and slings used for lifting and holding the coated metalwork shall be padded with rubber blocks or similar material to prevent damage to the external coating. The coating on the invert section of the steel tunnel liners and pressure pipes shall, during erection, be protected by rubber matting or other suitable material.

22.4.10. Defects

All coated areas which are defective or damaged shall be cleaned and repaired in accordance with the manufacturer's field application instruction. Coatings that are loose, weakly bonded, blistered, abraded or otherwise defective shall be removed and the surface recleaned in accordance with the method prescribed for the specified coating. The surface shall then be recoated in accordance with the provisions of this Technical Requirements.

22.4.11. Elapsed Time

The maximum allowable elapsed time between blast cleaning and application of paint shall be fixed having regard to climatic conditions existing at the time. If a period of more than the maximum allowable time has elapsed, the surface will be re- blasted to produce a fresh surface. The elapsed time between applications of successive coats shall not be less than the specified minimum recoat time, not more than the specified maximum recoat time. If the elapsed time since the previous coat exceeds the specified maximum recoat time, either the system shall be removed and reapplied or the approved manufacturer's recommended procedure for overcoating of old paint followed.

22.5. Coating Systems

a) The coating systems required for various features shall be as specified in Table 22.8-1 at the end of this Section.

b) Coating systems are named according to the generic system type. Each coating system comprises the following four components:

- type of surface preparation
- type of primer
- type of body coat, and
- type of finish coat.

c) Brand names, indicated in Table 22.12-1 by an asterisk, are suitable types of coating material and only such products or products equal in all respects shall be approved for use in the Works.

22.6. Epoxy Mastic Coating System (System B)

22.6.1. Requirement

The internal surfaces of the tunnel liners, bifurcates and pressure pipeline components and the upstream end and 300 mm length of the exterior surface of the upstream end of the tunnel liner, and 300 mm length of exterior surface of pressure pipelines inside of the line where the pressure pipeline emerges from the concrete surround and other surfaces expected to be continually immersed in water shall be coated with an epoxy mastic coating system.

22.6.2. Application of Coating

a) The Contractor may apply the coating to the inside of the tunnel liners, bifurcates and pressure pipeline before or after installation and embedment. However, at the upstream end of the tunnel liner, the liner end and the inside and outside surfaces at least 300 mm downstream from the liner end shall be prepared and painted in accordance with this Subclause with epoxy mastic prior to embedment of the lining.

b) Where the coating is applied before installation, the coating shall end not closer than 150 mm to, nor further than 200 mm from, proposed welds.

c) Where the coating is applied to the inside of the tunnel liners, bifurcates and pressure pipeline after field assembly the Contractor shall provide means of storage and/or protection such that the surface will not corrode. The application of a primer coating in the factory followed by finish coats in the field will not be accepted

d) Other structures to be in immersed conditions, shall have ends and a 300 mm length of surfaces to be embedded to be prepared and painted in accordance with this Subclause with epoxy mastic.

e) All weld zones and edges shall be stripe coated with one coat of epoxy mastic for a width of not less than 100 mm on either side of the weld including the weld and a similar distance from all edges.

22.6.3. Repair of Damage

The Contractor shall be responsible for cleaning and repairing all coated areas which become defective or are otherwise damaged. All repairs shall be carried out in accordance with the coating manufacturer's instructions.

22.6.4. Supervision

The Contractor shall arrange for an authorised technical supervisor, experienced in the preparation and application of the specified coating systems, from the epoxy mastic manufacturer to be present during all surface preparation and coating applications, including all repair work, of the internal surface of the steel tunnel liners, bifurcates, pressure pipelines, and other metal works subject to continually immersed conditions. Such authorised supervisor shall have a power of attorney from the paint manufacturer to certify that all such preparation and coating applications have been carried out in accordance with the paint manufacturer's recommendations in all respects and shall submit such certification directly to the Employer with a copy to the Contractor. Such certification shall not relieve the Contractor of its responsibility under the Contract nor its requirement to carry out quality assurance procedures. The Contractor shall obtain the Employer's approval of the technical supervisor prior to his despatch to the Site or other location where painting shall be carried out.

22.6.5. Health Hazards

The Contractor shall take precautions to eliminate any health hazard that may arise during the application of the coating. Adequate ventilation to remove toxic fumes or dust shall be provided.

22.7. Portland Cement Wash

22.7.1. Requirement

The external surface of the Steel liners, bifurcates and pressure pipeline components which are to be embedded shall be descaled and coated with a Portland cement wash containing an effective corrosion inhibitor.

22.7.2. Materials

The cement wash shall consist of Portland cement complying with ASTM C150 Type I and an effective corrosion inhibitor mixed with water until the mix attains a creamy consistency. A binder may be added to the mix to improve adhesion of the cement wash to the steel surfaces.

22.7.3. Application

Application of the cement wash shall be by hand brushing with a stiff bristle brush to give a coating with a uniform thickness.

22.8. Galvanising

22.8.1. General

a) Galvanising shall be applied by the hot-dip process in accordance with ASTM A385 and shall comply with all the requirements of ASTM A385.

b) The erection marks shall be legible after galvanising.

c) Unless otherwise approved, welding, drilling and other working required for fabrication of the material shall be completed and all burrs and other defects removed before the galvanising process commences. All joints shall be seal welded before galvanising.

22.8.2. Film Thickness

The surface after galvanising shall carry an unbroken covering, uniform and smooth in appearance and thickness. All drops, lumps and adhering foreign material shall be carefully removed so that the galvanising is not damaged. The coating weight and thickness shall be in accordance with Table 22.8-1.

Table 22.8-1 : Coating Mass for General Ferrous Articles

Product	**Minimum average coating on any individual test area**	
	Coating mass (g/m^2)	**Equivalent thickness (micron)**
Steel 5 mm thick and over	600	84
Steel under 5 mm thick but not less than 2 mm	450	63
Steel less than 2 mm thick	350	49

Castings (iron and steel)	600	84

22.8.3. Repairs to Galvanising

Where the galvanised coat has been broken during fabrication or damaged in handling, the exposed surface shall be painted as soon as possible in accordance with the following procedure:

- Clean back to bright steel.
- Feather the edges of the surrounding galvanised coating.
- Degrease in accordance with relevant IS.
- Apply two coats of two pack zinc-rich epoxy primer giving a total dry film thickness of not less than 75 micron.

22.9. Painting Concrete, Blockwork and Plasterboard Surfaces

22.9.1. General

a) Concrete, blockwork and plasterboard surfaces shall be painted. The colour of all paints shall be as approved by the Employer.

b) The surface preparation and painting system to be used shall be as specified in Table 22.12-1.

c) The concrete exterior of buildings not required to be painted, including theWeir Site Control BuildingPlant and Switchyard Control Building, Power Conduit gate shaft hoist building, terminal structures, and standby generator building and water treatment plant building at the power station site shall be sealed with a silicone based sealant as specified in Table 22.12-1.

22.10. Painting and Varnishing Timber

22.10.1. General

a) Timber surfaces shall be painted or varnished. Colours of all paint and stains shall be as approved by the Employer.

b) The surface preparation and painting system to be used shall be as specified in Table 22.12-1.

22.11. Road Painting and Signs

22.11.1. Requirement

The Contractor shall provide and apply all paint coating materials for road markings and road signs.

22.11.2. Materials

a) Signs shall be reflectorised adhesive type on aluminium plate and shall conform with relevant IS or similar, such as ASTM D4280.

b) Road markings and paint shall conform with relevant IS or similar, such as ASTM D2792.

22.12. Inspection and Testing

22.12.1. General

a) Full and uninterrupted access to the Contractor's and any of its Subcontractor's workshops shall be provided to the Employer. The workshops shall possess illumination which, in the opinion of the Employer, is adequate for the application and inspection of protective coatings.

b) The Contractor shall provide all necessary inspection and testing equipment to monitor the quality of surface preparations and application of coatings.

c) The Contractor shall perform all measurements and complete all the tests specified in this Clause.

22.12.2. Surface Profile

The profile of the prepared metallic surface shall be measured by direct means such as by surface roughness testers, optical focussing systems, or needle gauges. Routine control may be achieved by the use of standard reference plates.

22.12.3. Coating Thickness

The coating thickness on metallic surfaces shall be measured by electromagnetic thickness meters at sufficient locations to define the minimum, maximum and average thickness. In accordance with relevant IS these meters shall be calibrated against standard soft brass or plastic shims of known thickness free from burrs in contact with plates of the same type of steel prepared by the same blasting process and achieving the same profile as that of the base metal and of the same initial thickness of the base metal. The meters shall be calibrated at the beginning and end of each set of measurements in any section of the work on any one day and if any discrepancy exists between the two calibrations, the meter will be re-calibrated and the measurements and procedure repeated until the two consecutive calibrations, before and after measuring the coating thicknesses in a section, are the same.

22.12.4. Coating Continuity

The continuity of the epoxy mastic coating on the internal surfaces of the tunnel liners, bifurcates and pressure pipelines, other surfaces to be continually immersed in water shall be checked using a low voltage wet sponge type Holiday detector. High voltage Holiday detectors shall not be used unless recommended by the paint manufacturer and approved by the Employer.

22.12.5. Other Tests

To verify the compliance of the coating with this Technical Requirements, other tests including adhesion tests and paint film sections shall be performed. Such areas shall be repaired by the Contractor in accordance with the provisions of this Technical Requirements.

22.12.6. Rejection

(a) Coating Materials

Coating materials which have deteriorated due to improper storage or which have been otherwise damaged or impaired or which do not comply with the manufacturer's specification shall not be used for the Works.

(b) Surface Preparation

Surfaces which have become damaged by any means or which do not meet the specified profile or conditions of cleanliness shall be reprepared before work continues.

(c) Weather

Surface preparation or coating shall stop if the environmental conditions are such that there is reasonable doubt as to the ability of the Contractor to fulfil the work to the specified standard. For this purpose wet and dry bulb thermometers shall be used in conjunction with standard dew point tables.

Coatings which have been applied under weather conditions which prevent proper curing or which have been marked by rain or condensation shall be liable to rejection.

22.12.7. Properties of Coating

Surface coatings which do not comply with the requirements for thickness may be liable to rejection or repair. Where there is reasonable doubt as to the quality or adhesion of the paint film, the Employer may direct the use of other tests to determine compliance or otherwise with the Technical Requirements. Failure to comply with the manufacturer's recommendations may render such coatings liable to rejection. Discontinuities revealed by Holiday detectors shall be repaired and the coatings may be rejected if the incidence of defects revealed by such testing appears excessive. Coatings showing excessive sags or runs shall also be liable to rejections.

Table 22.12-1 : Coating Systems

Feature	Surface Preparation	Primer	Body Coats	Finish Coats	Total Dry Film Thickness (micron except as noted)	Generic Coating System
SYSTEM A Exterior surfaces of pressure conduit exposed in or outside power station, structural steelwork in external locations.	Abrasive blast clean Angular surface profile 50 µm	Inorganic zinc silicate, 1 coat 65-75 µm	In all external locations: First stripe coat all edges and weld zones with one coat of epoxy micaceous iron oxide 100-125 µm, brush application. Followed by: Epoxy micaceous iron oxide Coat 1: 100-125 m Coat 2: 100-125	Catalysed Acrylic One coat, 50 µm	315-375 (excluding stripe coat)	Inorgamic Zinc, Epoxy, Catalysed Acrylic
SYSTEM B Internal surface of steel tunnel liners, bifurcates and pressure pipes and other surfaces in immersed conditions.	Abrasive blast clean Angular surface profile of 70 µm	Holding Primer may be used, 1 coat of 40 µm	Stripe coat to all edges and weld zones with one coat of Epoxy Mastic 200 µm, brush application	Epoxy Mastic Coat 1: 200-225 µm Coat 2: 200-225 µm	440-490 (with primer)	Epoxy

Feature	Surface Preparation	Primer	Body Coats	Finish Coats	Total Dry Film Thickness (micron except as noted)	Generic Coating System
SYSTEM C Internal surfaces of fuel storage tanks.	Abrasive blast clean Angular surface profile of 50 µm			High-build epoxy 3 coats @ 100 µm	300	Epoxy
SYSTEM D Ladders, platforms and handrails	Solvent degrease, clean rust or stain with wire brush to bright metal	Epoxy mastic 2 coats @ 125 µm			240-260 (paint only)	Hot-dipped galvanising plus heavy duty epoxy surface tolerant
SYSTEM E External surfaces of embedded steel tunnel liners and pressure pipes	Abrasive clean	Portland cement wash coating containing an approved inhibitor diluted to brushing			3 mm (minimum)	Cement wash
SYSTEM F Concrete surfaces	High pressure water wash with 27-35 MPa. Allow to dry for 7 days and moisture <8%			Exterior acrylic gloss, satin or matte 3 coats @ 50 µm	150	Acrylic

SYSTEM G1 Concrete blockwork surfaces	Clean from dust and stain, dust down and remove all surface contamination			Acrylic 3 coats @ 50 µm	150	Acrylic
SYSTEM G2 Concrete and concrete blockwork surfaces in battery room. Walls and ceiling only	High pressure water wash with 27-35 MPa. Allow to dry for 7 days and moisture <8%			Chlorinated rubber 2 coats @ 75 µm	150	Chlorinated rubber - chemical resistant
SYSTEM G3 Internal surfaces of transformer bays, septic tanks.	High pressure water wash with 27-35 MPa. Allow to dry for 7 days and moisture <8%			Epoxy mastic 2 coats @ 200 µm	400-500	Epoxy - oil resistant
SYSTEM G4 Internal surfaces of water supply tanks.	High pressure water wash with 27-35 MPa. Allow to dry for 7 days and moisture <8%			High-build, solvent free cycloaliphatic amine cured epoxy 2 coats @ 250 µm	500	Solvent free cycloaliphatic amine cured epoxy

23. ELEVATORS / LIFTS

23.1. General

(a) The Contractor shall supply, install, commission and maintain passenger Elevators/Lifts to be located in the Main Powerhouse, Auxiliary Powerhouse and in Dam as shown on the Drawings.

(b) The design and operation of the Elevators/Lifts and their associated equipment shall satisfy in all respects the requirements of relevant Indian standards and this Specification.

(c) The Contractor shall be responsible for obtaining all necessary approvals and registrations related to each lift installation.

(d) The Contractor shall supply all the requisite safety gear on the car and within the lift machine room. All on-car safety devices shall be fitted above the car roof line or below the car platform level.

23.2. Operation and Duty

(a) Each lift shall be suitable for carrying 10 passengers or 1000 kg mass of goods or any combination within these limits and capable of operating at a nominal speed of 1.5 m/s. Each car shall be sized so that a stretcher and bearers can readily enter.

(b) Accurate floor levelling is essential and the Elevators/Lifts shall incorporate a self-levelling feature to ensure that each car will automatically stop within ± 6.0 mm of the floor landings.

(c) The Elevators/Lifts shall handle all loads over the specified range of movements, smoothly and safely without excessive noise, the standard of performance in these respects being equal to modern recognised standards of good practice.

23.3. Controls

(a) Lifts operation shall be automatic. The control system shall allow for selection buttons on each floor and in the car. The operation of each lift shall be such as to provide an efficient handling of all calls.

(b) The control system shall allow for the following operational modes:

(i) Passenger service;

(ii) Fire fighting service;

(iii) Maintenance operation;

(iv) Top of Car operation;

(v) Standby mode.

(c) During periods when a car is idle the car shall remain at the last landing served with doors closed and powered down into standby mode.

(d) Opening a door or pushing the STOP button in a car shall immediately stop the lift.

(e) A power door operator shall be fitted to each car to open both the car and landing doors as the car comes to rest at any landing. The doors shall remain open for a sufficient duration to enable passengers to leave and enter the car. In the event of an obstruction preventing the doors from closing they shall reopen for a further period. Buttons shall be provided in each car to both close and reopen the car and landing doors when the car is standing at a landing.

(f) Each control system shall permit car position adjustment at landings from within the car.

(g) A load sensing device shall be provided for each lift which shall activate an audible alarm when the rated load is exceeded. The overload sensor when activated shall lock the landing and car doors open until the load in the car is reduced to below the rated load.

(h) The control systems shall sense over car travel via over travel limit switches or other approved sensing device.

(i) A set of UP-DOWN buttons shall be mounted on the top of each car and machinery room to allow the car to be operated for lift well inspections and maintenance purposes. Internal car control shall be locked out when operation from the top of a car or machinery room is active or when any access trapdoor is open.

(j) Fire fighting service control shall only be accessible from a fire fighter’s key.

23.4. Tolerances for the Construction of Civil Works

The tolerances to be observed during construction of the pits, lift wells and machine rooms will permit deviations from plumb, level or position, not exceeding:

(i) 25 mm from plumb of the walls of a pit and lift well throughout the full height;

(ii) Plus 12 mm minus zero in cross-section of a pit and lift well, at any section

(iii) Plus or minus 6 mm in the location of;

- the openings for door frames, door frame trims (landing entrances), door heads and door sills; and
- the openings for call button assemblies

(iv) 5 mm in the position of any embedded anchor bolt or attachment serving a similar function;

(v) 3 mm in the level of embedded soleplates or foundation plates.

Each lift well will be of concrete construction throughout its height.

23.5. Lifts Construction and Fittings

23.5.1. Construction

(a) Each lift car shall be of steel frame construction. The exterior surface of a car shall be finished flush using steel sheeting.

(b) Car walls shall be unperforated except where ventilating apertures are required. They shall have fire retardant properties and shall be so constructed that the noise level is kept to a minimum.

(c) Car floors shall be finished in steel with a floor covering of an approved tile. The internal walls of each car shall be satin finish stainless steel. A stainless steel hand- rail of section approximately 50 mm x 10 mm shall be bracketed to the walls.

(d) The ceiling of each car shall be clad with a white semi-gloss plastic laminate on a suitable backing panel making provision for a recessed light fitting and shall be provided with an electrically interlocked hinged trapdoor the under-surface of which, when closed, shall be flush with the ceiling.

(e) As temporary protection during construction, heavy duty vinyl or similar protective material shall be fixed to the operating panels, the interior walls and ceiling of the car and suitable protective surfaces laid on the floors. The fixing arrangements shall not impair the final appearance of the walls or ceilings (the hand-rail fixings may be used for this purpose). The temporary protection shall be supplied before Taking Over. The Contractor shall remove the temporary protection at the end of the Defects Notification Period and shall then reinstate the cars' finish to "as new" condition.

(f) Suitable non-slip material shall be used to cover the roof of the cars which shall form a working platform for maintenance personnel.

23.5.2. Ventilation

Ventilators of regulation surface area shall be fitted in the walls of the cars and shall be satin stainless steel finish.

23.6. Lights

Each car shall be provided with electric lighting that is permanently illuminated ensuring a light intensity of at least 150 lux at floor level. These lights shall be operated simultaneously from within the cars by means of one key. In addition, lights shall be provided above the roof and below the floor. A weatherproof, 240 volt switched socket-outlet shall be mounted above the roof. The exterior lights shall be operated simultaneously by means of two-way switches mounted on the roof and below the floor of each car. The socket-outlet and exterior lighting of each car shall be supplied from the 415/240 volt, 3-phase (4 wire with earth) 50Hz a.c. main supply.

The cars shall contain an emergency lighting system in accordance with the requirements of Indian Standards.

23.7. Operating Panel and Car Position

A flush-mounted, satin finish stainless steel operating panel shall be provided in each car to contain all operating buttons. The floor selection buttons shall be placed in the sequence or landings served and each button shall be numbered as detailed herein. When a floor is selected the button shall be illuminated. A regulation emergency 'STOP' button and 'DOORS OPEN' and 'DOORS CLOSE' buttons shall be provided in each car adjacent to the floor selection buttons, together with an 'ALARM' button which will operate an alarm annunciator for the Elevators/Lifts in the Powerhouse Control Room for the Elevators/Lifts in the Powerhouse reading 'LIFT ALARM'. Where possible recognised symbols shall be used on alarm and control buttons rather than written information.

Key operated switches shall be provided on the panel to permit a car and landing doors to be held in the fully open position, for loading when a lift is being used as a goods lift; for the control of the lift during inspection and maintenance operations carried out from the top of the car, and for operating lift 'OUT OF SERVICE' indicators.

A floor level indicator including direction of travel indicators shall be mounted over the doorway within each car.

23.8. Car and Landing Doors

(a) Dimensions

Car and landing doors shall be power operated bi-parting to give a clear opening of at least 1500 mm wide by 2400 mm high.

(b) Construction

Car and landing doors shall be fire resistant, satin finish stainless steel construction and shall be suspended and guided so that they operate smoothly. Rubber bumpers and/or dash pots shall be incorporated to minimise shocks when opening and closing doors.

Interlocks shall be installed to prevent landing doors from being opened in the normal manner at any floor other than the one at which a lift is at rest. These shall be capable of testing without dismantling. The landing doors at the top and bottom levels of each well shall be capable of being opened by means of a special key which shall be kept in a receptacle clearly marked 'Emergency Lifts Use Only' provided by the Contractor and kept in the Lifts Machinery Room.

(c) Landing Door Frames

The frames of the landing doors shall be square cornered, manufactured from heavy gauge steel or satin finish stainless steel, finishing slightly proud of concrete or facing panel and shall include all fittings necessary for efficient operation of the doors.

(d) Car Indicator and Call Button Panel

Each landing shall be provided with a satin finish stainless steel panel incorporating 'UP' and 'DOWN' call buttons (except the terminal landings which shall be provided with single call buttons); a car position indicator showing all landings served and identifying each by number, in engraved lettering; directions of travel indicators; and an indicator showing whether the lift is 'Out of Service'.

23.8.1. Car Frames and Safety Gear

(a) Car Frames

Car frames shall consist of members of steel construction, adequately braced for the fitting of the hoisting ropes, car guide shoes, safety gear, car platform and car.

A minimum of four (4) guide shoes (sliding or roller type) shall be fitted to each car.

(b) Safety Gear

Safety gear shall be designed to bring a car to rest automatically and smoothly, without damage to the guides or equipment or shock to passengers, within the required stopping distance. The safety gear shall be operated by an overspeed governor in accordance with the requirements of Indian Standards.

Each car platform shall have a maximum stopping distance of less than 500 mm from activation elevation of the safety gear.

Safety device reset shall only occur when a lift is operated in maintenance mode in upward direction. The safety devices shall be fitted with a positively opening safety gear switch of a type that will not reset unless the safety gear is reset.

Each car shall stop parallel to the horizontal plane ± 20 mm when the safety devices are applied.

23.8.2. Liftsing Ropes and Governor Ropes

(a) Liftsing ropes and governor cones shall comply with the requirements of Indian Standards.

(b) Means for adjusting the effective lengths of individual ropes during the life of the ropes, shall be provided.

23.8.3. Counterweights

(a) The counterweights shall be in the form of a rigid steel frame containing solid filler weights or a rigid steel tank filled with steel or iron ballast.

(b) Each counterweight shall be adequately guided and shall operate smoothly and incorporate all necessary safety devices.

(c) Car and Counterweight Guide Rails, Buffers and Metalwork

(i) Car and Counterweight Guide Rails

All non-working surfaces of the guides shall be finish painted.

Guide rails shall be of the T section type with suitable bearing area for the compressive forces associated with application of safety devices during raising or lowering operations.

Devices to guide rail clearance shall not exceed 1.75 mm during normal operating conditions.

(ii) Buffers

Energy accumulation type buffers with buffered return movement or energy dissipation type buffers shall be provided for each car and counterweight.

(iii) Metalwork

Chequer plate decking covering openings in the machine room floors shall be supplied by the Contractor. The decking shall be of the non skid type and shall be capable of withstanding a loading of 400 kg/m2 and or any other load which may be imposed by the equipment or by any reaction from such equipment. The decking shall be supported by embedded bolts. These bolts together with their associated nuts and washers shall be supplied by the Contractor. Openings provided for traction ropes, governor ropes etc., shall be provided with coamings.

The Contractor shall provide a permanent vertical ladder to obtain access to the floor of each pit from the bottom terminal landing.

All pit and lift well metalwork including uni-struts, soleplates, brackets, steel frames, buffers and any other miscellaneous metalwork shall be hot-dip galvanized.

(iii) Machine, Diverting Sheave, Liftsing Lugs and Lubrication

Each lift machine and controller shall be of proven reliability and shall be capable of providing smooth acceleration, precise speed regulation, gradual braking and levelling to within ± 6.5 mm. They shall be suitable for continuous operation under full load conditions. Design submissions shall include full details of the machine and control system and its performance.

Anti-friction type bearings shall be fitted throughout each gear box and to the outer extremity of the extended output shaft. Each gear box shall be totally enclosed and shall incorporate provision for oil bath lubrication of gearing and bearings. A sheet steel, lubricant drip tray shall be provided under each gearbox.

Machine bedplates shall be of fabricated steel construction or high grade cast iron construction. Bedplates shall be machined for the location of components and fitted with oil resistant resilient mountings for attachment to the machine support beams.

Beams supporting the machine bedplates shall be supplied by the Contractor and shall incorporate bearing plates and means for fastening on Site.

Car operational controllers shall be located in each Lifts Machinery Room. All electrical contact points in the controller cabinet shall be protected against accidental contact when the controller door is open.

Microcomputer controllers shall be suitably protected from line noise and be designed to allow reprogramming.

Each controller cabinet shall be dust proof, insect and rodent proof, key lockable and not present any danger to personnel when locked.

Anti-friction bearings shall be used to support the shaft of each diverting sheave. If the diverting sheave bearings are located beneath the level of its Lifts Machinery Room floor, inspection and maintenance facilities shall be provided.

Liftsing lugs shall be provided on each major component to facilitate handling by means of a hoist suitably identified and provided for this purpose by the Contractor.

High pressure grease lubrication shall be used on all machine bearings, unless specified otherwise, and every point requiring lubrication shall be suitable for the same make and grade of grease and shall be provided with a separate pipe and nipple. All grease nipples shall be located at positions which can be reached safely even when a machine is in operation. For this purpose the Contractor shall provide all grease pipes, flexible hoses, swivel connections, pipe clips and other necessary fittings.

23.8.4. Power Supply Cabinet and Cables

(a) The Contractor shall provide a power supply cabinet for each lift containing a ‘lift mains’ isolating switch, the car’s light and power fuses, ‘out-of-service’ indicator light fuses, circuit-breaker fuses, alarm annunciator terminals and overload relays. The Contractor shall connect the incoming supply wiring into the cabinet. Each power supply cabinet shall be located in a Lifts Machinery Room.

(b) Travelling cables shall be connected to its car through a junction box. They shall be arranged so the cables do not touch the well walls or car except where connected.

23.8.5. Noise Level

Noise levels shall comply with the requirements of International Standards.

23.8.6. Alarm Circuits

(a) Alarm Button

The Contractor shall provide an alarm button labelled ‘ALARM’ in each lift car. Upon initiation of this alarm button, an alarm shall appear on the Powerhouse annunciation panel in each respective Control Room as well as on the Distributed Control Systems.

(b) Level Relay

The Contractor shall provide, install and connect a submersible level relay in the base of each lift well. The level relay shall be a Mobrey float-switch. Operation of the relay shall cause a lift to cancel all calls registered; to proceed to the top terminal landing where it shall remain inoperative until the relay is reset; and to actuate the ‘OUT-OF-SERVICE’ indicators at each landing. A contact shall be provided to actuate an alarm in the control rooms designated ‘LIFT WELL FLOODED’.

(c) Telephone

The Contractor shall provide a telephone for emergency communication in each lift car. The telephone wiring from the car shall be taken adjacent to, or inside, the power supply cabinet from where connection to the station or powerhouse control building telephone system will be made. All telephone wiring and terminals shall be segregated from other systems.

(d) Landing Bell

Each lift shall be fitted with a landing bell which will trigger just prior to a car coming to rest at any landing.

(e) Lifts Wells and Pits

Each lift well and pit shall be provided with lighting that ensures a light intensity of greater than 40 lux in the well.

Each pit shall include an access ladder from the lowest landing to the bottom of the pit. An emergency lift stop button shall be included in each pit within reach of the ladder.

A waterproof general purpose power outlet socket with residual current device shall be installed in each pit.

23.8.7. Instruction and Warning Notices

(a) The Contractor shall provide and affix all necessary load, warning and instruction notices for the installations in accordance with the local statutory requirements and Indian Standards.

(b) An Information Plate shall be fitted inside each car directly above the control panel. The plate shall indicate:

- Lifts manufacturer, address and contact details (and supplier if the supplier is not the manufacturer)
- Make, model and serial number of lift
- Rated maximum load in kilograms
- Rated maximum number of passengers; and
- Maintenance service providers address and contact details.

23.8.8. Maintenance Tools and Appliances

(a) Tools

The Contractor shall supply any tools and equipment necessary for adjustments and maintenance operations. The tools and equipment shall be included in the Tender Price.

(b) Lifts Machinery Room Liftsing Tackle

The Contractor shall provide and install an electrically operated underhung monorail hoist in each Lifts Machinery Room for installation of the lift machinery and future maintenance.

(c) Maintenance of Lifts

The Contractor shall be responsible for all routine and breakdown maintenance required to meet safety and regulatory requirements up until the end of the Defects Notification Period.

23.9. Control System Interface

The following table contains indicative data transfer for all Elevators/Lifts to the distributed control systems.

Ref	Description	Type	Local	DCS
1	Fault	Alarm	Π	Π
2	Shaft flooded	Alarm	Π	Π
3	Machinery Room Temperature High	Alarm	Π	Π

Types: alarm – alarm; analog – measurement or set point; control – control; prot – alarm and protection operation; status – digital (on/off) indication.

23.10. Tests on Plant

23.10.1. General

(a) Tests to establish whether the specified requirements have been met shall be carried out by the Contractor in accordance with the requirements below and the relevant engineering standards.

(b) The Contractor shall coordinate and liaise with the other Contractor's in planning and performing tests of his equipment with other Contractor's.

(c) All costs associated with Tests on Plant shall be included in the unit prices tendered for each item of equipment.

23.10.2. Tests During Manufacture

All plant and equipment shall be subject to tests during manufacture, plus any additional requirements for specific items as detailed in this Clause.

23.10.3. Tests at Site

The Contractor shall conduct the tests at Site in accordance with approved International Standard.

23.10.4. Reliability Tests and Reliability Test Periods

(a) All mechanical and electrical plant shall be subject to Reliability Tests and Reliability Test Periods in accordance with approved International Standard.

(b) The Reliability Tests shall be carried out upon satisfactory completion of all Commissioning and Performance Tests for that item of plant.

(c) The Reliability Test Period for each item shall commence after satisfactory completion of all Commissioning and Performance Tests for that item of plant.

23.10.5. Witnessing of Tests

The Tests on Completion (Commissioning, Performance and Reliability Tests) will be witnessed by the Engineer and the representative(s) of the Employer.

23.11. Tests on Elevators/Lifts

23.11.1. General

All materials and components shall be subject to type, sample and routine tests and inspection while in process of and upon completion of manufacture. For each piece of material, plant or components, the inspection and tests shall consist of, but shall not be limited to, the following:

- the relevant tests and inspections as specified;
- the tests and inspections required by the relevant standards; and

- such other tests and inspections as may be necessary in the opinion of the Engineer to demonstrate compliance with the Contract.

23.11.2. Test During Manufacture

Appropriate test certificates for main components shall be provided in accordance with Indian Standards.

24. ILLUMINATION SYSTEM

24.1. Scope Work

The scope of work to be covered under this specification shall include design, manufacture, engineering, inspection and testing at Contractor works, Insurance, packing, forwarding to site, unloading, erection, testing & commissioning of the equipment, handing over and compliance with guarantees as per the specification hereunder complete with auxiliaries, accessories, spare parts and warranting a trouble free & safe operation of the installation.

Any item or works though not specifically mentioned in this specification but needed to complete the equipment & systems for its trouble free & safe operation meeting the intent of the specification shall be deemed to be included in scope of Contractor.

24.2. Scope of Supply

The scope of supply shall be a comprehensive functional system covering all supply and services including but not be limited to following:

24.2.1. Normal Lighting

a. Lighting cabinets / distribution boards.

b. Lighting equipment, including the light fittings

c. All outdoor street lights with photocell operation and timer.

d. Control points, including push-buttons or switches, dimmers, smart switches / sensors.

e. Street light poles, masts for outdoor lighting.

f. All cabling and wiring including conduits, racks, ducts, channels or any other media of cable runs and associated accessories / fixtures/ fasteners for normal lighting system.

g. Conventional earthing system as per IS 3043

24.2.2. Emergency Outdoor Lighting System

a) Emergency outdoor lighting shall comprise of:

i) Emergency lighting boards.

ii) Power invertors.

iii) Lighting equipment, including the light fittings.

iv) All cabling and wiring including conduits, racks, ducts, channels or any other media of cable runs and associated accessories / fixtures/ fasteners for emergency lighting system.

b) Illumination panels as per requirement complete with cubicles, bus-bar system, circuit breakers, instrument transformers, instruments cabling and wiring and complete with all other accessories.

c) Spare parts as per this chapter

d) Tools and instruments as per this chapter.

Any other item not specified above but considered necessary for safe, reliable & trouble free operation shall be deemed to have been included in the scope of supply by Contractor.

24.3. Codes and Standards

Equipment shall be designed, built, tested and installed according to the latest relevant standards including amendments or complementary standards but not limited to the following:

Standards Description

IEC 60598 Luminaries

IEC 60309 Plugs, socket outlets and couplers for industrial requirements

IS 6665 Code of practice for industrial lighting

IS 10322 Specification for luminaries

IS 3646 Code of practice for interior illumination

ISO 9001 Quality systems – Model for quality assurance in design, development, production, installation and servicing.

Note: The latest edition of the above codes shall be referred.

Equipment conforming to any other equivalent standard(s) shall also be acceptable, however in such eventuality, the salient points of difference between the standards adopted and the standards mentioned above shall be clearly brought out for approval.

24.4. Rating and Design Requirement

The outdoor lighting for, Dam, Surge shaft, BFV area shall be supplied from respective illumination boards, which shall be fed from local Main LV Board.

24.4.1. Area for outdoor lighting

Outdoor lighting shall cover the following areas as listed below:

a) Approach road to dam up to 1000 m.

b) Approach road to Outdoor switchyard areas up to 1000 m.

c) Valve house approach road up-to 1000 m.

d) Valve house road to surge shaft top approach.

e) Downstream draft tube gate gallery.

24.4.2. Design Conditions

a) Lighting will be designed to provide different illumination levels in various facilities. The illumination system will comprise of the following:

i) Outdoor lighting system.

ii) Emergency lighting system.

b) In general, the type of lighting fixtures in all the areas shall be elegant, easily replicable and available in Indian market and of very high quality. Design & make of all the fittings & fixtures shall be approved by Owner during detail design stage. Following type of lighting may be used for illumination:

i) Road lighting – high pressure sodium.

ii) Parking areas – high pressure sodium.

iii) Solar light fixtures

24.4.3. Illumination levels

Lighting will be designed to provide the following illumination levels in various facilities, as indicated below. The illumination levels are in conformance with the values in the IES (Illuminating Engineering Society) lighting recommendations.

S No.	Area	Illumination Levels (Lux)
1	Road lighting	20
2	Paring / Yard lighting	20
3	Emergency Lighting	20

24.4.4. Emergency lighting system:

In case of Normal AC supply failure, an emergency lighting system shall be provided in all areas. Emergency lighting shall be provided from DC systems along with dedicated power inverter and associated accessories. It will provide essential lighting in all the areas such as entrance. Solar lighting shall also be considered.

24.5. Construction and Functional Characteristic

24.5.1. Distribution boards

The boards shall be of wall-mounted/panel type and shall be suitably located. The boards shall be made of sheet steel not less than 2.5 mm thick and provided with front hinged cover for further enabling the board to be unscrewed for inspection of wiring in the board.

Boards shall be waterproof and shall be provided with glands or adapters to receive a screwed conduit.

24.5.2. Switchboards

The switchboards shall be of heavy duty and modular type and shall be located 1.5 meters above the floors. All the switches shall be of piano type and shall have silver cadmium contacts. Multiple plug power sockets shall be capable of taking at least one 3-pin plug and one 2-pin plug simultaneously. Each type of power socket shall have elliptical spring loaded contacts.

24.5.3. Cables

The cables shall be of Aluminium, 1000 V grade, PVC insulated, armoured for interconnection of lighting poles & panels. All single core cables shall be of copper flexible conductor from pole control box to light fixtures. Minimum size of copper conductor for single core cable shall be 2.5 mm^2.

The insulating material of cable shall not deteriorate with age or due to the voltage stresses etc. Each cable coil shall be accompanied by the manufacturer’s test giving the results of the insulation test.

The wiring shall be done in looping back system. No joints shall be made at intermediate points in the given length of the cables.

The cable can be buried on road crossing using duct

The cables shall be properly terminated by using lugs or other approved arrangement.

24.5.4. Earthing

The earthing of all lighting poles & panels shall be provided with GI wire.

24.5.5. Maintenance ladders and platforms

Wheel mounted platform with ladder for maintenance of overhead lighting system shall be of collapsible type of height suitable for maintenance of outdoor fixtures.

24.6. Performance Guarantee

The Illumination system and associated equipment shall be capable of performing intended duties under specified conditions. The Contractor shall guarantee the reliability and performance of the individual equipment as well as of the complete system.

24.7. Quality Assurance and Control

The Contractor shall supply the equipment of best quality. The Contractor shall maintain control and quality assurance during the manufacturing, installation, testing and commissioning of equipment as per approved quality assurance plan.

24.8. Drawings, Documents and Design Calculations

24.8.1. Drawings & documents

The Contractor shall submit all the design drawings and documents for review / approval covering at least the following:

a) Layout plan for illumination system.

b) Type of luminaries, fittings, etc.

c) Drawings for Lighting panels etc.

d) Lighting Pole & mast details.

e) Details of Solar fixtures.

f) Cable routing details.

24.8.2. Design calculation

The Contractor shall submit all the design calculations for review / approval, covering at least the following:

a) Calculations for the illumination levels of the different areas with respect to installation plan

b) Cable sizing

24.9. Tests

24.9.1. Shop tests

The components of illumination system shall be routine tested as per relevant IEC with latest amendments. All shop tests shall be carried out at the manufacturer works.

The following tests shall be done:

a) Test on lighting fixtures and lamps shall be performed as per IS 10322 (part IV and V)

i) Resistance to dust and moisture.

ii) Insulation resistance test.

iii) High voltage test.

iv) Photometric test.

v) Dry IR and HV test.

vi) Photometry test.

b) HV and IR test on panels.

The lighting distribution boards and lighting panels (including the components) shall be assembled at the manufacturer’s works with complete equipment & accessories and shall be tested in accordance with the requirements of relevant Indian standards/Indian electricity rules etc.

24.9.2. Acceptance test and routine test

All lighting fixtures, lamps and other items shall be subjected to acceptance and routine tests, as per relevant specified standards.

Junction boxes etc. shall be subjected to Physical and dimensional checks.

24.9.3. Galvanizing tests

The quality of galvanizing shall be smooth, continuous, free from flux stains and shall be inspected visually.

In addition, following tests shall be conducted as Acceptance tests:

a) Uniformity of coating - The coating of any article shall withstand four 1-minute dips in standard copper sulphate solution without the formation of an adherent red spot of metallic copper upon the basic metal.

b) The quality of cadmium / zinc plating on items with screw threads shall be free from visible defects such as unplated areas, blisters and modules and shall be inspected visually.

c) In addition, the plating thickness shall be determined microscopically/ chemically or electronically.

24.9.4. Field Tests

All field tests including tests during installation shall be conducted by the Contractor in presence of representative of the Owner.

Following tests shall be performed:

a) Verification of electrical continuity between exposed conductive parts and the general earth circuit

b) Testing of main and auxiliary circuit insulation

c) Complete functional testing of illumination system d) Lux level measurement as per approved drawings

24.10. Spare Parts

24.10.1. Recommended spare parts

The Contractor shall propose the list of spare parts including their make and detailed specification for trouble free operation & maintenance of the equipment.

24.10.2. Mandatory spare parts

Mandatory Spare Parts to be supplied under this section are as follows:

S No.	Description	Quantity
1	High pressure sodium vapour lamps complete with all accessories and fittings	5 % of installed quantity
2	DC lamps complete with all accessories and fittings	5 % of installed quantity
3	All type of switches, contactors, terminal blocks	5 % of installed quantity

24.11. Tools and Instruments

24.11.1. Recommended tools and instruments

The Contractor shall propose one (1) set of all necessary special tools and maintenance equipment for repair and maintenance of system as recommended by the manufacturer.

24.11.2. Mandatory tools and instruments

The following tools & testing equipment shall be supplied by Contractor in addition to other recommended tools and testing instruments / equipment required for easy maintenance & repair /replacement of fittings.

a) Wheel mounted platforms with ladder for maintenance of overhead lighting system. b) Tool kit.

24.12. Installation and Commissioning

The Contractor shall arrange personnel to oversee proper storage of equipment at site, their transhipment to site, installation and commissioning etc.

All installation work shall be done by skilled workers in a workmanlike manner.

25. HEALTH & SAFETY

Suitable scaffolds in accordance with Indian Standard/ International Standards shall be provided for workmen for all works that cannot safely be done from the ground, or from solid construction except such short period work as can be done safely from ladders. When a ladder is used, an extra workman shall be engaged for holding the ladder. If the ladder is used for carrying materials as well, suitable footholds and handholds shall be provided on the ladder and the ladder shall be given an inclination not steeper than 0.25 to 1 (0.25 horizontal and 1 vertical)

Scaffolding or staging more than 3.6 m above the ground or erected floor, swung or suspended from an overhead support or erected with stationary support shall have a guard rail properly attached, bolted, braced and otherwise secured at least 0.9 m high above the floor or platform of such scaffolding or staging and extending along the entire length of the outside and ends thereof with only such opening as may be necessary for the delivery of the materials. Such scaffolding or staging shall be so fastened as to prevent it from swaying from the structure.

Working platform, gangways and stairways shall be so constructed that they do not sag unduly or unequally, and if the height of the platform or the gangway or the stairway is more than 3.6 m above ground level or floor level, they shall be closely boarded, and shall have adequate width and shall be suitably fastened

Every opening in the floor of a structure or in a working platform shall be provided with suitable means to prevent the fall of persons or materials by providing suitable fencing or railing whose minimum height shall be 0.9 m. Employees working on steep slopes or otherwise subject to possible falls from levels not protected by guard-rails or safety nets, shall be secured by safety belts and lifelines.

Safe means of access shall be provided to all working platforms and other working places. Every ladder shall be securely fixed. No portable single ladder shall be over 9.0 m in length while the width between side rails in huge ladder shall, in no case, be less than 28 cm. for ladder upto and including 3.0 m in length. For longer ladders, this width shall be increased at least by 6 mm for each additional 30 cm of length. Uniform step spacing shall not exceed 30 cm. Adequate precautions shall be taken to prevent danger from electrical equipment. No materials on any of the sites of work shall be so stacked or placed as to cause danger or inconvenience to any person or the public.Control of the Progress of Work

25.1. Excavation and Trenching

All trenches, 1.2 m or more in depth, shall, at all times, be supplied with at least one ladder for each 30 meters length or fraction thereof. Ladder shall be extended from bottom of the trench to at least 0.9 m above the surface of the ground. The side of the trenches which are 1.5 m or more in depth shall be stepped back to give suitable slope or securely held by timber bracing, so as to avoid the danger of sides to collapse. The excavated materials shall not be placed within 1.5 m of the edges of the trench of half of the depth by the trench whichever is more. Cutting shall be done from top to bottom. Under no circumstances undermining or undercutting shall be done.

25.2. Demolition

Before any demolition work is commenced and also during the process of the work:

(i) All roads and open areas adjacent to the site shall either be closed or suitably protected.

(ii) No electric cable or apparatus which is liable to be a source of danger over a cable or apparatus used by the operator shall remain electrically charged.

(iii) All practical steps shall be taken to prevent danger to persons employed from risk of fire or explosion or flooding. No floor, roof or other part of the structure shall be overloaded with debris or materials as to render it unsafe.

All necessary personal safety equipment conforming to Indian Standard/ International Standards as considered adequate by the Engineer shall be kept available for the use of the persons employed on the site and maintained in condition suitable for immediate use, and adequate steps shall be taken to ensure proper use of equipment by those concerned.

(i) Workers employed on mixing asphaltic materials, cement mortar and cement concrete shall be provided with protective footwear and protective goggles.

(ii) Those engaged in mixing or stacking of cement bags or any materials which is injurious to eyes shall be provided with protective goggles.

(iii) Those engaged in welding works shall be provided with welder's protective eye shields.

(iv) Stone breakers shall be provided with protective goggles and protective clothing and seated at sufficiently safe intervals.

(v) Men below the age of 18 years shall not be employed. Whenever men above the age of 18 years are employed on the work of lead painting, the following precautions shall be taken: -

(a) No paint containing lead, sulphate of lead or products containing their pigments shall be used except in the form of paste or ready-made paint.

(b) Suitable face masks shall be supplied for use by the workers when paint is applied in the form of spray or a surface having lead paint dry rubbed and scrapped.

(c) Overalls shall be supplied to the workmen and adequate facilities shall be provided to enable the working painters to wash on cessation of work.

(d) Measures shall be taken, wherever required, in order to prevent danger arising from the application of a paint in the form of spray.

(e) Measures shall be taken, whenever practicable, to prevent danger arising from dust caused by dry rubbing down and scrapping.

(f) Suitable arrangement shall be made to prevent clothing put off during working hours, being spoiled by painting materials.

(g) Cases of lead poisoning and suspected lead poisoning shall be notified and shall be subsequently verified by a medical officer.

(h) When necessary, medical examination of workers may be got done.

(i) Instructions with regard to special hygienic precautions to be taken in the painting trade shall be distributed to working painters.

(vi) Observe all safety precautions to control the noise on all sites and also provide all workmen deployed in the affected areas with the necessary equipment for safety against noise.

When the work is done near any place where there is risk of drowning, all necessary equipment shall be provided and kept ready for use and all necessary steps taken for prompt rescue of any person in danger and adequate provision shall be made for prompt first aid treatment of all injuries likely to be sustained during the course of the work.

Use of hoisting machines and shackle including their attachments, anchorage and supports shall conform to the following standards or conditions:-

(i) These shall be of good mechanical construction, sound materials and adequate strength and free from patent defect and shall be kept in good working order.

(ii) Every rope used in hoisting or lowering materials or as a means of suspension shall be of durable quality and adequate strength and free from patent defects.

(iii) Every crane driver or hoisting appliance operator shall be properly qualified for his job.

(iv) In case of every hoisting machine and of every chain ring hook, shakcle swivel and pulley block used in hoisting or as means of suspension, the safe working load shall be ascertained by adequate means. Every hoisting machine and all gears referred to above shall be plainly marked with the safe working load.

(v) In case of hoisting machine having a variable safe working load, each safe working load and the conditions under which it is applicable shall be clearly indicated. No part of any machine or any gear referred to above in this paragraph shall be loaded beyond the safe working load except for the purpose of testing. The capacity of the hoisting machines shall be periodically checked.

(vi) The safe working load of the machines whenever brought to site shall be verified and recorded.

Motors, gearing, transmission, electric wiring and other dangerous parts of hoisting appliances shall be provided with efficient safeguards. Hoisting appliances shall be provided with such means as shall reduce to the minimum, the risk of accidental descent of the load. Adequate precautions shall be taken to reduce to the minimum, the risk of any part of a suspended load becoming accidentally displaced. When workmen are employed on or near electrical installations which are already energized, insulating mats, wearing apparel, such as gloves, sleeves and boot, as may be necessary, shall be provided. The workers shall not wear any rings, watches and carry keys or other materials which are good conductors of electricity.

All scaffolds, ladders and other safety devices mentioned or described herein shall be maintained in safe conditions and no scaffold, ladder or equipment shall be altered or removed while it is in use. Adequate washing facilities shall be provided at or near places of work.

These safety provisions shall be brought to the notice of all concerned by display on a notice board at a prominent place on the site. The person responsible for compliance of the safety code shall be named and notified.

To ensure effective enforcement of the rules and regulations relating to safety precautions, the arrangements made shall be open to inspection by the Labour Officer or the Owner In addition to above, following specific precautions for the underground works shall be taken :

(i) All precautions regarding safety of personnel working in tunnels/caverns/shafts, in connection with the handling of electrical installations, loading, blasting and seepage water etc. as specified in the relevant stipulations of IS Codes shall be taken in order to ensure safe underground working. Adequate medical, drinking water, sanitation, lighting and ventilation facilities shall also be provided.

(ii) Emergency material shall be provided at each underground excavation heading. This equipment shall include, but not be limited to the following:-

- 3 stretchers
- 3 woolen blankets
- 2 appliances for artificial breathing
- 1 oxygen flask
- 3 explosion-proof lamps
- wool dressing and disinfection material
- anti-pain injections
- gas masks
- any other equipment as required as per Indian/International Standards

(i) At least two members of the Rescue Team as described hereinafter, properly instructed and trained in the rescue procedures, shall be in each crew working underground.

(ii) Prior to the commencement of construction, the Contractor shall organise and train a Rescue Team composed of his employees. This Rescue Team shall be capable to render help after accidents caused by fire, gas explosion and avalanche etc.

(iii) The Rescue Team shall be organised in such a way that sufficient number of members are ready for action at any time until the completion of works.

(iv) The Rescue Team members shall be instructed and trained for their task by a qualified and experienced person. If required, the contractor shall hire an outside specialist to perform such training. A refresher training for all members of the Rescue Team shall be conducted at least every six months.

(v) Each Rescue Team member shall be skilled in giving the first aid, dealing with the appliances for artificial respiration and fire fighting equipment and shall possess good local knowledge. Adequate equipment for reaching even the remotest working area shall be at their disposal.

(vi) The details of the proposed Rescue Team organisation shall be displayed.

At all times exercise reasonable and proper precautions for the safety of the people on the works shall be exercised and compliance with the provisions of current safety laws and building and construction codes of the State Government as may be applicable shall be ensured. All machinery and equipment and other sources of physical hazards shall be properly guarded.

Provide full time staff exclusively in-charge of safety of the work ensuring that all safety regulations are followed and in-charge of indoctrination and teaching courses on safety to the work force.

Provide all necessary fencing and lights to protect the public from accidents. Following shall be ensured for employees:-

(i) Each employee shall be provided initial indoctrination regarding safety so as to enable him to conduct his work in a safe manner.

(ii) No employee shall be given a new assignment of work unfamiliar to him without proper introduction as to the hazardous incident thereto, both to himself and his fellow employees.

(iii) Under no circumstances shall an employee hurry or take unnecessary chances when working under hazardous conditions.

(iv) Employees shall not leave naked fires unattended. Adequate fire fighting equipment shall be provided at crucial locations.

(v) Employees under the influence of any intoxicating beverage, even to the slightest degree, shall not be permitted to remain on work.

(vi) There shall be a suitable arrangement on every site for rendering prompt and sufficient first aid to the injured.

(vii) The stair cases and passage ways shall be adequately lighted.

(viii) The employees, when working around moving machinery, shall not be permitted to wear loose garments. Safety shoes are recommended when working in places where materials or tools are likely to fall. Only experienced workers shall be permitted to go behind guard rails or to clean around energised or moving equipment.

(ix) The employees shall use the standard protection equipment intended for each job.

Each piece of equipment shall be inspected before and after it is used. The following precautions shall be taken for fire prevention:

(i) All construction areas and storage yards shall be kept clean and well arranged.

(ii) A clear space of 15 metres around the outer boundary of saw mill and lumber storage area may be provided. All lumber shall be stored in sections with fire breaks with a distance of 15 metres between consecutive sections.

(iii) All combustible waste material, wood scaling and soiled rags etc. shall be removed daily and burnt in suitable burning areas. The saw mill and lumber yard shall be kept free from acm3ulation of combustible debris.

(iv) Fires, welding, flame cutting shall in general not be permitted in combustible areas. Fires and open flame devices shall not be left unattended.

(v) Smoking shall be prohibited in all fireprone areas, flammable material storages viz. carpentry, paint shops, garages, service stations etc. "No Smoking" signs shall be pasted on all such areas.

(vi) Accumulations of flammable liquids on floors, walkways etc. should be prohibited. All spills of flammable liquids shall be cleaned up immediately.

(vii) Smoke pipes from Diesel Engines passing through roof of combustible material e.g. in compressor stations on various sites shall be insulted by asbestos. All joints of smoke pipe shall be riveted, welded or otherwise securely fastened together and supported to prevent accidental displacement or separation. The joints shall not be leaky.

(viii) Flammable liquids, lubricants etc. shall be handled and transported in safety containers and drums which can be kept tightly capped.

(ix) Storage of fuels and other flammable materials and liquids shall be set not less than 100 m away from the works and permanent installations. All storage installations and tanks shall conform to the regulations set out in relevant Indian Standards.

(x) Petrol or other flammable liquids with a flash point below 100 degree centigrade shall not be used for cleaning purposes.

(xi) Oxygen cylinders shall not be stored with combustible materials.

(xii) All electric installations shall be properly earthed. Repairs shall not be made on electrical circuits until the circuit has been de-energized.

The following fire fighting arrangements shall be made.

(i) Fire extinguishers and fire buckets, painted red, shall be provided at all fire hazardous locations viz. Batching and Mixing Plant, Winch houses, Workshops, Store yards, Saw-Mill, Switch Gear Room, Compressor Stations, Office establishments etc. The extinguishers shall be inspected, serviced and maintained in accordance with manufacturer's instructions. The inspection shall be evidenced by notations on tag attached to the extinguisher.

(ii) Full reliance shall never be placed on portable hand extinguishers as all of these have a very limited capacity. Water, in ample quantity and under adequate pressure, shall always be available for fire fighting.

(iii) Where a group of work points are located beyond the range of protection from a public water supply, the installation of a water system for private fire protection shall be warranted.

(iv) Evacuation facilities and fire exit shall be provided at all locations featuring fire hazards.

(v) Siren or other suitable fire alarm arrangement shall be made on all sites. Warning signs shall be pasted at all locations having fire hazards.

(vi) All staff shall be conversant with the use of all types of fire extinguishing apparatuses.

(vii) Demonstrations and training in fire fighting shall be conducted at sufficient intervals to ensure that sufficient personnel are familiar with and are capable of operating fire fighting equipment.

When any work is carried on, which is likely to affect the security or stability of an installation or structure or any part thereof and endanger any person employed, all practicable precautions shall be taken by shoring or otherwise to prevent collapse of structure or fall of any part thereof and thus remove the cause of danger to such structures and the persons employed.

For persons engaged in handling of corrosive materials, adequate equipment shall be provided.

Where, in connection with any grinding, cleaning, spraying or manipulation of any material, there is emission of any dust or fume of such character and to such extent as likely to be injurious to the health of persons employed, all practical measures shall be taken by securing adequate ventilation or by the provision and use of suitable respirators or otherwise to prevent inhalation of such dust and fume.

In addition to instructions contained in this Chapter, the safety regulations contained in the following ISI Codes shall apply.

(i)	IS:3764-1966	Safety Code for Excavation Work
(ii)	IS:4756-1978	Safety Code for Tunnelling Work (Reaffirmed 1987)
(iii)	IS:7293-1974	Working with Construction Machinery (Reaffirmed 1987)
(iv)	IS:7969-1975	Handling and Storage of Building Materials. (Reaffirmed 1987)
(v)	IS:4081-1986	Blasting and related drilling operations
(vi)	IS:3696-1987 (Part-I)	Scaffolds & Ladders (Pt.I Scaffolds)
(vii)	IS:3696-1966 (Part-II)	Scaffolds & Ladders (Pt.II Ladders)
(viii)	IS:4138-1977	Working in compressed air (Ist revision) (Reaffirmed 1987)
(ix)	IS:4130-1976	Demolition of Buildings (Ist revision)
(x)	IS:5916-1970	Construction involving use of hot Bituminous materials
(xi)	IS:3016-1982	Fire protection in welding and cutting operation.
(xii)	IS:5878-1971	Code of practice for construction of Tunnels (Part-II Sec.2)

25.3. Environmental obligations

(i) The Contractor shall, during the whole period of the Works comply fully with all Indian laws and regulations relating to environmental protection, mitigating measures for reducing environmental impacts and remedial works on completion of the Works. This obligation shall extend to the construction sites themselves, all the Contractor's site installations, and all quarries, borrow areas and spoil pits.

(ii) Notwithstanding any specific obligations as these may be specified in prevailing Indian laws and regulations, the Contractor shall at all times comply with the following particular requirements for the protection of the environment, the local population and the workers at the construction site:

(a) Collect, treat, remove from site and dispose of in accordance with the regulations and to the satisfaction of the Engineer-in-charge all domestic and industrial waste and excess construction materials (both solid and liquid), fuel, chemicals and other matter.

(b) Make every effort to minimise the harmful effects of transport to and from the site, in particular vehicle emissions and noise and the control of dust on roads.

(c) Provide its work force with fuel for cooking and heating and ensure that workers on the site do not cut wood or other vegetation as firewood.

(d) Take measures and construct works, on the instructions of the Engineer- in-charge, to prevent soil erosion from slopes in the construction area.

(e) Not clear any areas of forest or woodland without the authority of the Engineer-in-charge.

(iii) In order to reduce adverse effect on public health resulting from the influx into the project area on construction workers, the Contractor will be obliged to undertake during the whole construction period the following preventive measures:

(a) Ensure that all construction staff and workers, prior to being accepted to work on site, submit certificates of good health and, during the construction period, ensure that all employees are give a periodic physical examination (at least once a year and following any serious illness) by a qualified medical practitioner.

(b) Ensure that any workers suffering from notifiable contagious illnesses are removed form the site for treatment and are not permitted to return to the site without an update medical certificate.

(c) Carry out regular spraying of all parts of the site and site installations to control mosquito vector diseases, using approved insecticides.

(d) Implement a control programme to ensure the maintenance of satisfactory sanitary conditions on the site and in the living areas, and report to the Engineer-in-charge all cases of serious enteric andlor water-borne illness.

(iv) The Contractor will send Environment Officer to constituted project environmental monitoring committees, as instructed by the Engineer-in-charge, and will at all times comply with the requests of said committees with regard to the need for environmental or health protection measures. He will also maintain close contact with local representatives and government institutions in addressing issues arising from the construction activities. Such issues needing particular attention are the following.

(a) Pollution caused by construction work.

(b) Disputes related to the leasing of land for construction activities and/or site installations etc,

(c) Disputes arising from traffic congestion and restrictions on the use of the main project access road and roads in the project area.

(d) All matters relating to road safety and the reduction to a minimum of the risk of traffic accidents.

(v) The Contractor will submit to the Engineer-in-charge monthly reports on environmental performance and control. These reports will give details of all environmental protection measures taken during the months, as well as:

(a) Any environmental problems encountered during the month.

(b) Details of health conditions, in particular any occurrence of contagious illness and any accidents.

(c) Any notices received from government or state institutions relating to environmental matters, and the action taken by the Contractor as a result.

(vi) In view of the limited space available for the site accommodation facilities and in order not to avoid problems of assimilation with the present population of the project region, the Contractor will be obliged to keep the number of workers imported from other areas to the minimum required for him to complete the Works on time and in accordance with the specifications. He has to give preference to local project oustees labourers. The Contractor will co-operate with the local authorities at all times to prevent migration to the area of unauthorised persons not involved directly in the construction work. To this end, he will at all times strictly control the movement of persons into and out of the construction areas and camps.

25.4. Maintenance of Traffic and Safety on Public Roads

(i) The Contractor shall be responsible for the safety along the roads related to the Site, and he shall take all necessary precautions for the protection of the work and the safety of the public on the roads affected by his activities. Where the work will be carried out at the site of, or close to an existing road, the Contractor shall maintain the vehicular and pedestrian traffic safe at all times. If his operations can cause traffic hazards, he shall repair or fence or take such other measures for ensuring safety which are satisfactory to the Engineer-in-Charge.

(ii) Roads subject to interference by the work shall be kept open or suitable detours shall be provided and maintained by the Contractor, who shall provide, erect, and maintain all necessary barricades, suitable and sufficient flashlights, flagmen, danger signals, and signs.

(iii) Roads which will be closed to traffic shall be protected by effective barricades on which acceptable warning and detour signs shall be placed. All barricades and all lights shall be kept burning from sunset to sunrise.

(iv) The Contractor shall submit his weekly activities schedule and the locations of his work along the existing public roads to the authorities concerned and obtain all necessary approvals prior to commencement of the respective work.

(v) At the road crossings or in heavy traffic locations, the Contractor shall carry out the work during the working hours as directed by the Engineer-in-Charge, and after the completion of the work he shall immediately make the necessary backfill and pavement at the crossings.

(vi) The Contractor shall provide temporary passes and bridges to give an access to the existing villages, houses, etc., to the satisfaction of the authorities concerned whenever he disturbs such existing way during the execution of the Works.

25.5. Control of Dust, and Silica, at Work Sites

25.5.1. Dust and Silica

(i) To reduce the amount of dust, only wet drilling will be allowed and during mucking, muck tips shall be kept constantly damp by sprinkling with water. The use of high pressure water jets for this purpose will not be permitted.

(ii) The Contractor shall measure the concentration of fine dust and content of silicon dioxide (SiO2) in all dust-producing operations by an approved method.

(iii) Air samples shall be taken within 10 days of commencing work of excavation, and at 90 days intervals thereafter. Further, within 30 days following major changes in excavation operation, or whenever required by the Engineer-in- Charge, samples shall be taken from actual working areas. The sampling and testing shall be performed by a qualified person or a laboratory to be proposed by the Contractor and approved by the Engineer-in-Charge. A copy of the test results shall be submitted to the Engineer-in- Charge within 2 weeks of the sampling date.

(iv) The concentration of fine dust (diameter less than 0.005 mm) may not in general exceed the value of 8.0 mg/m3 of air and in relation to the silicon dioxide content in the rock this value is lowered as follows:

Content of SiO2 in fine in percent by weight	Concentration of fine dust dust fine dust in milligrams per m of air
1-15%	8.0mg/m^3
20%	6.0 mg/m^3
30%	4.0 mg/m^3
60%	2.0 mg/m^3
80%	1.5 mg/m^3
100%	1.3 mg/m^3

(v) Should the concentration of fine dust exceed the limits stated above, the Contractor shall undertake such necessary measures and install such additional equipment which will ensure that the dust concentrations are within the specified safe hygienic limits.

26. QUALITY ASSURANCE & QUALITY CONTROL

26.1. General Obligations of the Contractor

(i) The Contractor shall establish, staff, equip and operate a comprehensive quality assurance organisation at the site during the full period of the Works. The principal responsibility and duty of this organisation shall be to ensure that all work carried out and materials produced or supplied by the Contractor comply fully with the Specifications as well as with all relevant Indian or other standards.

(ii) With his tender, the Contractor shall submit an outline quality control manual, organisation plan and staffing programme. This manual shall list all internal quality control procedures to be undertaken by The Contractors, give details of laboratories (listing their equipment and testing procedures), reporting procedures and quality control training programmes for Indian staff. Prior to finalisation of any contract, the Engineer-in-charge shall review and comment on these data, and request any modifications or additions, which are considered necessary.

(iii) Within 90 days of issue of the Order to Commence, the Contractor will submit to the Engineer-in-charge, for review and approval, a revised, more- detailed and updated quality control manual and programme, which will take into account all comments made previously by the Engineer-in-charge.

(iv) At all times, the Contractor’s quality control and other site personnel will co operate with and inform fully the Engineer-in-charge in all matters relating to the work in progress and testing of materials etc., and will reply promptly to any requests by the Engineer-in-charge and his site supervision personnel for additional information and data.

(v) The Engineer-in-charge may establish and operate his own site laboratories for materials testing, and the contractor will be required to provide samples at no cost for testing in these laboratories.

(vi) Supervision and testing which may be carried out by the Engineer-in-charge in no way relieves the Contractor of his full responsibility for the quality of the Works and for compliance with the requirements of these specifications.

26.2. Control of the Progress of Work

(i) Close progress control, and the preparation of corresponding progress reports, shall be an important part of the Contractor’s quality control responsibilities. The contractor must at all times provide the Engineer-in-charge with up to date information on the progress of work and must without delay bring to the attention of the Engineer-in- charge all delays or occurrences which could lead to delay or additional costs.

(ii) The Contractor shall submit detailed monthly progress reports to the Engineer-in-charge, in which the contractual programme for the works is updated and information is given on the quantitative completion of civil works (in the form of tables indicating the quantities of completed work).

(iii) The monthly progress reports shall give full details of any delays to work in progress or planned, delays in transport to/from the site, together with detailed proposals for overcoming or preventing delays, and for regaining any lost time.

(iv) The Contractor shall at any time, at the request of the Engineer-in-charge, submit detailed reports on particular matters relating to the execution and progress of the works, is such reports are required in order to assess the quality or progress of specific activities or works.

26.3. Contractor's Quality Control Staff

(i) The Contractor shall assign one experienced engineer to site as full-time quality control officer, responsible with complying with all requirement of this Section.

(ii) The experience and qualifications of this engineer shall he given in the contractor's tender and shall be subject to the approval of the Engineer-in-charge. The positions, and the qualifications and duties, of the contractor's quality control staff shall be indicated in the quality control organisation plan and manual respectively and shall likewise be subject approval by the Engineer-in-charge.

26.4. Contractor's Laboratories

(i) The Contractor shall establish, equip and operate on site laboratories for the testing of the principal construction materials.

(ii) The numbers of samples to be tested, and the timing of testing, shall be as may be given elsewhere in these specifications, or as may be instructed by the Engineer-in- charge.

(iii) The staff of the Contractor's laboratory shall have proven experience in similar previous work and their qualifications shall be subject to approval by the Engineer-in- charge.

(iv) Complete records shall be kept of all laboratory tests carried out and shall be available at any time to the Engineer-in-charge on request.

(v) The Engineer-in-charge shall be permitted at any time and without notice to observe tests being carried out in any of the Contractor's laboratories, to inspect equipment or to study results.

26.5. Materials Delivered to Site

(i) The Contractor's quality control staff shall keep full records of all materials delivered to site for use in the Works, and of all tests made on such materials either prior to or following delivery to site.

(ii) These records shall be available at all times to the Engineer-in-charge, together with any factory testing certification.

26.6. Supervision of Transport

(i) In view of the difficulties of access from the railhead to the site, the Contractor will be required to appoint a transport officer with responsibility for all haulage of materials and equipment to and from the site.

(ii) This officer will contribute a section of the monthly progress reports covering transport to, from and at the site and any problems related thereto. He will be responsible for notifying the Engineer-in-charge of any problems and/or delays related to transport and for making proposals for overcoming them.

(iii) This officer will have direct responsibility for ensuring that local public and private traffic is able to have unrestricted use of the road up to project site.

26.7. Environmental Control

(i) The Contractor shall appoint an environmental control officer to be responsible for ensuring compliance with all specified obligations, laws and regulations with regard to environmental protection of the site of the project, access roads and all site installations.

(ii) This officer must maintain close liaison with the provincial environmental department and its officers and must provide all data needed by this department and/or the Engineer-in-charge needed at any time to confirm full compliance with environmental regulations and obligations.

(iii) Details of all environmental protection activities, and of any cases of environmental damage, shall be included in the monthly progress reports.

26.8. Safety

The Contractor’s obligation with regard to site safety are detailed in these specifications.

26.9. Training of Owner’s Staff

(i) As part of his quality control obligations during the construction of the Works, the Contractor will be required to employ and train Owner’s staff in the supervisory, testing and recording activities.

(ii) A programme for said training shall be submitted to the Engineer-in-charge for approval with 28 days of the issue of the Notice to Proceed, together with the task descriptions and training objectives of the staff members in training.

(iii) The contractor must allow for providing quality control training to Owner’s personnel in during the construction period for a total of fifty (50) man/woman months (each trainee for a period on site of approximately six months).

26.10. QAQC for Project Commissioning

Based upon commissioning manuals prepared under “Planning, Design and Engineering Services”, the contractor (or consortium of contractors) shall carryout commissioning related activities of the project:

- Final inspection of civil structures upon completion
- Reservoir impoundment at specified rates, surveillance during impoundment and remedial action, if any

- Dry and wet testing of gates and other hydro-mechanical equipment
- Water Conductor system filling at specified rate, surveillance during filling and remedial action, if any
- Dry and wet testing of electro- mechanical equipments
- Commissioning of the project as a whole

The contractor shall fully involve the owner's site team during above process so that the team is fully trained with functioning of different components and equipments of the project.

Full documentation of commissioning activities shall be maintained and same shall be submitted to the owner as a complete report.

27. PARTICULAR TECHNICAL SPECIFICATIONS - CIVIL WORKS

27.1. Introduction

a) The permanent structures of the Civil Works shall be designed and constructed for completion of the Works by the Contractor in accordance with the Contract. The Contractor shall submit to the Employer detailed drawings for review in a timely manner.

b) Without prejudice to and without limiting or reducing the scope of or the requirements for the Works set forth in this document, the items in this chapter state the minimum requirements for the Contractor to conduct the Civil Works.

c) No alternatives shall be considered to the tender design presented in these bid documents and drawings, during procurement process.

The Song Dam Water Supply Project comprises the following components.

- River Diversion (Diversion Pipe with Gate and u/s Cofferdam)
- Conventional Concrete Gravity Dam and Plunge pool
- Intake Structure for Water Supply Steel Pressure Pipe.
- Steel Pressure Pipe for Water Supply
- Control Room Building

d) Facilities other than Project Components

- Muck dumping yard for rock and soft ground material.
- All other civil work structures and facilities necessary for completeness of the Song Dam Water Supply Project
- Structures and facilities for site installations.
- Protection and maintenance components, including slope protection works, river embankment protection works, steel linings, overhead travelling cranes.
- Earthling system of all civil structures with electro-mechanical equipment.
- As built drawing and operation and maintenance manual.

e) Interface with E&M and HM Equipment Sub Contractor of the Item rate Contractor

The works include close cooperation, coordination and exchange of data, calculations and drawings with the E&M and HM Works sub contractor of the contractor. Therefore, the Works also include the incorporation of all relevant data and information from E&M and HM Works Contractor into the execution drawings, in order to guarantee completeness of the overall design and the Works and to meet all requirements for the correct and timely construction of the civil work structures.

f) The Contractor shall submit Construction Methodology 60 days before start of Construction of any project component for review and approval of Employer.

g) Additional data and information related to the project which is available with the Employer and required for the works shall be furnished to the Contractor without change and the Employer may without obligation give suh assistance for obtaining of any additional data and information as may reasonably be requested by the Contractor.

h) The Contractor shall be deemed to have scrutinized the Employer's Requirements and shall be responsible to comply with the same.

The Contractor scope of works shall include but not limited to the following: Review of existing data / studies.

1) Review of available geological and geotechnical data as a basis of program for additional investigations to be carried out, if any, deemed necessary by the Contractor.

2) Review of available topographical information as a basis of program for additional detailed surveying to be carried out, if any, deemd necessary by the Contractor.

3) Review of technical parameters.

i) Addtional Investigations:

Additional field investigations for various work areas, additional laboratory and field tests required as a result of review of existing data and required for design and construction purposes both at the initial stage and also subsequently during construction stage shall be identified by the Contractor. The additional field investigations, if required shall be covered under this Contract of Works and shall be carried out by the Contractor.

j) Overall and detailed planning of the project: The outline proposal submitted at the bid stage shall be firmed up based upon the additional studies carried out; an overall planning report of the project shall be prepared and submitted. After incorporating the observations of the Employer on the draft version, the Contractor shall submit the field version of" overall planning report". The report shall be comprehensive enough to fully define the project and shall be accompanied by all necessary layout drawings. This overall planning report shall form the basis for detailed design.

k) The Contractor shall review and be fully responsible for and will coordinate and integrate all engineering and design services provided in relation to the work by Subcontractors and suppliers.

l) The Contractor shall be responsible for submitting all statutory calculations to the Employer for third party verification, and obtaining such approvals as are required.

m) Detailed Design

i. Preparation of design briefs / memorandum (Design Basis Report) along with layout drawings for all components of the project. These design after review/approval shall form the basis for further design and construction drawings.

ii. Preparation and submission for review/approval of the Employer of the specifications confirming to standard practice and references defining the execution of a particular item of Works.

iii. Preparation of detailed design for the civil works including drawings required for the execution of the project as a whole. Method of construction and sequence of work of all the works will be coordinated witth the construction program.

iv. Follow up of the civil works in order to verify the suitability of the design during construction, and to make or initiate such modifications as may be required.

v. Preparation of manuals required for the operation and maintenance of the civil works, including a manual for the initial filling up of the dam and water conductor system as part of the commissioning.

n) Project Completion Report:

Preparation and submission of project completion report based upon the earlier design reports and data generated during the course of execution of the project. This document should include key as-built drawings for different components of the Work.

o) Design Basis:

Basic and layout design of the project shall be in accordance with Indian standards or other internationally recognized standards (wherever Indian standards are not available). Detailed Design shall be based upon relevant IS codes, ICOLD recommendations, structural & geotechnical software's such as SAP, ANSYS, STAAD PRO, EAGD-SLIDE, FLAC, UDEC, SIGMA/W, SLOPE/W, SEEP/W, PHASE, SWEDGE, UNWEDGE and other FEM & CFD software/relevant software for analysis and design of the project component. The Contractor should be able to provide various international references, when required by the Employer. For hydraulics, geotechnical, structural calculations, the Contractor shall follow the relevant Indian standards and wherever Indian Standards are not available, International Codes and practices can be followed.

p) Functional Requirement

i. The facilities shall be designed such that they can be operated safely, reliably and economically and are fit for purpose. The design of the facilities shall be such that they can be readily maintained, are secure, and are capable of continuous operation with minimum attention and maintenance.

ii. The water conveyance systems shall provide for the required discharge safely and reliably under the specified head conditions. All discharge facilities shall provide capabilities to meet the functional requirements.

iii. Provisions shall be made for regular inspection and maintenance of all Works during the service life of the Project. Easy access and safety shall be provided for these operations.

iv. The exterior of all the buildings shall blend with the natural surroundings and shall have Indian & Uttarakhand architectural appearance consistent with their function and setting and with good quality design practice.

v. The Water Conductor System shall meet the following functional requirements regarding civil works. Any failure of the Works to meet the following criteria must be remedied prior to completion.

a. Operating range
- The proposed Water Conductor System is 1500mm dia Steel Pressurised Pipe and water flows through water conductor system principally under gravity to provide continuous water supply of 1.74 Cumec.

b. Net Head acting on water
- The FRLand MDDL at Dam Site is EL 980m and EL 923m respectively. The Outlet level of Water Conductor system (Steel Pressurised Pipe) is EL 900m. The Gross Head which is causing the flow through water conductor system with respect to MDDL is about 23m.The Net Head Loss through water conductor syatem for a design discharge of 1.74 Cumec is 6.68m. The Net head causing water flow through water conductor system shall be a minimum of 16.32m.

c. Leakage from water conductor system
- Water leakage through water conductor system (Steel Pressurised Pipe) should not be allowed (0L/S)

q) Standards

The work shall comply, with the latest issue of the applicable Bureau of Indian Standards (BIS) and equivalent internationally acceptable standards. The contractor shall identify standards he intends to use and shall submit 2 (Two) copies of latest editions of relevant standards used/referred in Detailed Design. List of Standards shall be approved by the Employer.

Should the Contractor request alternatives to the above standards, other relevant standards may not be used wlthout Engineer-in-Charge's approval. Differences between the standards specified and the proposed (alternative standards must be fully described in writing by the Contractor and submitted to the Employer for review and approval.

The latest editions of ths standards and codes, including amendments thereof, shall be used by the Contractor.

An English transalation shall be submitted if the standards and codes proposed by the Contractor are in a language other than English.

r) Approval of Designs

i. The Item Rate contractor shall coordinate the design of the civil works with his subcontractor who will supply, install and carry out E&M and H&M Works. Item Rate Contractor shall incorporate data and design of the E&M and H&M Works in his design and drawings, where necessary, without any delay according to the design work program to be submitted by the Item Rate Contractor.

ii. The Item Rate Contractor shall submit execution drawings minimum 90 days ahead of construction to the Employer for review and approval. The design and drawings shall be returned to the contractor within 21 days from the date of receipt by the Employer.

iii. The Contractor shall send two copies of all execution drawings with an interface to E&M and H&M Works Contractor for information or for his further design work, as the case may be.

iv The Contractor shall confirm in his bid, that delivery of drawings 90 days ahead of construction, considering the coordination and necessary sequences of exchange of drawings / information with E&M and H&M Works Contractor as well as the review period of the Employer, is sufficient.

Design Life

Materials, design and construction quality standards shall meet targeted design life requirement as follows:

- Civil works (excluding access works but including-structures and tunnels) 60 years.
- Corrosion protection (plating and coatings other than paint): 15 years,
- Corrosion protection (paint systems): Internal.10 years, External 8 years.

s) Hydraulic Model Studies

Physical Hydraulic Model Studies for Comprehensive 3D model and Sectional (2D) model of Dam, Intake Structure shall be carried out by the Item Rate Contractor and the results of these studies shall be submitted to the Employer for their approval. Results of the model studies and recommendations for the design thereof for proper operation of the relevant components of Dam and water conductor system shall be followed. If required necessary changes during the detailed design shall be made as per results and recommendations of the Physical Hydraulic model study. Prior to any Design change, approval from Employer shall be obtained.

t) Special Reference

Upon Employer requests for Expert Technical advice on certain issues, the relevant memoranda shall be prepared by the Contractor. These shall be vetted by the Employer and dully incorporated in all designs and related construction drawings. The cost of this account shall be deemed included in the Contract price for the relevant items of works.

u) Routine Operation and Maintenace System

The Song Dam and Water Conductor System shall be capable of operating unmanned for periods upto 24 hours.

The operating model used in the design may include that the Employer will have full time representation at the control building, undertaking routine tasks including:

i. Periodic inspection of Dam, Intake and removal of logs, leaves and debris.
ii. Removal of silt from the reservoir upstream of the Dam by flushing through the radial gates in the Dam.
iii. Manual adjustment of compensation discharges at the Dam.
iv. Manual inspection of the Water conductor system
v. Reading and logging of meteorological and hydrographic instruments (rain and river level gauges) installed by the Item Rate Contractor at the intake and discharge points
vi. General housekeeping and light routine maintenance.

Additionally, the Employer will engage such other resources as are required for periodic maintenance of the Song Dam and Water Conductor System according to schedules to be described in the operation and maintance manuals provided by the Contractor as part of the Works.

v) Major Maintenance

i. Permit access to plant and equipment to undertake maintenance with only minimal removal of other plant and equipment.
ii. Minimize any need to shut down the Water Supply for maintenance inspections and / or work.
iii. Restrict any major overhaul work to frequency greater than five years of normal operation.

w) Durability, Reliability and Redundancy

i. The Dam and Water Conductor System shall be designed for the following maximum outage criteria per annum excluding periods of scheduled overhauls at 5 or more-year intervals.
ii. All Civil structures shall be designed to operate reliably, considering the data (loads, provisions etc) arising from the equipment and E&M and H&M Works. The design of the civil works has to follow strictly the technical requirements of the E&M and H&M Works.

iii. All structures but not limited to dam, intake, Water Conductor System, Valve House, Control Room Building and all other civil structures shall have durable structures and wear surfaces suitable for the conditions in which they are placed and are required to work.

x) Flood Criteria

The Song Dam and Water Conductor System shall be desgined to meet the probable maximum flood of 1229 m^3/s.

y) Tests on Completion

Functional Requirements mentioned in this chapter under "Operating Range" and Leakage from Water Conductor system" above shall be site tested using methodologies described in internationally recognized standards/ practices.

During the "Tests on completion", the structures shall be operated by the Contractor for a period of 2 weeks prior to completion without any interruption or shortfall. Interruptions or shortfalls caused by the Employer or the trivial operator faults shall be permitted in the test.

All the necessary equipments, instruments and any other arrangements required for carrying out "Tests on Completion" shall be planned and provided by the Contractor during the construction stage.

z) As Built Drawings

The Contractor shall submit three hard copies and soft copy of detailed drawings of all areas used for site installation and of all structures and buildings, including equipment connected to or embedded in the Civil Works structures and required for sucfessful execution of all Civil works structures.

27.2. Employer's Requirements

General layout of the project has been provided in the Project Profile.

27.2.1. Fixed design parameters

Basic design parameters of the project shall be as under:

1	**Head Works**	
1.1	**Dam Complex (General)**	
1.1.1	Location	River Song near Sondhana Village
1.1.2	Type of Dam	Conventional Concrete Gravity Dam
1.1.3	Top of Dam	EL 982.00 m
1.1.4	Full reservoir level	EL 980.00 m
1.1.5	Maximum Water level	EL 980.00 m
1.1.6	Minimum draw down level	EL 923.00 m
1.1.7	No. of Spillway blocks	2 No's
1.1.8	Grade of Concrete	As Shown in the Employers Drawings.
1.2	**Orifice Spillway**	
1.2.1	Design flood (PMF)	1229 Cumec

1.2.2	Spillway Invert Level	EL 912.00
1.2.3	No of Gates	2 No's
1.2.4	Gate Type	Radial
1.2.5	Size	7.0 m (W) x 8.50 m (H)
1.2.6	Hoisting arrangement	Hydraulic cylinder
1.2.7	No of Stop log gates	One
1.2.8	Hoisting arrangement for Stoplog gate	Gantry Crane
1.2.9	Energy dissipation	Trajectory Bucket (Ski jump)
1.2.10	Plunge Pool	Pre-Excavated Hole for all overflow blocks
1.2.11	Maximum Discharge for Riparian flow	3.52 cumec
1.2.12	Diameter of Steel Pipe for Riparian flow	0.3 m
1.2.13	Invert level of Pipe for Riparian Flow (Ecological Release)	EL 968.0 m
1.2.14	Pipe Shall be completed with Inlet, and Outlet with Slide Valve and Hooded Cone Discharge Valve (HM Scope)	Yes
1.3	**Overflow Spillway**	
1.3.1	Spillway Crest level	EL 975.00 m
1.3.2	Gate Type	Fixed wheel gate
1.3.3	No of gates	One
1.3.4	Gate size	5.00 m (W) x 5.50 m (H)
1.3.5	Hoisting arrangement	Electrically operated rope drum Hoist
1.4	**River Diversion Scheme**	
1.4.1	Scheme	Single Stage Diversion
1.4.2	River Diversion Flood	19.36 Cumec (100 Years Return period non monsoon flood)
1.4.3	Diversion Pipe	1.5 dia- 350 m long, Left Bank (Steel Pipe – Slope 1.33%)
1.4.4	Inlet level for Diversion Pipe	EL 878.00 m
1.4.5	Location of Diversion Pipe	Block No 4
1.5	**Intake for Water Supply**	
1.5.1	Location	Left bank
1.5.2	Design discharge at Trash Rack	1.74 Cumec
1.5.3	Design discharge for main Plant	1.74 Cumec
1.5.4	No of trash rack bays	1 No's
1.5.5	Trash rack sill level	EL 918.00 m
1.5.6	Trash rack size	1.5 m (W) x 2.0m (H)
1.5.7	Type	Removable
1.5.8	Trash rack inclination	07º
1.5.9	TRCM	No
1.5.10	No. of gates	1 no. (Bulkhead Gate)
1.5.11	Gate size	1.50 m (W) x 1.50 m (H)
1.5.12	Crest Elevation	EL 918.00 m
1.5.13	Type of Intake Gate	Fixed wheel vertical lift gate
1.5.14	Grade of Concrete for Reinforced Concrete	M30
2	**Water Conductor System-Main plant**	
3	**Upstream Valve House**	

3.1	Type	Surface
3.2	Type of Valve	Butterfly
3.3	Size	5.0 m (W) x 5.0 (L)
3.4	Diameter of Valve	1.5m
3.5	Center Line of Valve	EL 918.75 m
4	**Surface Pressure Shaft (Water Conductor System)**	
4.1	**Water Conductor System**	
4.1.1	No.	One
4.1.2	Size & Shape	1.50 m, circular
4.1.3	Length	± 15.0 km
4.1.4	Steel lined	Yes
4.1.5	Grade of Backfill Concrete	M20
4.1.6	Head Loss through Water Conductor system	16.32m

27.2.2. Hydraulic Gradient

a) The whole water conveyance system from the intake to the outlet shall be designed without loss of water and a hydraulic head loss that shall not exceed 6.68 m corresponding to Design Discharge of 1.74 Cumec. The Item rate Contractor shall submit, as part of his Bid, hydraulic calculations to demonstrate the Contractor's preliminary design satisfies this requirement.

b) For the purposes of compliance, the head loss shall be calculated for steady state flow conditions at the design discharge of 1.74 Cumec (hereinafter referred as "the design discharge") between the following points:
- Upstream of the trash racks installed at the intake structure; and
- Outlet of Water Conductor System.

c) All head losses shall be accounted for, including, without limitation, the following:

- flow through the trash racks;
- entry losses through gates, valves and openings;
- friction losses along water conductor system (Steel Pressure Pipe).
- form losses in the Water Conductor System due to bends, transitions (expansion)

27.2.3. Seismic Design

a) The Works shall be designed to resist seismic loads and two earthquakes return periods shall be considered for the design of the project structures:
- the Design Basis Earthquake (DBE) – an earthquake ground motion that should not interrupt the operation of the structure; and
- the Maximum Credible Earthquake (MCE) – an earthquake that will cause severe damage but not total failure.

Department of Earthquake Engineering of IIT Roorkee had carried out Site studies for Site Specific Design Earthquake Parameters for Song Dam and Water Supply Project and same was approved by NCSDP. The Approved Seismic Design Parameters are as mentioned below.

The site-specific design earthquake parameters (Peak Ground Accelarations- PGA) for MCE and DBE are 0.495g and 0.278g for horizontal and 0.330g and 0.185g for vertical ground motion respectively. The design seismic coefficient for dam (primary structure) for preliminary design of Dam is evaluated as α_h = 0.18 and α_v = 0.12. Clearance from NCSDP (National Committee on Seismic Design Parameters) has been obtained at 34th meeting held on 26th February 2019 at New Delhi. Report on the Site-Specific Design Earthquake parameters carried out by Department of Earthquake of IIT Roorkee is attached to this contract document.

27.2.4. River Diversion Works

27.2.4.1. FUNCTION

The purpose of the river diversion works is to temporarily divert water flow from the natural river channel and site of the headworks to enable the headworks structures, namely the Dam, intake structure to be constructed within and adjacent to the natural river channel in dry foundation conditions.

27.2.4.2. EMPLOYER'S CONCEPT

Design discharge for river diversion works is 19.36 Cumec (Minimumu) which is 1 in 100 year non-monsoon flood. The complete river diversion works is envisaged in one stage. As a minimum, it is anticipated that the river diversion works shall comprise:

- Construction of upstream and downstream cofferdam (If required) or as envisaged during bid stage or as shown in the Tender drawings.
- Construction of Steel Diversion Pipe as shown in the Tender Drawings

27.2.4.3. DEWATERING SYSTEM.

b) Detailed design of the river diversion works to facilitate the construction of the headworks shall be prepared by the Contractor for concurrence of the Employer.

c) The diversion works shall be provided with a minimum 1.60m freeboard.

d) The Drawings and schedule for the River Diversion Works shall be submitted to the Employer by at least Ninety (90) days before commencement of the river diversion works.

e) The Contractor shall execute the maintenance of the diversion cofferdams during the period that dam (NOF & OF), intake structure, and appurtenant Works are under construction and shall be responsible for, and shall repair, any damage to the structures built by the Contractor caused by floods, rain or other reasons. During the period in which the water passes through the diversion conveyance, the Contractor shall keep all provisions necessary for maintaining a free flow of the water and shall remove from the inlets any object tending to restrict or obstruct the flow.

27.2.5. Conventional Vibrated Concrete Dam

27.2.5.1. FUNCTION

a) The Conventional vibrated concrete gravity dam shall be installed in order to raise the water level in the river and divert water for generation to the intake structure. The concrete gravity dam shall also safely pass the design flood over its spillway.

b) 2Nos Orifice spillways are provided to pass Design flood 1229 Cumec (PMF) with one gate inoperative condition. 1 no. overflow spillway is also provided at the left most overflow block to pass the debris. Ski-jump bucket is provided for energy dissipation.

c) Plunge Pool shall be provided immediately downstream of the Dam to promote energy dissipation of the flows and prevent scour of the downstream natural river channel.
d) Steel Diversion Pipe shall be plugged before demolition of Upstream Coffer Dam

27.2.5.2. EMPLOYER'S REQUIREMENT

Without prejudice to and without limiting or reducing the scope of or the requirements for the Works set forth in this document, the following conditions shall be taken into account in the design for the dam spillways.

- The crest level of the orifice spillway shall be El. 912m and overflow (debris) spillway shall be El. 975.0m.
- installation of Two radial gates (7.0m (W) x 8.50m (H) to pass design flood and periodically flush sediment; installation of one higher level vertical gate (5.00m (W) x 5.50m (H) to pass debris.
- Release of the maximum riparian flow discharge of 3.52 Cumec to the downstream through riparian pipe. The Riprain arrangement shall be planned, designed, supplied and installed by Item Rate Contractor. This pipe preferably shall be provided below MDDL EL 923m or any other elevation as approved by Employer.
- Plunge Pool (Pre-Excavated Hole) shall be provided as shown in the drawings.
- Grade of Concrete shall be strictly follow as mentioned Employers drawings.
- Top Width of Dam is 12.5m
- Minimum two Nos of Vertical Stair Cases shall be provided in either side of overflow blocks. In one stair shaft, Passenger Lift shall be provided to the bottom of foundation gallery and in another stair shaft, equipment shaft shall be provided as shown in the Employers drawings.
- Instrumentation shall be provided as shown in the Employers Drawings or as prescribed in Indian Standards.
- Curtain grouting, Drainage Holes and Consolidation shall be carried out as specified in Indian standards.
- One Sump Well shall be provided in the deepest overflow blocks.
- Dam illumination shall be provided.
- Control room building, DG Set building and Power Pack building shall be provided.
- Slope stability of both Left and Right banks at Dam, and Plunge pool shall be ensured.
- Land scape in and around the Dam site shall be executed.
- Form drains, Ventilation pipes, and Drainage galleries, Foundation galleries and Instrumentation galleries shall be provided as specified in Indian standards.
- Passive anchorage shaft shall be provided to anchor Trunnion beams.
- For maintenance of the Trunnion Beam Steel bridge shall be provided as shown in the Employers Drawings.
  a) In addition to the requirements shown in the Employer's drawings, Item Rate Contractor shall carryout Physical Hydraulic Model studies and shall incorporate the recommendations proposed by Hydraulic Model Studies.
  b) Lift having capacity for 15 persons (1000kg) shall be provided in Lift Shaft.
  c) 2D Thermal Studies shall be carried out for Conventional Compacted Concrete Dam.

27.2.6. Intake Structures

27.2.6.1. FUNCTION

The intake shall steadily and safely deliver the design discharge for Water Supply. The structure shall be comprised of reinforced concrete.

27.2.6.2. EMPLOYER'S REQUIREMENT

a) Intake Trash rack panels as shown in the Employers drawing shall be supplied and installed. The specifications of trash racks are specified in the following HM part of these documents.
b) In order to supply enough volume of air into the waterway in case of full gate closing, an air vent/shaft is provided on the downstream side of the intake gate.
c) During drawing water through the intake, harmful hydraulic phenomenon such as vortex nor harmful vibration at the trash rack(s) shall not be allowed.
d) The maximum net flow velocity through the trash rack(s) shall be less than 0.75m/s. Velocity through Trash rack with 25% clogging shall not be more than 1.0m/s. The form and arrangement of the intake structure shall be designed to satisfy this requirement and shall incorporate gradual hydraulic efficient transitions to minimize head losses.
e) Suitable permanent slope protection works shall be provided at the excavated area above operating platform, in order to prevent any land slide or rolling stones.
f) The Invert level of Intake at Trash Rack shall not be less than EL 918m (6m above the Dam spillway crest level EL 912.00m).
g) New Zero Elevation at Dam site is EL 910.366m whichis approved by CWC Hydrology department.

27.2.7. Valve House

27.2.7.1. FUNCTION

Valve House shall be provided to house butterfly valve.

27.2.7.2. EMPLOYER'S REQUIREMENT

a) The minimum size of Valve House shall be as shown in the Drawings.
b) Thrust Block shall be provided upstream of Valve House.
c) Grade of Concrete for Civil Works shall be M25.

27.2.8. Steel pressure pipe (Penstock)

27.2.8.1. FUNCTION

The Steel Pressure Pipe (penstock) either embedded or laid over surface supported on saddles, anchorblocks and steel bridges at River Crossings has the function to steadily and safely flow the design discharge for water supply (1.74 m^3/s) from Dam to the outlet.

27.2.8.2. EMPLOYER'S REQUIREMENT

a) The penstock pipes shall be designed to safely withstand extremes of internal and external pressure at all points. The embedded Steel Pipe shall be fully steel lined, backfilled with concrete between rock/soil surface and steel liner. The specifications of the steel penstock and the inner steel liner are specified in this document.
b) The penstock shall be provided with permanent drainage arrangements for the purposes of dewatering.
c) Suitable manhole shall be proposed from Dam to valve house and also beyond valve house for inspection and maintenance of entire surface penstock.
d) Expansion Joint shall be provided between two Anchor blocks preferably at downstream of uphill anchor block to permit longitudinal expansion of the steel pressure pipe (laid on the surface supported by saddles, anchor blocks and steel bridges) which results from the temperature change.

e) Wherever Horizontal and vertical bends are provided in Embedded Penstocks and Surface Penstock, Anchor Blocks shall be provided.

f) Supports for Surface Steel Pressure Pipe (Penstock) shall be of sliding type to accommodate longitudinal expansion of Penstock. Each support shall consist of concrete block with saddle plate mounted on it. Saddle plate shall be embedded in concrete saddle support. Penstock will rest on the saddle plate with provision of greasing arrangement to facilitate sliding. The four points of greasing arrangement shall be closed with thread greasing nipples, to facilitate replacement of greasing.

g) Wherever required Air relese Valves and piezometric connections shall be provided as per IS 11639 part -1,2 &3.

h) Thrust Block along with Thrust rings shall be provided upstream of Butterfly valve house.

i) Grade of Concrete for Embedded Penstock shall not be less than M25. Grade of Concrete for Anchor Blocks, Saddle supports, and Thrust Blocks shall not be less than M25.

j) As/ if requested by Engineer in charge, Embedded penstock shall be backfilled with soil up to natural surface level. Penstock encasement concrete shall be designed accordingly for the backfill soil pressure

k) Steel liner design shall include a pressure rise as per Transient analysis.

l) Hydrostatic Test Pressure shall be carried out for Straight shells at shop.

m) For Calculation of thickness of steel liner, Allowable Stresses Shall be considered as per IS 11639 part -1,2 &3.

n) Steel Bridges shall be provided Wherever Surface Pressure Pipe (Penstock) is crossing River. Steel Bridge shall be kept above High Flood Level. With reference to Indian Standards, Cutoff of Abutment Foundations of Steel Bridge shall be provided below the Scour Level. Span and width of steel bridges for tendering purposes shall be as per Employers drawings.

27.2.9. control room building

Control Room Building at Dam Site Shall be as shown in the Employers Drawings. During Construction stage, Item Rate Contractor shall plan, design and construct as approved by Employer. As mentioned in Electro-Mechanical works specifications, Item Rate Contractor shall carry out detailed design of Electro-Mechanical equipment and based on the approved design shall develop the detailed general arrangement drawings showing the equipment layout and other facilities which are required for operation and maintenance. These general arrangement drawings shall be submitted to Employer for their approval. Once General arrangement drawings are approved, detailed design of Control Room building shall be carried out and same shall be submitted to Employer for their approval.

The Control Room Building at a minimum shall contain the following building services:

- Water supply system; water drawn from the river shall be filtered and fed to a storage tank located on top of control room building. From this tank water shall be available for: industrial uses, firefighting and supply to a packaged water treatment plant that shall produce all of the control room building potable water requirements.
- Sewage treatment and disposal system
- Drainage and Dewatering
- lighting system during construction stage;
- plumbing system; and
- cutouts in walls for ventilation and air conditioning system.
- Grade of Concrete for Civil works of Control Room Building shall be M25.

27.2.10. Projects Roads

The General Technical Specifications shall follow terms specified in latest edition of "Ministry of Road Transport and Highways - Specifications for Road and Bridge Works" published by the Indian Roads Congress.

Lighting design shall conform to IS: 1944 (Part I & II) and National Lighting Code 2010 (SP-72-2010):

The specification is intended to cover the design engineering, manufacturing, testing, packing & transportation, receipt, storage of equipment at site, its erection, testing, and commissioning of all the equipment of street light high mast and Residential Colony Internal Electrical Works and Public Lighting.

It is not the intent of the specifications to explain completely herein all details of design, manufacturing, testing, installation, commissioning, operations and maintenance. However, it is required that the complete work shall confirm in all respects to the highest standard of engineering and workmanship and the equipment used shall be capable of performing in continuous commercial operation up to the defect liability period, subsequently during comprehensive operations and maintenance period and thereafter up to their design life. The supply, installation, testing, commissioning, operations and maintenance shall be carried out in accordance with design, technical data and drawings approved by the Employer, the technical specifications, all applicable codes and standards including local statutory requirements. All work shall be executed to the satisfaction of the Employer. The Employer shall have the right to reject any equipment or work, which in his judgment is not in full accordance therewith.

The details of project Roads have been mentioned in following Table.

Sl. No.	Description	Qty	Unit
1	Ring road arround the Reservoir		
	Stage I	8	km
	Stage II	8	km
2	Construction of haul road for various project components (Two Lane) Stage I	3.00	km
3	Widening and Strengthtening of approach road from Maldeota to Project site (Two Lane)		
	Extra widening for Road Stage I	10.00	km
	Extra widing for widening double Lane Road Stage II	10.00	km
4	Two lane 70T capicity of Maldeota Bridge for Carriage of construction materials	60.00	m
5	Bridge for Connecting Gurshal Gaon and Ragad Gaon	42.00	m

28. GENERAL TECHNICAL SPECIFICATIONS – HYDROMECHANICAL WORKS

28.1. General

This section covers general technical requirements pursuant to the contract and will form an integral part of the Contract. The following provisions shall be applicable to all the detailed technical specification except otherwise modified specially in Particular Technical Specification (PTS).

28.1.1. Introduction

Song Dam Drinking Water Project, Dehradun is built across the Song River in Dehradun district of the Uttarakhand. Song Dam is a drinking water scheme with a 130.6 m high concrete dam along with about 15 km long water conductor system.

28.1.2. Location

The project is located on Song River. The top level of dam is at EL 982.00m. Dam site of the project is proposed across the river near village Sondana 10.0 km upstream of Maldeota

The approximate distance of the dam site from different towns is as below:

Delhi to Dehradun	250 km
Dehradun to Dam site	25 km

The nearest railhead and airport from the project is approximately 25 Km at Dehradun. The Bidder is advised to visit the project site and assess the existing road conditions/limitations (width, curvature, etc.) prior to bidding.

28.1.3. Project Layout

Song Dam Drinking Water Project, Dehradun is having live storage capacity of about 22.4 million m^3 for water supply by utilizing a maximum hydraulic head of about 105 m.

The main features of the project are as under:

130.6 m high concrete gravity dam 225m long at the top equipped with two (2) orifice spillway radial gates of 7.00 m (h) x 8.50 m(w) size are provided to pass a design flood of 1229.00 cumec at crest level 912.00 m.

Water conductor system comprising of gated intake structure with removable type inclined trash racks in one unit of size 1.50 m (w) x 2.20 m (h).

28.1.4. Implementation

Song Dam Drinking Water Project, Dehradun will be financed by State / Central Government or any other financing Agency.

28.1.5. Specification

The Bidder shall strictly observe this "General Technical Specification" in conjunction with the Particular Technical Specification. All works shall be carried out in a skilled and workman like manner in compliance with modern methods of engineering. All design calculations, materials, works and testing shall conform to the latest applicable standards.

In addition, the Bidder shall conform to all applicable regulations regarding the execution of construction and installation work and shall follow all instructions issued by the competent authorized Engineer.

The Particular Technical Specification shall take precedence over the General Technical Specification in case of any contradiction.

Clause number cross-references refer to the volume in which they occur unless stated otherwise.

28.1.6. Scope under the Contract

It is not the intention of this specification to specify the complete details of equipment; however the Bidder shall supply the equipment, which will meet in all respect, the requirements of the Owner in regard to performance, durability and satisfactory operations. All the equipment supplied shall conform to the relevant Indian/specified standards. Wherever the Indian Standards are not existent or silent, relevant ASTM, DIN, JIS or EN standard shall be adopted.

The broad scope of the work of Hydro-mechanical equipment shall include gates operating systems along with its controls. The Bidder should take into account requirement for future inspection of gates and ensure safe access to components which are routinely maintained and inspected for easy replacement of worn out components.

The Bidder shall be fully responsible for the design, preparation of detailed drawings for fabrication, sub assembly and assembly, procurement, fabrication/ manufacturing, inspection, shop assembly, testing, painting, transportation, site storage & site erection, testing and commissioning including provision for all the required labour, plant & material for the above, handing over to the Owner, supply of necessary spares for 3 years trouble free operation for all the hydraulic gates and their operating systems, for every replacement of warranted components.

Supply and installation of all incidentals not specified but necessary for the proper completion and satisfactory functioning of works and guarantee of the permanent equipment, along with all auxiliary equipment in the designated location of the project as specified in the following sections of technical specifications, shall also be included in the scope of work.

The scope of work shall include all special tools, as well as all special devices including lifting devices, ropes, etc. necessary for total assembly and disassembly (if required) of all parts of the supplied Works.

A) Orifice Spillway Radial Gate

Two (2) submerged type radial gate each for a clear opening size of 7.00 m (w) x 8.50 m (h) will be provided to pass design flood, regulate flow and operate at partial openings under all specified water level conditions. The gates shall be operated by hydraulic hoists.

B) Orifice Spillway Stoplogs

For inspection and maintenance of the radial gates, Two (2) set of embedded parts and one set of stoplogs (in 3 units) for a clear opening size of 7.00 m (w) x 7.525 m (h) with gantry crane and lifting beam shall be provided.

C) Intake Trash Racks

The trash racks (removable panel type) shall be provided at the entrance of intake to protect from objectionable debris. The trash racks will be in one (1) spans and size of each span shall be 1.50 m (w) x 2.20 m (h) (vertical opening).

D) Intake Bulkhead Gate

One maintenance bulkhead gate for a clear opening size of 1.50 m (w) x 1.50 m (h) shall be provided at intake structure. The gate shall be operated by independent rope drum hoist.

E) Intake Service Gate

One number of Butterfly Valve of 1500 mm bore has been provided at 60 m downstream of the Dam on the Water Conductor for regulating the water supply.

F) Instrumentation and Remote Control System

PLC based Remote Control System including cabling shall be provided by the Bidder along with provision for picking up signal from “Local control panels”.

One uninterruptible power supply (battery backup) to provide minimum 30 minutes back-up shall be provided.

Two sets of water level measuring and indication equipment at dam area along with necessary alarms shall be provided.

Differential pressure measurement and indication equipment across intake trash racks

Water level measuring system to indicate balance head condition of orifice spillway stoplogs, intake bulkhead gate.

Main distribution board & feeder pillar for all HM equipment

Main distribution board shall be provided by the Owner at dam site near Diesel Generator set Room for 415/230V AC power supply to spillway and intake bulkhead gate hoisting equipment. Feeder pillars shall be provided in the vicinity of respective local control panels of above hoisting equipment. Cabling between main distribution board and above feeder pillars shall be in the scope of the Bidder.

The works shall be complete with all necessary auxiliaries such as primary elements (position transmitters, limit switches etc.), hardware, software, modules, transducers, cabling etc. as well as frames, built-in and embedded parts including all spare parts and special tools required. All the equipment shall be standard-type of well-known manufacturers.

G) Diesel Generating Set

Supply of one set of 500KVA, 415V, 50 Hz AC output three-phase synchronous type Diesel generating set complete with all accessories, equipment, instrument wiring and acoustic enclosures for making the equipment complete and for warranting a trouble free safe operation including its design, manufacturing, testing and commissioning. The diesel generating set shall be located in the dam area to provide back-up supply to HM hoisting equipment and also to the computerized control system in case of power failure.

Supply of mandatory tools as per the specified list.

28.1.7. Design/Drawings, O & M Manual and Completion Report

The scope under this contract shall also include submission of the following documents:

28.1.7.1. DESIGN AND DRAWINGS

a) Hard copies- 4 sets of approved design document and 6 sets of approved design drawings properly bound condition is to be submitted.
b) As Built drawings -4 sets properly bound condition.
c) Soft (PDF) copies-2 sets of approved design & drawings on good quality DVD.
d) Soft (PDF) copies- 2 sets of erection, installation/ commissioning manuals with approved design & drawings on good quality DVD.

28.1.7.2. O & M MANUALS

a) Hard copies -6 sets of operation and maintenance manual containing relevant drawings for operation and maintenance and related catalogues covered under this specification properly bound condition.
b) Soft (PDF) copies-2 sets of above manuals on good quality DVD.

28.1.7.3. COMPLETION REPORT

A document describing initial data and details in regard to the execution of HM equipment, beginning with the award of work to record the historical events, problems faced and corrections adopted during design, fabrication, shop assembly and testing, erection, commissioning (dry and wet testing up to FRL) and up to final taking over certificate given by Song Dam Drinking Water Project, Dehradun and shall also include such events for bought out equipment and machinery, etc.

28.1.8. Beyond Scope of HM

The following works are excluded from Hydro mechanical works and shall be provided by the Owner:

a) Installation of 1st stage anchors (supplied by HM Contractor) being embedded in the primary concrete and exposed for welding 2nd stage anchor bolts to facilitate installation of 2nd stage embedded parts and provision of bent dowels in the primary concrete along with first stage insert plates;
b) 2nd stage concreting (i.e. secondary concrete in blockouts) of embedded parts (sill beam, wall plates, guides, tracks, seal seats, foundation anchors with base plates, latch/dogging device etc.) and provision of additional dowels prior to concreting;
c) Chipping and denting of first stage concrete surface in block outs to provide roughening for proper bond with second stage embedded parts after alignment prior to concreting;
d) Concrete trunnion beams for supporting radial gate trunnion brackets.
e) Air vents for orifice spillway stoplog gate.
f) Aquatic life discharge piping in the dam and its accessories.
g) Pipes for water level measuring system in the reservoir, intake location.
h) Earthing pits

28.1.9. Work & Safety Regulations

The Bidder shall comply with all the requirements of “The building and other construction workers (Regulation of employment & conditions of service) Act and other statutory requirements.

The Bidder shall ensure proper safety of all the workmen, materials, plant and equipment belonging to him or to the employer or to others, working at site.

The contractor shall provide suitable latest personal protective equipment of prescribed standard to all their employees and workmen according to the need.

The contractor shall provide safe working condition to all workmen and employees at his workplace including safe means of access, railing, stairs and ladders, scaffolding, work platforms, safety belts, etc.

The Bidder shall have his own arrangements with nearby hospitals for treatment of sick and injured.

First Aid boxes equipped with requisite articles shall be provided at construction sites for use of workers. Training has to be provided on first aid to workmen at site.

28.1.10. Bought-out Items

List of some reputed manufacturers of steel plates /sections, mechanical and electrical equipment to be used in hydro-mechanical installation for reference.

Sl.No	Item	Make
1	**Structural/Alloy steel plates and sections**	**SAIL/TATA STEEL/ESSAR/JINDAL STEEL**
2	Reduction Unit	New Allenberry, Allen-max, Allmax, Shanti, Allroyd, Radicon, David Brown, Elecon etc.
3	Bearings	KOYA, NBC, NACHI, SKF, FAG, NSK, NTN etc
4	Flexible coupling	New Allenberry
5	Motors	Siemens, Kirloskar, NGEF, GEC, Crompton Greaves Cotton etc.
6	Brakes	Bhartia Cutler Hammer, Electromag, Strom Kraft, Elmar AEC Sterling etc.
7	Self- lubricating bronze bearings	Lubrite, Lubron, Devaglide, Oiless, Ferroglide
8	Welding electrodes	Modi, Adore, D&H, L&T, Esab etc.
9	Steel wire ropes	Usha Martine, Fort William, Bombay wires, winkel GMBH
10	Hydraulic Cylinder	Rexroth, Hydrodyne, Hunger, Montan
11	Hydraulic Power Packs	Rexroth, Vickers, Montan, Yuken
12	ARMAC/Remote Control System Type PLC	Allen Bradley, Rockwell, Siemens, ABB, Schneider Electric
13	Gantry Crane	WMI, Texmaco, equivalent
14	Gasoline Engine Portable Power Pack	Kohler, Honda, Yamaha

Sl.No	Item	Make
1	**Structural/Alloy steel plates and sections**	**SAIL/TATA STEEL/ESSAR/JINDAL STEEL**
15	D. G. Set	Caterpillar, Kirloskar, Cummins, Greaves Cotton, Jackson
16	Hydraulic Oil Cleaning Unit for Hydraulic Hoists	KLAROL/Alpha lavel/ Vaccum plant & instrument/ Fowler westrup India ltd
17	Rubber/Clad Seals	Lion Rubber, Asian Rubber
18	Oil filtering & cleaning unit	Alfa laval, John Fowler, Vacuum Plant & Instrument Mfg.co.Ltd

28.1.11. Construction Schedule

A detailed construction schedule shall be prepared and submitted for the Engineer's review showing the estimated time needed for procurement of materials, manufacture, delivery at project site, installation, testing and commissioning. The schedule shall be submitted along with the Bid document and include the time required for the field check-out, start-up, and testing procedures. After awarding the work, a detailed installation schedule –item wise (i.e. embedded parts, second stage concreting, gate parts, hoist support structure and hoist/crane, dry testing, wet testing and handing over) shall be submitted for approval of Song Dam Drinking Water Project, Dehradun. In addition to above, the schedule should indicate the interfacing activities which will affect the HM equipment progress or operation.

28.2. Allowable Stresses

The allowable stresses are determined according to the yield strength of the material and should take into account the load case. For structural elements of hydraulic gates, the permissible monoaxial stresses shall not be greater than those specified below and applicable to wet and dry conditions (Refer Annexure B of IS 4622, 4623 & Annexure C of IS 9349):

Table 28.2-1 : Allowable stresses

Sl. No.	Material & Type	Wet Condition		Dry Condition	
		Accessible	Inaccessible	Accessible	Inaccessible
A	Structural Steel				
a	Direct compression	0.45 Yp	0.40 Yp	0.55 Yp	0.45 Yp
b	Compression/ Tension in bending	0.45 Yp	0.40 Yp	0.55 Yp	0.45 Yp
c	Direct tension	0.45 Yp	0.40 Yp	0.55 Yp	0.45 Yp
d	Shear stress	0.35 Yp	0.30 Yp	0.40 Yp	0.35 Yp
e	Combined stress	0.60 Yp	0.50 Yp	0.75 Yp	0.60 Yp
f	Bearing stress	0.65 Yp	0.45 Yp	0.75 Yp	0.65 Yp

B	Bronze or Brass				
i	Bearing stress	0.035 UTS	0.030 UTS	0.040 UTS	0.035 UTS

Yp stands for minimum guaranteed yield point stress.

UTS stand for ultimate tensile strength.

The term "Accessible" applies to gates which are kept in easily accessible locations and can, therefore, be frequently inspected and maintained, for example, gates and stoplogs which are stored above water level and are lowered only during operations. The term "Inaccessible" applies to gates which are kept below water level and /or are not easily available for frequent inspection and maintenance.

Stresses under occasional forces

The stresses in the various parts of the gate and hoist under the action of occasional forces like occasional over topping, earthquake effect etc. shall not exceed 133% of the permissible stresses mentioned above, subject to the maximum of 85% of the yield stresses.

Wheel

i. Contact stress (line contact)	1.6 UTS for low head and 1.4 UTS for medium & high head
ii. Wheel bearings (FOS)	1.5 x static capacity

Wheel pin

i. Bearing	0.35 UTS
ii. Shear	0.30 Yp
iii. Bending	0.5 Yp or 0.2 UTS (whichever is less)

28.3. Technical Documents

28.3.1. General

This chapter specifies the general scope which, together with those listed in the Particular technical specifications, shall be delivered by the Bidder to the Engineer within the period, and number and quality as specified in the Bidding document.

The Engineer reserves the right to request the Bidder an additional document as may be required for proper understanding and definition of constructional, operational, co-ordination or other matters.

The Bidder shall co-operate with other Bidders in the exchange of drawings, dimensions, data and all other information required to ensure proper co-ordination of the work. All documents to be supplied shall be submitted in accordance with the agreed program so that any comment and change requested by the Engineer can be taken into account before starting of the manufacturing in the workshop and/or erection or installation at the site.

If the Bidder fails to submit such documents, then the later execution of changes requested by the Engineer and the resulting additional cost and/or delays shall be the Bidder's liability. The Bidder shall be fully responsible for the correctness and not be relieved of his responsibility and guarantee after drawings and computations have been approved by the Engineer.

The preparation of drawings, computations or other technical documents shall not be subcontracted by the Bidder without the written authorization of the Engineer. In such a case of subcontracting, the Bidder shall be fully responsible for such drawings, computations and other technical documents as if they were done by him.

If required for proper understanding of the documents, additional descriptions/ explanations shall be given on these documents or on separate sheets. All symbols, marks, abbreviations, etc., appearing on any document shall clearly be explained by a legend on the same document or on an attached sheet.

Each device appearing on any document (drawing, diagram, list, etc.) shall clearly be designated. The abbreviation mark used for an individual device shall be identical throughout the complete documentation so as to avoid confusion. All documents shall have a uniform title-block as outlined in the specification. Beginning with the very first submittal to the Engineer, the Bidder's drawings shall bear a serial number.

Revised technical documents replacing previously submitted documents shall be marked accordingly. Also, the revised part in the document itself shall be marked clearly. The documents required to be supplied shall be clearly marked as regard to their status namely **"FOR APPROVAL" (A), or "FOR INFORMATION" (I),** respectively.

Any comment given by the Engineer on "I" type drawing shall have the same effect as if it were given on "A" type drawing.

28.3.2. Design & Drawing

The Bidder shall submit details of estimated machinery imposed loads on concrete structures, location of first stage anchors, groove dimensions and checks in structures constructed by others shall be provided within 120 days of award of Contract for interfacing with civil works.

The Bidder shall inform Song Dam Drinking Water Project, Dehradun about the software to be used for analysis and design. If any professional software is used for design & engineering, the same shall be made available for review.

Manufacturer shall submit design computations and drawings to the Engineer-in-charge for approval/ information (as per requirement listed in these technical specifications, which shall include in sufficient detail to show:

- Design calculation for all components in accordance with design criteria & specification to prove their adequacy supported by catalogues / technical literature of all bought out components with selection criteria & characteristics.
- Supporting calculations (optimum hoist capacity) and Kinematic details in the form of line diagram/sketches of gate and hoist establishing and describing the cylinder working stroke, reserve stroke on piston head side and piston rod side, the cylinder mounting location and position while gate is in fully closed and fully open position.
- General assembly and sub-assemblies' and detailed dimensions of the parts of the equipment to be supplied under the contract.
- Block out drawings indicating dimensioning, locations of first stage anchors (being embedded in the primary concrete) and first stage concrete outlines.
- Material lists covering specifications, sizes, quantities, and weight of each component.

- For all larger pieces of works which, due to their dimensions and/ or weight and transport limitations, will require special means for their transportation, the Bidder shall submit binding loading drawings indicating dimensions weights, etc. of the respective pieces of works and the necessary trailer for its transportation to the site.
- Weld details.
- Machining and assembly tolerances and fits;

Diagrams

- The circuit diagrams shall show the power circuits in all phases with the main apparatus as well as the pilot circuits (measuring and control circuits). It shall show in full functioning of all installations, or circuits with required technical information. This shall show all technical blocks control cubicle, cable details, cable tracks etc.
- Electrical wiring diagrams of hoist, hydraulic circuit, piping / cable layout drawings, performance curves, specifications and catalogue of all motors, control panels, and accessories.
- Automatic or manual lubrication system.
- All handling attachment for site assembly.
- Control & Indicators.

All drawings shall be carefully checked by Manufacturer for accuracy, completeness and clarity before submission to Engineer-in-charge. Manufacturer shall be responsible for correctness and adequacy of the design in relationship to the specifications.

The approval of design or drawings shall not relieve or absolve the Bidder of his responsibilities regarding adequacy and correctness of operational strength of components and adequacy of design requirement.

The Engineer-in-charge shall have the right to ask the Bidder to make any change in the designs and drawings, which may be necessary in the opinion of the Engineer-in-charge to make the equipment conform to the provisions and intent of those specifications without additional cost to the purchaser.

The requirements of any such alterations requested by Engineer-in-charge shall not be construed to mean that the drawings have been checked in detail. It shall not be accepted as justification for an extension of time and shall not relieve Manufacturer from responsibility for the adequacy of the designs and correctness of the drawing.

The Bidder shall carry out and be responsible for the design of works. Design shall be prepared by qualified designers who are engineers or other professionals and have experience and capability necessary for the design. If any professional software is used for design & engineering, the same shall be made available. The Bidder undertakes that the designers shall be available to attend discussions with the Engineers at all reasonable times until the date of relevant defect notification period.

The Bidder shall prepare any other documents necessary to instruct the Bidder's Personnel. The Employer's Personnel shall have the right to inspect the preparation of all these documents, wherever they are being prepared and used.

Any approval or consent, or any review shall not relieve the Bidder from any obligation or responsibility.

If the Engineer-in-charge asks for any clarification/additional information, the Bidder shall furnish and satisfy.

28.3.3. Submissions

The design computations/drawings required to be submitted to Song Dam Drinking Water Project, Dehradun for approval or information is broadly listed hereunder and the bidder shall submit a separate list of documents and drawings (Approval category and only information category) along with his bids which will be reviewed and decided by Song Dam Drinking Water Project, Dehradun prior to awarding the work.

28.3.3.1. DESIGN DOCUMENT

Orifice Spillway radial gate and hydraulic hoist

Radial Gate

For approval	For information
Design basis report (DBR), design note (DN) of radial gate including trunnion assembly, lifting attachments, connection details between various members (welded/bolted), hydraulic cylinder supporting mechanism, load bearing anchors/bolts, Joints/welds, trunnion anchorage system, dogging arrangement, side guide roller assembly complete in all respects Calculation of hoist capacity.	C.G. calculation, walkway/ hand railings/ gratings etc.

Power pack and electrical controls for radial gate

For approval	For information
Selection of Pump, motor, oil tank capacity, hydraulic circuit, selection of portable power pack powered by petrol engine.	Selection of piping and pipe fittings, filters, valves, gauges, controls, pressure switches & other components of hydraulic power pack and electrical control panel.

Hydraulic cylinder for radial gate

For approval	For information
Design basis report, design note of cylinder, piston, stem rod end clevis, piston head end clevis/ attachment, Kinematics details (for working out optimum location of cylinder supporting structure) in form of line diagram/ sketches showing fully extended/ retracted length of cylinder, working stroke, reserve stroke on both ends, Specification of hydraulic oil and quantity required including flushing operation and type/make of limit switches.	Cylinder heads end connections (fasteners), piston, threads and connections among various mating components, details & specification of sealing and bearing components, position indicators, details of all other components.

Intake bulkhead gate, Upper Spillway Service Gate, Orifice & Upper Spillway stoplogs

For approval	For information
Design basis report (DBR), design notes (DN) of gate with lifting attachments, wheel assembly / bearing pads (on slide gates), wheel track/ bearing track, connection details (weld/bolt), dogging device, filling-in-valve and hoist capacity calculations.	Guide wheels/shoes & other components.

Rope drum hoist, Gantry crane, Monorail Crane & their supporting structures

For approval	For information
Design basis report (DBR), design note (DN)/ selection of rope drum, reduction gear box, shafts, wire rope and attachments, motors, brakes, wheels, hoist supporting structure/ gantry/ mobile crane	LT rails and fixtures, end carriage, buffer, pulleys & connection details, overload & slack rope mechanism, parking clamps/ anchors, turn buckles, cabin, walkway, ladders, handrails, chequered plate gratings, rope clamps, couplings, & Plummer blocks. Power supply arrangement & limit switches.

Lifting beam

For approval	For information
Design of Lifting beam & lifting hook	Probe mechanism, end guide frames/arrangement.

Trash Rack

For approval	For information
Design of trash rack screen, bar, horizontal members, connections (weld/bolt). Stability against vibration	Embedded frame and guides.

Instrumentation and Remote Control System

For approval	For information
Design criteria, system configuration, and detailed specification with installation instruction, and schematic diagram. Name of manufacturer.	Specifications of components with manufacturer's catalogue/ literature, Instrument technical data sheet/ catalogue, detailed drawings of all components, application software etc.

DG Set

For approval	For information
Name of manufacturer and capacity and detailed specification	**Test certificates**

Hydraulic Oil Filter Unit

For approval	For information
Name of manufacturer, operating characteristics, detailed specifications.	

28.3.3.2. DRAWINGS

Orifice Radial gate

For approval	For information
1) General arrangement including details of trunnion assembly & hoisting equipment. 2) Block out details, first stage anchors & 2nd stage embedded parts, trunnion anchorage system and dogging arrangement. 3) Details of all gate components. 4) Sub-assembly drawings	

Intake bulkhead gate, Upper Spillway Service Gate, Orifice & Upper spillway stoplogs

For approval	For information
1) General arrangement of fixed wheel gate including hoisting equipment. 2) Block out detail, first stage anchors & 2nd stage embedded parts and dogging arrangement. 3) Details of all gate components and wheel assembly	Sub-assembly drawings.

Lifting beam

For approval	For information
General assembly of lifting beam	Sub-assembly and detailed drawings of all components.

Trash rack

For approval	For information
1. General arrangement. 2. Block out details first stage anchors & 2nd stage embedded parts. 3. Details of trash rack panels. 4. Lifting beam	Handling arrangement

Hydraulic hoist/ portable power pack

For approval	For information
General arrangement, Cylinder assembly, hydraulic circuit, electrical circuit and functional description. Selection of petrol engine	Cable schedule, sub-assembly, Position indicator, hydraulic piping arrangement, and other detailed drawings such as platform and access ladder.

Rope drum hoist, gantry crane, Monorail Crane & their supporting structures

For approval	For information
1. General arrangement with gate (lifting & resting position) along with technical particulars. 2. General arrangement drawings of Hoist/LT/CT along with wheel bogie details 3. G.A. drawings of structure along with platform, access ladder and safety cage and connection details.	LT drive assembly, CT drive assembly, Drum assembly, end gear assembly, central drive unit assembly, Plummer blocks, wheels, Rail and fixtures, shafts, gears, couplings, structural detailed and sub-assembly drawings.

DG SET

For approval	For information
Foundation drawings and DG set room dimensions and exhaust location.	Sub-assembly and detailed drawings.
Note: **All details of equipment and materials required for fabrication and/or assembly and drawings to be cross-referenced to all other drawings**	

28.3.4. Installation and Commissioning Procedures

28.3.4.1. INSTALLATION PROCEDURES

The installation procedures shall describe in sequential steps the erection of major equipment and shall contain sufficient details such as equipment preparation on erection bay, handling of large and heavy pieces, leveling, anchoring, field welding, field painting, erection checks, field pressure tests, site flushing and cleaning of hydraulic systems, alignment and run out checks to allow the engineer to plan and supervise the works at site. The Bidder may submit his proposals for such installation but shall have to obtain the approval of the purchaser before acting. Detailed instruction to the installation of the gates shall be given by the purchaser or his authorized representatives at site and shall be binding on the Bidder.

28.3.4.2. COMMISSIONING & TESTING PROCEDURES

The commissioning & testing procedure shall sequentially and in sufficient detail describe activities and tests for all systems covered by the Contract document.

28.3.5. Operation and Maintenance Manual

The operation and maintenance manual shall be prepared and provided by the Bidder and shall contain following information in sufficient detail to enable the employer to maintain dismantle, reassemble, adjust and operate the works with all its works and installation.

The manual shall include a separate and complete section describing the following:

- Description of equipment.
- Operating principle & characteristics.
- Operating instruction (For normal & emergency operation.)
- Testing & adjustments.
- Maintenance instructions.
- As build drawings.
- Spares.

The manual shall describe and illustrate the procedure for assembling, adjusting, operating and dismantling of each component and control system. The maintenance of each component shall be described, including the recommended frequency of inspection and lubrication.

Three (3) copies of the manual shall be submitted in English in draft for approval of Engineer- in-charge within 3 months after the final approval of the drawings. Six (6) copies properly bound and placed in folder shall be provided to Engineer-in-charge along with soft copies on good quality DVD (two sets) suitable for printing of the text & drawings not later than 30 days after receipt of approval.

If revision of the manual becomes necessary, as a result of information gained during installation and initial operation, Manufacturer shall make the necessary revisions and furnish Six (6) copies of the revised section sheets with the revision symbols along with DVD.

The manual shall include a complete list of all drawings prepared by Manufacturer, a list of spare and a list of parts for each component or item of equipment. The parts list shall include manufacturer's name and serial numbers. The manual shall include data, literature and catalogues of bought out items.

Manufacturer shall ensure that his installation supervisor has a copy of all approved drawings and the manual in his site office.

28.3.6. Progress Reports

28.3.6.1. DURING DESIGN AND MANUFACTURING

The Bidder shall submit monthly progress report in a format acceptable to the Engineer, detailing the progress of the work at manufacturer workshop during the preceding period. The report shall contain (but not be limited to) the following information:

- A general description of the Works performed during the reporting period on each main activity.
- Overall percentages of the works completed, with reference to the approved CPM programme.
- The percentages of each main work completed during the reported month versus the scheduled programme.
- A list of activities scheduled to be started within the next period of three (3) months, with expected starting and completion dates. Any notable problems, deviations/differences, comments with reference to the schedule.

28.3.6.2. DURING INSTALLATION AT SITE

During erection, the Bidder shall submit the monthly progress reports in a format acceptable to the Engineer, detailing the progress of the work during the preceding month. The report shall contain but are not be limited to the following information:

- A general description of the works performed during the reporting period on each main activity.
- The total overall percentages of erection works completed, with reference to the CPM program.
- Pending critical activities and mobilization efforts proposed for the same.
- The percentages of each main work completed during the reported month versus the scheduled program.
- A list of all activities of scheduled and actual progress during the reporting period including actual starting dates versus scheduled starting dates; and actual completion dates versus scheduled completion dates for each activity.
- A list of activities scheduled to be started within the next period of two (2) months, with expected starting and completion dates. If the expected starting and/or completion dates are different from those shown on the CPM program, an explanation shall be given.
- Bidder shall also briefly report the manpower strength and expatriate personnel employed, equipment deployed during the reporting period.
- A statement concerning potential problems and recommendations on how they could be resolved.

28.4. Mandatory Spares

All spares to be supplied shall be interchangeable with the corresponding parts of all the equipment supplied under these specifications and shall be of the same material and workmanship. They shall be replaceable without cutting or destruction of adjacent components. Before issue of the Taking-Over Certificate the spares shall be checked and tested at the site by the Bidder in presence of the Owner's Engineer.

Acceptance of any spares will not take place before the Bidder has submitted the complete final detailed list of all spares.

All spares shall be protected against corrosion and shall be marked with identification labels in English. The identification shall be in accordance with the agreed Identification system.

All spares shall be delivered in boxes of sufficient sturdy construction to withstand long term storage.

The supply of mandatory spares is listed separately in the Price schedule 3 in Volume III. The price for each listed spares shall be quoted individually and the total price shall be included the cost of mandatory spares.

28.5. Design and Manufacture

28.5.1. Design and Construction Requirements

The following directions, information and technical requirements for layout, design and erection shall be observed as far as they are applicable to the works to be offered. The technical requirements of the General Technical Specification are valid for all parts of the works except where they are varied by additional and/or special requirements, specified in the Particular Technical Specification.

Whenever a Bidder deviates from these Specifications, he shall furnish the data called for in the Technical Data Sheet and give a summary of and the reasons for all deviations in the "List of Technical Deviations from Specifications". Failure to accomplish this may cause the elimination of his Bid, especially when a major deviation is involved. Any changes of the design of any part of the works, which may become necessary after signing the Contract, have to be submitted in writing to the Engineer for approval, being sufficiently substantiated and justified.

The works shall be designed, manufactured, arranged and installed to provide functional design and neat appearance. All parts of the Works shall be arranged to facilitate surveillance, maintenance and operation. All control sequences shall be simple and rational.

The parts of the works shall be designed and arranged so that they can be easily inspected, cleaned, erected and dismantled without involving large scale dismantling of other parts of the works. They shall be designed, and manufactured in accordance with the latest recognized rules of workmanship and modern engineering practice.

The regulations, standards and guidelines listed in these specifications shall be observed in the design, calculation and manufacture of the Works.

All parts of the Works shall be suitable in every respect for continuous operation at maximum output under the climatic conditions and operating conditions prevailing at the Site.

Special attention shall be given to works, parts of which are delivered by different manufacturers. Problems arising in this conjunction shall be solved by the Bidder and be defined in writing.

For individual items of the works, materials and design are to be selected which are best suited for the operating conditions to which the parts in question will be subjected. Only such design and types of works shall be offered which has confirmed its reliability in long-term continuous operation. Innovations cannot be accepted for the Main Tender but can be offered as an alternative proposal.

All live, moving and rotating parts shall be adequately secured in order to avoid danger to the operating staff. All electrical components shall be electrically earthed as per the latest practice.

Manufacturers shall take appropriate measure to prevent the ingress of dust into any works (such as bearings, relays, control and measuring equipment etc.) which may be endangered thereby.

Suitable lifting eyes and backing-out bolts shall be provided where required or where they will be useful for erection and dismantling.

Pockets and depressions likely to hold water shall be avoided, and if not avoidable they shall be properly drained. Parts of the works principally intended for standby purposes shall be protected from corrosion by careful choice of material and if necessary, by additional means these should not reduce their continuous standby readiness.

All design details and layout matters shall be discussed in periodic meetings with the Engineer. The first design meeting between the Bidder and the Engineer shall take place within 28 days after the date of commencement. Further design meetings shall take place as agreed between the participants until the design work is completed.

Lettering of the drawing shall be at least 3 mm high in block capitals. The sizes of Manufacturers drawings shall conform to International Organization for Standardization (ISO) sizes. All drawings shall bear the mutually agreed title block, and drawing number as per the coding and pattern available with the employer. All drawings shall be drawn in accordance with Indian Standards, to scale, and shall be legible. Wording on drawings shall be in English. Symbols shall be in accordance with Indian Standards. Manufacturer shall submit to the Engineer-in-Charge 4 prints each of all documents / drawings for **approval/ information.** If revisions are required after a drawing has been submitted, manufacturer shall resubmit 4 additional prints for **approval** after incorporating the comments. Fabrication shall not commence until Engineer in-charge has approved drawings and thereafter no change shall be made on any drawing without the approval of the Engineer in-charge.

Drawings shall be submitted to Engineer in-charges for approval sufficiently in advance prior to the date on which they will be required to ensure that the work is carried out in compliance with approved schedule of work.

28.5.2. Design Criteria

The Works shall be designed for the worst possible combination of the following loading conditions:

- All static and dynamic hydraulic loads,
- All loads due to dead weight and frictional forces,
- Seismic or wind loads, and
- Other loads

The full reservoir level, sill elevation and design criteria are described in particular specification required for the design.

The basic wind load of 1500 N/m. sq. shall be applied on the vertical projected area of exposed equipment, multiplied by the form factors for the different type of structures in accordance with IS: 875.

The wind load for the stability check of gantry crane, etc. shall be 600 N/m sq. while operating and 1500 N/m sq. when out of service.

Other Loads

Load on the footpath, balcony floor, and platform	: 5000N/m^2
Vertical load on steel roof structures	: 2500N/m^2
Vertical load on each part of ladder	: 1800N/m^2

28.5.3. Tolerance and Clearance

The following design clearance shall be submitted to the Engineer -in-charge for approval: -

- Clearance between end of main Roller housing (side of gate) and gate guide.
- Clearance between moving gate components with respect to face of concrete/steel lined grooves.

28.5.3.1. GENERAL CLEARANCES

- Side guide to guide track : 6 mm in any direction.
- pre-compression of side and top seals : 3 mm
- Pre-compression of bottom wedge type seal : 5 mm
- Minimum clearance between gate/stoplog bottom face to dogging or maintenance platform (whichever is higher) : 300 mm
- Minimum clearance from extreme top Part of gate /stoplog to crane/hoist : 300 mm
- Minimum recess from concrete face to Extreme part of gate / stoplog : 100 mm.

28.5.3.2. FABRICATION TOLERANCES

All components shall be fabricated in accordance with IS 4622, IS: 4623 & IS: 9349.

28.5.3.3. INSTALLATION TOLERANCES

Installation tolerances shall not exceed 1.5 times the corresponding fabrication tolerance or the tolerances specified in the relevant IS codes whichever is the more stringent. Design and fabrication of the gates, hoist and embedded parts shall be suitable for the achievement of such tolerances during installation.

28.5.4. Standardization

Every effort shall be made to standardize parts and minimize costs throughout the works in order to facilitate replacement, interchangeability, keeping stocks, maintenance etc.

The Engineer-in-Charge, therefore, reserves the right to request the different Bidders to use uniform types or makes of components and materials. The Bidder shall not be entitled to claim extra payment due to this request. This request shall especially be applicable to small mechanical and electrical works such as:

- seals
- fasteners
- oils and lubricants
- valves
- thermometers
- pressure gauges
- flow meters

- water level gauges
- terminals and terminal racks
- indicating instruments and meters
- auxiliary relays
- contactors, fuses
- motor protection switches
- control devices
- lights, bulbs, plugs, sockets

The types or makes to be used shall be decided later by the Engineer-in- Charge.

28.5.5. Quality of Material and Workmanship

For general requirements concerning the quality of materials and works refer to the General Conditions of contract.

All materials shall comply with the latest IS standards, or other standards specified unless otherwise specified. The materials and workmanship throughout shall be the best of their respective kind and free from defects. The design of all equipment shall be such that installation, replacements and general maintenance may be undertaken with the minimum of time and expense. All fitted joints shall be machined and castings shall be spot faced for nuts. All components shall be built in accordance with approved drawings only. No patching plugging or other such means of overcoming defects; discrepancies or errors shall be done without written permission of Engineer-in-charge.

No welding, burning, filling or plugging of defective castings or any other components shall be permitted without the Engineer's agreement in writing.

Where stainless steel cladding consists of plates welded to mild steel sections, the welds shall be adequate to ensure that the stainless steel is securely fixed for all conditions of load and wear. Generally, all stainless steel parts shall be welded with stainless electrodes. The thickness of the stainless steel cladding shall not be less than 3 mm.

Similar parts shall be made to gauge where possible, to ensure that such parts are interchangeable one with the other.

The Bidder shall be responsible for the accurate manufacture and fabrication of equipment in accordance with the best modern practice in the manufacture and fabrication of materials of the types covered by these specifications notwithstanding the minor errors or omission there from.

Dimensions shown on the drawings shall be adhered to closely and the work shall in all cases be of high grade and carefully performed to the satisfaction of the Engineer-in-Charge. The Bidder shall warrant all materials and workmanship furnished by him to be free from injurious defects. He shall replace free of cost any defective materials or workmanship discovered during erection or in guarantee period and shall pay the actual cost of the correction on the field of any errors for which he is responsible.

The Bidder shall be responsible for erection and supervise the leveling and adjustment of all embedded parts after each item is set up and the Engineer's approval obtained to supervise grouting or concreting which will be carried out by the civil agency and verified by the Bidder. The Bidder shall be responsible for ensuring that such work is carried out to his satisfaction and those levels and adjustments made by him are not disturbed by the second stage concreting. The Bidder shall be responsible for ensuring that the positions, levels and dimensions of the works are correct according to the drawings notwithstanding that he may have been assisted by the Engineer in setting out the said position, levels and dimensions.

28.5.6. Works Identification System

An approved, uniform Works identification system shall be applied for all mechanical, electrical and Instrumentation and Control (I&C) works to be agreed upon during detailed design.

28.5.7. Identification Plates

28.5.7.1. GENERAL

Each important part to be delivered under this Contract shall be equipped with permanent identification plates in readily visible locations. Whether a part shall be considered as important in this respect shall be decided by the Engineer.

The identification plates shall be protected during erection and especially during painting. Damaged or illegible identification plates shall be replaced by new ones. The identification plates of non-corroding, non-disintegrating material (except manufacturer's nameplates of small standardized components) shall be inscribed in English.

The inscription shall be printed, stenciled, or handwritten, but in any case water-proof, oil-proof and wear-resistant. Works (machines, transformers, etc.) nameplates shall be either of the enameled type or be of stainless steel covered after stamping with a transparent paint. Wording, size and material of all labels and plates shall be subject to the Engineer's approval.

28.5.7.2. MANUFACTURER'S NAME-PLATES

All equipment shall be provided by a securely fastened name plate showing the maker's name, model, serial numbers, year of manufacture, main characteristics data of the respective equipment and further relevant information specified in the applicable standards or necessary for the proper identification of the equipment involved.

28.5.7.3. INSTRUCTION PLATES

All plates showing designations or instructions for operation, safety, lubrication, etc., shall have a uniform design. Instruction plates, sequence diagrams or instruction to operating staff shall be displayed on the inside of the front door of the control panel/switch board. All works inside cubicles, panels, boxes etc. shall be properly labeled with their item numbers. This number shall be the same as indicated in the wiring diagrams works lists, operation and maintenance manual.

All instruction plates displayed on the sub-assemblies like servomotors, power pack hoist etc. shall show operational parameters, safety, lubrication etc. which shall have a uniform format.

28.5.7.4. WARNING PLATES

Warning labels for safety of equipment as well as operating staff shall be provided and shall be of synthetic resin with letters engraved in the contract language.

28.5.8. Steel Works

Rounding's, Chamfers, Edges: The edges of surfaces to be painted shall be rounded (minimum radius 2 mm) or chamfered accordingly. This requirement must be stated in all shop drawings for the relevant parts.

Structural steel: Work shall conform to the requirement hereinafter specified, unless otherwise called for in these specifications or on the drawings. Finished members shall be free from twists, bends and open joints. Compression joints shall have surfaces truly faced so as to have full contact bearing when aligned and welded or bolted.

Straightening of materials: Before being laid off or taken-up for work, rolled material shall be straightened and shall be cleaned off all rust and dirt. If straightening is necessary, it shall be done by methods that will not be cause for rejection of the material.

Shearing and cutting: Shearing and cutting by torch shall be performed carefully and in all work which will be exposed to view after completing shall be finished neatly. Sheared or cut edges of plates more than 16mm thick which carry computed stresses shall be planned to a depth of 6mm. Re-entrant cuts shall be filleted before cutting.

Holes: Holes in structural steel members carrying calculated stresses shall be sub-punched to 3mm less than the nominal diameter and reamed to full size or drilled after assembly. All other members may be punched to full size. Main members shall be assembled in the shop prior to reaming or drilling holes for field connection.

Accuracy of punched holes: Holes shall be punched so accurately that after assembling the component parts of a member, a cylindrical pin 3mm smaller in diameter than the nominal diameter of the punched hole may be entered perpendicular to the face of the member, without drifting in not less than 75 percent of any group of continuous holes in the same plane. All holes shall punch a pin 5 mm smaller in diameter than the nominal diameter of the holes.

Reaming: Reamed holes shall be cylindrical, perpendicular to the member, and neither less than 1.5 mm nor more than 2.5 mm than the nominal diameter of the bolts. Built up members shall be assembled and firmly bolted together before any reaming is done. Reamed parts shall not be interchanged. Burrs and savings from reaming shall be removed and, if necessary, reamed pieces shall be taken apart before being joined and the shavings removed.

Drilling: Drilled holes shall be cylindrical perpendicular to the member and 1.5mm larger than the nominal diameter of the rivet.

Accuracy of reamed and drilled holes: Holes shall be drilled and reamed so accurately after assembly that not less than 85 percent of any group of continuous holes in the same plane shall show any off-set greater than 0.8mm between adjacent thicknesses of metal.

Removal of burrs: Burrs resulting from reaming or drilling shall be removed with a tool making a 1.5mm level.

28.5.9. Surface Finish

28.5.9.1. FINISHED SURFACES

Where the finish is not indicated or specified, the type of finish shall be that type which is most suitable for the surface to which it applies and shall be consistent with the class of fit required.

Surface finish shall be indicated on the shop drawings by symbols. Compliance with the specified surface shall be determined by the sense of feel and by visual inspection of the work compared to applicable "Standard Roughness Specimens", or with roughness feeler gauge instruments. Both "Standard Roughness Specimens" and feeler gauge instrument shall be provided by the Bidder at the request of the Engineer.

28.5.9.2. UNFINISHED SURFACES

As far as practicable, all work shall be laid out to secure proper matching of adjoining unfinished surfaces. Where there is a large discrepancy between adjoining unfinished surfaces, they shall be chipped and ground smooth, or machined to secure proper alignment.

Unfinished surfaces shall be true to the lines and dimensions shown on the drawings and shall be chipped or ground free of all projections and rough spots. Depressions or holes not affecting the strength or usefulness of the parts shall be filled in a manner approved by the Engineer.

28.5.10. Fasteners

Bolts, Studs, Nuts and Screws: They shall have standard threads and be of high quality steel. All standard size bolts, studs, nuts and screws (including their washers) shall be heavily protected against corrosion or made of stainless steel if so specified in the technical Specifications. Nuts and bolts heads shall be hexagonal in shape & truly faced. Nuts & bolts and screws which might become loose during operation shall be locked in fastened position by means approved by the Engineer-in-charge.

All bolts shall have unified threads. Bolts in tension shall have a net section at root of thread, 15 percent in excess of the net section required in tension.

Field Jointing: All fasteners for field joint shall be supplied 5 percent in excess of actual requirements. This should be indicated in the drawings/bill of material.

28.5.11. Welding

Members to be joined by welding shall be cut accurately to size, and where required, shall be rolled or pressed to proper curvature in accordance with the approved drawings. The dimensions and shape of edges to be joined shall be such as to allow thorough fusion and complete penetration and plates shall be planed if necessary, to accomplish this result. Members to be welded together shall be in sufficient intimate contact at the time of welding so that members will not be forced more closely together with the cooling of the weld, thus setting up additional strains and distortions in the weld and parent metal.

The cut surface shall be free from all visible defects such as lamination, surface defects caused due to shearing or cutting or flame cutting operations. The surfaces of plates to be welded shall be free from dust, grease and scale for a distance of 12mm from the welding edge at the time of welding. Flame cutting may be used in the preparation of the various members provided the operation is performed carefully and the edge so cut are cleaned thoroughly after being cut so as to expose clean metal. Any contour irregularities at points of critical stress shall be removed by grinding.

All welding shall be carried out using a suitable welding sequence/procedures approved by the Engineer and in such a way that harmful effects of welding are avoided.

When the welding process has been approved by the Engineer, the Bidder shall produce a record drawing to show the approved process. The drawing shall include details such as the form of edges to be welded, electrodes and other welding materials, welding sequence etc. Changes in the welding process after the welding method has been approved shall require the consent of the Engineer.

Additional copies of all records of all welding procedures, including preheating and stress relieving, chemical analysis and physical properties, shall be made available to the Engineer-in-Charge upon request.

Unless otherwise allowed by the Engineer all welded parts to be welded shall be manufactured of steel produced by open hearth or electric furnace with carbon content not more than 0.20 % and a Phosphorous content not more than 0.05%.

A welding process approved by the Engineer generally in accordance with the standards specified in the Technical Specification shall be followed. Approval of the welding procedure shall not relieve the Bidder of his responsibility for correct welding and correct selection of electrodes and minimizing of defects in the finished structure.

All welding shall be done by the electric arc method or by a process, which will exclude the atmosphere from the molten metal, except where otherwise specifically permitted. The welding electrodes shall be heavily coated type designed for all position welding. In assembling and during welding, the component parts of built up members shall be held in place by sufficient number of clamps or other adequate means to keep all parts in proper position.

The Bidder shall follow the steel manufacturers instructions/ recommendations concerning electrodes and other materials and post & preheat treatment. Notwithstanding the above, the suitability of electrodes to be used for welding for both shop and field welding shall be demonstrated by trials to the satisfaction of the Engineer-in-Charge.

The strength of welding of all equipment subject to high and/ or alternating stresses, vibrations etc. shall be at least equal to the strength of the parts being welded. Between plates and other sections where such stresses are to be transmitted only butt welds shall be permitted. At welded butt joints, where the weld material is required to be deposited on both sides of the joints, the weld shall be chipped thoroughly to obtain a clean surface prior to the application on the first head of the welding on the opposite side of the joint. Where fillet welds are used, the lapped sections shall fit closely and shall be held together during the welding operation. Surfaces to be welded shall be cleaned of loose scale, slag, rust, paint and other foreign matter, except that a thin coat of linseed oil need not be removed before welding. When weld metal is deposited in two or more layers, each layer shall be brushed with a wire brush or otherwise cleaned before subsequent layer is deposited. In welding precautions shall be taken to minimise stresses due to expansion or contraction by peening the welds while hot, or by other satisfactory methods. Correction of distortion by blows, after welding is completed and the place is cold, will not be permitted. Upon completion, the welds shall be brushed with wire brushes and shall show uniform section, smoothness of weld metal, feather edges without excessive overlaps and freedom from porosity and clinkers. Visual inspection at edges and ends of fillets and butt joints welds shall indicate good fusion and penetration into base metals.

The specification regarding welding including the technique of welding employed, the appearance and quality of welds made, and the methods used in testing of the welds, and in correcting defective work shall conform to relevant Indian Standard or other standards specified.

All shop and field welding performed on the work shall be subject to inspection by Engineer-in-charge when welding plates, of which one or both exceed 25mm in thickness. Continuous areas of plates around the welding operation shall be preheated to not less than 70^0 C and kept at a substantially uniform temperature throughout the process. The temperature shall be measured by Tempil sticks or other approved means. Low hydrogen electrodes shall be used everywhere. Peening of multiple pass welds to control distortion or to minimize residual stresses may be carried out with light blows from a power hammer using an elongated round nosed tool. Peening shall be done after the weld has cooled to a temperature warm to the hand. Care shall be exercised to prevent scaling, flaking or rupturing of weld and base metal from over peening. Neither the first nor the last pass of a multiple pass weld shall be peened.

All welds on stress carrying members shall be done in Manufacturer's shop unless otherwise agreed by Engineer-in-charge. In general, only no-load- carrying seal welds will be permitted in the field. All fields welding shall have prior agreement of Engineer-in-charge. Tack welds shall be permitted only as a temporary welds required for assembly purposes.

The welding sequence shall be planned to control and minimise distortion and, where necessary, shall include stress relief to minimise residual stresses. Minimum stress relieving requirements are specified in the appropriate sections of these specifications.

Welded components subject to vibration and stress reversals shall be fabricated with full penetration welds.

For welding of principal stress carrying parts the standards of welding procedures, qualification of welders and welding accessories shall conform to relevant Indian Standards or equivalent to the requirements of the ASME Boiler and pressure vessel codes section VIII and IX. All welders assigned to the work shall have passed a performance qualification test. If more than one year has elapsed since the welder passed his last test, then he shall be tested and qualified again.

28.5.12. Stress Relieving, Heat Treatment

The stress relieving of parts fabricated from carbon and low alloy steels, where required shall be thermally stress-relieved as a whole in an enclosed furnace wherever practicable after all welding including their radiographic examination is completed but before they are machined or assembled into structure. The stress relieving of equipment, materials and supplies, containing plates thicker than 30 mm shall be carried out as per the standard industrial practice.

All castings and forgings shall be suitably heat treated in a properly constructed furnace (to attain the specified mechanical properties), having adequate means of temperature control, which shall permit the whole of the castings/forgings to be uniformly heated to the necessary temperature. All castings/forgings shall either be fully annealed or normalized or normalized and tempered.

The stainless steel track plates (such as x20Cr13 or 30Cr13) shall be heat treated for use in hardened and tempered condition. The recommended heat treatment for these steels shall be followed as specified in Table 3 of IS 6911:1992.

The method of heat treatment and the relevant records of heat treatment shall be furnished by the Bidder to the Song Dam Drinking Water Project, Dehradun

28.5.13. Corrosion Protection

28.5.13.1. SURFACE TREATMENT AND PROTECTION

The manufacturer shall provide as part of his work/supply the surface treatment, priming, corrosion protection and painting of the equipment furnished. Such work shall include the coating and painting work at the workshop and at the site unto and including the finish painting. Unless otherwise specified the coating and painting shall be carried out in accordance with the latest Indian Standards or International standards.

All priming and painting material shall satisfactorily fulfill the requirements imposed by the site conditions, as well as the stresses to which the respective equipment is subjected during operation of the works. Shades of the finishing coatings shall be as approved by the Engineer-in-charge.

Each coat of primer and paint shall be compatible with the previous and subsequent coats. All pigmented primers and paints which will be used for priming and painting at the site shall be delivered in original and sealed containers packed by the manufacturer bearing brand name, colour designation, storage and handling instructions.

The manufacturer shall supply full details regarding the extent to which sand blasting, priming and paintings will be carried out in his workshops (or his sub-Bidders, as the case may be) at the site and after erection. A properly equipped paint shop shall be set up at the site using a specialist organization, experienced and skilled in the preparation and application or protective coatings at the conditions prevailing at the site.

Each coat shall be free from runs, drops, pinholes, waves, laps, sags and unnecessary brush marks and shall be allowed to dry or to harden before the succeeding coat is applied.

Machinery paint may be thinned, if necessary to permit satisfactory application, but the amount of thinner shall be kept to a minimum.

For removing rust and mill scale from structural steel, plate sheets, piping and other steel surfaces, as well as from other parts blast cleaning shall be carried out to clean bare metal. Parts which cannot be blast- cleaned shall be cleaned free from rust and scale by power tool cleaning to the highest possible degree.

28.5.13.2. SURFACE PREPARATION

For adherence and durability of the paint system it is extremely important that a suitable surface preparation is carried out.

Blast cleaning

Surfaces requiring blast cleaning should be sand/grit/shot blasted after fabrication prior to painting. The average surface roughness after sand –blasting should not exceed 40 microns. Blast cleaning should be performed with sand/grit/shot as per requirements given in IS 1477 (Part 1). After blast cleaning, the surface should be cleaned from loose dust and debris preferably by air blast with the help of blower. Whole surface of steel should be cleaned to bare metal (Class A) without any residual in any form as specified in clause 4.2.1.1 of IS 14177.

28.5.13.3. APPLICATION OF PAINT

Surface preparation leaves the material in vulnerable condition. It is therefore essential that immediately after surface preparation but not later than a time gap of 6 hours, the prepared surface of the steel metal should be covered with a primer.

A primer coat cannot be expected to last for an extensive period. It must receive finish coats before it deteriorates. Each coat should be thoroughly dried and cured before application of succeeding coats. Care should be taken to prevent contamination of surfaces between coats of paint. All coats should be applied in such a manner that produce an even film of uniform thickness completely covering all corners. Coating should be done by qualified workers experienced in applying the specific coating materials.

Spray application should be performed with airless spray equipment. Spray guns should be suited to the type of paint being used and should be operated with orifices, nozzles and air pressure suited to the type of paint and its consistency.

All cleaning, surface preparation and coating application work should be done after the parts are completely fabricated and machine finished and checked in the shop.

28.5.14. Painting Systems

28.5.14.1. GATES AND EMBEDDED PARTS

Perfect cleaning of all surfaces, which are not to be covered with concrete, shall be carried out by sand blasting to the requirements of SA2½ of Swedish Standard.

Over the prepared surfaces one coat of in organic zinc (not less than 85%) silicon by spray (preferably airless spray) should be applied giving a dry film thickness of 75 ± 5 microns.

The interval between surface preparation and painting shall be as short as practicable and in no case longer than 4 hours. Over the primer, two coats of solvent less coal tar epoxy paint shall be provided at an interval of about 24 hours. Each coat shall give a dry film thickness of 150 microns. The total dry film thickness of all the coats shall not be less than 350 microns.

Lifting Beams

The following painting system shall be adopted for lifting beams. Over the prepared surfaces by sand blasting, two coats of priming with primer conforming to IS 102, each coat giving a dry film thickness of 45 microns shall be applied. The finished paint shall consist of two coats of micaceous iron oxide paint. Each coat of paint shall give a dry film thickness of 75 microns. The interval between coats shall be 24 hours. The total DFT of all the coats shall not be less than 210 microns.

28.5.14.2. HOISTS, CRANES AND MONORAIL CRANE

a) **Structural components:** Cleaning of all the surfaces shall be done by sand blasting to SA 2½. In such areas where it is not possible the parts shall be cleaned by brushing and scraping.

The parts after surface preparation shall be given one coat of zinc silicate/ zinc chromate primer paint conforming to IS: 102 in the shop before dispatch. One further coat of primer shall be applied after erection. The primer coats shall give a minimum dry film thickness of 45 microns per coat. The finish paint shall consist of two coats of micaceous iron oxide paint or synthetic enamel paint. Each coat of paint shall give a dry film thickness of 50 microns. The interval between coats of micaceous iron oxide paint or synthetic enamel paint shall be 24 hours. The total dry film thickness minimum should not be less than 175 microns.

b) **Machinery:** All surfaces of machinery (except machined surfaces) including motor, gearing, housing, shafting bearing pedestals shall be given two heavy duty chemically resistant epoxy coatings (thick), each of having thickness more than 60 microns followed by another heavy duty chemically resistant epoxy coatings (thin) of thickness not less than 40 microns. Total DFT of paint should not be less than 160 microns. Unfinished interior surfaces of oil reservoir and gearboxes and unfinished surfaces of gears which will run in oil need not be painted.

28.5.14.3. POWER PACK & HYDRAULIC HOIST

Cleaning of all the surfaces shall be done by sand blasting to SA 2½ as per SSPC.

Power pack

The **oil tank outside surface** shall be given one coat of epoxy zinc rich primer by spray giving a dry film thickness of 50 microns. Over the primer, one coat of epoxy primer zinc chromate paint to give a dry film thickness of 50 micron followed by one coat of epoxy to give a dry film thickness of 75 microns. The total DFT of all the coats shall not be less than 165 microns.

Hydraulic hoist cylinder

The surfaces shall be given one coat of epoxy primer giving a dry film thickness of 50 microns. Over the surface, one intermediate epoxy coat giving a dry film thickness of 125 microns and top coat of epoxy to give a dry film thickness of 60 microns to have end colour as mentioned in the technical specification as specified and agreed by the manufacturer. The total DFT of all the coats shall not be less than 225 microns.

28.5.14.4. MACHINED SURFACES

Machined surfaces shall be protected with adhesive tapes/or other suitable means during the cleaning and painting operations. All machined surfaces of ferrous metal including screw threads, which will be exposed during shipment or while awaiting installation, shall be cleaned with solvent and coated with a gasoline soluble rust preventive compound.

28.5.15. Colour Scheme

S. No.	Item	Colour/Scheme
1.	Embedded Parts, and other components immersed in water.	Black
2.	Super structure including columns, trestles, hoist platform, lifting beam, staircase etc.	Grey
3.	Hoist Machinery	Grey
4.	Trash rake/Gantry Crane/TRCM	Orange
5.	Hand rails	Black & white alternate

28.5.16. Touch up

For touching up, the same paint shall be used as for the original painting work. Repaired finish coats shall be of identical appearance with the original and no difference in the colour shall occur. The Engineer may require severely damaged coatings to be removed and repainted. The necessary paint shall be supplied by the Bidder free of cost.

28.5.17. Quality Control

The minimum dry film thickness prescribed in these Specifications shall be observed. Of each 100 m sq. one area of 10m sq. will be measured for dry film thickness. No measured thickness shall be less than the specified thickness. Where the minimum thickness is not achieved, the coat shall be reapplied to reach the specified minimum dry film thickness.

The dry film thickness shall be measured by approved gauges, and the cost of two new electronic gauges shall be included in the Tender for the use of Engineer.

For checks on porosity, the Bidder shall furnish a D.C. variable high tension test instrument with built-in pore counter. The test voltage shall not exceed 2000 V. The tests shall not be performed within 0.5 m distance from uncovered, corrosion resistance surfaces.

Upon completion of each coat, the painter shall make a detailed inspection of the painting finish and shall remove from all adjoining works all splattering of paint material. He shall make good all damage that can be caused by such cleaning operations.

A detailed inspection of all painting work shall likewise be made, and all abraded, stained, or otherwise disfigured portions shall be touched up satisfactorily or refinished as required to produce a first-class job throughout and to leave the entire work clean and acceptable condition.

28.5.18. Metal Work

28.5.18.1. EMBEDDED METAL WORK

Unless otherwise specified, any foundations, wall and roof openings and coverings, concrete floor filling, sleeves in foundations and walls and trenches with floor plates for cables & hydraulic pipe will be provided by the Civil Bidder.

The Bidder shall supply all anchors, fasteners, embedded metalwork, piping, and sleeves associated with and required for the equipment to be installed under this Contract, except if otherwise mentioned in the Specifications.

As far as practicable, the supports shall be of consistent design throughout and preferably of an approved proprietary type.

Attachments to concrete shall wherever practicable be by means of embedded inserts of an approved proprietary type.

The Bidder will be responsible for the determination and details of all loads and forces exerted by his equipment and transferred to the foundation.

The Bidder shall show the location and full details of all embedded components on his drawings and shall be responsible for the completeness and accuracy of his drawings and the information supplied to others. Anchorages to be embedded in primary concrete will be installed by the civil Bidder as per Bidder's drawings. The Bidder shall be responsible for the adequacy and accuracy of the location of all embedded components supplied by him as this work was supervised by his authorized representative whether installed by himself or by others.

All adjustments to foundation levels, embedment, bedding and grouting of Works on foundations and cementing into walls and floors will be carried out by the civil Bidder, but all leveling and adjusting of Works on foundations shall be carried out by the Bidder.

The grouting will be carried out by the civil Bidder under the supervision of the Bidder and the mix and grouting pressure shall be approved by the Bidder. The Bidder shall satisfy himself that the grouting has been carried out to his entire satisfaction.

Any steel work which is to be built into the concrete foundations shall not be painted or coated unless otherwise approved or specified.

28.5.18.2. MISCELLANEOUS METAL WORK

Except where otherwise indicated elsewhere in the Particular Technical Specifications, the Bidder shall supply the following:

All platforms, ladders, guards and handrails necessary for easy and safe access to Works are supplied under the Contract. Handrails shall be of tubular steel construction.

The use of ladders shall be kept to a practicable minimum. Where ladders are approved for use they shall be of steel, have an inclination of 70^{o} to the horizontal and a minimum width of 450 mm.

Safety guards at each point where normal access provision would permit personnel to come within reach of any moving equipment to be provided under the Contract.

All covers for pipe and cable trenches, required for completing the floors around and over Works supplied under the Contract will be supplied and installed by the owner. Unless otherwise approved, floor plates shall be of an angular pattern.

Covers and curbing for dismantling hatches in main floors will be provided by the civil Bidder.

28.6. Fabrication

28.6.1. Gates and Stoplogs

The gates shall be of welded steel construction with dimensions as shown in drawings. All parts of the gate shall be fabricated in strict accordance with the Standards as per specification. Special care shall be taken in fabrication of parts affecting the strength, rigidity or water tightness of the gates. Caulking of rolled edge plates will not be permitted. All pockets or depressions shall be provided with drain holes to prevent collection of water.

The structural members of gates shall be securely connected by welding or by fit bolts. Highly important joints and connections which will be heavily stressed under load shall be made without flaw. These joints shall include the connection between horizontal girders and end girder box, splicing joints in gates and stoplogs. For welding of such connection only, the approved qualified welders shall be assigned. The splicing arrangement shall be designed to allow flexibility in the gate assembly to facilitate installation. **The lengths of the members shall be so selected to keep splice joints to a minimum subject to transportation limitations**. All splices shall be designed with watertight sealing arrangement. The welding procedure for the gate body shall be planned to control and minimize distortion. All welded connections shall be fully welded.

Care shall be taken that the side seals of gate bear evenly and with uniform pressure throughout their length on the side seal seats embedded in the faces of the piers and that the bottom seals bear evenly on the bottom seal seat (sill) embedded in crest. The roller axle supports and lifting connection shall be accurately line bored so that the axis of all such holes will be perpendicular to the vertical centre line of the gate and shall lie in a common plane which shall be parallel to the finished surface for the seal bases. The wheel pins shall be finished to required surface finish. The sealing faces for the vertical seals, bearing bars and lintel seal shall be finished to required surface finish. The bolt holes for guide rollers shall be accurately bored only after the gate has been completely field assembled and position of guide rollers located in stoplogs/gates.

The structural members of radial gates shall be securely connected by welding or by fit bolts. Highly important joints and connections which will be heavily stressed under load shall be made without flaw. These joints shall include the connection between thrust block, rest beam and trunnion pedestal (Bracket), trunnion bearing hub and end arms, and arms and the horizontal girders and vertical stiffeners, splicing joints or welding of such connections only, the best qualified welders shall be assigned.

Trunnion bearing hub prior to matching of casting shall be stress relieved if welded.

28.6.2. Embedded Parts

All structures, parts of the gate frames anchorages shall be straight and free from twist. The bottom sill beam, seal seats etc., shall be fabricated as steel plates, structural sections and shall be provided with suitable anchorage for rigid connection to the crest and the piers.

Both faces of the track base flanges carrying the track shall be truly perpendicular to the web. The flange face shall be finished to provide a truly plane surface for the track. The faces of the seal seats shall be finished so as to lie in one place within permitted tolerances. The crowns of the track shall lie in a true vertical plane. **The splice length for embedded parts such as seal seats, track paths, guides etc. shall not be less than 6.0m**.

All structures, parts of the gate frames shall be straight and free from twist. Trunnion pedestal shall be stress relieved. The rest beam supporting the trunnion bearings shall be securely fastened to anchor bolts embedded in the piers. All the connections in the trunnion pedestal are heavily stressed under load and special precaution should therefore be taken to ensure that such joints are without flaw. The bottom sill beam, wall plates liners etc. shall be fabricated of steel plates, structural sections and shall be provided with suitable anchorages for rigid connection to the spillway crest breast wall and the piers.

28.6.3. Installation

28.6.3.1. INSTALLATION OF GATES AND STOPLOGS

The gate completes with the seal arrangement and guides shall be properly assembled and installed as per the drawings approved by the owner. All these assemblies and installations have to be done in the most workmen like manner, to the specifications and tolerances etc. indicated in the drawings. After installation, it shall be checked that all the parts are smooth with no wavy surface. Each gate leaf transported in sub-assemblies and seal sub-assemblies shall be assembled and erected in strict compliance with the details shown on the final approved shop drawing and with manufacturer's instructions, special precautions have to be taken to ensure joints are made water tight where required. The side, top and bottom of gates shall be in true alignments so that Rubber seals when installed shall have tight and even bearing on the sealing surface of embedded frame.

28.6.3.2. INSTALLATION OF FRAME, GUIDE AND TRACKS

Assembly and Erection: Each set of frame, guides, tracks and seal seat arrangements shall be assembled in the respective block outs, brought to line, grade and plumb within the erection tolerance and secured in place by anchorage as shown on the drawings or otherwise, according to best modern practice and as necessary for successful functioning of these units. The erection tolerances for frames and guides will be as indicated on the drawings. Extreme care should be taken to ensure that their surfaces be in a true plane within the tolerances (as stated above) throughout their length, otherwise serious damage to the gate may result during operation. Assembly shall be by bolting and welding and connections to embedded anchorages shall be adjusted and firmly tightened to hold the frames and guides securely in position while concrete is being placed in the blockouts.

1st stage inserts shall be embedded in primary concrete by the civil Bidder if not mentioned otherwise.

Erection supports shall be suitably braced so that activities like chipping/ denting of 1st stage concreting, opening out of bent dowels & 2nd stage concreting operation does not in any way affect the alignment.

After the erection/installation of the second stage embedded parts, there is time gap during which the embedded parts remain un-concreted and have a tendency to get displaced/ misaligned due to some of the work activities going on in the vicinity of the embedded parts. It is therefore the responsibility of the manufacturer to ensure that the alignment of the embedded parts remain intact and does not get dislodged/displaced due to any activity in the neighbourhood. To ensure this, the manufacturer may suitably brace the embedded parts by provision of additional steel members, if necessary. The cost of all labour, materials and use of tools and equipment for ensuring the same shall be included in the item rates of second stage embedded parts in the price schedule.

28.6.3.3. PLACING CONCRETE IN BLOCKOUT

Placement of concrete in block outs will be done by the Owner and Bidder shall give a detailed programme of fixing and aligning the second stage embedded parts to the Owner for this purpose. Before placing the concrete in any one lift and between placements of successive lifts, alignment tolerances shall be checked and remedial action taken if any displacement has occurred. **The block out concrete (i.e. 2nd stage concreting) will conform to the grade M-25 (minimum) unless otherwise specified on drawings.**

It is the responsibility of the HM Contractor to oversee (a) provision of dowels in the 1st stage concrete along with first stage insert plates, and exposure, (b) additional dowelling prior to second stage concreting, (c) providing bracings to the second stage embedded parts after alignment and prior to concreting, and (d) chipping and denting of first stage concrete surface in block outs by the civil agency.

28.6.3.4. HOISTS, CRANES & MONORAIL CRANE

Hoist bridge and hoist/crane sub-assemblies shall be assembled and erected in strict compliance with the details shown in the final approved shop drawing and with manufacturer's instructions. Special precautions shall be taken to ensure perfect alignment between mating components and for placements of the hoist drums so as to match with the centre to centre of lifting lugs of the gates.

For hoist and gantry crane / TRCM the Bidder shall prepare a complete erection procedure which shall describe the sequence of operations to be carried out, the methods to be used, the measurements to be taken and the tolerances to be met, in the erection and alignment of the equipment.

28.6.4. Rubber Seals

Rubber seals shall be of the moulded type only. The materials used for rubber seals shall be compound of natural rubber, a copolymer of butadiene and styrene, or a blend of both, and shall contain reinforcing carbon black, zinc oxide, accelerators, anti-oxidants, vulcanizing agents and plasticizers. The Bidder shall provide all seals with adequate temperature and age resistant properties which will provide, in the moulded form, suitable sealing properties.

The seals shall meet the properties as per IS: 11855 (latest edition).

All corners shall be remoulded and have a suitable radius on the inside edge. All joints, shop and field, shall be located at reasonable distance from the corners and shall meet the following requirements:

a) All shop joints shall be vulcanised. Joint geometry shall be such as to avoid feather edges on the sealing surfaces.
b) Field joints shall be kept to a minimum and shall be accurately machine cut and carefully butted during assembly to an interference fit. The field joints shall be held with double fasteners on each side of the joint.
c) Vulcanised joints shall not break on tear when bent 180 degrees around a mandrel of a diameter equal to the maximum cross section thickness of the seal
d) The longitudinal strength in tension of vulcanised joints shall be not less than 71.4 kg/cm^2 as verified by tests on a tensile specimen prepared from one joint in accordance with ASTM D15 Part C. The joint tested shall be located at the midpoint of the test specimen and its strength determined in accordance with ASTM D 412.
e) The joints in the rubber seal shall be vulcanised but joints and at right angle to the rubber seal. Oblique joints at the corner shall not be permitted in the rubber seal. Vertically placed strips of rubber seals shall be formed in one piece and no joints of any sort shall be permitted in them.
f) Sufficient quantity of seal jointing compound shall be supplied along with rubber seals for site requirements. Only during the final attachment of the seals to the gate, rubber cement shall be applied to assure a water-tight seal.
g) Whenever a full-moulded corner is available it should be used. An alternative is a "Fabricated Corner". This means that pre-made, full-moulded corners are spliced and vulcanized to the strip. Full-moulded corners, when available, require no hand fitting and splicing.
h) Avoid placing a splice line through a bolt hole. Factory splices are made in vulcanizing presses under ideal conditions. The seals are firmly held and clamped during vulcanization in special splicing moulds. The preferred method is a 90º right angle butt joint. To produce the best possible splice, a minimum of 6"of free and straight" strip must extend beyond the limits of the splice line in both directions. This strip allows a firmer "grip" in the splicing mould that is maintained during the splice cure. For this reason, a splice should not be positioned so close to the other leg of a corner that the free strip is eliminated.
i) Unvulcanized field splices should never be made on a bevel. Pieces should be cut at a 90º (right) angle and butted tightly to produce a water-tight joint that will not "climb".

Joints shall be water tight and seal materials shall have following physical properties as determined by tests made in accordance with the relevant Standards.

Property	Limits
Tensile strength	14.5 Mpa minimum
Ultimate elongation	450% minimum
Durometer hardness (Shore, Type A)	60 - 70
Specific gravity	1.1 to 1.3
Water absorption (70^0C for 48 hours)	5%by weight (max.)
Compression set	30% maximum
Tensile strength after oxygen bomb ageing (48 hours at 70^0C)	80% (min.) of tensile strength before ageing

28.6.5. Drives and Gears

All moving parts of machinery including shafts, couplings, and collars, projecting key heads, gear wheels, and sprocket/chain shall be completely guarded to provide full protection. All set screws on revolving shafts shall be countersunk or suitably protected. The guards shall be of approved design and shall be fitted, where necessary, with inspection doors/openings. All guards shall be arranged so that they can be removed without disturbing the parts of the gears and Works, which they protect.

Gears shall be designed so that all stresses are within allowable limits when the maximum loads are being handled. All gears shall be designed and calculated in accordance with IS Standards or equivalent international standards, or widely approved methods and to the individual experience of the manufacturer. On request of the Engineer, the manufacturer shall submit the calculation of the gears.

Where worm gears are used as a direct drive, they shall have the same load and time rating as the motors driving them. The gears shall work in oil and the temperature rise of the oil bath shall not exceed 40^0C – 50^0C under normal working conditions at Site. The materials of the mating faces of worm wheel and worm shall be of a bronze/steel alloy.

Where practicable gear wheels shall be forced fit on the shaft and in addition, shall be keyed adequately to prevent any relative motion between the wheel and shaft. Where gears and couplings are secured in position by means of keys, they shall be easily accessible for tightening or removal. All keyways shall be machine cut. Couplings and collars shall be the shrouded or protected-type, free from projections of any kind.

All bearings shall be mounted in dustproof housings. Base of bearing supports shall be machined and shall rest on machined-surfaces.

28.6.6. Lubrication Oil

Efficient means of lubrication, suitable for use under site conditions, shall be provided for all moving parts.

Self-lubricating types of bearings shall be given preference, unless otherwise specified or practicable.

The contamination of the air, water and soil by lubricants and fuel shall by all means be avoided by applying an appropriate design and layout of the Works in conformity with the latest recognized standards for modern engineering practice.

The number of different lubricants, transformer oils, oils for pressure systems, etc. used in the items of Works throughout the Works shall be limited to a minimum in order to facilitate keeping stocks and maintenance.

The Owner reserves the right to request the Bidders to use certain types of lubricants, oils etc. The Bidder shall not be entitled to claim extra payment for this request. All different types of oils, lubricants, etc., shall be stated in the Tender and are subject to the written approval of the Engineer.

Unless otherwise stated in the Particular Technical Specifications, the first oil or grease filling for bearings, pressure oil systems, transformers, etc., including the necessary quantity for flushing and for the first oil change, shall be included in the Tender Price.

28.6.7. Oil Piping

Pipes shall be made of stainless steel. They shall be welded except at terminal points and as necessary for erection and future dismantling. The Bidder shall select the location of the weldments as to ensure sufficient access for adequate touch-up treatment for corrosion protection. Pipe connections larger than 50 mm in diameter shall be provided with steel-flanged connections.

All piping shall be hydrostatically tested at a pressure 150 % than the maximum working pressure for 30 minutes. The entire pipe arrangement shall be subjected to the pressure test after complete assembly at the site.

Oil pipes shall not be embedded in concrete. Oil pipes crossing civil structures shall be routed through sleeves embedded in the concrete.

All oil piping shall be acid-treated to guarantee clean surfaces, completely free from welding residues.

The piping can either be treated in an acid-bath or being completely filled with acid. The duration of the treatment shall be approx. 6 hours. After that the piping shall be neutralized, flushed and corrosion protected for final installation.

28.6.7.1. PIPE SUPPORTS AND HANGERS

All pipe work and accessories shall be mounted and supported in a safe and neat manner. All brackets, stays, frames, hangers and supports for carrying and staying the pipes, including their fasteners shall be included in the supply and completed by the Bidder at the Site. Pipes and fittings shall be supported at or near flanges wherever possible.

Supports and hangers shall be designed and arranged so that any pipe can be withdrawn without disturbing the others. Minimum spacing of piping supports shall be as per BS: 4575 Part-I.

All heavy valves and other mountings shall be supported independently of the pipes to which they connect, to the satisfaction of the Engineer.

The Bidder shall supply drawings showing the location of each major anchor and support and the weight to be carried by that support.

28.6.8. Mechanical Instruments

All mechanical parts of instruments shall be suitably protected against shocks and vibrations, heat, humidity and splash water etc.

Pressures gauges shall be provided with a damping liquid, e.g., glycerin, to compensate vibrations. Pressure gauges without damping means are not permitted, unless approved by the Engineer.

28.6.9. Hydraulic System

Hydraulic tanks shall be designed, fabricated and tested in accordance with approved standards. The appropriate inspection certificates shall be furnished.

Oil tanks shall be provided with:

- suitable access openings

- fine mesh strainer combined with a magnetic filter through which all oil returning from the servomotors shall pass. The strainer shall be readily removable for cleaning.
- dehumidifying air filter
- flush-mounted oil-level indicator
- filling connection with a suitable strainer
- drain connection with hand operated shut-off valve.

Oil tanks shall be installed considering the bottom of the tank and the drain connection are at least 40 cm above the floor. The bottom of the tank shall be inclined in the direction of the drainage. The pumps shall be removable without the necessity of emptying the tank.

Servomotors shall be provided with suitable connections for pressure gauges on the pressure and suction sides of the piston.

Servomotor piston rods made-up of stainless steel with multi-layered chrome plating needs to satisfy the requirement of surface hardness not less than 320 BHN and surface finish $\leq$ 0.3 µm.

Servomotor piston rods made-up of carbon steel provided with ceramic coating not less than 250 microns shall have following requirements ensured by manufacturer:

Surface hardness	>	650 HV to 750 HV
Adhesion according ASTM C633	>	25 N/mm^2 to 50N/mm^2
Impact to ASTM D 2794	>	50 J to 100 J
Surface roughness of ceramic coating	>	Ra 0.15 µm to 0.30 µm
Bending Stress	>	300 N/mm^2
Surface preparation for steel substrate	>	9 µm to 13 µm

28.7. Electrical Works

28.7.1. General

The electrical items of works of any electrical or mechanical installation to be provided under this Contract according to the Particular Technical Specification shall - if not stated otherwise therein-fulfill the requirements of this section.

All components shall be of an approved and reliable design. The highest extent of uniformity and interchangeability shall be reached. The design shall facilitate maintenance and repair of the components.

The works shall be pre-assembled to the highest possible extent in the Bidder's or Sub-Bidder's workshop, complete with all devices and wired up to common terminal blocks.

Unless otherwise agreed, ratings of main electrical Works (in feeds, bus-ties) as selected or proposed by the Bidder, whether originally specified or not, shall generally include a safety margin of 10% under consideration of the worst case to be met in service. Prior to approval of such basic characteristics, the Bidder shall submit all relevant information such as consumer lists, short circuit calculations, de-rating factors etc.

Short-circuit calculations shall be evaluated giving full evidence that every electrical component can withstand the maximum stresses under fault conditions, for fault levels and duration's obtained under the worst conditions, e.g., upon failure of the corresponding main protection device and time delayed fault clearing by the back-up protection device.

All works shall be suitable for the prevailing climatic conditions.

Outdoor installations shall be protected against solar radiation by means of adequate covers, where required.

The Bidder shall ensure that all the supplied Works is insensitive to any signals emitted by wireless communication equipment.

28.7.2. Main Distribution board

The above panels shall be an Indoor/ outdoor type (degree of protection of enclosure type IP-55) made of steel sheet of thickness not less than 2.5mm, containing all necessary equipment for the control, protection/safety and supervisory elements as required and shall be completely painted and wired. The panel frame structure shall be self-supporting, free standing on floor or suitable for wall/vertical post mounting.

Cubicles and panels shall be vermin proof. Removable gland plates shall be supplied and located to provide adequate working clearance for the termination of cables. Under no circumstances shall the floor/ roof plate be used as a gland plate. The cables and wiring shall enter from bottom or top as approved by Engineer.

The cubicles and panels shall be adequately ventilated, if required, by vents or louvers, and shall be so placed as not to detract from the appearance. All ventilating openings shall be provided with corrosion resistant metal screens or a suitable filter to prevent entrance of insects or vermin. Space heating elements with thermostatic control shall be included in each panel.

Cubical/panel will be of sufficient size so as to neatly and methodically accommodate all the electrical power and control equipment. Indicating lamps, push buttons, all the necessary relays, starters, fuses, limit switches, selector switches, terminal blocks, circuit breakers, contactors, current transformers, protection gears, Inter locks, alarms, measuring instruments including all wiring and all other accessories necessary for safety, control and operation of the hoist.

The controls, indicating lamps, push button, selector switches etc. will be installed flush mounted on the outside door of the control panel so as to give clear view of all the indicating lights, measuring instruments, position indicator so that the gate and hoist can be operated with the cabinet door closed. The remaining equipment will be installed inside the cabinet being accessible when the door is opened.

The panel door shall have close fitting, gasketted, hinged, swing off construction capable of being opened through 180 degree. The doors shall be provided with integral lock and master key. A mechanical interlock shall be provided so as to ensure de-energisation of the panel as soon as the door is opened. Suitable provision may, however, be made to bypass the above interlock under extraordinary requirements when manual energisation of panel is necessary under open condition. Panel shall be provided with door switch operated illumination.

All terminals will be of block type. Wiring inside the control panel is made at least with 650 Volt insulation grade, 1.0 sq. mm, 1.5 Sq.mm. and 2.5 sq.mm. Control cable and required size of power cable. All cables shall be brought at terminal blocks mounted inside the control panels to facilitate connection with the external cables. All the metallic parts of the switch- boards and all the earth wires of the circuits shall be connected with the Earthing bus of not less than 25 sq. mm. copper conductors. All control cables and components will be marked in a systematic manner on drawings on the accordingly tagged cables and components in the control panel. All necessary auxiliary devices for connection to limit switch shall also be provided. The control equipment for rope drum hoist shall generally meet the requirements of Clause 6.6 of IS: 6938-1989.

28.7.3. Standards

The design, manufacture and testing of all works and installations shall strictly comply with the latest edition of the relevant IEC publications.

28.7.4. Colour Code

The manufacturer's painting systems shall be used to the maximum possible extent, but shall by all means be subject to the approval of the Engineer. Final coats of paint shall be matching adjacent installations, where required.

28.7.5. Electric Motors

28.7.5.1. GENERAL

All motors shall be of approved Make and shall comply with the requirements of this Chapter. Motors of the same type and size shall be fully interchangeable and shall comply with Indian standard and to IEC standard motor dimensions.

The general construction shall be stiff and rigid, no light metal alloy casings will be accepted. All precautions shall be taken to avoid any type of corrosion.

All motors shall be fitted with approved types of lifting hooks or eye bolts as suitable.

AC motors shall have squirrel cage type rotors.

28.7.5.2. RATING

The rating of motor other than Hydraulic Hoist motors shall be adequate to meet the requirement of its associated equipment. The service factor, being the ratio of the installed motor output to the required power at the shaft of the driven machine at its expected maximum power demand, shall be applied as follows:

Power Demand of Driven Machine	**Service Factor**
Up to 5 kW	1.2
More than 5 kW	1.1

AC motors shall be capable of operating continuously under rated output conditions at any frequency between 95% and 105% of the rated frequency and/or with any voltage variation between 90% and 110% of the nominal voltage. A transient over voltage of 130% of the nominal voltage shall as well be sustained.

Further, the motors shall be capable of maintaining stable operation when running at 70% nominal voltage for a period of 10 seconds. The pull-out torque for motors shall not be less than 225% of the rated torque.

28.7.5.3. STARTING

A.C. motors shall be designed for Thyristorised controlled/ direct on-line starting. They shall be capable of being switched on without damage to an infinite busbar at 110% of the nominal voltage with an inherent residual voltage of 100% even in phase opposition. For starting the motors from the individual main and auxiliary busbars, a momentary voltage drop of 20% referred to nominal voltage should be taken into consideration. With 85% of the nominal voltage applied to the motor terminals, each motor shall be capable of accelerating its associated load to full speed with a minimum accelerating torque of 5% of full load torque.

The maximum starting currents (without any tolerance) shall not exceed value 5 times of rated current for motors.

Generally, all motors shall be able to withstand three cold starts per hour, equally spaced. In addition, each motor shall be capable of enduring two successive starts with the motor initially at operating temperature under the same conditions or once every twenty minutes without detrimental heating.

Motors for frequent automatic starting shall have an adequate rating. In the motor list the Bidder shall state the frequency of starts permitted in compliance with the motor design.

28.7.5.4. WINDINGS AND INSULATION CLASS

The insulation of all motors shall be of class F but maintain in operation the temperature limits of class B materials. It shall be suitable for operation in damp locations, for occasional contact with corrosive gases and vapors and for considerable fluctuations in temperature.

The stator winding shall be suitably braced to withstand the forces due to thyristorised controlled/ direct-on-line starting and transfer conditions as mentioned before. The winding envelopment and tails shall be non-hygroscopic. The stator winding shall withstand the maximum fault current for the period determined by the associated protective devices.

The rotor winding (if applicable) shall be designed to give trouble-free continuous service including repeated thyristorised/direct-on-line starting. The rotor shall be subjected to a 120% over speed test for 2 minutes without showing any winding dislocation.

28.7.5.5. VENTILATION AND TYPE OF ENCLOSURE

All motors shall be of the totally enclosed fan-cooled type, protection class IP 54 according to IEC Recommendation 144. Cable terminal boxes shall be of class IP 55.

They shall have a closed internal cooling air circuit re-cooled by an external cooling air circuit drawn from the opposite side of the driving end.

Where motors are installed outdoors, a weather-proof design shall be chosen. Above shall be equipped with automatically controlled heating elements for protection against internal condensation of moisture during stand-still periods.

Motors installed outdoors and directly subjected to solar radiation shall be rated such as not to exceed a maximum metal temperature of 85^{0}C. Where necessary, such motors shall be provided with sun shields.

Vertical motors shall be provided with a top cover to prevent the ingress of dirt etc.

28.7.5.6. BEARINGS

As far as possible, the motors shall have sealed ball or roller bearings lubricated for life. All other motors with ratings of about 1 kW and above shall be equipped with lubricators permitting greasing while the motor is running and preventing over-lubrication. Additionally, the bearings shall be fitted with grease nipples permitting the use of a universal grease gun. Vertical motors shall have approved thrust bearings.

All bearings shall be easily controllable during operation or stand-still without dismantling the bearings. The bearings shall further be protected and sealed against dust penetration and oil leakage.

In case of independent bearings, motor and bearing pedestals shall be fitted on a common base plate.

Suitable packing/special bearing inserts shall be provided to prevent damage during transport of motors equipped with ball or roller bearings.

28.7.5.7. SHAFTS AND COUPLINGS

The motors shall be provided with a free shaft extension of cylindrical shape with key and keyway according to IEC Recommendation 72-1 and with the motor side-coupling, which shall be pressed on the motor shaft and be balanced together with it. A coupling guard shall be provided.

28.7.5.8. TERMINAL BOXES AND EARTHING

The terminal leads, terminals, terminal boxes and associated equipment shall be suitable for terminating the respective type of cables as specified in these General Technical Specifications and in the Particular Technical Specifications.

The terminal boxes shall be of ample size to enable connections to be made in a satisfactory manner. Supports shall be provided at terminal boxes as required for proper guidance and fixing of the incoming cable.

The terminal boxes with the cables installed shall be suitable for connection to supply systems with the short-circuit current and the fault clearance time determined by the motor protective devices.

A permanently attached connection diagram shall be mounted inside the terminal box cover. If motors are provided for only one direction of rotation, this shall be clearly indicated.

Terminal boxes shall be totally enclosed and designed to prevent the ingress of moisture and dust. All joints shall be flanged with gaskets of neoprene or similar material. For motors above 1 kW, the terminal box shall be sealed from the internal air circuit of the motor.

Depending on the size, the terminal box of L.V. motors shall be fitted either with an approved cable sealing-end or with a gland plate drilled as required and provided with suitable fittings for cable fixing and sealing. Such openings shall be temporarily plugged or sealed during transportation.

Terminal boxes of M.V. motors shall be fitted with an approved cable sealing end and a pressure relief diaphragm suitably located. For plastic insulated and sheathed cables filling with compound is not required.

The three neutral ends of the windings of M.V. motors shall be brought out to a separate terminal box.

For earthing purposes, each motor shall have adequately sized bolts with washers at the lower part of the frame. In addition, each terminal box shall contain one earthing screw.

28.7.5.9. NOISE-LEVEL AND VIBRATIONS

Under all operating conditions, the noise level of motors shall not exceed 85 dB(A).

In order to prevent undue and harmful vibrations, all motors shall be statically and dynamically balanced. Vibration displacements or velocity shall be measured in accordance with DIN 45 665 for IEC motor sizes 80 to 315. The results for all motors shall be within the "R" (reduced) limits.

28.7.5.10. TESTS

Each motor shall be factory tested and shall undergo a test at site. The following tests shall be performed under full responsibility of the Bidder.

Workshop Tests:

- Measurement of winding resistance
- No-load and short-circuit measurements
- Measurement of starting current and torque
- Efficiency measurement (type test)
- Heat test run
- Dielectric test
- Measurement of insulating resistance
- Over speed test

Site Tests:

- Measurement of insulation resistance
- Measurement of motor vibrations
- Measurement of starting time

28.7.6. Auxiliary Works

28.7.6.1. AUXILIARY SWITCHES

Where appropriate, each item of Works shall be equipped with all necessary auxiliary switches, contactors and devices for indication, protection, metering, control, interlocking, supervision and other services. All auxiliary switches shall be wired up to terminal blocks on the fixed portion of the Works.

All auxiliary switches and mechanisms shall be mounted in approved accessible positions clear of the operating mechanism and are to be protected in an approved manner. The contacts of all auxiliary switches shall be strong and shall have a positive wiping action when closing.

Control Switches

Control switches for electrically operated circuit breakers shall be of the pistol grip or discrepancy type. They shall operate clockwise when closing the circuit breakers and anti-clockwise when opening them. The control switches shall be so designed as to prevent them from being operated inadvertently, and where switches of the discrepancy type are used they shall require two independent movements to effect operation. Control switches shall be so designed that when released by the operator, they return automatically to the neutral position after having been turned to the "closed" position and shall at the same time interrupt the control voltage supply to the operating mechanism of the circuit breaker.

Switches for other apparatus shall be operated by shrouded push buttons or have handles of the spade type, the pistol grip type shall be used for circuit breaker operation only.

Control, reversing, selector and test switches shall be so mounted, constructed and wired as to facilitate the maintenance of contacts without the necessity for disconnecting wiring.

28.7.6.2. ANTI-CONDENSATION HEATERS

Each individual enclosure accommodating electrical Works which is liable to suffer from internal condensation due to atmospheric or load variations shall be fitted with heating devices suitable for electrical operation at the specified standard A.C. voltage, being of sufficient capacity to raise the internal temperature by about 15°C above the ambient temperature. Heaters in motors and similar devices shall be switched on automatically upon opening of the motor starter, and vice-versa. Heaters in switchgear/MCC cubicles, control cubicles, panels, desks, etc., shall be controlled automatically by adjustable hydrostats (setting range about 50 - 100% relative humidity) The electrical apparatus so protected shall be of such design that the maximum permitted temperature is not exceeded if the heaters are energised while the apparatus is in operation.

Heaters shall be equipped with a suitable terminal box. All Works, whether fitted with a heating device or not, shall be provided with suitable drainage and be free from pockets in which moisture can collect.

28.7.6.3. PROTECTION DEVICES

The main parts of the Works shall be protected and interlocked so as to prevent malfunctions and other fault occurrences, and to maintain safety during all operation phases.

Electric protection relays shall be the standard product of an experienced and reliable protection relay manufacturer. They shall be of the static or mechanic/magnetic, tropicalized type and be mounted in suitable dust proof and shock-absorbing casings. They shall not be affected by external magnetic fields or any other influence (radio, computer, signals, impulses, etc.) consistent with the place or method of mounting. Electro-magnetic relays shall have a transparent cover with appropriate seals.

The protection relays shall be equipped with all necessary auxiliaries such as tripping unit, time relay, external resetting device (hand reset flag with seal-in operation). The relays shall provide easy access for testing and setting purposes.

Pre-warning alarms shall be initiated as early as possible before the protection system trips, in order to enable the operators to take precautions. Tripping of a protection system as well as the sources of the protective action shall be indicated and recorded as an alarm.

Unless otherwise required for special purposes, protection relays shall remain in the tripped position until the operator resets the relay manually. The protection and auxiliary relays shall be grouped and mounted on plug-in modules or stationary-mounted on swing frame with separate plugs and sockets to feature easy replacement and testing. The construction shall be sturdy and such that all parts are easily accessible for adjustment. Relays installed in switchboards shall be arranged in compartments separated from the switchgear.

Besides the mechanical-operated flag type indicator, all relays shall have sufficient contacts and/or auxiliary relay contacts to perform all the tripping, inter tripping, interlocking, indication and alarm functions required. Spare contacts (1 N.O.1 N.C.) shall be provided for later use. The contacts shall be silver-plated or of the seal-in type with the main contacts adjustable. The relay contact rating shall be for the specified standard voltage and for 200% of the nominal passing current. The relay coil shall be able to operate properly at voltage variations of -25% to +15%.

Relays shall be capable of withstanding at least one million operations without any defect.

Testing of the individual relays shall either be effected by stationary-mounted or portable testing devices.

28.7.7. Terminal Points

The Bidder shall be provided the following electric power supply points as applicable:

i) 415/230V AC supply at the Diesel Generating Room at Dam top for Spillway Equipment, Automatic remote control system, Intake equipment, and rope drum hoist.

The electric service power provided by the Employer or the other Bidders shall be as follows:

- 415/230 V, 50 Hz, three-phase system with earthed neutral for feeding three-phase and single- phase consumers (connected between neutral).
- 230 V, 50 Hz, permanent supply, single phase earthed.
- 48 V, D.C. systems isolated from earth, for the supply of electronic equipment, telecontrol, telecommunications, etc. wherever necessary shall be provided by the Bidder.

Supply Tolerances

System	415/230 V	230 V	48 V DC
Limits of supply voltage			
a) Steady	+5 or – 10%	± 2%	+10 or – 15%
b) Transient	+ 305	± 10%	-
Limits of frequency	± 2%	± 1%	

The Bidder shall supply and install all terminals, control boxes, cables, conduits, fittings including main distribution system comprising of Air Circuit Breaker (ACB), Moulded case circuit breaker (MCCB), Current Transformer (CT), Potential Transformer (PT), bus bars in sufficient capacity along with at least two nos. of spare MCCBs for operating units supplied by others from terminal points for the distribution of electric power supply to the electrical equipment and its controls including lighting to be supplied under this contract. The power supply cables shall be designed so that the voltage drop between the terminal points and the respective equipment shall be limited to within 2.5 % of the rated voltage. In MDS, the provision shall also be made for automatic changeover from mains to DG so that no time lag may be there.

28.7.8. Cables

28.7.8.1. GENERAL

The Bidder shall provide the relevant design and engineering of the relevant cable systems and, in close co-operation with the **Civil Works Bidder**, prepare the cable installation drawings with cable routing, connection diagrams, and cable lists, details, etc.

The power cables and control cables shall be of copper as per Indian Standards or IEC publications and the power cables shall be of minimum size 16 mm^2 and control cables shall be of minimum size 1.5 mm^2.

All cables and accessories shall be suitable for installation under site conditions (e.g. aggressive soil conditions, etc.).

The Bidder shall select the most suitable cable routes and raceways ensuring a minimum of interference with other installations.

28.7.8.2. COLOUR CODE

Live parts of electrical connections shall be colour coded as follows.

Conductor Designation	Coding Alphanumeric	Symbol	Colour
AC Network	Phase 1	L1	Red
	Phase 2	L2	Yellow
	Phase 3	L3	Blue
	Neutral	N	Black
DC Network	Positive	L+	+ White
	Negative	L-	-Black
	Neutral	M	Blue
Protective earthed	Neutral	PE/N	Green/yellow
Earth		E	Grey

Colour Coding for Mimic Diagrams

Mimic diagrams to be arranged on switchgear cubicles, control panels/desks etc. shall be colour coded as bellow:

380 V	White
110 V D.C.	Violet

28.7.9. Earthing

All electrical equipment shall be properly earthed as per the latest ruling practice for the safety of the equipment, and operating staff as well. **The bidder should connect all the HM control equipment to the earthing system provided by Song Dam Drinking Water Project at dam location.**

28.7.10. Labels and Plates

28.7.10.1. GENERAL

Labels and data plates shall be provided in accordance with applicable standards and as detailed hereunder.

The proposed material of the labels, size, exact label lettering and proposals for the arrangement of the labels shall be submitted to the Engineer for approval.

Where applicable, designations in the selected local language shall appear above or to the right of the designation in English.

28.7.10.2. EQUIPMENT LABELS AND INSTRUCTION PLATES

Labels written in the Contract language shall be provided for all instruments, relays, control switches, push-buttons, indication lights, breakers, etc. In case of instruments, instrument switches and control switches, where the function is indicated on the device, no label is required. The label shall be fixed close to the devices in such a way that easy identification is possible. Fixing on the dial glass of instruments will not be accepted. The wording shall conform to the wording used in engineering documents.

Each separate construction unit (cubicle, panel, desk, box etc.) shall be identified by its Works identification number. Cubicles and similar units shall also bear this identification number on the rear side if rear access is possible. The overall designation of each unit shall be given in the Contract language and - if required - also in a selected local language. These labels shall be made of anodized aluminum with black engraved inscriptions, arranged at the top section of the units. Manufacturer's trade labels shall - if desired - appear in the bottom section of the units.

All Works inside cubicles, panels, boxes, etc., shall be properly labeled with their item number. This number shall be the same as indicated in the pertaining documents (wiring diagrams, Works list etc.).

Instruction plates sequence diagrams or instructions for maintenance shall be fitted on the inside of the front door of the electrical switchboards. These shall be in the contract language and if required in the selected local language.

28.7.10.3. WARNING LABELS

Warning labels shall be made of synthetic resin with letters engraved in the Contract language and in particular cases, where required, in the selected local language.

For indoor circuit-breakers, starters etc. transparent plastic material with suitably contrasting colours and engraved lettering would be acceptable.

28.7.10.4. LABELS FOR CONDUITS

The material shall be non-corrosive and the description be done with 4 mm high letters/figures.

28.7.10.5. LABELS FOR CABLES

Each cable when completely installed shall have permanently attached to each end and at intermediate positions as may be considered necessary by the Engineer, non-corrosive labels detailing identification number of the cable, voltage, and conductor size.

The cable identification numbers shall comply with those of the cable list.

All cables in cable pits and at the entry to buildings shall be labeled utilising the aforementioned type of label.

28.7.10.6. RATING PLATES

Works (hoists, machines, transformers etc.) rating plates and other technical data/informative plates shall either be of the enameled type or be of stainless steel suitably protected after engraving with a transparent paint resistant to aggressive atmosphere and solar radiation.

28.7.11. Key System for Electric Boards

The locks or padlocks shall be coordinated for the different applications and shall be supplied with three keys. A key cabinet at the end of each board (distribution board, MCC, control cubicles etc.) shall be provided for storing the keys of that board. For all locks supplied there shall be six master keys to open any lock or padlock supplied. Each key shall have one identification label fixed above the key hanging hook inside the cabinet.

The cabinet door keys shall be similar and shall be six (6) in number.

28.8. Transport and Storage

28.8.1. General

Shipping, transportation, loading and storage shall be performed by or under the responsible direction of the Bidder. An appropriate period for transportation shall be considered.

The general co-ordination of storage and erection work as well as the civil engineering work on site will be done by the Engineer.

The delivery dates, transportation and erection periods indicated in the Contract documents shall be strictly adhered to.

From the time of manufacturing until commissioning all parts of the plant shall be protected against damage of any kind. Parts, which are damaged during transport, shall be replaced at the Bidder's expense.

The Bidder shall provide the Engineer with complete packing lists of each performed shipment.

28.8.2. Packing

After the workshop assembly and shop inspection and tests including witness inspection by the Engineer or his authorised representative wherever specified and prior to dismantling for shipment to the site, all items shall be carefully marked to facilitate site erection. Wherever applicable, these markings shall be punched or painted so they are clearly visible.

Dismantling shall be done into convenient sections, so that the weights and sizes are suitable for transport to site and for handling on the site under the special conditions of the Project.

All individual pieces shall be marked with the correct designation shown on the Bidder's detailed drawings and other documents (packing lists, spare part lists, in Operating and Maintenance Instructions etc.).

Marking shall be done preferably by punching the marks into the metal before painting, and shall be clearly legible after painting. In labeling, the Bidder shall endeavour to use as few designations as possible and each part of identical size and detail shall have the same designation, regardless of its final position in the plant.

All parts of the Works shall be packed at the place of manufacture the packing shall be suitable for shipment by sea and for all special requirements/limitations of the transportation to site. Where necessary, double packing shall be used in order to prevent damage and corrosion during transportation, unloading, reloading or during intermediate storage.

All parts including electrical parts shall be suitably protected against corrosion, water, sand, heat, atmospheric conditions, shocks, impact, vibrations etc. by packing them into high pressure polyethylene foil.

The Engineer reserves the right to inspect and approve the packing before the items are dispatched but the Bidder shall be entirely responsible for ensuring that the packing is suitable for transit and such inspection will not exonerate the Bidder from any loss or damage due to faulty packing.

All packing costs shall be included in the scope of Work.

28.8.3. Marking

The Bidder shall mark all containers with the implementing document number pertinent to the shipment. Each shipping container shall also be clearly marked on at least two sides as detailed below:

Consignee :
Contract No. :
Port of destination :
Item number (if applicable) :
Package number, in sequence :
Quantity per package
Description of item :
Net and gross weight :

28.8.4. Storage at site

The Bidder shall conform himself fully as to all relevant transport facilities and requirements, loading facilities and other limitations and shall ensure that the equipment as prepared for transport shall conform to such limitations. The Bidder shall also be responsible for obtaining from the railway or highway authorities any permit that may be required for the transport of loads exceeding the normal gauges.

The Bidder shall be responsible for all Custom clearance of the consignments from the Indian port if by sea and or from airport if shipped as air cargo, local storage and further transportation to site.

The Bidder shall provide means for all unloading and reloading for all consignments of the plant, during transport to Site. Unloading on the Site will be provided for by the Bidder. Consignments shall be unloaded immediately on arrival at site. The Bidder is required to take the necessary steps in order to provide the carriage, special supporting structures for heavy loads etc.

The Bidder shall develop necessary storage facility for proper and safe storage of all the materials. The warehouses shall be waterproof, well ventilated and of designated floor etc.

If large parts are stored in the open air, they shall be provided with weather resistant and fire-resistant covers. Electrical parts which are not packed in heavy duty polyethylene foil and those so packed but whose packing has been damaged shall be kept in suitable places from the moment of storage to the moment of installation.

All insulation materials which will be taken from the warehouse for installation and which are stored temporarily in the station shall be protected from weather or humidity.

Storage of equipment can be divided into three categories (General guidelines):

i) Large parts which can be stored in open atmosphere on wooden sleepers.

ii) Small parts which are normally packed in proper wooden boxes and should be kept in warehouse.

iii) Parts to be protected against direct influence of the weather and to be stored under shed in dry conditions.

General

Develop necessary storage facility at project site (Area required shall be intimated by the Bidder) for proper and safe storage of all the Gate materials (Embedded parts, Gate leaf and Hydraulic/Rope drum hoist) in a horizontal plane, protected from floods and any aggressive environment. This area shall also be protected with a fence and kept clean with proper approach. Storage must be adequate to each kind of equipment. Small parts are normally packed in proper boxes and shall be kept in the warehouse. The warehouse shall be water proof and well ventilated. On arrival to site, all equipment shall be unloaded and handled as carefully as possible with the necessary means to take care of the materials. Generally Gate parts are stored in open atmosphere. Parts that are mechanically protected shall remain with their protection until assembly. If any damage occurs on the protection, it must be rectified before start of work. The gate parts like skin plates, arms, cylinder supports, articulated supports, trunnion hub and arm terminals etc. and gate units (prior to site assembly), hoist supporting structure parts, hoist assembly parts, etc. shall be kept preferentially on some wooden sleepers to avoid direct contact with the ground.

Stainless steel and bronze surfaces shall only be cleaned but not painted. All surfaces of the embedded parts which are to come in contact with concrete shall be cleaned as mentioned above and given two coats of cement latex to prevent rusting during shipment and while awaiting installation. All finished surfaces of the gates and stoplogs that will be exposed to atmosphere during shipment or while awaiting installation shall be given a coat of gasoline soluble rust preventive compound. For preservation of hydraulic cylinders during shipment and while awaiting installation these shall be filled minimum 10% with hydraulic oil suited to temperature range for the particular Project, and 2% VSI or equivalent corrosion inhibitor shall be added prior to dispatch to site .

All materials and equipment should be received properly in quantity and quality on arrival to site. The Person in charge of the warehouse shall keep an updated list of all entries and exits of materials. Prior to the assembly of each item / set, confirm that all parts are available.

Suitable Trailer and Crane are required to be arranged by the Bidder transport the gate parts from storage yard to site of erection. Make sure to leave some space for handling the parts in each storage area. Good access to storage area must be guaranteed at all times not only keep the parts available but also easy access to trailers or other large means of transportation.

In loading and unloading and during installation, use the lifting lugs provided to handle the gate elements and other gate parts with a suitable tested wire rope slings.

Storage in open atmosphere

Sill beam, wall plates, side seal seats and top seal seat having stainless steel plate machined surfaces should be kept at top (with protective tape) and shall be stacked in horizontal plane in a manner not to not to damage the machined surfaces.

Gate elements should be kept on wooden sleepers equally spaced to avoid direct contact with the ground and upstream face of the skin plate should be kept at the top. Bottom and side rubber seals clamp plates with match marks (packed in wooden boxes) shall be stored gate wise.

Trunnion assembly fitted with self- lubricating bush shall be stored in dry condition and the bush shall be protected with the help of plastic sheet. Trunnion supports, and Cylinder supports, horizontal girders, Arms etc. shall be kept on wooden pieces to protect painted surface.

Stored in Warehouse

Finished surfaces shall be thoroughly cleaned of foreign matter. Finished surfaces of large parts and other surfaces shall be protected with wooden pads or other suitable means. Unassembled pins or bolts shall be oiled or greased and wrapped with moisture-resistant paper or protected by other approved means.

Bolts, nuts, washers and other small items shall be tagged and keep in a proper place for easy identification which are required for assembly. The threaded portion of second stage anchor bolts & Anchors/studs shall be applied grease to protect from rusting.

Trunnion axles, supports & bars shall be stored in warehouse.

Storage under shed in dry condition

All the rubber seals shall be kept properly in the ware house. Recommended storage procedures for seals are given below:

1. For shipping convenience, rubber seals may be rolled into tight coils. When furnished as seal assemblies, they can be coiled and/or folded and packed in the most economic sized crates or packages.
2. The distortion resulting from such packing is minor and will not result in a permanent set detrimental to the use intended.
3. The seals should be removed from the crates upon arrival and laid out into their natural position until attached to the gates. If limited space is available, then it is recommended that seals be coiled in as large a coil as practical. Before mounting, minor distortions in the seals can be removed by placing them in their normal natural position in a warm building or by exposing them to direct sunlight for a few hours.
4. It is suggested that seals be stored in a shaded area. Avoid piling too high and do not store other items on top of rubber seals. Fluorocarbon clad seals should remain flat in the crate as packed. Handling this type of seal with caution is essential, as bending or rolling fluorocarbon seals will cause irrevocable damage.

For the storage of hydraulic cylinders, refer Cylinder manufacturer's Storage and Handling document.

The Hydraulic power pack assembly and electrical control panel and Hydraulic oil barrels shall be stored in their original packing under shed in dry condition. Due care shall be taken to protect from rain or damp ground. The storage space shall also permit easy inspection, removal and re-storage of the materials.

28.9. Inspections and Tests

28.9.1. General

In addition to the provisions established in the Conditions of Contract regarding general procedure of inspections and tests, terms and definitions, and time schedules for inspections and tests the following stipulations shall apply.

Approval of assemblies, tests, inspections, related procedures etc. and acceptance of pertinent test and inspection certificates, or waiving of inspections or tests, shall in no way relieve the Bidder of his contractual obligations for finishing the Works in accordance with the provisions of the Specifications.

Six (6) sets of all test records, test certificates, performance curves, tables etc. of all inspections and tests, whether or not attended by the Engineer shall be supplied soonest after performance of each inspection or test. After completion of testing, two (2) sets of the above mentioned documents shall be supplied properly bound condition along with one CD.

All test certificates shall be endorsed with sufficient information for identification of the equipment and material to which the certificates refer.

In addition, the following references shall be entered in the top right-hand corner:

Bidder's name

Project title

Equipment name

Bidder's drawing no.

Date

Inspection and testing of equipment shall include all inspections, tests, checks etc., whether mechanical, hydraulically or electrical, as required to ensure that the equipment supplied meets the requirements of the Specifications.

They shall comprise, but not be limited to the following:

- Chemical analysis of materials
- Destructive and non-destructive tests of materials
- Checks and examination of welds
- Checks of fits and assemblies
- Dimensional checks
- Balancing tests
- Inspection of paints and coatings (thickness and porosity)
- Hydrostatic pressure and leakage tests
- Electrical tests
- Functional tests
- Performance tests
- Load and overload tests
- Acceptance Test

The technique, equipment and instrumentation to be used for these tests, checks, inspections, examinations, etc. shall be in accordance with the pertinent and internationally accepted Standards, rules or Codes, in particular these mentioned in the specifications.

If in the Employer's Representative opinion instruments apparatus, devices, etc, used by the Bidder (or his Sub-Bidder) need calibration or recalibration, then such instruments, apparatus, devices etc. shall be calibrated at the Bidder's cost by an independent authority or institute subject to approval by the Employer's Representative.

All inspections and tests shall be conducted in accordance with the approved **"Quality Assurance Plan" and Prescribed Formats are attached with the Bid Documents.**

The Bidder shall be responsible to carry out and keep record (as per approved QAPs) of all inspection/tests during manufacture through his quality assurance group. **Song Dam Drinking Water Project authority** shall carry out critical inspection and shop testing to be conducted by the Bidder in his manufacturing workshop. The inspection stages shall be decided while reviewing and approving QAPs. In addition **Song Dam Drinking Water Project** inspection representatives shall get associated for specific inspections as specified in the approved quality assurance plan.

Song Dam Drinking Water Project will have discretion to engage a third party inspection for any specific work under this contract.

In case these parties do not operate in the region of the manufacturer, he may propose suitable alternative Inspection agencies of international repute furnishing their detailed particulars, previous references etc. The owner reserves the right to reject any or all of such proposed agencies. Manufacturer shall arrange the third party inspection through one of the above named agencies or the alternative approved agency, without any financial implication for the owner.

The Bidder shall also be responsible for implementation of quality assurance standards as per approved plans and procedures.

28.9.2. Workshop Inspections and Tests

As far as practicable, quality of materials, workmanship and performance of all items of the Works to be furnished under this Contract shall be inspected at the places of manufacture.

When placing orders for major material and equipment with sub suppliers, the Bidder shall send unpriced copies of such orders in triplicate to the Engineer.

Where the Bidder desires to use stock material, not manufactured specifically for the Works, satisfactory evidence that such material conforms to the requirements of the Contract shall be submitted. Tests on these materials can be waived.

Arrangements shall be made for expediting the shop inspection by having all shop assemblies or pieces covering a single shipment ready at one time. Any painting work as well as transport to the site of the Works shall not be started before the approval of the Engineer has been obtained.

Free and unrestricted access to the Bidder's factory and shops (including those of his Sub-Bidders) shall be granted to the Engineer, and upon reasonable notice by the Engineer or others nominated by him if deemed necessary by the same for additional witnessing of assembly work or inspections and tests.

Should an agreed inspection not be carried out as proposed because of lack of preparation, obvious negligence or material and/or equipment being presented in a state, which does not correspond to the proposed procedure or is clearly not acceptable such an inspection shall be repeated? The cost incurred for all regular as well as repeated inspections shall be fully borne by the Bidder. The travel expenses for each additional or repeated inspection shall be borne by the Bidder.

Inspection at manufacturer's works/ vendor's works (for bought out items)

All the requirements of section 9.2.1 to 9.3.1 of the specifications shall be covered including the following

- Inspection of materials with material verification test certificate
- Inspection of bought out items/ components with manufacturer's test certificate.
- NDT for welding (Radiography, Ultrasonic, MPT, DPT)
- Inspection of shop assembly of embedded parts
- Inspection of shop assembly of gates
- Inspection of shop assembly of hoist/ operating equipment including operational tests (Gate manufacturer works or vendor's works).
- Inspection of shop assembly of hoist supporting structure.

The above inspections shall also include dimensional accuracy checks, tolerance check for critical dimensions.

28.9.2.1. MATERIAL TESTS

Unless otherwise specified, the quality of materials shall be verified generally by:

- Chemical analysis
- Mechanical tests (yield point, tensile strength, elongation's, notch impact strength etc.)
- Welding tests (welding procedure, welding material, welding tensile strength, welding bend test, welding reversed bend test, etc.)
- Non-destructive x-rays, ultrasonic, magnaflux, liquid penetration tests visual inspection, magnetic properties etc.)
- Electrical tests (voltage losses, tan-delta, insulation, magnetic properties)

Certified mill test reports of plates will be acceptable when these comply with the requirement for "Reports of Inspections and Tests" as stated in the Special Conditions. Test specimen and samples for analysis shall be plainly marked to indicate the materials they represent.

Castings and forgings shall be tested in the rough state in order to detect flaws in time thus avoiding delays. Magnetic particle inspection of important castings shall cover the whole surface of the casting. After partial machining again tests shall be conducted. Important castings and forgings like Gate wheels, hoist drum gears, crane wheels etc. shall be ultrasonically tested. The acceptable limit for ultrasonic testing of castings shall be level I of SA-603 of ASME Section-5 and that of forgings shall be as per SA 388 of ASME Section-5.Load tests on crane hooks, steel wire ropes, chains, etc. shall be considered as material tests.

28.9.2.2. CHECKING OF DIMENSIONS

The dimensions, especially clearances and fits, (ISO 286) which are essential for operation and efficiency shall be carefully checked in an approved manner, as for example:

- run out and roundness tolerances of shafts, pistons etc., to be measured on single parts as well as (wherever possible) on the assembled components,
- Fits and clearances of gates, bearings, servomotor pistons, valves, guiding, distributing and actual actuating elements etc.
- accuracy, surface roughness and shape of sliding and guiding surfaces of seals, bearings, water passages in hydraulic machinery, valves etc.,
- Dimensions of couplings or connections for assembly with other deliveries from the Bidder, Sub-Bidders or other Bidders.

28.9.2.3. WORKSHOP ASSEMBLY

In addition to the quality and production control tests, the following shop assembly work and tests shall be made to check measurements, fitting and functioning.

Works to be furnished shall be shop assembled to a status sufficient to prove that the design and workmanship have been executed in accordance with the Specifications, that the delivery is complete, and that no work remains to be done at Site which reasonably can or should be done in the shop.

The metal work shall be shop-assembled to ensure that all parts are properly fitted and that the dimensional and tolerance requirements shown on the drawings have been obtained. All holes for field connections of parts furnished under these specifications shall be drilled or reamed as noted on the drawings, with the embedment so assembled. Members to be shop-bolted shall have all parts well pinned up and drawn together with bolts before bolting is commenced.

To commence the shop assembly of radial gates the gate arms shall be supported in their relative position at the same elevation properly spaced centre to centre and so that the machined pin holes have a common horizontal axis. With the arms in the position the gate leaf shall be erected between them. The vertical lift gates shall be assembled in a vertical position and holes for field connections carefully drilled or reamed. Connections which have to be dissembled for shipment shall be made by the use of erection pins, one size less in diameter than the designed size of temporary machine bolts.

Stoplog/gate & lifting beam shall be assembled in shop for checking all dimensions specifically critical dimensions as per final approved shop drawings and manufacturer's instructions. The lifting beam shall be checked for its verticality for the both the positions of counter weight and shall be checked for satisfactory operation of grappling and ungrappling of its hook with stoplog units.

The Hoist machinery / crane shall be completely assembled in the shop to ensure that all parts are properly fitted. Surfaces of metal which will be in contact shall be cleaned before the parts are assembled. The parts shall be adjusted to line and fit and shall be well pinned and bolted so that the surfaces are in close contact before reaming, drilling, bolting or welding is commenced. The field connections shall be fitted and checked in the shop to assure proper fit during field erection.

After shop assembly the Hoist machinery / crane shall be tested at manufacturer's workshop for functional tests.

Where applicable each item of the works shall be assembled completely prior to painting.

Field joints shall be temporarily connected.

All parts shall be properly match marked, identified and doweled where practicable, to facilitate correct and quick field assembly and alignment. Suitable dowels shall be provided where necessary for insertion after field assembly and drilling. The holes for any fitted bolt shall be accurately reamed.

During workshop assembly all instruments, control devices and piping shall be fitted.

If the assembly shows defects in the design or manufacture or unforeseen difficulties in assembling and dismantling, these shall be eliminated. If required, design alterations or corrective measures can be executed provided that reliability of operation or interchangeability is not reduced and provided that the agreement of the Engineer has been obtained.

If the corrections cannot be carried out in accordance with the terms mentioned above, the components concerned will be rejected. The decision on possible subsequent corrections is reserved exclusively to the Engineer. Faulty parts or Works shall by no means be delivered.

The assembled parts shall subsequently be subject to tests as per applicable standards or required by the Engineer.

28.9.2.4. HYDROSTATIC PRESSURE TESTS

Before final machining, each of the hydraulic hoist cylinders shall be subjected to a one and a half times the design pressure or 3 kg/mm^2, whichever is more. The test pressure shall be held on each cylinder for a sufficient length of time to permit inspection of all joints. Any leakage in joints may be repaired by re-welding at the discretion of and, in a manner acceptable to the purchaser. The purchaser, at his discretion may require additional stress relieving and radiographic examination of the hoist cylinder that has been repaired by re-welding. All test heads and other equipment required for testing shall be furnished by the Bidder free of cost and will remain his property after the completion of the tests.

28.9.2.5. FUNCTIONAL TESTS

Functional tests shall be defined as tests of the function of assemblies, sub-assemblies or parts of the Works under no load conditions. Functional tests shall be performed on all Works prior to the execution of operational tests.

28.9.2.6. OPERATIONAL TESTS

As far as practicable operational test shall be carried out on all Works, simulating operating conditions.

Parts to be delivered by sub suppliers shall be tested either at the premises of the sub supplier or of the Bidder, as agreed by the Engineer.

Before testing the Bidder shall submit a notice containing full information on the tests with detailed tables or graphs on the latest edition of the characteristic values of the Works to be tested and on the test facilities and equipment.

i) **Operational tests of Rope Drum Hoists**: in accordance to clause no.2.3 of IS: 10096 (Part 1/Sec 2): at least one rope drum hoist of each type shall be tested under no load condition at the shop & is also to be load tested for designed forces coming on the rope drum corresponding to 125 percent of the hoist capacity.

ii) **Operational tests of Gantry crane & Monorail Crane**: in accordance to clause no.26.2 of IS: 3177: All electrical and mechanical equipment shall be tested in accordance with the appropriate Indian Standard at either the crane maker's or equipment manufacturer's works. The crane shall be tested at manufacturer's works under full load and 25 percent overload of hoisting and cross traverse motions. Travelling gear may be run light to check shaft and gear alignments.

The deflection test shall be carried out with the safe working load at rest.

28.9.2.7. INSULATION TEST

The following tests shall be carried out at shop as well as at site after erection.

i) After erection but before the hoist/crane is connected to the supply, the insulation of the electrical equipment shall be tested by a suitable instrument and any defects revealed shall be rectified. The voltage required for the insulation resistance test shall be d.c. voltage not less than twice the rated voltage.
ii) Any reading less than 0.5 mega ohm obtained with an insulation resistance tester of the un-regulated type shall be disregarded and the wiring under test shall be sub-divided until a reading higher than 0.5 mega ohm is obtained. Failure to obtain a higher reading shows an unsatisfactory state of insulation. If an installation has been sub-divided for test purposes, each sub-division shall meet the requirement.
iii) The insulation resistance of each wiring circuit exclusive of connected apparatus shall be not less than 2 mega ohm, if necessary; it shall be permissible to disconnect individual items of equipment while making this test.

28.9.2.8. ELECTRICAL TESTS

Electrical Works shall be tested in accordance with applicable Standards and agreed test programs and procedures. Testing of the electrical Works shall be performed in accordance with applicable Standards; they shall include but not be limited to tests or heating, loading, overloading, losses. However before the complete installation is put to commercial service, tests shall be carried out to ascertain the following:

i) The satisfactory operation of each controller, switches contactor, relay and other control devices and in particular the correct operation of all limit switches under the most unfavorable conditions.
ii) The correctness of all circuits and interlocks and sequence of operation.
iii) Satisfactory operation of all protective devices.
iv) The satisfactory operation of each motion of the crane.
v) The compliance of the crane with the specified performance requirement.
vi) Tolerances on specified speeds on full load shall be within 10%

The measurement shall not be taken on the first application of the load.

28.9.3. Site Inspection and Tests

28.9.3.1. GENERAL

During erection, commissioning and trial operation **the Bidder shall organize at suitable intervals all inspections and tests in the presence of the Engineer in order to prove the orderly execution of the works in accordance with the Contract.**

Unless otherwise specified, all costs for testing at site and of the works and charges associated with it shall be borne by the Bidder. This includes the measuring devices, properly calibrated, and any pertinent accessories, which shall be made available by the Bidder for the entire duration of the tests. The Bidder shall delegate his experts to supervise the tests at site.

The tests, checks, examinations at site shall comprise but not be limited to:

- Checks and examinations of welds
- Hydrostatic pressure test
- Tightness tests
- Functional checks
- Performance tests
- Load tests

All such tests and checks shall be performed in the presence of the Employer's Representative. If not satisfied with the performance of the tests and checks the Owner's Representative shall have the liberty to ask for additional tests or repetition of same.

The testing at Site shall be complete in every respect to prove the successful performance and operation of all the works and Works supplied and erected under the Contract.

For the procedure of inspections and test at site, notice to the Engineer, reports, commissioning, trial runs and trial operation, and acceptance tests refer to General Conditions.

28.9.3.2. STAGE INSPECTION

Inspection of embedded parts duly assembled/ erected in location, fully aligned and adjusted including installation of sill beam, side guide members, lintel members, sill seats/ tracks/ bearing pads and hoist supporting structure. This inspection involves measurement of critical dimensions, verticality, coplanerness of sealing/ bearing surfaces and dimensional accuracy within permissible erection tolerances.

Prior to concreting, it shall be ensured that the embedded parts which have been erected/ aligned and inspected are supported by additional bracing etc. so that they do not get disturbed during concreting.

After concreting, critical dimensions of embedded parts shall again be inspected for clearance of any excess concreting requiring chipping etc.

Inspection of gate at site after its complete assembly and checking of dimensional accuracy, critical dimensions, coplanerness of skin plate and bearing / sealing faces.

Inspection of structural components of hoist support, their dimensional accuracy, corrects location and rigidity.
Inspection of lifting beam for proper matching with all units of stoplogs.

Inspection of hoist/ Crane for exact location of hook/ pulley block over the lifting point of the gate and for proper matching and connections.

28.9.3.3. FINAL CHECKING AT SITE

General

After completion of various phases of works final checking of the entire work shall be done, by the Bidder to ensure that all the equipments erection and wiring etc. have been done strictly according to the specification drawings and as approved by the Engineer-in-charge. All the works shall be thoroughly inspected keeping in view the following main points:

Check for completion of all works in accordance with specifications and drawings
Checking of alignment of all mating components
Checks for correctness of connections, continuity check, insulation resistance test
Checks, adjustment and characteristic test of all controls/ protective equipment in accordance with manufacturer's instructions.
Setting of components e.g. relays, control valves, pressure relief valves etc.
Checking of equipment for proper mechanical adjustment and proper operation.

Hydraulic Hoist

The functional tests on hydraulic hoist shall be carried out by the hydraulic hoist manufacturer's representative.

Checking of fluid tank and piping for completion as per drawings as well as for cleanliness before filling the hydraulic fluid.

Checking of connections of individual actuators to hydraulic installations according to circuit diagram.
Aligning the pump and motor.

Filling of hydraulic fluid.

Commissioning of pump and motor.

Setting of pressure relief valves/ safety valves, pressure switches, temperature controllers and pressure unloading valves to the prescribed value and locking.

Commissioning of control gear and actuators.

Lifting Beam

Functional tests with all units.

Gantry Crane / Monorail Crane

Ensuring completion of all works in accordance with the drawings.
Ensuring proper lubrication of all components.
Functional test of various assemblies including hoist, LT drive, etc.

Dry Testing of Gate & Hoist

The dry testing of the gate and hoist shall be carried out generally in accordance with Cl. 8.1, 8.2, 8.3 and 8.4 of IS 7718. The gate & hoist shall be functionally operated, fully closed, fully opened and it shall be ensured that there is no obstruction during the operation, the movements are smooth without any jerks and no undue effort is required for operation. Contact between gate seals and seal seats shall be checked and pre-compression ensured by viewing the contact surface against a light source/feeler gauge. The operation of the hoist shall be smooth without any undue noise/ excessive friction and without excessive vibrations in the gate, hoist and supporting structure. The operation of hydraulic hoist shall be without any increase in oil pressure beyond design limits and motor current shall be within design value.

IMPORTANT: During 'Dry' testing of gate pour water over the side rubber seals (Do not use grease/ oil) and keep it thoroughly wet during testing period.

28.9.3.4. ACCEPTANCE

The taking-over testing of any part or section of the Permanent works which can operate as an independent unit, shall be performed in accordance with the standards and regulations laid down in the "Particular Technical Specification" and following the test procedure agreed upon between Engineer and Bidder.

Immediately upon termination of any such testing of a part or section of the permanent Works a "Protocol of Acceptance" shall be issued by the Engineer.

This document shall be signed by an authorized representative of the Owner's, the Engineer and the Bidder and shall form an integral part of the later "Taking-Over Certificate".

The acceptance of the equipment will be based upon:

- Mutual acceptance of results of test between the Bidder and the purchaser
- Acceptance of Inspection and test records/ Test certificate carried out at "Works" and at "Site".

This "Protocol of Acceptance" shall state:

- The date of testing
- Statement of all minor defects and/or irregularities, which have to be corrected by the Bidder.
- Confirmation that the guaranteed data have been proven.
- Confirmation that all contractual documents have been submitted.
- Confirmation that the Owner's personnel has been familiarized with the Works and that they will be able to operate and maintain the Works.

If any test for the verification of the guaranteed data could not be performed for operational reasons beyond the Bidder's responsibility, this part of the acceptance shall be stated in the "Protocol of Acceptance" and be postponed for a mutually agreed period.

28.9.3.5. MISCELLANEOUS

Where ever the gate items are embedded, structural steel supports and bracings required for holding them in position without any disturbance in the alignment and which are finally embedded in concrete shall be deemed to be included in the unit prices of various items mentioned. No separate payment shall be made for such supports or any other type of temporary or permanent supports. The unit price accepted for the various items shall be considered to include cost of all materials, transport, plant and equipment, labour, tools and tackles, fabrication, erection, non-destructive tests (both at shop and field), surface preparation, painting, protective coating, wrapping, machining, supervision, Supply, installation, testing and commissioning of equipment, etc. complete as required for all the operations specified herein above in addition to those specifically so provided or otherwise so specifically directed for particular item of work.

29. PARTICULAR TECHNICAL SPECIFICATIONS – HYDROMECHANICAL WORKS

29.1. General

Scope of this Contract include the following items of work relevant to various hydraulic gates, stoplogs, trash racks, hoists and crane. The Particular Technical Specification shall take precedence over the General Technical Specification in case of any contradiction.

29.2. Blockouts, 1st & 2nd Stage Embedded parts

The slot final dimensions should be kept as small as possible, so as to minimize hydraulic flow disturbances and to avoid trapping of debris. However, niches constructed in the first stage concrete, in turn, should be wide enough to accommodate 2nd stage EPs like wheel tracks/side seal seats and side guides/counter guides and to allow welding of the anchor studs to the 1st stage anchor plates, as well as providing adequate access to the adjusting nuts.

Second stage embedded parts such as sill beams, side-seal contact cum roller faces of radial gates, wheel tracks or sliding tracks, seal seats, side guides, counter guides, concrete edge protectors for vertical lift gates have to be embedded in concrete. Normally concreting behind the gate groove shall be done in two stages. Direct installation of second stage embedded parts in the primary concrete (1st stage concrete) is usually avoided because it hinders the attainment of the required tolerances for the proper positioning of the elements. Thus, most of the times, the second stage embedded parts are installed within niches or pits built in the primary concrete.

1st Stage Inserts (in primary concrete)

While raising the piers just from sill beam level, the 1st stage inserts (i.e. 10 mm thick anchor plate with 16/20 dia J/U anchor rods) shall be positioned with respect to blockout drawings and the anchor rod shall be welded to re-bars and after their checking the location and alignment, primary concrete shall be poured so as to expose the plate surface outside and along the primary concrete contour. Setting of the 1st stage inserts shall be made, whenever possible, in two main directions, that is, in the flow direction and orthogonal to it with suitable blockout openings, to hold the embedded parts in the secondary concrete (i.e 2nd stage concrete). The requisite dowel bars of adequate length are to be left in the blockouts to give necessary bond between primary and secondary concrete.

2nd Stage Embedded Parts

The second stage embedded parts installation can only start for each bay/vent when all the primary concrete work is finished up to the top of the pier, the grooves pricked, cleaned and 1st stage anchor plates totally visible and cleared of concrete. The second stage embedded parts are set up in the left out blockouts and second stage concrete is cast around them. Anchorages should be welded rigidly, after final adjustment of the embedded parts, so as to prevent dislocation of the parts while pouring second stage concrete. In the design of the embedded parts, holes should be provided in the stiffeners and horizontal ribs, thereby making it easier for pouring and vibration of the concrete.

Additional bracings shall be provided after the alignment of 2nd stage Eps and prior to pouring of second stage concrete to avoid disturbance in the final alignment.

29.3. Orifice Spillway Radial Gate

These gates are used in the spillway primarily for upstream level control and to discharge of flood and also flushing the accumulated sediment. The conceptual form of the radial gate with hydraulic hoist is shown in drawing no. P.012745-W-20321-001 (Sheet 1 of 3, 2 of 3 & 3 of 3).

29.3.1. Gate

The gate leaf shall be fabricated out of stainless steel (Type AISI304/ AISI 316L) skin plate forming the upstream curved surface and stiffened suitably spaced in the rear by suitable stiffeners. The centre of the arc is at the centre of the trunnion pins, about which the gate rotates. They shall transmit the load to horizontal girders, which shall be supported by inclined radial arms, so that the water load is transmitted to the trunnions through radial arms. Finally, the trunnions transmit the load to an in-situ cast cantilever concrete beam

Suitable sealing arrangement shall be provided on sides, top and bottom including corners. The seals shall conform to the provisions contained in IS 11855 (latest edition). The seal interference/compression for side seals shall be 3 mm and for top seal and bottom seal 5 mm.The side seals shall be of Teflon Cladded solid square bulb type and top seals shall be of Teflon cladded double stem solid bulb type seal two Nos, (i) one attached to gate skin plate and (ii) the other attached to lintel beam, the bottom seal shall be of wedge type. The seals shall be fixed with the help of seal clamp plates and stainless steel socket head screws so as to ensure positive pressure between seal and gate and to bear tightly on the seals to prevent leakage.

The minimum thickness of skin plate shall not be less than 25mm.

The skin plate shall be finished smooth at bottom for proper seating on sill beam. Similarly the upstream face of skin plate shall be finished smooth throughout so that the sealing is effective under partial opening of gate because the upstream face of skin plate will function as seal seat for top seal attached to lintel beam.

Guide rollers shall be provided near the side seals to limit the lateral movement of the gate during raising or lowering. A curved structural steel plate (wall plates) in suitable sections to form the curve shall be embedded in the face of the pier adjacent to sides of the gate to serve as track for the guide rollers. It will also bear a smooth stainless steel plate of corrosion resistance type against which the side rubber seals will rub during the movement of the gate.

The radial gate is proposed to be operated by hydraulic hoist and the piston rod eye end is connected to downstream of gate. The hydraulic hoist cylinder is to be connected to hoist supporting structure at the top and shall be located such that all the parts are sufficiently clear from civil structure and inclined arms. The hydraulic hoist stem shall be connected to the bracket over the bottom horizontal girder and shall be sufficiently rigid. The pin connecting the hydraulic cylinder with gate shall be of stainless steel and fitted with suitable bearing provided / recommended by the Hydraulic cylinder manufacturer.

The Bidder shall include necessary access ladders, safety gauge, platforms, hand rails in and around gate installations and hydraulic hoist cylinders (for gate inspection and maintenance only). The Bidder shall quote for these items separately to decide during tender finalization.

The gate shall be designed for various load conditions described in the specification and in accordance with the provisions of IS 4623 (latest edition). The gate shall be designed for a total head corresponding to water level at FRL and normal allowable stresses and shall be checked for maximum flood level.

29.3.2. Guide Rollers

Guide roller shall be provided on the sides of radial gate to limit the lateral movement not more than 6 mm in either direction. The rollers shall be provided with self lubricating bush rotating on fixed stainless steel pin. At least two guide rollers on each side shall remain within the wall plate area (structural steel portion), when the gate is in fully raised position and the rollers shall be adjustable and removable. The tolerance for guide roller assembly should be as per provision in IS code. A minimum load of 5 percent of the total dead weight of the gate is recommended for the design of each guide roller.

29.3.3. Horizontal Girders and Bracings

The horizontal girders shall have built up plate girders suitably welded in shop. Minimum number of girders shall be provided as per IS 4623 (latest revision). The vertical stiffeners shall be designed as continuous beam resting on horizontal girders. The design of horizontal girders shall be done taking into account of the fact that the central part of the girder is subject to axial compressive stress due to the arms load. Also, the horizontal girders shall be checked for shear at the points where they are supported by the arms.

The horizontal girder should also be suitably braced to ensure rigidity. The spacing and design of bracing and intermediate stiffeners shall be governed by relevant portions of IS 800.

29.3.4. Arms and Bracings

As many arms as the number of horizontal girders, shall be used, unless vertical end girders are provided. The inclined arms shall be fabricated out of rolled steel sections or structural steel plates. The arms shall be rigidly connected to the trunnion hub of cast steel (by welding using suitable electrode) and shall be suitably braced in between arms to withstand buckling at the downstream. The bracings shall be so spaced, that the slenderness ratio of arms in both the longitudinal and transverse directions are nearly equal.

The arms shall be designed as columns for axial loads and bending moments from horizontal girders considering their fixity. The allowable stresses shall not exceed the permissible limits as per clause 6.8.4 of IS 4623 (latest revision).

29.3.5. Trunnion Hub

The tunnion hub shall rotate about the trunnion pin. The arms of the gate shall be connected to the hub to ensure full transfer of load. The hub shall be sufficiently long so as to allow arms of the gate to be fixed to the respective limbs of the hub without having to cut and shape the flanges of the arms. The limbs of the hub shall be on the apex of a cone with the base of the cone along with joints of the arms and the horizontal girders. The thickness of the webs and flanges of each of the limbs of hub shall be greater to the extent so as to provide adequate space for the weld. Sufficient ribs and stiffeners shall be provided in between its webs and flanges to ensure rigidity of the trunnion hub. The thickness of hub shall be as per clause 6.9.5 of IS 4623 (latest revision). The bush thickness shall not be considered as hub thickness.

29.3.6. Trunnion Axle

The trunnion axle shall normally be supported at both ends on the trunnion bracket which is fixed to the concrete trunnion girder. The trunnion axle shall be designed for bending for the total load transferred through the trunnion hub. The load shall be taken as uniformly distributed over the length of the axle bearing against the hub. The axle shall be checked for shearing and bearing also for the same load. The trunnion axle shall be of corrosion resistant steel (X 20 Cr 13) conforming to IS 1570 Part V (latest revision) and suitably locked against rotation.

29.3.7. Trunnion Bush

Trunnion Bush shall have force fit in the trunnion hub and running fit on the trunnion pin.

The bearing should be self – lubricating, completely maintenance free during its life time. They should consist of bronze (ASTM B271 C86300) with solid deposits of special lubricants (white).

The lubricant should be free from graphite and molybdenum to avoid electrolysis. It should be distributed on the whole sliding surface, covering more than 25% of the area. The sliding surface should be covered with a running in film containing the same lubricant (PTFE with about 0.02 mm of thickness). The bearing should have high static and dynamic load capacity, consistent low coefficient of friction (<0.01), without “stick – slip” and should be consistent over all load ranges.

Table 29.3-1 : Physical Properties of Trunnion Bush

Sl. No	Properties	Values
1	Density	8.2 gms/cm²
2	0.2% Strain	480 MPa
3	Tensile strength	750 MPa
4	Strain	5%
5	E Modulus	115000 MPa
6	Hardness	180 BHN

Table 29.3-2 : Bearing Properties of Trunnion Bush

Sl.No	Properties	Values
1	Maximum permissible load	150 MPa
2	Maximum sliding speed (dry)	0.4 m/s
3	Maximum PU value	1.5 Mpa, m/s
4	Temperature range	- 10º to + 250º C

Design stresses for the trunnion bushing and bearing shall be 10% of YP over worst calculated value or have a factor of safety of 2 over the bush bearings manufacturers dynamic load specifications, whichever is lower.

Mating Material : Axle Properties

Axle should be corrosion resistant and should have the following properties:

Minimum Axle Hardness : 300 BHN

Axle Surface Roughness : 0.2 to 0.8 Microns

29.3.8. Trunnion Bracket

The trunnion brackets shall be fabricated out of structural steel and rigidly fixed to an in-situ cast cantilever concrete beam by bolts and shall transfer the total load from the trunnion to the dam body. The arms of the bracket shall be designed to transfer the load from each trunnion on bearing. The arms of the bracket shall also be designed to resist any bending which may be encountered by them due to the component of the load parallel to the base of the trunnion bracket. Ribs and stiffeners shall be provided on the trunnion bracket, particularly on the sides to ensure sufficient structural rigidity. The bearing stress and bending stress shall not exceed the values specified in IS: 4623 (latest revision).

29.3.9. Trunnion Ties

The Trunnion ties shall be designed to take care of lateral force acting on the arms due to inclination of arms. While designing this, bending due to self weight of ties shall also be kept within permissible limits. The stresses induced in trunnion ties due to variation of atmospheric temperature of project site shall also be calculated. The stresses in compression / tension in bending and combined stress shall not exceed the values specified in **Annex 'B' of IS 4623.**

29.3.10. Embedded Parts

Anchor rods with plates (1st stage inserts) shall be embedded in the first stage concrete at spacing not exceeding 500 mm center to center leaving suitable block out openings for second stage embedded parts. The second stage anchor bolts with double nuts and washers attached to second stage embedded parts shall then be welded to these inserts and shall be used for proper alignment of the embedded parts. The size of the anchor bolts shall not be less than 16mm in diameter and the length to suit the proposed block outs.

The second stage embedded parts consist of fabricated sill beam, wall plates with stainless steel sealing surfaces and roller support beams, dogging devices, trunnion anchor rods and anchor bolts/nuts.

The sill beam and side guide roller paths (wall plates in segments) will be of structural steel and all seal seats shall be machined after welding. The minimum thickness of stainless steel seal seats after machining shall not be less than 10 mm. The side seal seats shall be provided from sill level to level upto the top of gate in closed position along the skin plate radius. Minimum 150 mm recess shall be provided on face of concrete above side seal seats for facilitating replacement of side seals. The side roller path shall be provided from sill level to the top of piers along the skin plate radius. The side embedded parts shall be taken below the sill for a distance of 300 mm.

The seal seat bases and sill beam shall be aligned and securely fixed for embedment in 2nd stage concrete. Relative alignment of top, side and bottom seal seat when gate fully closed and seals are compressed shall be maintained.

The maintenance of gates will be carried out by raising the gate and resting on the dogging beams.

29.3.11. Anchorages

The trunnions shall be located on an in-situ cast cantilever concrete beam (civil scope). The trunnions shall be so located that the resultant hydraulic thrust through the gate in the closed position for reservoir full condition lies as close to the horizontal as possible. This will reduce the upward or downward force that will otherwise be imposed on the anchorage system. The forces to be borne by the load carrying anchors shall be determined for the following two conditions:

i) Gate resting on sill and head on the gate varying from zero to maximum.
ii) Water level constant at FRL for which the gate has to be designed and the gate position varying from fully closed to fully open. The worst combination of horizontal and vertical forces shall then be chosen.

29.3.12. Design Considerartions

a) The Radial gate and hydraulic hoist shall be designed in accordance with the provisions of IS: 4623-2000 (3rd revision) and IS: 10210 respectively.

b) The cantilever concrete trunnion beam shall be designed to withstand the resultant water thrust on the gate and transfer it to the dam body. Its maximum value occurs with the gate closed and subject to the maximum head of water level (FRL).

c) Due to some technical reasons, the gates remain closed during flood season for an extended duration; silt is likely to get settled on their upstream. Due to heavy concentration of silt in water, the silt deposit may go up to full height of the gate and put additional load, which definitely need to be considered appropriately in the design. The semi-liquid silt deposited on the upstream side of the gate is of heavier density as compared to water. Horizontal thrust on gate due to silt and water can be worked out taking the density of semi-liquid silt as 1360 kg/m³, which is as per recommendations in Para 5.5.2 (a) of IS 6512.

d) The hydrodynamic forces due to horizontal earthquake acceleration at the top of opening and at sill shall be worked out as per Para 7.2 of IS 1893 and considered in the design. The stresses in the various parts of the gate under the action of occasional forces shall not exceed 133% of the permissible stresses specified in Annex B of IS 4623 subject to the maximum of 85% of the yield stress.

29.3.13. Technical Requirements

The Scope of work shall conform to the following basic technical requirements and specifications. The gate components and embedded parts shall be designed in accordance with the provisions of IS 4623:2000 (or latest edition). The radial gate shall be designed for hydrostatic and hydrodynamic forces taking into consideration of silt load, wave effect, earthquake effect.

Table 29.3-3 : Forces to be considered in the Design

Sl. No.	Loading condition	Position of gate and supporting details
1	Normal	Gate in fully closed position and rest on the sill beam. Silt load shall be considered.

Sl. No.	Loading condition	Position of gate and supporting details
2	Normal	Gate, supported by two hydraulic cylinders, starts to open. Maximum cylinder force applied to each gate cylinder connection eye. Hydrostatic and hydrodynamic forces, trunnion friction, seal friction and silt load shall be considered.
3	Normal load	Gate in any partially open position, supported by cylinders.
4	Normal load	Gate in fully open position, supported by cylinders.
5	Over load	Gate in fully closed position and rest on the sill beam. Seismic load acting on the gate.
6	Over load	Gate supported on one hydraulic cylinder and gate opened just above sill.

Note: The earthquake forces, the wave effect shall not be considered to act simultaneously while computing the increased stress in the gate.

Table 29.3-4 : Design Data

Sl. No.	Particulars	
1	Clear width of opening (m)	7.00
2	Vertical height of opening (m)	8.50
3	Number of bays	2
4	Top of dam/Road bridge (m)	EL 982.00
7	FRL (m)	EL 980.00
8	Trunnion level (m)	EL 921.00
9	Crest level (m)	EL 912.00
10	Sill level (m)	EL 911.00
11	Design head (FRL-Sill) (m)	69.00 +Silt load upto full height of gate
12	Bottom level of gate in fully raised position (m)	EL 920.50
13	Type of proposed hoist	Twin hydraulic cylinder (single acting)
14	Stroke and capacity of hoist	To be decided by the Bidder
15	Type of rubber seals	Bottom – Flat wedge type Sides - Teflon Cladded solid square bulb type

Sl. No.	Particulars	
		Top - Teflon cladded double stem solid bulb type
16	Radius of skin plate (mid point)	12.00 m
17	Minimum thickness of skin plate	25 mm (after machining)
18	Minimum thickness of stainless steel plate for seal seats	10 mm (after machining)
19	Operating criteria	Regulating type
20	Governing IS codes (latest)	4623, 6934, 800, 10210, 11855, 14177
21	Grade of 2nd stage concreting	M 25
22	Coefficient of horizontal & vertical acceleration due to earthquake effect (design consideration)	α_h =0.18 α_v =0.12

i) Permissible Stresses

Permissible stresses in structural components for gate and embedded parts shall be in accordance with Annexure B of IS 4623 (latest edition). The stresses in various parts of the gate under the action of occasional forces shall not exceed 133% of the permissible stresses specified in Annexure B subject to the maximum of 85% of the yield stress of the specified material.

Skin plate Wet & Inaccessible

All other structural components (gate) Dry & Accessible

Embedded parts Wet & Inaccessible

Permissible bearing & shearing stresses in concrete – as per IS 456 (latest)

ii) Recommended Materials

As a general guidance materials used for various items of radial gates and hydraulic hoists are given in recommended material of this document.

iii) Operating Criteria

The spillway radial gate shall normally be kept at fully closed position and shall be operated during flood season to maintain the pond level at FRL on the upstream side. The raising/lowering of gate shall be under unbalanced head condition. Since these gates are meant for regulation, it shall be capable of being held in partially open position within the range of travel to pass the discharge without undue vibration. Minimum gate opening shall be 300 mm to prevent damage to bottom rubber seal and to avoid gate vibration.

Automatic Reservoir Monitoring and Control system shall be provided to open or close the spillway orifice gates to achieve the required flows and maintain water levels.

The gate in general, shall satisfy the following requirements:

a. It shall be reasonably water tight. However, the maximum permissible leakage shall not exceed 5 litres per min. per metre length of periphery of sealing surface of gates;
b. It shall be capable of being raised or lowered by the hoist at the specified speed;
c. Manual operation arrangement shall be provided in case of power failure.

iv) Deflection of Gate

The maximum deflection of gate shall not exceed 1/800 of the span, where span is centre to centre distance of supports considered. The gate shall be rigid enough so that the maximum deflection of the gate at top seal should not exceed 80% of initial interference of seal.

29.4. Orifice Spillway Stoplogs

Stoplogs are mainly intended to undertake maintenance and repair of the spillway radial gates and used on the upstream side. Placement of the stoplog panels in the vertical slots is carried out by a moving gantry crane together with automatic engaging/ disengaging lifting beam which travels over the spillway bridge. The conceptual form of the spillway stoplogs with moving gantry crane along with lifting beam is shown in drawing no.P.012745-W-20322-002 (Sheet 1 of 2 & 2 of 2).

29.4.1. Stoplogs

Stoplogs (Slide type) is structural steel frame consisting of end verticals with properly spaced horizontal girders between them. The frame is held a piece by secure welding and shall be of slide type moving on stainless steel track plate welded to track base embedded in concrete. Stoplogs shall consist of 3 (three) units and out of which 2 (two) interchangeable panels and one non-interchangeable top panel with top seal and filling valves. Each panel shall consist of downstream skin plate and downstream sealing arrangement. The skin plate is supported by horizontal girders spaced at suitable intervals. The horizontal girders shall be supported by end vertical girders. The total water load shall be transmitted through the sliding pads fixed on end vertical girders to the track embedded in concrete.

Each panel shall be fitted with guide rollers, two on each side to limit the lateral movement of gate to not more than 6mm in each direction and to engage the element in the guides embedded in concrete. Guide rollers may also be provided with suitable springs. The guide roller/shoes should be designed for the maximum load to which they may be subjected to during operartion. A minimum load of 5% of the total ded weight of the gate is recommended for the design of each guide roller. The thickness of the skin plate shall be 1.5 mm more than the effective thickness required as per the design to allow for corrosion. The minimum thickness of the skin plate shall not be less than 25 mm. Each element shall be provided with lifting lugs. The stop log gate shall be designed for a maximum water head and in accordance with the provisions contained in IS: 9349 (latest revision).

The side and top rubber seals shall be Teflon cladded double stem music note type and the bottom seal shall be flat wedge type. The rubber seal at corner shall be Teflon cladded moulded type.The seals shall be fixed by means of seal clamps and stainless steel bolts and nuts with washers so as to ensure a positive water pressure between the seals and the gate and to bear tightly on the seal seat to prevent leakage. Two lifting pins with bracket shall be provided on the top of each stoplog panels except in top unit where lifting lugs are provided on the filling-in-valves. The location of pins shall be such that the stolpog, when hung, shall remain truely vertical. Each stoplog unit shall be provided with two pilot bars and corresponding pilot tubes for proper matching/guidance for correct placement and engagement.

Air vents shall be provided downstream of stoplog grooves (civil scope).

The top panel shall have filling valves for pressure balancing. All panels shall be lowered or lifted under balanced water head condition.

The deflection of stop log gate shall not be more than L/1200 of the span, as per IS 9349 (2006) Clause no. 9.1.12 (b).

29.4.2. Latching and Storing

Stoplog panels (1 No) shall be stored in the upper portion of the stoplog gate slot by providing latching arrangement and the remaining two panels shall be stored in storage pits provided in the breastwall.

29.4.3. Embedded Parts

The embedded parts which provide sealing surfaces, bearing surfaces and guides for the gate are embedded in concrete as a second stage and suitable anchors shall be provided to align the embedded parts within the tolerance.

i) Anchorages

Anchorages shall be provided in the first stage concrete, with suitable blockout openings, to hold the embedded parts in the second stage concrete. The anchor bolts in the second stage concrete shall be with double nuts and washers. For adjustment purposes enlarged holes in the embedded parts of the second stage concrete shall be provided. Preferably the anchor plates may be embedded with first stage concrete and anchor bolts welded subsequently. The minimum size (diameter) of anchor bolts shall not be less than 16 mm and the anchor plate thickness shall not be less than 10 mm.

ii) Seal Seats

The sill beam, side seal & top seal seat bases shall be fabricated from structural steel and embedded in concrete. The minimum width of seal seat shall be 100 mm and stainless steel plate conforming to IS 1570 (Part 5) (latest edition) shall be 10 mm (after machining) in order to have corrosion resisting surface with a low coefficient of friction and shall be welded with the base. The seal seats shall be finished smooth to triple delta. The edges of side seal seats shall be rounded/ chambered to prevent damage to rubber seal during gate operation. The surface of sill beam shall be machined smooth and made flush with the surrounding concrete.

iii) Slide Tracks

Track / bearing plates shall be made of Corrosion Resistant steel conforming to I.S:1570(Part **5**). The tracks shall provide a true and smooth machined surface for the sliding pads and transmit the loads through the pads to track base (structural steel) embedded in concrete. The minimum edge distance of the bearing plate flange shall in no case be less than 150 mm. It shall be designed as a beam on elastic foundation. The width of the bearing plate surface should be so chosen that the bearing pressure does not exceed the permissible limit. The surface of track plates shall be finished smooth to two delta.

The stress in bearing for concrete shall not exceed the values specified in IS 456. Second stage concrete shall be at least M25. The depth of second stage concrete shall be such that the 45 degrees plane drawn from the inner edge of the track base beam passes through anchors provided in the first stage concrte. Diagonal shear stress in the concrete due to maximum load derived from the bearing stress under the track base be within allowable limits permitted by the IS 456. Where excecessive shear stress in the concrete is unavoidable, reinforcement properly designed for shear and placed in the first stage concrete can be taken into account. In no case shall the alignment bolts be considered as shear reinforcement.

iv) Guides

The side guides shall be fixed inside the groove in Dam body. The guide shall be flat plate of thickness 40 mm (structural steel) anchored into concrete to limit lateral and longitudinal movement of gate within a tolerance of 3 mm in every 3 m height with overall tolerance of 5 mm. The guide shall be continued up to the full range of travel of the gate (i.e. up to top of dam).

29.4.4. Storage Pits

One panels will be stored and latched (sliding type-manually operated) over the stoplog gate grooves and provision shall be made in storage pits to keep the remaining 2 (two) panels when not in use. The necessary sill beam and bottom extended plate to protect bottom sealing arrangement and side guides for placement in the pit shall also be provided. Suitable drain hole shall be provided by the civil agency in the pit.

29.4.5. Design Considerartions

a) The slide type orifice spillway stoplog panels shall be designed in accordance with IS: 9349. The stoplog units shall be designed for water head corresponding to FRL plus 0.3 m head for wave effect with normal allowable stresses.
b) The skin plate shall be provided on downstream side as per the requirement and the sealing arrangement shall be provided on the downstream side.
c) The hydrodynamic forces due to horizontal earthquake acceleration at the top of opening and at sill shall be worked out as per Para 7.2 of IS 1893 and considered in the design. The stresses in the various parts of the gate under the action of occasional forces shall not exceed 133% of the permissible stresses specified in Annex C of IS 9349 subject to the maximum of 85% of the yield stress.
d) Hydrodynamic forces namely uplift and downpull forces shall be considered in the design.
e) Stoplog panels shall be designed for operation under balanced head condition (i.e. no flow) and shall be placed by a rail mounted gantry crane with the help of lifting beam.

29.4.6. Technical Requirements

The Scope of work shall conform to the following basic technical requirements and specifications. The gate components and embedded parts shall be designed in accordance with the provisions of IS 9349.

The stoplogs shall be designed for hydrostatic forces taking into consideration of silt load, and earthquake effect.

The dogging/Latching devices shall be designed to support twice the calculated dead weight of the gate to allow for impact.

Table 29.4-1 : Forces to be Considered in the Design

Sl.No	Loading condition	Position of gate and supporting details
1	Normal	Multiple stoplog panels placed one above the other. Bottom unit resting on sill beam.
2	Normal	Stoplogs in operation (inside the slot).
3	Over load	Gate Jammed

Table 29.4-2 : Design Data

Sl.No	Particulars	
1	Clear width of opening (m)	7.00
2	Vertical height from sill up to top seal of opening (m)	7.525
3	Number of bays	2
4	Number of stolpog panels	1 set (3 panels), one top unit with filling valves and 2 interchangeable panels.
5	Type of gate	Slide gate with d/s skin plate & d/s sealing
6	Top of dam/Road bridge (m)	EL 982.00
9	FRL (m)	EL 980.00
10	Crest level (m)	EL 912.00
11	Sill level (m)	EL 911.975 (Flat at the bottom)
12	Design head (FRL-Sill) (m)	68.025 + Silt load
13	Type of proposed hoist	Travelling gantry crane and Lifting beam
14	Type of rubber seals	Bottom - Flat wedge type Side, top and moulded corner- Double stem solid bulb Teflon cladded
15	Minimum thickness of skin plate	25 mm
16	Minimum thickness of stainless steel plate for seal seats	8 mm (after machining)
17	Minimum thickness of stainless steel plate for track	12 mm (after machining)
18	Operating criteria	Balanced condition
19	Governing IS codes (latest)	9349 , 800, 807, 3177, 11855, 14177
20	Grade of 2nd stage concreting	Minimum M 25

i) Permissible Stresses

As the stoplogs are stored above water level and are only occationally used, permissible stresses in structural components for gate and embedded parts shall be in accordance with Annexure C of IS 9349 (latest edition). The stresses in various parts of the gate under the action of occasional forces shall not exceed 133% of the permissible stresses specified in Annexure C subject to the maximum of 85% of the yield stress. The earthquake forces and the wave effect shall not be considered to act simultaneously while computing the increased stress in the gate.

Stoplogs	Dry & Accessible
Embedded parts	Wet & Inaccessible

Permissible bearing & shearing stresses in concrete – as per IS 456 (latest)

ii) Recomended Materials

As a general guidance materials used for various items of radial gates and hydraulic hoists are given in recommended material of this document.

iii) Operating Criteria

All the stoplog panels shall be lowered/raised under balanced water head condition i.e under no flow condition. Each stoplog panel shall be capable of self-closing i.e by gravity under its own weight. A lifting beam having automatic engaging and disengaging arrangement has been provided to handle stoplog panels.

The slide gate in general, shall satisfy the following requirements:

a. It shall be reasonably water tight. However, the maximum permissible leakage shall not exceed 5 litres per min. per metre length of periphery of sealing surface of gates;
b. It shall be capable of being raised or lowered by the hoist at the specified speed;
c. These shall be rigid and free from vibration.

iv) Deflection of Gate

The maximum deflection of gate under normal load shall be limited to 1/1200 of the span (centre to centre of the tracks).

29.5. Upper Spillway Service Gate

Upper Spillwy Service Gate 1 (one) No. has been provided to facilitate discharge of flood and the removal of floating trash and debris. This gate is intended to fully open or fully closed type. The operation of the gate in the vertical slot is carried out by a rope drum hoist of adequate capacity. The conceptual form of the Upper Spillwy Service Gate with rope drum hoist is shown in drawing no.P.012745-W-20323-004 (Sheet 1 of 2 & 2 of 2).

29.5.1. Gate

Upper Spillwy Service Gate of fixed wheel type for a clear vent opening of size 5.0 m (w) x 5.5 m (h) is proposed for the upper spillway and shall be designed as per IS 4622 (latest edition) for the water level up to FRL. The height of gate shall be determined considering 0.30 m freeboard above FRL. The gate leaf shall consist of upstream skin plate supported on horizontal girders which in turn be mounted on end vertical girders so that the total water load is transmitted through the wheels to the track plates embedded in concrete. Single stem Teflon cladded hollow bulb rubber seals shall be provided on upstream face of the gate leaf on the sides and wedge type flat rubber seal for the bottom. The rubber seals shall be fixed to skin plate by means of CSK stainless steel screws or bolts, so as to ensure positive water pressure between the skin plate and seal and to bear tightly on the seal seat to prevent leakage of water. The thickness of skin plate shall not be less than 10 mm. The gate shall be designed and checked for self-closing under full hydrostatic head corresponding to full water level. The gate shall be operated by means of rope drum hoist of adequate capacity placed over the steel trestles. The gate shall be lifted/ lowered under unbalanced water head conditions.

The gate wheels shall be suitable to withstand the stresses developed due to hydrostatic loads, which they will carry. The wheels shall be mounted on fixed pins and supported at both ends, on one side of the web of the vertical girder and on the otherside by stiffener plate. The wheel pin shall be designed for bearing, bending and shear; the load shall be taken as wheel load acting on the width of the bearing. The pin supports shall be suitably stiffened against bearing and tearing. The pins may be given suitable eccentricity to permit of wheels. SKF make or equivalent anti-friction spherical roller or self lubricating bronze bearings of reputed make (as approved by the Engineer-in-Charge) and proven capabilities with proper lubricating arrangement shall be adopted. Bearing should have minimum 10000 hours of life and their static capacities should be at least 1.5 times the wheel load. However, the dynamic capacities should also not be less than the wheel load. Bearing should also be safe against axial loading. Bearings shall be fully protected from entry of the silt.

The gate and embedded parts shall be designed for appropriate load combinations described to suit the operating criteria and shall be designed for wet and accessible conditions and embedded parts shall be designed for wet and inaccessible condition as per provision contained in IS 4622 (latest edition).

29.5.2. Latching

Latching arrangement shall be provided in the upper portion of the gate slot.

29.5.3. Embedded Parts

The embedded parts which provide sealing surfaces, bearing surfaces and guides for the gate are embedded in concrete as a second stage and suitable anchors shall be provided to align the embedded parts within the tolerance.

i) Anchorages

Anchorages shall be provided in the first stage concrete, with suitable blockout openings, to hold the embedded parts in the second stage concrete. The anchor bolts in the second stage concrete shall be with double nuts and washers. For adjustment purposes enlarged holes in the embedded parts of the second stage concrete shall be provided. Preferably the anchor plates may be embedded with first stage concrete and anchor bolts welded subsequently. The minimum size (diameter) of anchor bolts shall not be less than 16mm and the anchor plate thickness shall not be less than 10 mm.

ii) Seal Seats

The sill beam, side seal seat bases shall be fabricated from structural steel and embedded in concrete. The minimum width of seal seat shall be 100 mm and stainless steel plate conforming to IS 1570 (Part 5) (latest edition) shall be 8 mm (after machining) in order to have corrosion resisting surface with a low coefficient of friction and shall be welded with the base. The seal seats shall be finished smooth to triple delta. The edges of side seal seats shall be rounded/ chambered to prevent damage to rubber seal during gate operation. The surface of sill beam shall be machined smooth and made flush with the surrounding concrete.

iii) Wheel Track

Track / bearing plates shall be made of Corrosion Resistant steel conforming to I.S:1570(Part **5**). The hardness of surface of the track plates shall be kept 50 points BHN higher than that of the wheel tread to reduce the wear on the track. The hardness of surface of the track plates shall be kept 250 points BHN (minimum). The thickness of track plate shall be calculated as per para 5.7.3 of I.S: 4622. However, the minimum thickness of track plate shall not be less than 12.0 mm after machining. The tracks shall provide a true and finished smooth to two delta for the wheels and transmit the loads through the wheel to track base (structural steel) embedded in concrete. The minimum edge distance of the bearing plate flange shall in no case be less than 150 mm. The track base shall be checked for bending and shear also. The web of the track base shall also be checked for web compression. Permissible stress in compression for web shall be taken as 85% of yield point for normal condition and equal to yield point for occasional load condition.

The stress in bearing for concrete shall not exceed the values specified in IS 456. Second stage concrete shall be at least M25. The depth of second stage concrete shall be such that the 45 degrees plane drawn from the inner edge of the track base beam passes through anchors provided in the first stage concrte. Diagonal shear stress in the concrete due to maximum load derived from the bearing stress under the track base be within allowable limits permitted by the IS 456. Where excecessive shear stress in the concrete is unavoidable, reinforcement properly designed for shear and placed in the first stage concrete can be taken into account. In no case shall the alignment bolts be considered as shear reinforcement.

iv) Guides

The side guides shall be fixed inside the groove in Dam. The guide shall be flat plate of thickness 20 mm

(structural steel) anchored into concrete to limit lateral and longitudinal movement of gate within a tolerance of 3 mm in every 3 m height with overall tolerance of 5 mm. The guide shall be continued up to the full range of travel of the gate (i.e. up to Top of Dam).

29.5.4. Design Considerations

The Upper Spillwy Service Gate shall be designed in accordance with the provisions of IS: 4622-2003 (or latest edition). The service gate shall be designed for a total head corresponding to water level at FRL and normal allowable stresses.

a) The hydrodynamic forces due to horizontal earthquake acceleration at the top of opening and at sill shall be worked out as per Para 7.2 of IS 1893 and considered in the design. The stresses in the various parts of the gate under the action of occasional forces shall not exceed 133% of the permissible stresses specified in Annex B of IS 4622 subject to the maximum of 85% of the yield stress.
b) The gate shall usually remain closed and will be opened to facilitate discharge of flood and the removal of floating trash and debris.

c) The gate shall be designed to be opened and closed under unbalanced head conditions and water stored up to FRL; the closing the gate against this head shall, therefore, be able to go under its own weight (self-closing). To meet this requirement the weight of the gate shall be at least 20% more than the forces opposing the closure of the gate.

29.5.5. Technical Requirements

The Scope of work shall conform to the following basic technical requirements and specifications. The gate components and embedded parts shall be designed in accordance with the provisions of IS 4622.

The upper spillway shall be designed for hydrostatic forces taking into consideration of and earthquake effect.

The dogging/Latching devices shall be designed to support twice the calculated dead weight of the gate to allow for impact.

Table 29.5-1 : Forces to be Considered in the Design

Sl.No	**Loading condition**	**Position of gate and supporting details**
1	Normal	Gate closed and resting on sill beam.
2	Normal	Gate in operation (inside the slot).
3	Over load	Gate Jammed

Table 29.5-2 : Design Data

Sl.No	**Particulars**	
1	Clear width opening (m)	5.00
2	Vertical height of opening (m)	5.50
3	Number of bay	1
4	Number of gate	1 (one)
5	Type of gate	Fixed wheel gate with u/s skin plate & u/s sealing
6	Top of dam level (m)	EL 982.00
7	FRL (m)	EL 980.00
8	Crest level (m)	EL 975.00
9	Sill level (m)	EL 974.50
10	Design head (FRL-Sill) (m)	5.50
11	Type of proposed hoist	Rope drum hoist
12	Type of rubber seals	Bottom – Flat wedge type

Sl.No	Particulars	
		Sides – Single stem Hollow bulb Teflon clad seals
13	Minimum thickness of skin plate	10 mm
14	Minimum thickness of stainless steel plate for seal seats	8 mm (after machining)
15	Minimum thickness of stainless steel plate for track	12 mm (after machining)
16	Operating criteria	Unbalanced condition
17	Governing IS codes (latest)	4622 , 800, 807, 11855, 14177
18	Grade of 2nd stage concreting	M 25

i) Permissible stresses

The Upper Spillwy Service Gate is kept closed, permissible stresses in structural components for gate and embedded parts shall be in accordance with Annexure B of IS 4622 (latest edition). The stresses in various parts of the gate under the action of occasional forces shall not exceed 133% of the permissible stresses specified in Annexure B subject to the maximum of 85% of the yield stress. The earthquake forces and the wave effect shall not be considered to act simultaneously while computing the increased stress in the gate.

ii) Service Gate

a) Skin Plate Wet & Accessible

b) Gate component (except skin plate) Dry & Accessible

c) Embedded parts Wet & Inaccessible

Permissible bearing & shearing stresses in concrete – as per IS 456 (latest).

iii) Recomended Materials

As a general guidance materials used for various items of radial gates and hydraulic hoists are given in recommended material of this document.

iv) Operating Criteria

The Upper Spillwy Service Gate shall be either fully open or fully closed type. The lowering/raising of gate shall be under unbalanced head conditions and therefore this gate shall be capable of gravity closing for all operating conditions (i.e. due to self-weight of gate). For meeting this requirement the weight of the gate shall be at least 20% more than the forces opposing the closure of the gate.

The gate in general, shall satisfy the following requirements:

a. It shall be reasonably water tight. However, the maximum permissible leakage shall not exceed 5 litres per min. per metre length of periphery of sealing surface of gates;
b. It shall be capable of being raised or lowered by the hoist at the specified speed;
c. These shall be rigid and free from vibration.

v) Deflection of Gate

The maximum deflection of gate under normal load shall be limited to 1/800 of the span (centre to centre of the wheels) as per clause 5.3.5 IS: 4622 (latest Edition).

29.6. Upper Spillway Stoplogs

Stoplogs are mainly intended to undertake maintenance and repair of the upper spillway service gate and used on the upstream side. The top of stoplog top unit shall be determined considering 0.30 m freeboard above FRL. Placement of the stoplog panels in the vertical slots is carried out by a moving monorail crane together with automatic engaging/ disengaging lifting beam. The conceptual form of the spillway stoplogs with moving monorail crane along with lifting beam is shown in drawing no.P.012745-W-20322-003 (Sheet 1 of 2 & 2 of 2).

29.6.1. Stoplogs

Stoplogs (Slide type) is structural steel frame consisting of end verticals with properly spaced horizontal girders between them. The frame is held a piece by secure welding and shall be of slide type moving on stainless steel track plate welded to track base embedded in concrete. Stoplogs shall consist of 2 (two) units. Each panel shall consist of downstream skin plate and downstream sealing arrangement. The skin plate is supported by horizontal girders spaced at suitable intervals. The horizontal girders shall be supported by end vertical girders. The total water load shall be transmitted through the sliding pads fixed on end vertical girders to the track embedded in concrete.

Each panel shall be fitted with guide rollers, two on each side to limit the lateral movement of gate to not more than 6mm in each direction and to engage the element in the guides embedded in concrete. Guide rollers may also be provided with suitable springs. The guide roller/shoes should be designed for the maximum load to which they may be subjected to during operartion. A minimum load of 5% of the total ded weight of the gate is recommended for the design of each guide roller. The thickness of the skin plate shall be 1.5 mm more than the effective thickness required as per the design to allow for corrosion. The minimum thickness of the skin plate shall not be less than 10 mm. Each element shall be provided with lifting lugs. The stop log gate shall be designed for a maximum water head and in accordance with the provisions contained in IS: 5620 (latest revision).

The side and top rubber seals shall be Teflon cladded hollow bulb music note type and the bottom seal shall be flat wedge type. The seals shall be fixed by means of seal clamps and stainless steel bolts and nuts with washers so as to ensure a positive water pressure between the seals and the gate and to bear tightly on the seal seat to prevent leakage. Two lifting pins with bracket shall be provided on the top of each stoplog panels. The location of pins shall be such that the stolpog, when hung, shall remain truely vertical. Each stoplog unit shall be provided with two pilot bars and corresponding pilot tubes for proper matching/guidance for correct placement and engagement.

All panels shall be lowered or lifted under balanced water head condition.

The deflection of stop log gate shall not be more than L/800 of the span, as per IS 5620 Clause no. 6.1.3.

29.6.2. Latching and Storing

Stoplog panels (1 No) shall be stored in the upper portion of the stoplog gate slot by providing latching arrangement and the remaining one panel shall be stored in storage pit provided in the breastwall.

29.6.3. Embedded Parts

The embedded parts which provide sealing surfaces, bearing surfaces and guides for the gate are embedded in concrete as a second stage and suitable anchors shall be provided to align the embedded parts within the tolerance.

v) Anchorages

Anchorages shall be provided in the first stage concrete, with suitable blockout openings, to hold the embedded parts in the second stage concrete. The anchor bolts in the second stage concrete shall be with double nuts and washers. For adjustment purposes enlarged holes in the embedded parts of the second stage concrete shall be provided. Preferably the anchor plates may be embedded with first stage concrete and anchor bolts welded subsequently. The minimum size (diameter) of anchor bolts shall not be less than 16 mm and the anchor plate thickness shall not be less than 10 mm.

vi) Seal Seats

The sill beam, side seal seat bases shall be fabricated from structural steel and embedded in concrete. The minimum width of seal seat shall be 100 mm and stainless steel plate conforming to IS 1570 (Part 5) (latest edition) shall be 8 mm (after machining) in order to have corrosion resisting surface with a low coefficient of friction and shall be welded with the base. The seal seats shall be finished smooth to triple delta. The edges of side seal seats shall be rounded/ chambered to prevent damage to rubber seal during gate operation. The surface of sill beam shall be machined smooth and made flush with the surrounding concrete.

vii) Slide Tracks

Track / bearing plates shall be made of Corrosion Resistant steel conforming to I.S:1570(Part **5**). The tracks shall provide a true and smooth machined surface for the sliding pads and transmit the loads through the pads to track base (structural steel) embedded in concrete. The minimum edge distance of the bearing plate flange shall in no case be less than 150 mm. It shall be designed as a beam on elastic foundation. The width of the bearing plate surface should be so chosen that the bearing pressure does not exceed the permissible limit. The surface of track plates shall be finished smooth to two delta.

The stress in bearing for concrete shall not exceed the values specified in IS 456. Second stage concrete shall be at least M25. The depth of second stage concrete shall be such that the 45 degrees plane drawn from the inner edge of the track base beam passes through anchors provided in the first stage concrte. Diagonal shear stress in the concrete due to maximum load derived from the bearing stress under the track base be within allowable limits permitted by the IS 456. Where excecessive shear stress in the concrete is unavoidable, reinforcement properly designed for shear and placed in the first stage concrete can be taken into account. In no case shall the alignment bolts be considered as shear reinforcement.

viii) Guides

The side guides shall be fixed inside the groove in Dam body. The guide shall be flat plate of thickness 20 mm (structural steel) anchored into concrete to limit lateral and longitudinal movement of gate within a tolerance of 3 mm in every 3 m height with overall tolerance of 5 mm. The guide shall be continued up to the full range of travel of the gate (i.e. up to top of dam).

29.6.4. Storage Pits

One panels will be stored and latched over the stoplog gate groove and provision shall be made in storage pit to keep the remaining 1 (one) panel when not in use. The necessary sill beam and bottom extended plate to protect bottom sealing arrangement and side guides for placement in the pit shall also be provided. Suitable drain hole shall be provided by the civil agency in the pit.

29.6.5. Design Considerartions

a) The slide type upper spillway stoplog panels shall be designed in accordance with IS: 5620. The stoplog units shall be designed for water head corresponding to FRL plus 0.3 m head for wave effect with normal allowable stresses.

b) The skin plate shall be provided on downstream side as per the requirement and the sealing arrangement shall be provided on the downstream side.

c) The hydrodynamic forces due to horizontal earthquake acceleration at the top of opening and at sill shall be worked out as per Para 7.2 of IS 1893 and considered in the design. The stresses in the various parts of the gate under the action of occasional forces shall not exceed 133% of the permissible stresses specified in Annex C of IS 9349 subject to the maximum of 85% of the yield stress.

d) Hydrodynamic forces namely uplift and downpull forces shall be considered in the design.

e) Stoplog panels shall be designed for operation under balanced head condition (i.e. no flow) and shall be placed by a monorail crane with the help of lifting beam.

29.6.6. Technical Requirements

The Scope of work shall conform to the following basic technical requirements and specifications. The gate components and embedded parts shall be designed in accordance with the provisions of IS 5620.

The stoplogs shall be designed for hydrostatic forces taking into consideration of silt load, and earthquake effect.

The dogging/Latching devices shall be designed to support twice the calculated dead weight of the gate to allow for impact.

Table 29.6-1 : Forces to be Considered in the Design

Sl.No	Loading condition	Position of gate and supporting details
1	Normal	Multiple stoplog panels placed one above the other. Bottom unit resting on sill beam.
2	Normal	Stoplogs in operation (inside the slot).
3	Over load	Gate Jammed

Table 29.6-2 : Design Data

Sl.No	Particulars	
1	Clear width of opening (m)	5.00
2	Vertical height from sill up to top seal of opening (m)	5.12
3	Number of bays	1
4	Number of stolpog panels	1 set (2 panels), 2 interchangeable panels.
5	Type of gate	Slide gate with d/s skin plate & d/s sealing
6	Top of dam/Road bridge (m)	EL 982.00
7	FRL (m)	EL 980.00
8	Crest level (m)	EL 975.00
9	Sill level (m)	EL 974.88
10	Design head (FRL-Sill) (m)	5.12 + Silt load
11	Type of proposed hoist	Travelling monorail crane and Lifting beam
12	Type of rubber seals	Bottom - Flat wedge type Sides - Teflon cladded hollow bulb music note type
13	Minimum thickness of skin plate	10 mm
14	Minimum thickness of stainless steel plate for seal seats	8 mm (after machining)
15	Minimum thickness of stainless steel plate for track	12 mm (after machining)
16	Operating criteria	Balanced condition
17	Governing IS codes (latest)	9349 , 800, 807, 3177, 11855, 14177
18	Grade of 2nd stage concreting	Minimum M 25

i) Permissible Stresses

As the stoplogs are stored above water level and are only occationally used, permissible stresses in structural components for gate and embedded parts shall be in accordance with Annexure C of IS 9349 (latest edition). The stresses in various parts of the gate under the action of occasional forces shall not exceed 133% of the permissible stresses specified in Annexure C subject to the maximum of 85% of the yield stress. The earthquake forces and the wave effect shall not be considered to act simultaneously while computing the increased stress in the gate.

Stoplogs	Dry & Accessible
Embedded parts	Wet & Inaccessible

Permissible bearing & shearing stresses in concrete – as per IS 456 (latest)

ii) Recomended Materials

As a general guidance materials used for various items of radial gates and hydraulic hoists are given in recommended material of this document.

iii) Operating Criteria

All the stoplog panels shall be lowered/raised under balanced water head condition i.e under no flow condition. Each stoplog panel shall be capable of self-closing i.e by gravity under its own weight. A lifting beam having automatic engaging and disengaging arrangement has been provided to handle stoplog panels.

The slide gate in general, shall satisfy the following requirements:

a. It shall be reasonably water tight. However, the maximum permissible leakage shall not exceed 5 litres per min. per metre length of periphery of sealing surface of gates;
b. It shall be capable of being raised or lowered by the monorail crane at the specified speed;
c. These shall be rigid and free from vibration.

iv) Deflection of Gate

The maximum deflection of gate under normal load shall be limited to 1/800 of the span (centre to centre of the tracks).

29.7. Intake Trash Racks

The trash racks are provided at the entrance of intake to protect from objectionable large debris. The conceptual form of the intake trsh rack is shown in drawing no.P.012745-W-20325-006 (Sheet 1 of 2 & 2 of 2).

29.7.1. Trash Rack Panel

Racks shall be installed in slanting position and may be 7° to vertical plane. To simplify site erection, the trash rack panels should be identical. The structural arrangement of racks generally consist of equally spaced trash rack vertical bars supported on horizontal members connected to end vertical members which is placed inside the pier grooves. The size of each panel shall be proportioned from consideration of hoisting capacity. The panels shall be fabricated from structural steel conforming to IS 2062 and follow IS 800 for general construction.

1 set of trash rack suitable for handling shall be designed, supplied and installed by the Bidder in the Intake structure. The width of bay shall be 1.50 m and may consist of 1 panel and the overall size of 1.50 m (w) × 2.00 m.

The design of trash rack should be such as to result in minimum hydraulic losses and prevent/minimize floating trash etc. entering the Water Coductor Pipe. The trash bars shall preferably be fabricated from flats with rounded edge.

The depth of trash bar should not be more than 12 times its thickness and not less than 50 mm. The thickness of trash bars shall not be less than 12 mm. These will be fabricated steel construction consisting of trash bars, having clear opening of 100 mm between them, which will be supported on horizontal members. These horizontal members in turn will be supported on end vertical members to bear against the vertical girders embedded in concrete. Trash racks panel will have two lifting points. Trash rack unit shall be raised and lowered during maintenance by monorail crane using an automatic lifting beam capable of grappling / ungrappling under water.

Slide blocks of Trash Rack Panel shall be of corrosion resistant steel for smooth operation of Panels.

To ensure rigidity during handling, the lateral deflection of the beam member due to load should not exceed 1/325 of the span.

29.7.2. Embedded Parts

The embedded parts shall consist of '['shaped with suitable track groove lining. It shall be provided for the groove up to the top of dam. It shall be embedded in the first stage concrete itself hence suitable anchor rods in all three sides shall be provided. Size of welds shall not be less than 6 mm and continuous.

29.7.3. Design Considerartions

a) The structural design of trash racks shall confirm to IS: 11388-2012 (or latest edition).
b) Selection of type of rack for installation depends on size and quantity of trash expected and requirement of racking.
c) Racks should be installed in slanting position. For racks which are to be cleaned by mechanical means, the slope should be 7 degree with the vertical.
d) The trash racks shall be fabricated with steel ISMC sections and steel flats. To simplify site erection, the trash rack panels should be identical.
e) Corrosion resistant steel plates of suitable size (for tracks) shall be provided on downstream side of inclined embedded guide channel for smooth operation Trash Rack Panels.
f) Suitable arrangement should be made for cleaning the racks at regular intervals. The frequency of cleaning of the racks would depend upon the rate of accumulation of trash. Not more than 33% of the trash racks area should be allowed to clog the racks at any time.
g) Trash racks should be checked for vibration/resonance while operating under turbine mode, the design and disposition of the members should be so made that the resonance does not take place.

29.7.4. Design Head

The trash rack should be designed for the following loads:

a) Racks protecting power intakes to withstand 6 m differential hydraulic head
b) Steel supporting members other than trash bars should be designed for a differential hydraulic head of 7 m; and
c) Hydraulic pressure due to allowable clogging (restricted to 33%).

29.7.5. Design Data

Table 29.7-1 : Design Data

Sl.No	Particulars	
1	Clear span (m)	1.5
2	Inclined height of Trash Rack (m)	2.2
3	Number of span	1
4	Panel size (m x m)	1.5 (w) x 2.2 (h)
5	Number of panels	1
6	Position of racks	Approx 7º inclination to vertical
7	Invert level (m)	EL 918.00
8	Top of Dam (m)	EL 982.00
9	FRL (m)	EL 980.00
10	Design head for trash bars (m)	6 m differential hydraulic head
11	Design head for steel supporting members other than trash bars (m)	7 m differential hydraulic head
12	Discharge	1.74 m^3/s
13	Spacing, c/c of bars	100 mm (Tentative only and to suit the requirement)
14	Operating arrangement	Manual Racking arrangement for maintenance
15	Embedded parts shape	[shaped with suitable guide track made out of structural steel
16	Minimum thickness of bar	12 mm
17	Permissible stresses	Wet & inaccessible; Safe stress 0.66 Yp
18	Governing IS codes (latest)	11388, 800
19	Grade of 2nd stage concreting	M 25

29.8. Intake Bulkhead Gate

Bulkhead gate is mainly intended to undertake maintenance of the Butterfly Valve and used on the upstream side. Placement of the gate in the vertical slot is carried out by a rope drum hoist. The conceptual form of the intake bulkhead gate with rope drum hoist is shown in drawing no. P.012745-W-20324-005 (Sheet 1 of 2 & 2 of 2).

29.8.1. Gate

Bulkhead gate of fixed wheel vertical lift type for a clear vent opening of size 1.5 m (w) x 1.5 m (h) is proposed for the intake and shall be designed corresponding to water level up to FRL as per IS 4622 (latest Edition). The gate leaf shall consist of downstream skin plate supported on horizontal girders which in turn be mounted on end vertical girders so that the total water load is transmitted through the wheels to the track plates embedded in concrete. Double stem Teflon cladded rubber seals shall be provided on downstream face of the gate leaf on the sides and top and wedge type flat rubber seal for the bottom. The rubber seals shall be fixed to skin plate by means of CSK stainless steel screws or bolts, so as to ensure positive water pressure between the skin plate and seal and to bear tightly on the seal seat to prevent leakage of water. The thickness of skin plate shall not be less than 20 mm. The gate shall be designed and checked for self-closing under full hydrostatic head corresponding to FRL and water flow condition and lifted in balanced head condition achieved with the help of filling in valves provided in gate. The gate shall be operated by means of independent rope drum hoist of adequate capacity and the hoisting platform shall rest on trestles.

The gate and embedded parts shall be designed for appropriate load combinations described to suit the operating criteria and shall be designed for dry and accessible conditions and embedded parts shall be designed for wet and inaccessible condition as per provision contained in IS 4622 (latest edition).

29.8.2. Latching

Latching arrangement shall be provided in the upper portion of the gate slot.

29.8.3. Embedded Parts

The embedded parts which provide sealing surfaces, bearing surfaces and guides for the gate are embedded in concrete as a second stage and suitable anchors shall be provided to align the embedded parts within the tolerance.

i) Anchorages

Anchorages shall be provided in the first stage concrete, with suitable blockout openings, to hold the embedded parts in the second stage concrete. The anchor bolts in the second stage concrete shall be with double nuts and washers. For adjustment purposes enlarged holes in the embedded parts of the second stage concrete shall be provided. Preferably the anchor plates may be embedded with first stage concrete and anchor bolts welded subsequently. The minimum size (diameter) of anchor bolts shall not be less than 16mm and the anchor plate thickness shall not be less than 10 mm.

v) Seal Seats

The sill beam, side seal seat bases shall be fabricated from structural steel and embedded in concrete. The minimum width of seal seat shall be 100 mm and thickness of stainless steel plate conforming to IS 1570 (Part 5) (latest edition) shall be 10 mm (after machining) in order to have corrosion resisting surface with a low coefficient of friction and shall be welded with the base. The seal seats shall be finished smooth to triple delta. The edges of side seal seats shall be rounded/ chambered to prevent damage to rubber seal during gate operation. The surface of sill beam shall be machined smooth and made flush with the surrounding concrete.

vi) Wheel Track

Track / bearing plates shall be made of Corrosion Resistant steel conforming to I.S:1570(Part **5**). The hardness of surface of the track plates shall be kept 50 points BHN higher than that of the wheel tread to reduce the wear on the track. The hardness of surface of the track plates shall be kept 250 points BHN (minimum). The thickness of track plate shall be calculated as per para 5.7.3 of I.S: 4622. However, the minimum thickness of track plate shall not be less than 12.0 mm after machining. The tracks shall provide a true and finished smooth to two delta for the wheels and transmit the loads through the wheel to track base (structural steel) embedded in concrete. The minimum edge distance of the bearing plate flange shall in no case be less than 150 mm. The track base shall be checked for bending and shear also. The web of the track base shall also be checked for web compression. Permissible stress in compression for web shall be taken as 85% of yield point for normal condition and equal to yield point for occasional load condition.

The stress in bearing for concrete shall not exceed the values specified in IS 456. Second stage concrete shall be at least M25. The depth of second stage concrete shall be such that the 45 degrees plane drawn from the inner edge of the track base beam passes through anchors provided in the first stage concrte. Diagonal shear stress in the concrete due to maximum load derived from the bearing stress under the track base be within allowable limits permitted by the IS 456. Where excecessive shear stress in the concrete is unavoidable, reinforcement properly designed for shear and placed in the first stage concrete can be taken into account. In no case shall the alignment bolts be considered as shear reinforcement.

vii) Guides

The side guides shall be fixed inside the groove in Dam. The guide shall be flat plate of thickness 40 mm

(structural steel) anchored into concrete to limit lateral and longitudinal movement of gate within a tolerance of 3 mm in every 3 m height with overall tolerance of 5 mm. The guide shall be continued up to the full range of travel of the gate (i.e. up to Top of Dam).

29.8.4. Design considerartions

The intake bulkhead gate shall be designed in accordance with the provisions of IS: 4622-2003 (or latest edition). The bulkhead gate shall be designed for a total head corresponding to water level at FRL and normal allowable stresses.

a) The hydrodynamic forces due to horizontal earthquake acceleration at the top of opening and at sill shall be worked out as per Para 7.2 of IS 1893 and considered in the design. The stresses in the various parts of the gate under the action of occasional forces shall not exceed 133% of the permissible stresses specified in Annex B of IS 4622 subject to the maximum of 85% of the yield stress.
b) The gate is required to be closed for maintenance of the Butterfly Valve.
c) The gate shall be designed to be closed under unbalanced head conditions & lifting under balanced head.
d) In closed position, the gate must be completely water tight. The bulkhead gate shall have downstream skin plate and sealing.

29.8.5. Technical Requirements

The Scope of work shall conform to the following basic technical requirements and specifications. The gate components and embedded parts shall be designed in accordance with the provisions of IS 4622.

The bulkhead gate shall be designed for hydrostatic forces taking into consideration and earthquake effect.

The dogging/Latching devices shall be designed to support twice the calculated dead weight of gate to allow for impact.

Table 29.8-1 : Forces to be Considered in the Design

Sl.No	Loading condition	Position of gate and supporting details
1	Normal	Gate closed and resting on sill beam.
2	Normal	Gate in operation (inside the slot).
3	Over load	Gate Jammed

Table 29.8-2 : Design data

Sl.No	Particulars	
1	Clear width of opening (m)	1.5
2	Vertical height of opening (m)	1.5
3	Number of vent	1
4	Number of bulkhead gate	1 (one)
5	Type of gate	Fixed wheel gate with d/s skin plate & d/s sealing
6	Top of dam (m)	EL 982.00
8	FRL (m)	EL 980.00
9	Top seal level (m)	EL 919.60
10	Sill level (m)	EL 918.00
11	Design head (FRL-Sill) (m)	62.00
12	Type of proposed hoist	Rope drum hoist of adequate capacity
13	Type of rubber seals	Bottom – Flat wedge type Sides, Top and Corners– Double stem Solid bulb Teflon clad (moulded)
14	Minimum thickness of skin plate	20 mm
15	Minimum thickness of stainless steel plate for seal seats	10 mm (after machining)
16	Minimum thickness of stainless steel plate for track	12 mm (after machining)
17	Operating criteria	Lifting of gate shall be in balanced head conditions and gate shall be self lowering under full water load.

Sl.No	Particulars	
18	Governing IS codes (latest)	4622 , 800, 807, 11855, 14177
19	Grade of 2nd stage concreting	M 25

i) Permissible Stresses

As the gate is stored above water level and are only occationally used, permissible stresses in structural components for gate and embedded parts shall be in accordance with Annexure B of IS 4622 (latest edition). The stresses in various parts of the gate under the action of occasional forces shall not exceed 133% of the permissible stresses specified in Annexure B subject to the maximum of 85% of the yield stress. The earthquake forces and the wave effect shall not be considered to act simultaneously while computing the increased stress in the gate.

Bulkhead gate	Dry & Accessible
Embedded parts	Wet & Inaccessible

Permissible bearing & shearing stresses in concrete – as per IS 456 (latest).

ii) Recomended Materials

As a general guidance materials used for various items of radial gates and hydraulic hoists are given in recommended material of this document.

iii) Operating Criteria

The bulkhead gate shall be raised under balanced head condition i.e under no flow condition. The gate shall be capable of self-closing i.e by gravity under its own weight under full design head.

The gate in general, shall satisfy the following requirements:

a. It shall be reasonably water tight. However, the maximum permissible leakage shall not exceed 5 litres per min. per metre length of periphery of sealing surface of gates;

b. It shall be capable of being raised or lowered by the hoist at the specified speed.

c. The gate shall be rigid and free from vibration.

iv) Deflection of Gate

The maximum deflection of gate under normal load shall be limited to 1/800 of the span (centre to centre of the wheels) as per clause 5.3.5 as per IS 4622 (latest Edition).

29.9. Butterfly Valve

One number of Butterfly Valve of 1500 mm bore has been provided at 60 m downstream of the Dam on the Water Conductor. It shall be capable to operate under water head of 62.00 m. Butterfly Valve shall be double eccentric butterfly valve conforming to EN 593 W, Stainless Steel seat and 180 input IP 64 gear box for drinking water supply to max. 70° C temperature. Double eccentric butterfly valves shall be designed with tilted and fixated disc for extended service life and easy operation. The disc seal shall be made of drinking water approved EPDM rubber featuring an excellent compression set and thus has ability to regain its original shape. The GSK approved epoxy coating and the corrosion protected shaft end zones shall ensure high durability. The valves shall be suitable for bi-directional application. The tilted disc shall release the compression of the disc sealing after a few degrees of opening, which will extend the durability and give low operating torques. The disc shall be fixated to prevent wear and fluttering. The disc seal profile and rubber quality should ensure low closing torques. Seal retainer ring shall be of stainless steel

The threaded bolt holes in the disc shall be corrosion protected with O-rings. Shaft shall be of stainless steel with self-lubricating bearings. The shaft ends shall be corrosion protected with a stainless steel security plate and a gasket. Replaceable seat ring shall be of stainless steel pressed into the body and sealed with an O-ring and Replaceable shaft sealing shall be with an EPDM O-ring on a stainless steel ring, a back-up EPDM O-ring in the housing, and a flat NBR gasket. Butterfly Valve shall be provided with Optional locking device.

Body and disc shall be of ductile iron with epoxy coating to DIN 30677-2, GSK approved, RAL 5017

i) Recomended Materials

As a general guidance materials used for various items of radial gates and hydraulic hoists are given in recommended material of this document.

29.9.1. Test/Approvals

Butterfly valve shall be hydraulic tested according to EN 1074-1 and 2 / EN 12266.

Standards

Butterfly valve shall be designed according to EN 593

29.10. Hydraulic Hoist

29.10.1. General

One of the most commonly used gate driving mechanisms is the hydraulic hoist; it associates high load capacity with design simplicity, ease of control and operating reliability. It comprises a hydraulic cylinder operated by oil pressure supplied by a pumping unit. The hydraulic cylinder shall be single acting and suitable for gravity-closing of gates.

Orifice Spillway Radial Gate will be equipped with Hydraulic hoists (single acting) and shall be designed in accordance with IS: 10210 (latest revision).

All aspects of hydraulic hoists, which are not covered in the specifications, shall conform to the applicable requirements of IS or any equivalent national/international standards (latest revision) for industrial hydraulics.

All hydraulic hoists components, such as seals, gaskets, pumps, valves and hoses that are normally in contact with hydraulic fluid shall be compatible. All hydraulic hoists parts and components that are permanently or occasionally submerges in water shall be adequate to resist without damage. It shall be ensured that cylinders and piping are permanently and completely full of hydraulic fluid under normal working conditions at all times, to avoid internal corrosion effects of moisture.

Shut off valves shall be provided at all hose connections and other suitable locations in the hydraulic system to enable convenience of hose replacement.

29.10.2. Design Considerations

a) Hydraulic hoists have widely superseded conventional hoists in recent times due to associated advantages. They also found to be economical and smooth in operation under special circumstances.

b) Hydraulic hoists are generally custom made specific to the requirements of individual installations by specialized manufacturers, since the manufacturing process involves special skills and quality assurance requirements. They are designed in India as per IS: 10210-1993 (or latest edition). Internationally, DIN 19704 along with its various parts.

c) The hoist capacity shall be calculated as per clause 5.1 of IS 10210 and consider additional spare capacity of 20% as reserve.

d) A maximum design pressure of 20 N/mm² may be considered in the design.

e) Towards the end of the closing stroke, the hoist piston shall slow down to create dampening effect. Hoist cylinder shall therefore be equipped with a suitable dampening device to slow down the gate when it is about 300 mm above the closed position. While opening the gate the hoist piston shall stop without a bang against the upper cylinder head at the end of the opening cycle.

29.10.3. Description

All components and accessories that are required for the hoist's intended function shall be furnished, even if they are not described herein. The items to be supplied by the contractor shall also include all field piping and field wiring and conduit including pipe clamps and supports. Cabling between main distribution panel to local control panel and LCP to position transmitters and limit switches and cabling between remote and local control shall be carried out as per the requirements and scope of work as per Contract.

Each hydraulic hoist shall have the following major sub-assemblies:

Hydraulic cylinder

Hoist mounting structure

Hydraulic power unit

Piping, pipe fittings and supports

Hydraulic oil

Electrical local control panel

Gate position tramsmitter, indicator including limit switches

Cabling complete including accessories for operation and monitoring of gates.

29.10.4. Hoist Cylinder

This section provides an overview of the technical specifications applicable to the hydraulic cylinder. A general description of the main components of the cylinder is described below.

Whenever the term cylinder is used this must be taken as hydraulic cylinder, and whenever oil is referred to, this is intended to mean the hydraulic medium. In a cylinder, hydraulic energy is converted into longitudinal movement in order to move the gate. The driving force is determined by the pressure in the cylinder compartments and the diameters of the bore and the rod. The cylinder consists of a cylinder shell, in which a piston connected to a piston rod moves back and forth. The shell is closed on each end by the cylinder bottom and by the cylinder head where the piston rod comes out of the cylinder. The piston rod also has mounting attachments (clevis or eye) to connect the cylinder to the gate lifting bracket.

a) Design stroke

Hydraulic cylinder shall be designed in such a way that when the gate and hoist are erected, the piston rod shall have an over stroke length of not less than 100 mm on either side in addition to the stroke required for complete rod extension to fully lower the gate or fully raised the gate.

b) Standards & Permissible Stresses

Hydraulic cylinder assemblies shall conform to all applicable requirements of IS-2825 (latest revision), IS-10210 (latest revision) and Section VIII division-I of the ASME code.

The calculation of cylinder working pressure and various frictional losses shall be as per DIN 19704-1. However, maximum theoretical working pressure at cylinder rod end shall be restricted to 20 MPa. Relief valve at cylinder side may be adjusted as 10% (maximum) cylinder working pressure. The permissible stresses of various components of hoist cylinder shall be as per Table 1 of IS 10210 (latest Edition).

The design of various components of power pack, piping, tank etc. shall be as DIN 19704. The hydraulic power pack unit shall be designed for a maximum design pressure at pump restricted to 22.5 MP. However, relief valve at pump side may be adjusted at 10% (maximum) higher than the design pressure. The allowable stresses of hydraulic pipe shall be as per Appendix A of IS 6631 (latest edition).

b) Cylinder body

i) Construction

Small diameter cylinder shell (or body) is mostly manufactured from cold drawn seamless steel pipe of carbon steel conforming to ASTM A106 Gr B, whereas the large ones are fabricated from rolled plates longitudinally welded. The cylinder bore is machined and honed. Long cylinders are designed with minimum possible number of transverse joints. Radiographic examination of all welds is required. Cylinders are required to pass a hydrostatic test of 150% of the design pressure.

Outer surface of cylinder shall be sand blasted and preserved in accordance with standard practice for surface protection.

ii) Ports

Ports shall preferably be located in the Cylinder heads. If located on the cylinder tube, their edges shall be at least 6 mm from the piston seal contact line in all positions of the piston.

iii) Cylinder heads

The cylinder body shall be connected to cylinder bottom through flanged connections. Cylinder heads are made of cast or forged steel although plates are sometimes used. In most cases, the requirements of the ASME-Unfired Pressure Vessel Code, Section VIII are followed in the design of cylinders. The cylinder head is connected through flange connections. The advantage is that the connection is bolted and always simple to remove.

Gland shall be provided in the rod-end cylinder head to prevent the pressurized oil from leaking past the interface between the rod and the head. It often has another seal called a rod wiper which prevents contaminants from entering the cylinder when the extended rod retracts back into the cylinder. The rod gland also has a rod bearing (or guide) to ensure the concentric movement of the piston rod with respect to the cylinder shell. This bearing supports the weight of the piston rod and guides it as it passes back and forth through the rod gland.

Design of the rod end head shall permit servicing of the piston rod seal (s) without disassembling the cylinder and while the cylinder remains in its normal working position.

Water exclusion seals shall be provided as necessary to prevent the entry of water into the cylinder.

iv) Piston

The piston is a short, cylinder-shaped metal component that separates the two sides of the cylinder barrel internally. Piston shall be cast steel or forged steel in one piece and machined with grooves to provide circumferential split rings and also with stuffing box with V-packing rings. They prevent the pressurized hydraulic oil from passing by the piston causes the cylinder to extend and retract.

v) Piston rod

(a) Piston rod shall be manufactured from ceramic coated laminated carbon steel rod (ASTM A271 A27M) or
(b) corrosion resistant stainless steel rod (ASTM A276 type 316)
which attaches to the piston and extends from the cylinder through the rod -end head. High quality stainless steel such as type 316 may be used for low stress applications. Other stainless steels such as type 431 may also be used where there are higher stresses, but lower corrosion concerns.

The piston rod of the hydraulic cylinder operates both inside and outside the barrel, and consequently both in and out of the hydraulic fluid and surrounding atmosphere. Smooth and hard surfaces are desirable on the outer diameter of the piston rod and slide rings for proper sealing. Corrosion resistant is also advantageous.

Connecting of the piston rod to the piston shall be a rigid attachment and shall permit disassembly for maintenance.

A hydraulic cylinder should be used for pushing or pulling only. No bending moments or side loads should be transmitted to piston rod or the cylinder. For this reason, the ideal connection of a hydraulic cylinder is a single clevis with a spherical ball bearing. This allows the hydraulic cylinder to move and allow for any misalignment between the cylinder and the gate it lifts.

Connection pin where used, shall be of corrosion resistant steel of ASTM A276 Type 316. The arrangement of fixing piston rod to the gate should be such that it can be easily disconnected by using normal tools.

vi) Seals

Seals shall be of the chevron type packing for piston and piston rod, and mechanically locked in place. Seals shall resist roll, turn, and extrusion. On hoist cylinders designed for fluid pressure acting from either side, a separate set of piston seals shall be provided on each side.

For radial gate cylinder assembly, the design of seals at piston shall be suitable for the forces due to bending when fully closed position. Cylinder and piston assembly shall also be checked for these forces.

vii) Packing

Packing or static seals such as rings shall be provided between all connected parts where leak- tight joints are required, such as between cylinder tube and heads or between piston and piston rod.

viii) Speed limiting orifice

Cylinder shall have a permanently mounted speed limiting orifice to limit the downward speed of the gate to 3.5m/min. in case of emergency closure/rupture in the connecting pipes.

ix) Bosses, drains, air-vents and test connections

If bosses are provided at the hydraulic cylinder ports, they shall be welded.

All necessary drains shall be provided.

Cylinder shall be furnished with at lest 2 air bleed valves for complete removal of trapped air. All air bleed valves shall be of stainless steel.

Test Connections: Cylinder shall be furnished with one test connection in each of the fluid ports for attaching a pressure gauge or transducer. Additional test connections shall be provided on the cylinder as required. All test connections shall be provided with corrosion resistant steel minimum type connectors equipped with check valves; no shut off valves shall be used.

x) Cylider mounting components

Except for pipe connectors, supports, air bleed valves, test connections, plugs and the necessary pressure piping, no other components shall be mounted on the hydraulic cylinder. However, from safety consideration, a control plate with at least one shut off valve, lock valve and pressure release valve may be flanged on to the cylinder directly.

Each cylinder shall be equipped with handling lugs to facilitate easy handling during transportation and erection.

29.10.5. Hoist Controls

The hoist control module shall be furnished complete with all accessories to provide pressurized hydraulic fluid for the operation and control of the hydraulic hoist cylinders.

The hoist control module shall include a hydraulic power unit and an electrical control cabinet. The hoist control module shall also include all interconnecting wiring between these 2 sub assembles, and all other appurtenances.

The hoist cylinders are driven by individual hydraulic power unit and gear pumps driven by electric motors are usually selected to operate hydraulic hoists. Pumps are commonly designed with a rated pressure 25% greater than the design pressure and flow capacity about 10% more than the requirement.

Sufficient space (at least 600mm) shall be provided all around the control module to facilitate operation and maintenance. For radial gates they shall be housed in a control room located in/nearby Dam Body.

A) Hydraulic Power Unit

i) General

The hydraulic power unit shall include a hydraulic reservoir, two electric motor driven pumps, manual pump, automatic control, pressure relief valve, check valve, flow control valve and directional control valves, pressure and temperature gauges, fluid level switch, filters and strainers, piping, and all accessories and wiring. All the components shall be mounted on the hydraulic reservoir with suitable supports.

ii) Oil Tank

The tank serves primarily as a storage space and supply point for the hydraulic system fluid and its structure shall be used for mounting the control devices. The oil tank is constructed from corrosion resistant stainless steel plate having welded joints with a drain plug at the lowest point for easy and complete draining of the tank and anchored at the base. The oil tank should be properly cleaned and painted to ensure cleanliness and to avoid rusting. The capacity of the tank shall be not less than 120% of the volume of cylinders. The tank shall be fitted with moisture absorber. All pipelines shall have suitable bleeding arrangement.

The minimum oil level must be such that the pump suction remains submerged about 100 mm so that air cannot be drawn in. Also, it is recommended locating the pump suction 50 mm far from the tank bottom so that sludge or any solid matter cannot be picked up. All return lines to the tank are always located below the minimum oil level and separated from the suction pipes by vertical bafflers to prevent the fluid coming back to the tank from returning immediately to the circuit without having performed effective heat dissipation. Generally, the maximum oil temperature should be limited to 55°C and 80°C inside the tank and piping, respectively. Tanks are also provided with oil filling cap (combination of air vent, dust screen and air filter), oil level gauges, breather openings, drain plugs and two large removable maintenance covers are provided on each end for medium and large size tanks to permit easy access for cleaning.

The reservoir shall be provided with lifting and jacking lugs for its handling.

iii) Motor Driven Oil Pump

Two electric motor driven oil pumps for each hydraulic power unit shall be provided. The motor driven hydraulic oil pumps shall be of the self-priming, positive and constant displacement type. The pumps shall be driven by direct coupled electric motors and shall be equipped with individual “Manual auto switches” and “Start-Stop” push buttons for operating the pump in the “Manual” mode. The motor should conform to specified horse power and speed. It should be totally enclosed, air cooled direct driven with normal starting torque and low starting current, continuous rating, three phase squirrel cage induction type. The starter winding should have insulation specially treated to withstand wet and humid conditions, and should be suitable for the required altitude. Motors shall also be provided with in-built anti-condensation heaters to protect the windings against moisture.

iv) Hand Pump

One Manual pump shall be provided for each power unit and shall be connected in parallel with the motor driven pump. The pump shall be of the lever operated piston type and mounted front side of the tank. It shall be operated from standing position, and shall not require more than 14 kg of force on the pump lever to reach nominal system pressure.

v) Suction Strainer and Filters

Suction strainers are constructed of fine mesh wire with a filtration capability of 125 microns and the capacity is about 2 to 2.5 times the pump flow. They are used on pump inlet lines and they offer very little resistance of flow, thus keeping the pressure drop to a minimum.

The oil filter unit shall have disposable and replaceable filter element and the filter element shall not be coarser than screen having 150 microns opening. The top of filter housing shall be equipped with pipe plugs or a comparable means for venting air from the line. The filter shall be of type, which filters all the oil, passing through the line with pressure drop not more than 0.1 kg/sq.cm based on hydraulic oil having specified viscosity.

Strainers shall be of the cleanable, replaceable element type and shall be stainless steel or Monel woven or wound wire.

These filters are usually provided with by-pass check valve to by-pass flow valve when the filter element cannot handle the full flow or when the element is clogged with contaminants.

Each filter and strainer shall be furnished with a differential pressure or minimum pressure switch to energize a warning light when the pressure drop across the filter or strainer reaches a predetermined value.

The oil filter provided in the pressure line shall be of duplex type thus enabling to clean the filter under pressure and when the pumps are working. All hydraulic fluid being discharged from each pump shall pass through its own pressure filter before entering the rest of the hydraulic system.

A filter shall also be provided in the return line to remove particles above 10-micron size. Hydraulic fluid returning from the system to the hydraulic reservoir shall pass through a return line filter.

Filter elements shall be screw type and with the following absolute ratings.

Pump suction filter	150 microns
Low Pressure Line Strainer	160 microns
Pressure filter	10 microns
Return line filter	10 microns

The filters shall be provided with bypass valves which shall be set to open when the pressure drop across the filter elements exceeds 1.05 kg/cm².

vi) Shut-off Valves

All shut-off valves shall be ball valves. 2 way ball valves are units which serve to shut-off the flow of an operating medium in both directions. Ball valves are not designed to be used as flow control valves; therefore they should always be either fully open or fully closed to avoid damaging the sealing cups.

vii) Check Valves

The check valves, which are also directional valves, permit free flow in one direction and prevent flow in the reverse direction. The check valve shall be of spring closed construction with threaded ends and shall be rated for working pressure up to 250 kg/sq.cm. One check valve shall be provided in the pressure line of each pump between the pressure line filter and the rest of the system to prevent back pressure on the pumps when they are not in operation. Pilot-controlled check valves are used to permit flow in the reverse direction beyond a determined point in the working cycle.

viii) System Pressure Relief Valve

The system pressure relief valve (safety device) shall be included in the circuit to protect the hydraulic system against overpressure and consist of relief valves installed in the pump discharge line. The relief valve causes the oil to return to the tank when the pressure exceeds a preset value. It shall be balanced piston type with internal drain, having sufficient capacity and shall have an adjustable pressure range of approximately 20 to 250 kg/sq.cm. The valves shall have independent outside adjustment for setting the pressure and shall maintain the pressure within 5% of the preset value. In the event of power failure, it should be possible to operate the valve manually.

ix) Surge Suppressors

Surge suppressors shall be provided in the pressure line and elsewhere as required to dampen pulsations, surges, and pressure shocks in the hydraulic system resulting from valve operation.

x) Pressure Gauge

All pressure gauges shall be of the Bourdon tube type with glycerin filled housing. The accuracy of pressure gauges shall conform to relevant BIS Standards (latest revision). All pressure gauge dials shall be at least 100 mm diameter and shall have dial graduations equal to their accuracy. The total measuring range of the gauge shall be between 110 and 200% of the maximum pressure expected.

xi) Pressure Switches

The oil pressure switch shall be of suitable type to operate at 240 V AC. The case shall have an approximate diameter of 150 mm suitable for flush mounting and shall have suitable threaded nipples at the back for pressure connection and electrical conduit connections. The switch shall have a capacity of at least twice the maximum operating pressure obtaining in the control system. All pressure switches shall be heavy duty piston type.

xii) Directional Control Valve

The four way valve for the control system for operating the gate shall be a double solenoid controlled, spring centered, 3 position (to control start, stop and direction) spool type and shall have suitable rated capacity and suitable for a test pressure for the control system. The valve shall be equipped with a mounting sub-plate suitably tapped to permit mounting or removal of valve without disconnecting the pipes and shall be furnished with threaded external drain and shall be suitable for operating pressure on the tank port. Electrical contacts shall be provided with each solenoid of each valve which shall operate during the period, the solenoid remains energized. Two contacts shall be normally closed and other two contacts open. The above electrical contacts and the operating solenoids of the four way shall be rated for 5 A, 230 V, 50 Hzs, AC supply. The valve shall be equipped with pushpins for manual operation in case of power failure.

All directional control valves shall be of standard manufacture and nominally rated for zero leakage.

xiii) Flow Control Valve

Flow control valves shall be of the adjustable pressure and temperature compensated type with an integral check valve for free return. All valves shall be shop tested to pass the required flow within 5%.

xiv) Temperature Sensor

Temperature sensor with digital display shall be mounted directly with the oil tank to monitor the system oil temperature.

xv) Test Connections

The power unit shall be furnished with test connection at appropriate locations for attaching a pressure gauge or transducer. Each test connection shall be provided with corrosion resistant steel minimize type connector equipped with check valves.

B) Electrical Control Cabinet

Electrical control cabinet consist of circuit breaker for power supply to motor and control circuits, starter, control transformer, HRC fuses, control relays, selector switches, control switches, push buttons, and indicating lamps, gate position indicator and alarm system etc. to achieve the required operation and control of the hoisting system. A 100 W strip heater should be provided in the cabinet to prevent condensation of moisture on electrical components. All the controls should be so interlocked that proper functioning of individual parts for the purpose is ensured. The push buttons should be suitably labeled as 'Raise', 'Stop', 'Lower' or to meet other requirements.

All internal wiring required for the electrical equipment shall be made at manufacturer's workshop. All wiring shall be installed in conduits. Wiring and conduits shall be installed so as not to interfere with access and maintenance of any part of the power unit. The hydraulic power unit and the electrical control cabinet shall be completely wired to terminals in the shop for field interconnection.

The base frame shall be rigid and shall have adequate strength to support the weight of the equipment. All necessary fixtures such as bolts, nut, washers, anchor bolts, embedded anchor rails or frames and other accessories required for assembly of base frame shall be provided. Suitable lifting lugs shall also be provided for handling during transportation and installation.

29.10.6. Shop Assembly and Testing

The hydraulic power unit and local control cabinet shall be assembled and electrically interconnected at shop and test the operation of the system. Material test certificate of all the items used in the system shall be furnished.

29.10.7. Hydraulic Oil

Petroleum based hydraulic oil (ISO standards – VG 32) may be used in the system. Oil shall be clean and free from contamination. In order to insure peak performance and extended operating life of the equipment, it is recommended that an ISO cleanliness code of 16/14/11, be maintained regardless of system pressure.

29.10.8. Connecting Pipes and Fittings

i) General

Pipes and fittings used in the hydraulic system shall be stainless steel of type 304 L. Piping should be as short as possible and sharp curves should be avoided. A minimum bend radius equal to three times the pipe diameter is recommended. Welded construction using socket welding fittings, O ring flange type unions and heavy walled tubing should be used for high pressure piping above 20 mm in size. The piping joints should be perfectly oil tight and pipe lines shall also have suitable bleeding arrangement.

Piping should not be designed for field butt joints.

Piping should not be designed for embedment in concrete.

The pipe lines shall be of sufficient size that the fluid velocity in the working lines, both pressure and non-pressure lines, shall not exceed 4.5 m/sec respectively. All pipes and pipe fittings shall be suitable for testing pressure of 150% of the operating pressure.

Care shall be taken to avoid vibrations at pipe supports.

ii) Piping arrangement

The general arrangement of all piping shall be in accordance with the space and clearances available from gate and operation chamber. Pressure and return line piping of both cylinders are installed symmetrically in relation to the vertical plane that passes through the span centre, in order to equalize the head losses.

The flexible connections shall allow reconnection of the hydraulic power unit or hoist cylinder without realignment and shall also permit the necessary freedom of movement of the hoist cylinder in its mounting. For this purpose, all hydraulic lines connecting the hydraulic cylinders to the hydraulic power unit shall be provided with flexible connections at the cylinders.

All flexible hoses shall be corrugated, flexible metal hose. All flexible hoses shall be furnished with factory installed fittings which shall be of corrosion resistant material. Both ends of all flexible connections shall be connected with corrosion resistant steel shut off valves so that the piping, cylinder and hydraulic power unit can be shut-off when the connections are removed.

All pipe fittings shall be of the socket welding type conforming to the applicable requirements of ANSI-B 16.11 or equivalent standards.

All pipe flanges shall be of the weld neck type conforming to the applicable requirements of ANSI-B 16.5 or equivalent standards.

All pipe supports such as pipe hangers, anchors, heavy duty pipe clamps, etc., shall conform to the applicable requirements of ANSI-B3.1.1 MSS SP-58 and MSS SP-69 or equivalent standards.

iii) Inter-connection of HPUs

Each hoist shall have a separate controls (hydraulic and electrical). It shall be possible to operate only one hoist at a time or both the hoists simultaneously with the help of a special interconnection. It shall also be possible to interchange the driving units from one hoist to the other. The hydraulic systems of each two adjacent gates shall be inter-connected so as to operate one gate at full speed of 0.5 m per minute or both adjacent gates at half-speed. A separate drawing for interconnecting hydraulic power units as well electrical control panels indicating the operational sequence shall be prepared by the Bidder and submit for approval of Project Authority.

29.10.9. Flushing cum Filtering Unit

Flushing fluid shall be compatible with the hydraulic working fluid. A separate flushing cum filtering unit (consist of motor, pump, filter and suitable hoses) shall be engaged for cleaning the system. The hydraulic power unit (meant for gate operations) should not be used for flushing.

a) System Cleanliness

All pipes shall be thoroughly cleaned to remove all dirt and scale from the inside surfaces. All burns and chips shall be removed before the pipes are assembled and care shall be taken to prevent any foreign matter from entering the system after fabrication and then sealed to prevent accumulation of foreign matter during transportation to the site. The piping shall remain sealed during storage at the site, that the seal shall be removed just prior to installation.

The cylinders, hydraulic power units, and manifold shall be clean and free of all foreign matter which occurs as result of manufacture, assembly, transportation and storage at the site.

b) Flushing Operation

i) General

Installation instructions shall also include the procedures for flushing the hydraulic system. The instructions shall conform to relevant BIS Standards (latest revision) and shall include the criteria specified below.

ii) Hydraulic Cylinder

Normally the cylinders are delivered filled with 10% oil with anti wear type additives. Hence the cylinders need not be flushed at site. First remove the entire oil from cylinder prior to fill with new cleaned and filtered hydraulic oil. During commissioning, before the cylinder is connected to the gate, both head and rod ends of the cylinder must be flushed to remove the foreign matter by mechanically moving the piston back and forth for its full stroke. The cylinders must not be connected to the hydraulic system until the Engineer is satisfied that the cylinders have been cleaned properly and ready for oil filling. Subsequently connect the cylinder to the piping of the system and fill oil. Bleed the cylinder using the minimize couplings. Continue bleeding until the oil is free from air bubbles. To guarantee satisfactory operation of the cylinder, it must be completely filled and bleed.

iii) Hydraulic Power Unit

After cleaning and prior to shipment, each hydraulic power unit shall be flushed in the supplier's workshop. The hydraulic tank shall be filled with hydraulic oil as specified and the oil filtration system actuated with a 10 micron element in the filter. The oil shall be circulated and filters changed as they become clogged until the unit runs for 24 hrs without becoming clogged. After flushing of the fluid in the tank is complete, a by-pass loop with filter shall be installed on the pressure and tank lines of the unit and the pumps shall be run alternately until the return oil line has no foreign particles greater than 10 microns in size.

iv) Piping and Fittings

Before installation of hydraulic power unit, cylinders and manifolds, all hydraulic piping must be flushed. By-pass loops of piping must be installed in place of cylinders, manifolds, and the power units. Hydraulic oil must be circulated through each and every pipe until returning oil meets relevant NAS 1638, class 8 requirements.

v) Valve manifolds

After cleaning and prior to installation, each valve manifold must be flushed by circulating hydraulic oil through all ports until the cleanliness of the return meets relevant NAS 1638, class 8 requirements.

29.10.10.Gate Position Indicator

CERAMAX Integrated Measuring System CIMS shall be provided for gate position measurement. It consists in a sensor mounted on the cylinder head outside the pressure zone that measures systematic differences in the thickness of the ceramic coating. The pattern of grooves cut in the piston rod base material induces changes in a magnetic field and the additional electronics convert the sensor signal into logic pulse count. The number of counted pulses represents the position information. The signal can be read directly into a PC so that the complete position control of the stroke and synchronization is possible.

29.10.11.Cylinder Mounting Structure

Each cylinder assembly shall be provided with two mountings, a cylinder trunnion (or cylinder end) along with a support structure and rod-end mounting as the case may be. Wherever necessary, hydraulic cylinder should be suspended from the cylinder support frame through a suitable hoist trunnion either of hinged or rocking type. Trunnions should be designed to safely take the load of the entire gate and the hoist assembly including oil. Suitable access ladder and steel platform shall be provided for maintenance of hoist cylinder and flexible hose connections.

a) Cylinder Trunnion & Rod end mounting

Cylinder can be either trunnion mounted or supported at ends. In case the cylinder trunnion is provided, it shall connect the cylinder tube to the support structure which will transfer the loads to the concrete Dam Body. For cylinder end suspensions, the pin cantilevers from the Dam Body shall be supported and firmly secured with concrete through properly designed steel work. For maintaining accuracy of suspension, suitable blockouts at the level of hoist support pin shall be provided as necessary. The concrete in blockouts shall be well bonded with first stage concrete by providing a rough surface and adequate dowel bars. For filling up any gaps between first and second stage concrete, suitable grouting shall also be done. Manufacturer shall furnish loading details of hydraulic hoist for incorporation in the civil design at the location cylinder Trunnion support.

The cylinder shall pivot freely as the gate moves along its radial path. Pivoting angle allowed by the mounting shall not be less than the maximum angle required for gate operation, maintenance or erection plus 75mm in each direction.

Bearings for cylinder mountings shall include permanent self-lubricating bushings on corrosion-resistant pins. The pin materials shall be IS: 1570 Part V or ASTM A 564 Type 630.

Counter balancing weights shall be provided or the pivoting point on the hoist cylinder shall be arranged so as to minimize bearings pressure on the piston and piston guide rings caused by the weight of the hoist assembly and contained hydraulic fluid.

The piston rod also has mounting attachment (single clevis with a spherical ball bearing) to connect the cylinder to the gate bracket at the bottom horizontal girder ends (LH & RH) through a stainless steel pins with lock plates.

b) Cylinder Support Structures

The cylinders will be suspended on a tubular cantilever supporting beams (LH & RH) by means of axles mounted on thick plates extending perpendicular from the outside diameter of the tube. The support beams shall be anchored to the Dam Body concrete.

The suspension support assembly will be held in specified position by a suitable numbers of load bearing anchors embedded in the first stage concrete, to transfer the imposed cylinder effect.

At each end of the cylinder will be equipped with maintenance –free Radial Spherical plain bearing (particularly suitable for arrangement where alignment, oscillating recurrent tilting or slewing movements have to be accommodated), working on stainless steel axles. The angle of tilt of each bearing is about 7°.

Cylinder support structure shall be designed to allow adjustment and leveling during erection. The support structures shall be adjustable in either direction at least 16mm after it is set to the nominally correct position.

29.10.12.Design Data

Table 29.10-1 : Design Data for submerged Radial gate

Sl.No	Particulars	
1	Type of hoist cylinder & mounting	Single acting, fixed at the ends
2	Capacity and stroke	To be decided by bidder
3	Number of cylider for each gate	Two
4	Operation of hoist	Independent HPU
5	Design pressure	20 N/mm²
6	Test pressure	150% of design pressure
7	Creep	150 mm
8	Cushioning (opening & closing)	100 mm each side
9	Operating criteria – hoisting/lowering	Unbalanced head (flowing water condition)
10	Speed –Normal	0.5 m/minute
11	Speed -cushioning	0.1 m/minute for last 300 mm during lowering

29.10.13.Mobile Power Pack

One trolley mounted (mobile) petrol engine capable of lifting of one gate at 25% of the normal speed when water is stored up to FRL shall be provided for operating the submerged radial gates during emergency and shall be kept in a local control room which can be easily accessible and moved manually from one local control room to another. The mobile hydraulic power unit consists of petrol driven engine with tank, 12 V battery, starter, preset internal system protection relief valve, suction/ discharge hose pipes cum couplings to connect HPU/ exhaust pipe of sufficient length. The entire unit is mounted on a robust, wheeled trolley.

29.11. Rope Drum Hoist

Independent electrically operated rope drum hoist of suitable capacity shall be provided to operate the following hydraulic gates. The capacity of the hoist to meet the operational requirements shall be 20% more than all the forces opposing the raising of the gate. The hoist and its components shall be simple in design and rugged in construction so as to give trouble free operation with minimum maintenance. These shall be suitable for outdoor service. The hoist shall be designed to conform to IS 6938 (latest edition).

A. Upper Spillway Service Gate
B. Intake Bulkhead Gate

29.11.1. Technical Requirements

Suitable hoist support structure along with trestles shall be designed and provided. General description of hoist support structure shall be as under.

The hoist supporting structure shall be made of structural steel conforming to IS 2062-2011 (Latest revision) and shall be designed to withstand the hoisting load, dead weight of hoist and its all components as well as vibrations caused due to operation. In addition, wind/seismic load shall also be taken into account. The chequred plate of hoist platform should not be less than 8 (eight) mm in thickness and should be reinforced. Suitable anchorages for the hoist frame shall be provided to take the worst combination of all loads under which the gates and hoists are under operation.

While determining the Hoist Capacity, positive closure of the gate under designed weight shall be ensured (considering seating force should be greater than 20% of opposing forces). Live load due to crowd shall be considered as 500 kg/ m² in addition to other natural loading as per IS 875 (latest edition). Supporting columns shall be designed considering effecting length of 2L where as “L” is the height of the column from base to meeting point of centre of main beams and column sections. They shall be braced properly as per provisions of IS 800 (latest version) and as indicated in specification drawings.

Main beams for supporting the hoist machinery shall be designed as simply supported beams having provisions for thermal expansion on one end. They shall be designed all the load combinations stated for which the hoist may be subjected to. Permissible resultant deflection of hoist support beams and cross beams shall not exceed span/800, for spans up to 12 m and 1/1000 for spans above 12 m. The main beam and cross beams shall be provided with intermediate and load bearing stiffeners at appropriate locations. In case box sections are proposed, diaphragms shall be provided.

The structure shall be designed for each of the following combinations in addition to load combinations mentioned in the specification. The impact factor for the design of hoist support structure and trestles shall be taken as 1.3.

- Dead loads plus live load, impact load, wind load @ 50 kg/sq.m and crowd load @ 500 kg/sq.m on entire area of Hoist Bridge including walkway.
- Dead load with no hoisting load plus effect of storm wind load @ 150 kg/sq.m.

Breakdown torque of the motor shall be taken as 225% of normal torque or the actual breakdown torque as specified in the manufacturer’s catalogue, whichever is higher.

The permissible stresses as specified in IS 800 (latest version) for normal operation shall be increased by 33-1/3.

29.11.2. Hoist Components

Each hoist shall comprise of the following components:

a) Central drive unit

Central drive unit shall comprise an electric motor, worm reducer unit, electro-magnetic brake, manual drive unit and floating shaft with necessary couplings.

b) End Gear Boxes

The end gear speed reduction unit shall comprise rope drums, gear wheels, pinions, shafts, pedestals, bearings, plummer blocks, couplings and all other such accessories, which may form in-separable components for the satisfactory operations. Drum supports shall be of fabricated type and adequately stiffened for carrying drum shaft reactions. Gear boxes shall be sufficiently rigid and strong.

c) Local Control Panel

The Local control panel shall have circuit breakers, motor starters, fuses, thermal overload relays of suitable rating and provided in the motor circuit and single phase preventer, indicating lights complete with suitable wiring, push buttons, and thermostatically controlled heater of suitable capacity etc, may also be provided for satisfactory operation. One step down transformer of adequate capacity shall be fitted to get 110 V AC supply for the control circuit.

d) Miscellaneous Parts

Miscellaneous parts like wire ropes, rope sockets, equalizers, turn buckles, pulley/sheaves, hoist base frames, cover for gear boxes and hoist supporting structure etc.

29.11.3. Design Data

Table 29.11-1 : Upper Spillway Service Gate

Sl.No	Particulars	
1	Type of hoist	Fixed rope drum hoist
2	Hoist capacity	Adequate Capacity
3	Total lift	8.5 m (tentative)
4	Lifting speed	0.5 m/minute
5	Gate operation	Local control panel
6	Top of Dam	982 m
7	Governing IS codes (latest)	6938, 800

Table 29.11-2 : Intake Bulkhead Gate

Sl.No	Particulars	
1	Type of hoist	Fixed rope drum hoist
2	Hoist capacity	Adequate Capacity

Sl.No	Particulars	
3	Total lift	65 m (tentative)
4	Lifting speed	0.5 m/minute
5	Gate operation	Local control panel
6	Top of Dam	982 m
7	Governing IS codes (latest)	6938, 800

29.11.4. Permissible Stresses

The overall design of the hoist support structure shall conform to IS 800.

29.11.5. Structures

The hoist is of outdoor type, care shall be taken such that the hoist structure when fabricated and erected it should present a pleasing appearance. The necessary streamlined appearance and architectural features shall be incorporated in the design of hoist.

The trestles and hoist support base frame shall be fabricated using structural steel (Grade E 250) sections and plates and shall be of welded construction. The trestles shall be fabricated out of rolled I-beams with bracings. Shop connections in the frame shall be bolted.

Ladder, platform and walkway necessary to access to the hoist drive, shall be provided from deck level. The platform and walkways shall be designed for a live load of at least 500 kg/sq.m and shall consist of suitable non-slip steel plates welded together or bolted to the steel frame except that the walkway on the top of deck of the hoist shall be constructed of floor grating. The ladders shall be not less than 400 mm width between side parts and shall have round rungs 20 mm dia spaced at 300 mm. Hand railing shall be provided along the open sides of the walkway platform. The platforms are to be proportioned for a moving single load of 300 kg. Railings are to be proportioned for traveling horizontal single load of 30 kg acting on the rail iron.

Galvanized hand railing not less than 40mm dia pipe and 1000 mm height shall be provided all around the hoist supporting structure/machinery complete with elbow connector. Minimum clear walkway of 1000 mm width shall also be provided.

29.11.6. Mechanical Components

The hoist shall be designed in accordance with IS 6938. All mechanical equipments shall be simple, substantial in design, and capable of being easily erected, inspected, adjusted, painted and taken apart. The hoist shall be of single motor, twin drum type / single drum type connected through gearing and shafting. The capacity of motor shall be such that the specific performance of hoist at rated load will not demand more than full load torque. The shaft connecting the end gear trains shall be provided with flexible coupling of the geared type, or any other approved arrangements which permit one drum to be rotated with respect to the other drum and keeps the lifting beam in a level position. All shaft loads shall be transmitted by suitable keys, splices or pins. The transmission of loads by press fit only will not be permitted. A factor of safety of five over Ultimate Tensile Strength, based on the rated capacity of the hoist (exclusive of duty factor, impact factor, acceleration and retardation) shall be used in design of all mechanical parts provided. All parts of the equipment shall have sufficient strength to resist the forces produced by the rated break down torque of motor without exceeding 80% of the yield point strength of the material used. The hoist shall be so designed as to limit the maximum rope fleet angles not more than one in twelve, unless other-wise approved. The reeling of rope on the drum of the hoist shall be such as to allow the lifting beam to travel vertically.

The hoist shall be provided with an electromagnetic automatic brake and means for position control of the lowering movements of the hook.

Various components of hoist such as wire rope, drum, gears/pinions, sheaves/ pulleys, worm reducer, shafts, bearings and couplings etc. and their design shall meet the requirements of IS 6938 (latest edition).

Bolts, nuts and screws used shall conform to relevant Indian Standards. Bolts and screws in rotating parts shall be locked. Bolts in tension shall be avoided as far as possible. Wherever necessary, net section of such bolts at the root shall be increased by 15%.

a) Wire rope

The wire rope shall be galvanized and made of special improvement plough steel of 6x37 construction Lang's Lay and fiber core and shall conform to IS: 2266 (latest revision). While selecting the diameter of the wire rope the efficiency of pulleys, sheaves and drum shall be taken into account.

The wire ropes shall be provided with a device to take care of unequal stretch of rope. Wire rope shall be guided over as few pulleys as possible. Reverse 'S' shaped bends shall be avoided as far as possible. The rope end shall not be subjected to undue twist and turns. The wire rope strands fastened with the rope drum should not slip away under maximum load. The wire rope shall be sufficient length to provide for specific lift plus two extra turns on the drum on each side. Anti rope slackening / over load protection devices shall be provided as per requirement.

The breaking strength of wire rope, if not specified by the wire rope manufacturer, shall be taken on the basis of IS: 2266 (latest revision).

The minimum factor of safety based on breaking strength and safe working load of the wire rope shall not be less than 6 (six) under normal conditions and not less than 3 (three) under breakdown torque condition of electric motor selected. The strength of socket of the wire rope shall be approximately equal to that of rope itself. The material for socket shall conform to IS 2485.

b) Drum

The drum shall be strong enough to withstand the crushing as well as bending. The crushing strength of the drum shall be calculated as per IS: 6938-2005 (latest revision). The minimum pitch diameter of the drum shall be 20 (twenty) times the diameter of the wire rope of 6x37 construction. The drum shall be made of cast steel IS: 1030.

The length of the drum shall be such that to accommodate the full length of rope for the specified lift, plus minimum 2 (two) full turns on the drum. When the gate is at its lowest i.e. closed position and 1 (one) spare groove for each lead off the drum, when the gate is at its highest position.

The drum may be with flanged ends. The flanges shall be projected to a height of not less than 2 (two) times the rope diameter above the rope.

The drum shall be machine-grooved (LH & RH) and the contour at the bottom of the groove shall be circular over an angle of at least 120º. The radius of the groove shall be 0.53 times the diameter of the wire rope duly rounded off to next full millimeter. The depth of the groove shall not be less than 0.35 times the diameter of the rope. The grooves of the drum shall be so pitched that there is clearance between adjacent turns of the rope as under:

i) 1.50mm for ropes up to and including 12.0mm diameter.
ii) 2.50mm for ropes over 12.0 mm and including 30.0mm diameter.
iii) 3.00mm for ropes over 30.0mm diameter.

The lead angle i.e. fleet angle of the rope shall not be more than 5° or 1 in 12 either side of helix angle of the groove in the drum.

The ends of the rope shall be fixed at minimum two points on the drum in such a way that the fixing device is easily accessible and the rope is not subjected to undue twists and turns.

c) Gears and Pinions (Spur gears)

The gear shall be machine-cut with smooth finish. Spur gears of 20° full depth involutes system shall be used in the reduction units of these hoists and designed as per IS 6938 (Latest edition). Face width of spur gear shall not be less than 8 and more than 12 modules. All spur gears shall be of cast steel, forged steel, carbon steel surface hardened steel. The material of pinions shall be harder than that of gears by at least 30 BHN higher and shall be free from imperfections such as chatter marks and below holes etc.

The allowable stress shall be taken as 20% of the ultimate tensile strength of material used for the manufacture of the gear for the normal operating condition. For breakdown torque condition, the allowable stress shall be taken as 80% of the yield point stress of the material.

d) Standard Worm Reducers

Standard worm or helical reducers (standard make like Radicon, Elecon, and Allen Berry) shall be used, for the first stage heavy reduction at the central drive unit, suitable for the service intended. The proportions of all the parts, therein, shall be in accordance with the best engineering practices. Rating and efficiency of the reducers used in design calculations shall be as per the manufacturer's recommendations. The whole assembly shall be housed in a dust proof casing with suitable lubrication facility. The reducers shall have self locking characteristics.

e) Shafts

The solid shafts shall be designed for appropriate load/torque that is being transmitted. Drum shaft shall be manufactured from high strength forged steel. The shaft shall have ample strength, rigidity and adequate bearing surfaces. They shall be finished smoothly and, if shouldered, shall be provided with fillets of large radius. Hollow shafts made from pipes shall not be acceptable.

In dimensioning of shafts, the ratio of length to diameter shall greater than 50, the angle of twist and the rev / min shall be taken into account in addition to simple bending, pure torsion, or the combined effect of bending and torsion. The twist angle, that shall be permitted, is from $1/4^0$ to $1/3^0$ per meter length. The linear deflection in the shaft shall not exceed 1.0 (one) mm per meter length of shaft.

The allowable stress for solid shafts shall be considered as per IS: 6938 (Latest revision).

f) Pulleys

All pulleys shall be in true running balance and shall be provided with pressure grease arrangements. The minimum pitch diameter of pulleys/sheaves shall not be less than that shown in Table 3 of IS: 6938 (latest revision). Their material shall conform to cast steel of IS: 1030 (latest revision). The sheaves or pulleys shall be machine-grooved to a depth of not less than 1.5 times the diameter of rope. The grooves shall be finished smooth and shall be free from the surface defects, which may damage the rope. The contour at the bottom of the groove shall be circular over an angle of approximately 130^0 +/- 5^0. The radius of the groove shall be 0.53 times the diameter of rope. The included angle which is the angle between the straight slopes at the sides of grooves shall be approximately 52^0. The sheaves / pulleys shall be provided with guard plates in order to retain the rope within the groove. All pulleys should be fitted with roller/bush bearings.

g) Idler Pulleys

Idler pulleys shall be provided to adjust the elongation of wire rope to ensure equal loading and tension on both sides of the pulley. Idler pulley shall be made of cast steel IS: 1030.

h) Bearings

All the running shafts shall be provided with ball or roller or bush bearings at their supports except for drum shafts where bush bearings can be provided. The selection of bearings shall be done on the consideration of duty, load and speed of the shafts. The life of bearings shall be determined in accordance with the recommendations of the manufacturer. The thickness of bush bearings shall be calculated as per IS: 6938 (latest revision). The bearings shall be easily accessible for lubrication or replacement.

i) Couplings

All couplings shall be of Forged or cast steel and shall be designed to transmit the maximum torque that may be developed. All flexible coupling shall be metallic, fully enclosed, dust proof, self lubricating type and shall be bored for tight fits on the shafts. Solid couplings shall be aligned in such a way that these meet accurately. Flexible couplings shall be initially aligned with the same accuracy as in case of solid couplings. Flexible couplings shall be fitted between the motor shaft and extension shafts. The flexible coupling between the motor and worm gear reducer and driving shaft shall be provided for angular misalignment only and the coupled shaft shall be interact.

j) Keys and Keyways

These shall conform to technical provision, dimensions and tolerances of IS 2048.

k) Main Base Frame

The hoist main frame shall be manufactured from rolled steel sections and plate with chequered plate to form a composite support structure. The various components of the hoist equipments shall be mounted on mild steel sub-frames which shall be bolted to the upper faces of the main frame. Shimming allowance shall be included at critical positions for final alignment of couplings and gears.

Rope guide brackets shall be installed on the hoist main frame to limit movement of the equalizing rope/socket to approx. 200 mm, if mis-coiling takes place or unequal loading of the ropes takes place due to snagging of the gate in the guides.

Anti-rotation brackets shall be incorporated in the rope guide bracket to present excessive movement of the rope sockets. The rope socket guard shall also be provided.

29.11.7. Electrical Components

All electrical equipment furnished under these specifications will be subjected to serve in moisture condition and shall be designed to prevent deterioration from corrosion and shall be insulated accordingly. All wirings of the electrical equipment shall be in accordance with the Indian Electricity Act in force and relevant IS code. The wiring shall be in hot dipped galvanized metal conduits. Conductors having nominal equivalent copper area of cross section of 9.5 sq.mm shall be used for power circuit and 1.5 sq.mm for control circuits and auxiliary wiring. Conductors shall be insulated for not less than 600 volts and shall have standard moisture resisting, double braided insulation cover.

In addition to the provision of required IS Codes, the following guidelines shall also be followed:

The usual values of efficiencies adopted for the various elements of hoisting mechanism shall be taken from Table 5 of IS: 6938 (latest edition). The overall efficiency of the system, which is the product of individual efficiency of elements, shall then be worked out. The overall efficiency of the system shall be used in calculating the capacity of the electric motor. The ratio of overall running efficiency to the overall starting efficiency shall be less than the ratio of starting torque to running torque of motor.

a) Electric Motor

The electric motors shall be totally enclosed fan cooled, high starting torque, squirrel cage/slip ring induction motor of required rated capacity and suitable for operation on 400/440 volts, 3phase, 50 cycles/sec AC power supply, 40% CDF, 150 starts/hr and outdoor type duty conforming to IS: 325 (latest revision) or equivalent. The motor shall be suitable for reversing frequent acceleration and mechanical braking. The breakdown torque of the motor at the rated voltage shall not be less than 225% of the rated torque. During this condition, for checking the components of hoist and the hoist supporting structure, the starting efficiency of the system shall be taken into account. The motors shall be so located that the bush, gears and terminals are readily available for inspection and maintenance with proper ventilation. The motor chosen shall be of standard and of reputed make like Siemens, Kirloskar, N.G.E.F, Crompton greaves, etc. Motors shall be provided with strip type anti-condensation heater.

b) E M Brake

The electro-magnetic brake shall be of spring set, shoe type. It shall be solenoid operated and of continuously rated. The brake shall be effective in both directions of travel and shall be capable of overcoming at least 150% of the full load torque exerted by the motor. The brake shall be set automatically, when the current is cut off from the motor and shall be electrically released, when the current is applied to the motor.

The brake shall be equipped with a hand operated release lever.

c) Limit switches

The limit switches, after being tripped, shall automatically reset themselves with a reasonable distance traveled in opposite direction. This does not prevent the use of change over type limit switches, where resetting is achieved by striker when moving in opposite direction. These may be mechanically driven from the shaft.

The limit switch shall be of totally enclosed type. It is a device provided to cut off the current and to stop the motion of the hoist mechanism and to apply the brake, when the gate has reached to the pre-determined level. The limit switches shall be weather proof type and shall be suitably designed and tested for satisfactory operations under humid climatic conditions. Inter locking arrangements shall be provided to isolate the power supply when the hoist is being operated manually. Adequate adjustment shall also be provided to compensate for rope elongation.

d) Gate position indicator

The gate position indicator shall invariably be provided with each hoist to show the position of the gate, when raised or lowered. The dial indicator shall be made of non-rusting metal or enameled plates. The markings on the dial in operating range shall have minimum readability of 1/20th of meter. The meter markings shall be very bold. The words “CLOSED”, “OPEN” and “FULLY RAISED” shall also be engraved or permanently marked.

The dial shall be located at a convenient place from where it can be read easily. The indicator point shall be made of non-rusting metal. Electro – plated pointer can also be provided, if mutually agreed to. Digital type indicator may also be provided.

e) Control Equipment

Suitable electrical control equipment as per IS 6938 (latest edition) shall be provided. Local control panel near the drive unit shall be provided for each gate. The manufacturer shall submit the arrangements showing sub-stations, main panel’s i.e. distribution panels and control panels, including all wiring and other accessories for approval of the Owner. The hoist mechanism shall be complete with one local control panel with push buttons, which shall be suitably labeled as ‘Raise’, ‘Stop’ and ‘Lower’. Lamps to indicate the condition of the control circuits and directions of motion shall be provided. The control panel shall be totally enclosed with IP 54 protection.

The hoist shall be provided with all necessary relays, starters, heaters if required, fuses, limit switches, indicating lights complete with suitable wiring so that all the functions are carried out smoothly. All the controls shall be so inter-locked that the proper functioning of individual parts for the purpose is ensured and the wiring shall be as per relevant standards.

f) Inter-locking and Earthing

All electrical equipment shall be provided with Off Position Inter-locked and earthing arrangement in terms of provisions contained in IS: 3043 (latest revision).

g) Manual Operation

Provision in the hoist mechanism shall also be made to operate it manually in the event of power failure. An electric inter lock shall be provided to prevent the operation due to restoration of power supply, when the manual operation is engaged.

The manual operation should be designed in such a manner that the continuous effort per man does not exceed a crank force of 100 N with 400 mm of crank radius at a continuous rating of 24 rev. /min. The maximum number of persons shall not exceed 4 (four).

Manual operation shall be provided with ratchet and pawl arrangement so that the gate does not fall due to self-weight during manual operation.

h) Emergency Push Button

A push button emergency stop shall be so located as to be readily available for use by the operator in case of emergency. This emergency push button shall be connected in the operating coil circuit in case of contactor and in the under voltage release circuit in the case of a circuit breaker.

i) Wiring Diagram

A wiring diagram giving the rating of each of the motors, brakes, relays, contractor, air circuit breakers, transformers, indicating lamps and cable sizes and such other information as will tend to facilitate inspection and maintenance of the crane shall be furnished by the Contractor.

j) Lighting

The permanent 240 + 10% V lighting system on the crane shall consist of four 500 W high way lighting units to illuminate the area under the crane; one 500 W high way lighting unit to illuminate the area of the crane platform; and two 100 W lighting in the operator’s cabin with a convenient outlet in the operator’s cage. The system shall be supplied from 415+10% V circuit breaker. One branch of circuit system shall be connected to give convenient outlets. The wiring shall be done in accordance with the Indian Electricity Rules 1937.

k) Field tests and Acceptance

The insulation of electrical equipment shall be tested and any defect revealed shall be rectified. The voltage required for the insulation resistance test shall be DC, not less than twice the rated voltage. Any reading less than 0.5 mega ohms obtained with an insulation resistance tester of the unregulated type shall be disregarded and the wiring under test shall be sub-divided until a reading higher than 0.5 mega ohms is obtained. Failure to obtain a higher reading shows an unsatisfactory state of the insulation.

If insulation has been sub-divided for test purposes each sub-division shall meet the requirements. The insulation resistance of each wiring circuit exclusive of connected apparatus shall not be less than 2 mega ohms.

After the supply has been connected and before the hoist installation is put into commercial service, tests shall be carried out to prove the following:

- The satisfactory operation of each controller switch, contactor, relay and other control devices and in particular the correct operation of all limit-switches under the most unfavorable conditions.
- The correctness of all circuits and interlocks and sequence of operation.
- The satisfactory operation of all protective devices.
- The compliance of the hoist with the specified performance requirement.
- The satisfactory operation of lowering/raising of the hoist.
- Tolerance on specified speed at full load shall be within + 10%
- The deflection test shall be carried out with the safe working load at rest.
- After the above tests, but before the crane is put in to service, it shall be tested to lift and sustain a minimum test load of 125% of the working load.

During the overload test, the hoist shall sustain the load under full control. The specified speed need not be attained, but the hoist shall show itself capable of dealing with the overload without difficulty.

29.11.8. Shop Assembly

The rope drum hoist shall be assembled completely in the shop to ensure all parts are properly fitted. The hoist shall be operated by power to check the operation. The hoist shall be operated under load to check its operation. The manufacturer shall supply all material, equipment, and labour required for shop assembly and load tests, and cost thereof shall be included in the bid price.

All shop tests shall be made in the presence of the representative of Project Authority. The hoist shall be prepared for shipment in as large units as practicable.

29.12. Gantry Crane

The gantry crane shall be class of mechanism M 5 as per IS: 3177 Outdoor Traveling Type with rope drum hoist mounted on the top of crane structure. The operation of the crane shall be completely electrical with 415 + 10% volts, 3 phase, and 50 cycles/sec and the power supply will be made available from the plug receptacles located at suitable intervals along with the crane runway. To facilitate a better control of the crane, an operator's cabin shall be provided with the crane. All the controls required for the electrical equipment on the crane shall be provided in the operator's cabin along with indicating lights for the various operations. The crane shall be suitable for operating the stoplogs. The hoist capacity shall be worked out considering 20% reserve capacity.

The design calculations shall be done by adopting the best engineering practices and shall be clear and easily understandable. All relevant references quoted in the calculations shall be supplied along with the design. Views of the Owner for any procedural dispute regarding practices to be adopted in the design shall be binding on the contractor and he will have to modify the design based on that; if warranted, at no extra cost whatsoever.

Placement of the Orifice spillway stoplog panels in the vertical slots is carried out by a gantry crane together with automatic engaging/disengaging lifting beam which travels over the Dam Top. The conceptual form of the Orifice spillway stoplogs with gantry crane is shown in drawing no.P.012745-W-20322-002 (Sheet 1 of 2).

29.12.1. Technical Requirements

a) Loading

All structural loads shall be computed as follows:-

i) The dead load shall include the weights of the crane structure, crane drive mechanism, and hoist mechanism, and operator's cabin. The effect of the eccentricity of the locations of the crane drive mechanism, hoisting mechanism and operating cabin shall be included in the design.
ii) The live loads shall include the weight of hoisting arrangement and the hook, and rope. The impact factor as per IS: 807 shall be considered for live loads.
iii) The tractive force on each wheel shall be considered as 5% of the resultant maximum wheel load considering the weight of crane and live load equal to hoist capacity.
iv) The wind load on the crane at 50 kg/sq.m and also in accordance with IS: 807 & IS: 875 (latest version). The wind area of the crane shall be taken as the vertical projection of the structure, normal to direction of wind.

b) Stability

Any eccentricity of the crane legs with reference to the runway rails shall be considered in determining the stresses. The equipment shall be designed so as to be adequate for each of the following load combinations.

i) The stability factor shall not be less than 1.30 considering load under breakdown condition of motor and a steady wind pressure of 50 kg/sq.m.
ii) The ratio of stabilizing moments to the overturning moments for stability under service condition and steady wind pressure of 50kg/sq.m shall not be less than 1.80.
iii) The stability factor shall not be less than 1.50 under storm condition (wind pressure 150kg/sq.m), without load and crane not operating.

29.12.2. Design Data for orifice spillway stoploges

Table 29.12-1 : Design Data

Sl.No	Particulars	
1	Number of gantry	One
2	Capacity	Adequate Capacity
3	Total lift	71 m (tentative)
4	Lifting speed	1.5 m/minute
5	Gantry travel speed	5 m/minute
7	Rail/length of travel	45 Kg/m; Length 150 m (approx)
8	C/C of rail track	Tentatively 4.5 m
9	Governing IS codes (latest)	3177, 6938 , 800, 807
10	Class of Crame	M5 as per IS 3177 Outdoor travelling Type with Rope Drum Hoist

29.12.3. Permissible Stresses

The crane and its structural members shall be proportioned in such a way that actual stresses in the members, arrived at by any of the accepted methods of calculations, shall not exceed the permissible stresses specified in relevant Indian Standards.

The design of the component parts of the mechanism relating to crane motion shall include due allowance for the effects of the duty, which the mechanism will perform in service.

The design and fabrication of gantry crane shall conform to IS:3177, IS:6936, IS:807, IS:800, IS:806, IS:816, IS:822, IS:9595 (all latest versions). If the code provisions conflicts in any way with the technical specifications, the technical specifications shall govern.

29.12.4. Structures

The gantry crane to be provided is of outdoor type, care shall be taken such that the gantry crane when fabricated and erected it should present a pleasing appearance. The necessary streamlined appearance and architectural features shall be incorporated in the design of gantry crane.

a) Frame

The gantry crane frame shall be fabricated using structural steel (Grade E 250 C) sections and plates and shall be of welded construction. The chequred plate of hoist platform should not be less than 8 (eight) mm in thickness and should be reinforced. The legs shall be of box type, with all angles on the inside of the leg. Diaphragm shall be provided to distribute the loads properly to the two sides of the legs and plane stiffeners shall be provided where necessary. Bearing surfaces of joints designed to transmit stress by bearing shall be machine finished to provide full contact. Shop connections in the frame shall be welded so that the surface of the crane, including the outside of the frame, case and hoist housing when viewed along with the runway shall present plane surface, except for the projection of rivet heads. The structure shall be designed to be adequate for each of the following load combinations:

- Dead loads and no live loads and wind pressure of 50 kg/sq.m on crane and impact loads.
- Dead loads and live loads and wind pressure of 50 kg/sq.m on crane and tractive forces.
- Dead loads and no load on lifting blocks and wind pressure of 150 kg/sq.m (storm load) on crane and impact loads.
- Actual breakdown condition of motor.

b) Legs

The gantry legs shall be connected to the crane members by heavy gussets in a manner that will prevent skewing and ensure rigidity and strength. Diaphragms shall be provide to distribute properly the loads from the cross members to the side of the legs. If the centre lines of the legs are not matching with the centre lines of the crane runway rails, the eccentricity shall be considered in determining the stresses.

c) Walkway, Ladder and Hand Railing

Ladder, platform and walkway necessary to access to the crane drive machines, shall be provided. The platform and walkways shall be designed for a live load of at least 500kg/sq.m and shall consist of suitable non-slip steel plates welded together or bolted to the steel frame except that the walkway on the top of deck of the gantry shall be constructed of floor grating. The ladders shall be not less than 400 mm width between side parts and shall have round rungs 20 mm dia spaced at 300 mm. Hand railing shall be provided along the open sides of the walkway platform. The platforms are to be proportioned for a moving single load of 300 kg. Railings are to be proportioned for traveling horizontal single load of 30 kg acting on the rail iron.

d) Buffers

The spring/rubber shall be provided at either end of the LT bogies of gantry crane and shall be capable of bringing the crane to a gradual stop in a distance of not more than 200 mm when traveling in either direction at rated speed while power off and brakes not applied, without producing excessive stress or damage in the structure. The buffers stops shall be of structural steel. The centre line of contact shall not be more than the centre line of wheel base. The design of the buffers shall provide minimum factor of safety of six. Alternatively rubber buffers of standard and reputed make could also be provided which satisfy the design requirements explained above. The shore hardness of rubber shall be in the range of 70 to 80.

e) Gantry Rails

The gantry track shall consist of two parallel and leveled rails (tested rails having weight 44.61 kg per meter) including base plates, anchor bolts and nuts, clamps and end stoppers spaced 4 m between centers to form the runway.

29.12.5. Mechanical Components

The hoist shall be designed in accordance with IS 6938 and IS 3177. All mechanical equipments shall be simple, substantial in design, and capable of being easily erected, inspected, adjusted, painted and taken apart. The hoist shall be of single motor, twin drum type connected through gearing and shafting. The capacity of motor shall be such that the specific performance of hoist at rated load will not demand more than full load torque. The shaft connecting the end gear trains shall be provided with flexible coupling of the geared type, or any other approved arrangements which permit one drum to be rotated with respect to the other drum and keeps the lifting beam in a level position. All shaft loads shall be transmitted by suitable keys, splices or pins. The transmission of loads by press fit only will not be permitted. A factor of safety of five over Ultimate Tensile Strength, based on the rated capacity of the crane (exclusive of duty factor, impact factor, acceleration and retardation) shall be used in design of all mechanical parts provided. All parts of the equipment shall have sufficient strength to resist the forces produced by the rated break down torque of motor without exceeding 80% of the yield point strength of the material used. The hoist shall be so designed as to limit the maximum rope fleet angles not more than one in twelve, unless other-wise approved. The reeling of rope on the drum of the hoist shall be such as to allow the lifting beam to travel vertically.

The hoist shall be provided with an electromagnetic automatic brake and means for position control of the lowering movements of the hook.

a) Wheels and Axles

The gantry shall be carried on not less than eight (8) wheels. Two wheels in tandem fully equalized, shall be provided for the crane travel base. The trolley shall be carried on not less than four wheels. The wheels shall be of cast steel or forged steel. The diameter of the wheels shall not be less than that specified in IS: 3177 (latest version). The width shall have the proper clearance for the rail head and shall be of adequate size to withstand the maximum standing and rolling loads. All wheels shall be double flanged and shall be turned or ground true and of uniform diameter concentric with the bore.

The wheel axles shall be made of forged carbon or alloy steel and shall be accurately turned, ground and polished at journals. All axles shall be forced into the wheel at a pressure of not less than 3200 kg per sq.cm of axle diameter and the driving wheels shall be keyed to the axles in addition to force fit. All wheel journal boxes shall be drip proof and shall be provided with self lubricating bronze bearings, accurately machined and correctly bored, for the axle fit or shall be provided with roller bearings with high pressure grease lubrication. All crane wheel and trolley wheel bearings shall be interchangeable.

The wheel assemblies shall be designed to facilitate the removal of the wheels, bearings and journals from the frames. They shall be so arranged that wear may be compensated in order to maintain the drive gears in proper mesh. The size of the journal shall be ample to carry the load at the specified speed without excessive heating during continuous operation. The track sweepers at each end and also on the trolley shall be provided and shall extend below the top of the rail on both sides.

b) Gantry Drive

The gantry drive shall be designed to move the crane at the rated speed while supporting a maximum load for operating the gates. Not less than 50% of the wheels on each track shall be connected for driving. Each motor shall be mounted at one end of the gantry crane and shall be arranged to drive one truck on each side of the crane through gears. The drive shall be free from vibration, and while moving there shall not be any tendency for gantry crane structure to get out of the line.

c) Brakes

The hoist shall be provided with an automatic electro magnetic brake. The electro magnetic brake shall be mounted on the same base as the hoist motor and shall be electrically operated, spring set, solenoid release, shoe type. The brake shall be equally effective in both directions of motor rotation. The brake shall have a capacity equal to one and a half time the rated full load torque of the motor. The brake shall be rated on the continuous duty basis and shall be capable of withstanding not less than four operations per minute. The brake shall be equipped with manual release, which must be held by hand and cannot be left in the released position. The brake shall automatically reset at all times when the power is disconnected.

The terminals of the brake magnets shall be protected from accidental contact. The connection and winding shall be effectively protected from mechanical damage where necessary magnet shall be provided with an effective cushioning device.

In addition, a thruster brake shall be interposed between the winding drum and the source of power. It shall have a capacity to hold one and half times the rated load and shall be designed to prevent the load from moving downward unless the hoist motors are revolving under power in the lowering direction.

The thruster shall be energized from the rotor circuit of the motor for actuating the brake so that creeping speed control of the hoisting and lowering movement can be achieved. The thruster shall be mounted on the special lug mounting allowing them to be tilted up to ten degrees on either side of the vertical.

Shoes type mechanically or hydraulically operated brake, controlled through a foot pedal in the operator’s cage shall be provided to control the crane travel in both directions of motion. The brakes shall have a capacity equal to one and half times the rated full load torque of the driving motors and shall be so designed that it may be secured in the set position. The foot brake shall require a force not more than 20 kg at pedal and the pedal stroke shall not exceed 150 mm.

Electro magnetic brakes shall be provided for parking of crane, which shall apply automatically when the current supply to the mains is switched off. These parking brakes shall be in accordance with IS: 3177 (latest version).

d) Wire Rope

The wire ropes shall be made from special improved plough steel of 6x37 or 6x 36 construction, long’s lay, fiber core, galvanized and shall conform to IS:2266 (latest version). While selecting the diameter of wire ropes, the overall efficiency of the system including rope drum, open gears, pulleys shall be taken into account.

The minimum factor of safety based on breaking strength of safe working load of the wire rope shall be not less than 6 under normal operating conditions and not less than 3 under break down torque condition of motor. The strength of the socket shall be approximately equal to that of the rope itself.

e) Hooks and Blocks

The blocks shall be arranged to lift without twisting or sidewise pull of the load and dead end ropes should be avoided. The hook shall be of ram shorn type and made of forged alloy or carbon steel.

The hoist shall be provided with fixed type hook mounted on thrust bearing. The bearing shall be totally enclosed, dust proof and arranged to prevent leakage of grease. The hook beams or cross beams shall be made of annealed forged carbon or alloy steel and shall have such proportions as to provide ample sheaves bearing area. The bottom blocks shall be constructed so as to guard the hoisting ropes fully and prevent them from leaving the sheaves under any operating conditions. The guards shall be made of cast steel or structural steel plates, machined at the joints, fitted close to the periphery of the sheaves, and arranged for proper drainage. There should be adequate locking arrangement in the hook to guard the wire rope from clearing the hook.

f) Rope Drum

The rope drum shall be made of cast steel or of structural steel and shall be reinforced to sustain the concentrated loads due to the rope tensions. A drum shall have a diameter not less than 20 times the corresponding rope diameter and shall be of sufficient length to accommodate the full length of rope for the specified lift, plus two extra turns at each fastening and one extra groove. Right and left hand helical grooves shall be machined on the surface of the drum. Depth of the grooves shall be not less than 0.35 times the diameter of the rope. The combined crushing and bending stresses shall not exceed 840 kg/sq.cm for cast steel drum. The drum shall be of such size that there will not be more than one layer of rope on the drum when the rope is in its fully wound position. The rope attachments to the drum shall be simple and secure so that adjustment and replacement of the rope may be accomplished without dismantling the parts.

g) Gears and Pinions

Gears shall be Spur gears of 20° full depth involutes system shall be provided in end reduction units. The correction factor for peripheral speeds and the efficiency shall also be considered. The gears and pinions shall be made of two different grades of materials. The material of pinions shall be harder than that of gears and shall be free from imperfections such as chatter marks and blow holes etc. The gears shall be machine cut and shall be designed as per para 4.5 of IS 6938 (latest edition) or other relevant Indian Standards. The face width of gears shall not be less than two times of circular pitch. Duty factor of appropriate class of mechanism shall be taken into account in the design calculations. The keys in gear trains shall be tight fit and should not become loose in service. Overhung gears shall not be permitted except on motor shafts. Pinions shall be forged integral with shaft where practicable. Gears shall be of cast steel or forged steel. The material for pinion shall be harder than that of gears by at least 50 BHN.

h) Reduction Gear Units

Standard worm used, for the 1st stage heavy reduction at the central drive unit, shall be high grade reduction unit suitable for the service intended. The proportions of all the parts, therein, shall be in accordance with the best engineering practices. Rating and efficiency of the reducers used in design calculations shall be as per the contractor's recommendations. The whole assembly shall be housed in a dust proof casing with suitable lubrication facility. The reducers shall have self locking characteristics.

Gear boxes shall be of rigid construction fitted with inspection covers and lifting handles. Proper facilities for oil filling and drawing, connections for oil level indicator and adequate breathing shall be provided. The boxes shall be mounted on a leveled surface.

i) Shafts

The shafts shall be solid shafts made of Forged / Rolled steel and shall be designed for appropriate load / torque that is being transmitted by them. Drum shaft shall be manufactured from high strength forged steel. The shaft shall have ample strength, rigidity and adequate bearing surfaces. They shall be finished smoothly and, if shouldered, shall be provided with fillets of large radius. Hollow shafts made from pipes shall not be acceptable.

The shafts shall be designed for combined torsion and bending and angle of twist shall be taken into account, as detailed in IS 6938.

j) Sheaves and Pulleys

All rope sheaves shall be made of cast steel with turned rope grooves with suitable tolerance. All revolving sheaves shall be in true running balance and shall be provided with antifriction bearings. The sheaves in the lower block shall be mounted on self lubricated bronze blushing.

k) Bearings

All bearings shall be of the roller, ball or sleeve type with removable bronze linings, preferably flanged at both ends. The shaft bearing shall be placed as close as possible to the points of loading. Unless otherwise specified herein, bearings on revolving shafts shall be divided type, so that each shaft may be removed from the crane with its pinions and gear in position. In all cases where divided bronze bearings are used, the bearing caps, unless dowelled shall be recessed into the base and secured by turned bolts. Cap screws shall not be used for this purpose. This requirement will not apply in the case of roller or ball bearings. The design shall be such that any shaft may be removed without disturbing adjacent parts. Base castings for gear train bearings shall be made in one piece, to ensure that accurate that alignment and spacing will be maintained. They shall be held securely in place by turned bolts. Provision shall be made to hold off actively all bearings against rotation or changing position under load. All grease lubricated split bearings shall be provided with an adequate base in the centre of the top half, drilled and tapped for lubrication. All bearings shall be weather proof, drip proof and shall be protected fully against the entrance of rain, dust and any foreign matter. All bearings shall be easily replaceable. Bushings at the ends of shafts shall be scaled by approved methods so as to be drip proof if oil lubrication is used. Open ends of bushings shall be sealed with approved grease retainers where bronze bearings are used; the pressure on shaft shall not exceed 70 kg/sq.cm on the projected area. The thickness of the bronze bush shall be as per clause 4.8.1.3 of IS 6938 (latest Edition).

l) Flexible Couplings

All flexible couplings shall be metallic, fully enclosed, dust proof, self lubricating type and shall be bored for tight fits on the shafts and shall be fitted with straight square keys accurately on the shaft, shall be of the size rated for shafts which they connect and shall have torque ratings suitable for the load transmitted. The flexible couplings between the motor and worm gear reducer shall be provided for both angular and offset misalignment of the coupled shafts. Flexible coupling between worm gear reducer and the driving shaft shall be provided for angular misalignment only and the axis of coupled shafts shall interact.

m) Lifting

The hoist system shall be so arranged to lift the lifting beam & stoplog units without twisting and shall be so designed & constructed as to guide the hoisting ropes fully and prevent them from leaving the sheaves under any operating conditions. A locking arrangement shall be provided to prevent the rope from leaving the rope sheaves due to any jerk.

n) Sockets for Ropes

The sockets may be cast, forged or machined. Molten zinc shall be used to socket the rope. Each socket shall be tested subjected to proof load in accordance with the procedure laid down in IS 2485.

o) Gear box covers

Gear box covers shall be rigid construction fitted with inspection covers and lifting handles. The covers shall be so shaped that the gears can be easily removed or replaced. Facilities for lubrication, oil draining, oil level indicator etc. shall be provided wherever necessary. The thickness of metal sheet for cover shall be not less than 3.15 mm.

p) Counter Weight

Suitable counter weight shall be provided, to make the crane stable under specified working conditions. The counter weight shall be in the form of steel scrap or concrete blocks suitably housed in a steel counterweight box.

q) Keys and Keyways

The size of the keys shall be as to be within safe bearing and shear limits for the material in contact and in general shall conform to the relevant Indian Standards where round end keys are used, the total cross sectional area may be considered in shear but for bearing stresses in key and keyways, the projected area of the rounded ends shall not be included in the effective bearing area. If two keys are used, they shall be placed 120 degrees apart. The design shall be such as to hold all keys effectively in place. Further, keyways shall not be extended into the bearings.

r) Bolts and Nuts

All bolts for mechanical equipments shall have hexagonal heads and nuts. On castings, the seats shall be on finished bases or on spot faced surfaces. Nuts subject to vibration and frequent changes of load shall be secured by effective lock nuts. Double nuts shall be of standard thickness. Bolts in tension shall be of standard thickness. Bolts and nuts used shall be as per relevant Indian Standard.

s) Lubrication

Oil lubrication shall be provided for all gear trains, sleeve bearings on motors and bearings for truck wheels. Lubrication for all other mechanical operating parts shall be by means of high pressure grease. The lubrication fittings of bearings and journals shall be readily accessible and where necessary shall be piped to convenient points with copper or brass pipe of ample size and adequately fastened. Grease grooves shall be provided in bearing lining for the satisfactory distribution of the lubrication. The edges of the grooves shall be rounded and the grooves shall not come within 10 mm of the end faces of bearings.

A lubricating chart shall be provided indicating all the lubricating points, the type of lubricant and recommended frequency of lubrication.

t) Tools

A complete set of tools including grease gun, wrenches etc., shall be supplied for the crane in steel tool box for maintenance of the crane. Each tool and wrench shall be stamped so as to be easily identified as to its use and size. Operating instructions in a suitable metal frame covered with glass, shall be mounted in convenient locations in the operator's cabin.

29.12.6. Electrical Components

All electrical equipment furnished under these specifications will be subjected to serve in moisture condition and shall be designed to prevent deterioration from corrosion and shall be insulated accordingly. All wirings of the electrical equipment shall be in accordance with the Indian Electricity Act in force and relevant IS code. The wiring shall be in hot dipped galvanized metal conduits. Conductors having nominal equivalent copper area of cross section of 9.5 sq.mm shall be used for power circuit and 1.5 sq.mm for control circuits and auxiliary wiring. Conductors shall be insulated for not less than 600 volts and shall have standard moisture resisting, double braided insulation cover.

a) Electric Motor

Motors shall be of totally enclosed, fan cooled slip-ring type design for operation on 3 phase, 400/440 volts, 50 cycles per sec AC power supply conforming to IS 325 of rated capacity.

The contractor shall clearly specify in his bid the breakdown torque of the motor. The important hoist components e.g. drum, shafts, gears and wire rope, etc. shall be checked for their stress value under breakdown torque conditions of motors.

Selection of motors shall be as per IS 3177. Motors shall be IS or equivalent international standard and of reputed make like Siemens, Kirloskar, N.G.E.F, Crompton Greaves, G.E.C. etc.

b) Cables and Cable Reel

The rubber of polyvinyl chloride insulated cables used for crane wring shall comply with relevant Indian Standard Specifications. The gantry crane shall be equipped with an electric motor driven cable reeling drum to take up cable reel. Power supply will be made available from plug receptacles located in the dam parapet at convenient intervals. The cable reel shall be provided with sufficient length of flexible cable and with limit switches arranged to cut off the power supply to the travel of the crane when the crane approaches the end of runway. The attachment plug for the receptacle and of the cable shall be furnished by the Bidder

c) Wiring

All wiring shall be in hot dip galvanized metal conduits. All conductors for primary power lightning and control circuits shall be insulated for not less than 600 V and shall have standard moist resisting double braid covering. All conductors between the secondary of the motor contractors and resistors shall have a sufficient current carrying capacity in accordance with Indian Standard and shall be insulated with 600 V class asbestos. The primary conductors to thermometer shall have standard, continuous current carrying capacity of not less than 100 percent of the rated full load primary current of the motors. Cables having conductors smaller than 2.5 sq mm nominal equivalent copper area of cross section shall not be used for the power wiring to any of the motors. For control circuits and auxiliary wiring, cables having a sectional area smaller than 1.5 sq mm nominal equivalent copper area shall not be used.

All cables shall be adequately protected against mechanical damage and metal trenching may be used as desired. Electrical conduits shall comply with the relevant Indian Standard specifications. Except where flexible unarmored cables are essential cable shall be either armored or enclosed throughout their length in galvanized trenching or conduit, either flexible or rigid. A flexible metallic tube or duct which may not form an affective earth connection shall not be used. Tapped and braided varnished cambric insulated cables shall not be used.

d) Limit Switches

All limit switches shall be of the totally enclosed type. The limit switch shall be provided for the following operations.

- To limit the travel of the gantry crane at both ends of the travel and to stop the crane at the centre of each bay.
- To limit the hoisting travel of the lifting beam while operating the gates.

All limit switches shall be capable of being reset by reversing the controllers. The limit switches shall have water proof coverings and shall be suitably designed and tested for normal lift and satisfactory operation under the humid climatic conditions.

e) Isolating switches

A main isolating switch shall be provided in the cabin or adjacent to it capable of disconnecting the supply for all power driven and associated equipment on the crane but not auxiliary loads such as lighting and heating circuits. In the case of main isolating switch being combined with the crane protection pale, it shall be mechanically interlocked with the door giving access to the panel and the terminals shall be screwed to prevent accidental contact when the door is open. When not so combined a suitably worded red warming place shall be attached to the cover of the protective gear and all other panels and controllers, not fitted with inter-locked isolators. The main isolating switch and the additional switches shall be so situated to carry out any maintenance work or functional testing on them without danger.Protective Equipment

Iron clad electrical protective gear in accordance with IS: 3177 (Latest revision) shall be provided except that in case when the aggregate power of the two largest motors is less than 30 kW and their aggregate current rating is less than 60 A, a manually operated equipment as per IS:3177 (latest revision) may be used.

f) Emergency Push Button

A push button emergency stop shall be so located as to be readily available for use by the operator in case of emergency. This emergency push button shall be connected in the operating coil circuit in case of contactor and in the under voltage release circuit in the case of a circuit breaker.

g) Wiring Diagram

A wiring diagram giving the rating of each of the motors, brakes, relays, contractor, air circuit breakers, transformers, indicating lamps and cable sizes and such other information as will tend to facilitate inspection and maintenance of the crane shall be furnished by the Contractor.

h) Lighting

The permanent 240 + 10% V lighting system on the crane shall consist of four 500 W high way lighting units to illuminate the area under the crane; one 500 W high way lighting unit to illuminate the area of the crane platform; and two 100 W lighting in the operator’s cabin with a convenient outlet in the operator’s cage. The system shall be supplied from 415+10% V circuit breaker. One branch of circuit system shall be connected to give convenient outlets. The wiring shall be done in accordance with the Indian Electricity Rules 1937.

i) Interlocking and Earthing

‘Off’ position inter-locking, earthing and other electrical equipments shall be provided as per IS: 3177 (Latest revision).

j) Field Tests and Acceptance

The insulation of electrical equipment shall be tested and any defect revealed shall be rectified. The voltage required for the insulation resistance test shall be DC, not less than twice the rated voltage. Any reading less than 0.5 mega ohms obtained with an insulation resistance tester of the unregulated type shall be disregarded and the wiring under test shall be sub-divided until a reading higher than 0.5 mega ohms is obtained. Failure to obtain a higher reading shows an unsatisfactory state of the insulation.

If insulation has been sub-divided for test purposes each sub-division shall meet the requirements. The insulation resistance of each wiring circuit exclusive of connected apparatus shall not be less than 2 mega ohms.

After the supply has been connected and before the complete crane installation is put into commercial service, tests shall be carried out to prove the following:

- The satisfactory operation of each controller switch, contactor, relay and other control devices and in particular the correct operation of all limit-switches under the most unfavorable conditions.
- The correctness of all circuits and interlocks and sequence of operation.
- The satisfactory operation of all protective devices.
- The compliance of the crane with the specified performance requirement.
- The satisfactory operation of each motion of the crane
- Tolerance on specified speed at full load shall be within + 10%
- The deflection test shall be carried out with the safe working load at rest as per IS: 3177 (Latest revision) and IS: 807 (Latest revision).
- After the above tests, but before the crane is put in to service, it shall be tested to lift and sustain a minimum test load of 125% of the working load.

During the overload test, the crane shall sustain the load under full control. The specified speed need not be attained, but the crane shall show itself capable of dealing with the overload without difficulty.

29.12.7. Shop Assembly

The gantry crane together with lifting beam shall be assembled completely in the shop to ensure all parts are properly fitted. The hoist and gantry drive shall be operated by power to check the operation. The gantry shall be made to travel for distance of about 20 m. After shop assembly, the gantry shall be tested under full load and 25% overloads on hoisting. The hoist shall be operated under load to check its operation. The manufacturer shall supply all material, equipment, and labour required for shop assembly and load tests, and cost thereof shall be included in the bid price.

All shop tests shall be made in the presence of the Owner’s representative. The hoist shall be prepared for shipment in as large units as practicable.

29.13. Mono-Rail Crane

29.13.1. General

The monorail hoist shall be class of mechanism M5 as per IS: 3177 the standard product of a reputable national / international manufacturer suitable for outdoor, heavy duty, service, except that the materials specified in these Specifications shall be followed. The hoist shall be operated by a local control panel mounted on the deck or a pendant pushbutton control. The operation of the mono-rail crane shall be completely electrical with 415 + 10% volts, 3 phase, and 50 cycles/sec power supply. All applicable provisions of IS 3938, IS 6938, IS 3177 or equivalent international Standards shall apply, except as otherwise stated herein. The hoist capacity shall be worked out considering 20% reserve capacity.

The hoist shall be underhung monorail hoist with motorized trolley, and shall include the following:

- Festooned power supply with terminal box
- Pendant operated controls plus controls installed on the deck
- Monorail beam of suitable capacity, with end stops
- Monorail beam support brackets, including steel anchors.

The design calculations shall be done by adopting the best engineering practices and shall be clear and easily understandable. All relevant references quoted in the calculations shall be supplied along with the design. Views of the Owner for any procedural dispute regarding practices to be adopted in the design shall be binding on the contractor and he will have to modify the design based on that; if warranted, at no extra cost whatsoever.

Placement of the Upper Spillway stoplog panels in the vertical slots is carried out by a mono-rail crane together with automatic engaging/disengaging lifting beam. The conceptual form of the Upper spillway stoplogs with gantry crane is shown in drawing no.P.012745-W-20322-003 (Sheet 1 of 2).

a) Operating Conditions

The hoists shall be suitable for outdoor operation. Accordingly, the hoist shall be of weatherproof construction. The trolley frame shall be of rigid, welded structural steel construction and shall permit equal distribution of the load on all wheels without undue deflection. The hoist shall be designed and constructed to withstand the earthquake loading for the site conditions. Emergency guide shoes shall be provided to limit the lateral displacement of trolley so as to prevent derailing if wheel flanges are damaged.

The hoist reeving shall provide a true vertical lift throughout the full height of travel. The hoist shall be fully factory assembled and wired, except for reeving of drums and blocks. Access to the hoist shall be from the diversion conduit deck. Access ladders shall be provided.

b) Design Data for Upper spillway stoplogs

Table 29.13-1 : Design Data

Sl.No	Particulars	
1	Number of mono-rail crane	One

Sl.No	Particulars	
2	Capacity	Adequate Capacity
3	Total lift	8.2 m (tentative)
4	Lifting speed	0.5 – 0.7 m/minute
5	Gantry travel speed	5 m/minute
7	Length of travel	20 m (approx)
8	Governing IS codes (latest)	3177, 6938 , 800
9	Class of Crame	M5 as per IS 3177 Outdoor travelling Type with underhung Rope Hoist

c) Runway

The hoist shall operate on a single monorail beam of suitable capacity, installed on the civil structure above the diversion conduit gate slot. The location of the beam shall be such that the hoisting wire rope for hoist is truly in line with the lifting lug of the diversion conduit gate. The lifting lug will be located at center of gravity of the diversion conduit gate.

c) Load Block

A lifting eye shall be installed on the load block in a mounting swivelling in a self-lubricating (Lubrite or equal) bearing ring. The lifting eyes shall match the design of the lifting lugs of lifting beam. Each lifting eye shall be connected to the respective lifting lug with a safely secured, but easily removable stainless steel pin.

29.13.2. Hoisting Speed & Trolley Speed

a) The hoisting speed shall be between 0.5 m to 0.7 m per minute.

b) The trolley speed shall be 5 m/min.

29.13.3. Hoist Equipment

The various components of the hoist shall be in accordance with the specifications given below. All other accessories necessary for the satisfactory operation of the hoist and shall conform to best engineering practice and standard.

Each hoist shall comprise following components:

a) Control Equipment

The control equipment shall comprise of electric motor, switch gears, limit switches, control panel, and various electrical relays required for satisfactory operation of motors and brakes etc.

b) Miscellaneous Parts

Miscellaneous parts like rope drum, wire ropes, rope sockets, pulleys / sheaves, hoist frames, hoist machinery housing and monorail crane support bracket etc.

29.13.4. Mechanical Equipment

a) Wire Ropes

i) General

The wire ropes shall be made of special improved plough steel of 6 x 37 construction Lang's and fibre core and shall conform to IS 2266 (latest edition) or equivalent. While selecting the diameter of the wire ropes the efficiency of pulleys, sheaves and drums shall be taken into account. The wire ropes shall be provided with a device to take care of unequal stretch of rope. Wire ropes shall be guided over as few pulleys as possible. Reverse 'S' shaped bends shall be avoided as far as possible. The ends of rope shall not be subjected to undue twists and turns. The wire rope ends fastened with the rope drum should not slip away under maximum loads.

ii) Breaking Strength

The breaking strength of wire ropes, if not specified by the wire rope manufacturer, shall be taken on the basis of IS 2266.

iii) Factor of Safety

The minimum factor of safety based on breaking strength and safe working load of the wire ropes shall not be less than 6 (six) under normal conditions and not less than 3 (three) under breakdown torque condition of electric motor selected.

b) Drums

The drum shall be strong enough to withstand the crushing as well as bending. The minimum diameter of the drum shall be as per IS 3177 (latest edition).

The length of the drum shall be such that each lead off rope has minimum 2(two) full turns on the drum, when the gate is at its lowest i.e. closed position, and 1(one) spare groove for each lead off the drum, when the gate is at its highest position.

The drum may be with flanged ends. The flanges shall project to a height of not less than 2(two) times the rope diameter above the rope. A spur gear secured to the drum maybe regarded as forming one of the flanges.

The drum shall be machine grooved and the contour at the bottom of the groove shall be circular over an angle of at least 120°. The radius of the groove shall be 0.53 times the diameter of the wire rope duly rounded off to next full millimetre. The depth of the groove shall not be less than 0.35 times the diameter of the rope .The grooves of the drum shall be so pitched that there is a clearance between adjacent turns of the rope as per IS 3177 (latest edition).The lead angle i.e. fleet angle of the rope shall not be more than 5° or 1 in 12 on either side of helix angle of the groove in the drum.

c) Gears

i) Spur Gears

Spur gears of 20° full depth involute system shall be provided in end reduction units. The correction factor for peripheral speeds and the efficiency shall also be considered .The material of pinions shall be harder than that of gears and shall be free from imperfections such as chatter marks and blow holes etc. The gears shall be machine cut and shall be designed as per IS 6938.

ii) Speed Reducers

Standard worm or helical reducers, if used, for the 1st stage heavy reduction at the central drive unit, shall be high grade reduction unit suitable for the service intended. The proportions of all the parts, therein, shall be in accordance with the best engineering practices. Rating and efficiency of the reducers used in design calculations shall be as per the manufacturer's recommendations. The whole assembly shall be housed in a dust proof casing with suitable lubrication facility. The reducers shall have self locking characteristics.

d) Gate Position Indicator

The gate position indicators shall be provided to show the position of the gates, when these are being raised or being lowered. The indicator dial shall be made of non - rusting metal or enameled plates. The markings on the dial in operating range shall have minimum readability of 1/20th of metre. The metre markings shall be very bold. The words 'CLOSED', 'OPEN' and 'FULLY RAISED' shall also be engraved or permanently marked.

The dial shall be located at a convenient place from where it can be read easily. The indicator points shall be made of non -rusting metal. Electro- plated or digital type indicator may also be provided.

e) Shafts

i) General

The shafts shall be solid shafts made of Forged / Rolled steel and shall be designed for appropriate load/ torque that is being transmitted by them. The shafts shall have ample strength, rigidity and adequate bearing surfaces. These shall be finished smooth and, if shouldered, the same shall be provided with fillets of large radius.

ii) Dimensioning of Shafts

In dimensioning of shafts, the ratio of length to diameter > 50, the angle of twist and the rev /min shall be taken into account in addition to simple bending, pure torsion or the combined effect of bending and torsion. The twist angle, that shall be permitted, is from 1/4° to 1/3° per metre. The linear deflection in the shaft shall not exceed 1.0 (one) mm per metre length of shaft.

iii) Allowable Stresses

The allowable stresses for shafts shall be as per IS 3177.

f) Sheaves or Pulleys

All pulleys shall be in true running balance and shall be provided with pressure grease arrangements. The ratio of sheaves / pulleys pitch diameter and the rope diameter shall be as per IS 3177.

The sheaves or pulleys shall be machine grooved to a depth of not less than 1.5 times the dia. of rope. The grooves shall be finished smooth and shall be free from the surface defects, which may injure the ropes. The contour at the bottom of the groove shall be circular over an angle of approximately 130° ± 5°. The radius of the groove shall be 0.53 times the dia. of rope .The included angle which is the angle between the straight slopes at the sides of grooves shall be approximately 52°. The sheaves / pulleys shall be provided with guard plates in order to retain the rope with in the groove.

g) Sockets for Wire Ropes

The sockets end shall be slightly stronger than the wire rope. Molten zinc shall be used to socket the ropes. The material for wire rope sockets shall conform to IS 2485.

h) Bearings

All the running shafts shall be provided with ball or roller or bush bearings at their supports. The selection of bearings shall be done on the consideration of duty, load and speed of the shafts. The life of bearings shall be determined in accordance with the recommendations of their manufacturer .The thickness of bush bearings shall be calculated as per IS 6938.

The bearings shall be easily accessible for lubrication and /or replacement. Every bearing shall be provided with individual lubrication arrangement.

29.13.5. Electrical Equipment

a) Efficiency of System

The usual values of efficiencies adopted for the various elements of hoisting mechanism shall be adopted as given in IS 3177 / IS 6938. The overall efficiency of the system, which is the product of individual efficiency of elements, shall than be worked out. The overall efficiency of the system shall be used in calculating the capacity of the electric motor. The ratio of overall running efficiency to the overall starting efficiency shall be less than the ration of starting torque to running torque of motor.

b) Motors

The hoist and trolley travel motors shall be totally enclosed, non-ventilated type, with Class B insulation, rated for continuous duty, high staring torque, squirrel cage, 3(three) phase induction electric motor of rated capacity suitable for operation on 400/440 volts, 3 phase, 50 cycles / sec. A.C. power supply, 40% CDF, 150 starts/hr and outdoor type duty conforming to IS 325 (latest edition) or equivalent. The motor shall be suitable for reversing frequent acceleration and mechanical braking. The break-down torque of the motor at rated voltage shall not be less than 2.25 times i.e. 225% of the rated torque .During this condition, for checking the components of hoist and the hoist supporting structure, the starting efficiency of the system shall be taken into account. The motors shall be so located that the bush, gears and terminals are readily available for inspection and maintenance with proper ventilation. The motor chosen shall be of standard make easily available in the market and shall have rated speed not more than 1000 rev./ minute. Motors especially designed for the purpose shall not be accepted.

c) Electro-Magnetic Brakes

The electro-magnetic brakes shall be of spring set, shoe type solenoid operated and continuously rated. These shall be effective in both directions of travel and shall be capable of overcoming at least 150% of the full load torque exerted by the motor.

The brake shall set automatically, when the current is cut off from the motor and shall be electrically released, when the current is applied to the motor. The brake shall be equipped with a hand operated release lever and a weather proof cover complete with heaters to prevent the condensation on moving parts Hydraulically operated thruster brakes may also be used.

d) Pushbutton Switch

A pendant pushbutton switch shall be provided for the control of hoist. Control switch shall include for gate “Raise” and “Lower” pushbuttons and gate “Closed”, “Open”, lights and a led type position indicator (meters and centimeters), The pushbuttons shall be of the type with spring return to the “Off” position. The motion shall stop when the pushbutton is released.

e) Limit Switches for Diversion Conduit Gate

The hoist shall include limit switches for the upper and lower end position of the hoisting block, and for both ends of the trolley travel. The cams shall be furnished with mounting brackets, which are required for operation of the trolley travel limit switch.

29.13.6. Control Equipment

The hoist mechanism shall be complete with one control panel with push buttons, which shall be suitably labeled as 'Raise', 'Stop' and 'Lower' Lamps to indicate the condition of the control circuits and directions of motion may be provided.

The hoist shall be provided with all necessary relays, starters, heaters, if required, fuses, limit switches, indicating lights complete with suitable wiring so that all the functions are carried out smoothly.

All the controls shall be so inter-locked that the proper functioning of individual parts for the purpose is ensured. The wiring shall be as per relevant standards.

29.13.7. Hoist Power Supply

The hoist power supply shall be through a festooned cable arrangement. The cable shall extend the entire span of the monorail and be connected to supplied power outlet. All connectors, insulators, and brackets shall be supplied with the hoist.

29.13.8. Inter - Locking and Earthing

All electrical equipment shall be provided with Off Position Inter-locking and earthing arrangement in terms of provisions contained in IS 3043.

29.13.9. Enclosures

All hoist machinery shall be enclosed in weather-tight machinery housing.

29.13.10.Monorail Support Brackets

The monorail support bracket and trestle shall be made of structural steel (weldable) conforming to IS 2062 (latest edition) and shall be designed to withstand the dead weight of the hoist, hoisting load as well as vibrations coming on the hoist, while in operation. Suitable anchorages for the monorail support bracket frame shall be provided to take the worst combinations of all loads under which the gate and hoist are under operation .The monorail support bracket and trestle shall be either in riveted or welded construction. Diaphragms shall be provided to distribute the loads to the sides properly. Shop connection in the frame shall be either riveted or welded. The structure shall be designed for each of the following combinations.

i) Dead loads plus live load, impact load, wind load @ 50 kg / sq. m and crowed load @ 500 kg/ sq. m on entire area of walkway.

ii) Dead load with no hoisting load plus effect of storm wind load @ 150 kg/sq.m.

iii) Breakdown torque of the motor as specified in the manufacturers catalogue. The permissible stresses as specified in IS 800 for normal operation shall be increased by 33-1/3 %.

29.14. Lifting Beam

Lifting Beams one number each are proposed for operation of following stoplog panels:

i) Orifice Spillway Stoplog panels – 1 No (suspended from the gantry crane)

ii) Upper Spillway Stoplog panels – 1 No. (suspended from the mono-rail crane)

A beam (with gripping mechanism) suspended from the gantry crane / mono-rail crane and moves vertically in the gate groove for lifting or lowering of stoplog is called "Lifting beam". The lifting beam shall be of adequate capacity for operating all the stoplog panels and shall be fabricated out of structural steel as detailed below:

Since the stoplogs are lifted and lowered under water, the lifting beam shall be so designed that it can automatically hold the lifting pin of the panel when the lifting beam is lowered by the crane to the top level of the gate. Further suitable locking arrangement shall be provided so that the lifting beam locks the lifting pin once it holds the hook of the beam. The lifting beam shall unlock the locking arrangement of the hook when the panel sitting on the sill beam. The lifting beam shall be provided with guide rollers suitable for lowering and rising along the side guide tracks provided in the gate slot.

The lifting beam shall be designed as per IS: 13591 (latest revision). Impact factor of 1.3 shall be considered. Hooks shall be of forged steel. The pins for lifting beam shall be corrosion resistant steel conforming to IS: 1570 (part V) (latest revision).

Stoplog panels are placed and removed by means of gantry crane, which moves on rails (including storage pit and parking area) fixed on the spillway road bridge and with the help of lifting beam. The lifting beam is provided with lifting hooks operated by a system of levers and counter weight. It operates as follows:

a. To remove the panel – the lifting beam is suspended by the gantry crane and the counter weight is set to the position 'close'. The beam is introduced into the guides and lowered till it hits the panel. The beam hooks then slide their sloped faces over the suspension lug holes, when by action of the counter weight; the hooks regain the vertical initial position, fastening the panel.
b. To place the panel – with the panel suspended by the lifting beam, the counter weight is moved to the position 'open'. The panel is introduced into the guides, being lowered until it reaches the lowest point of the guide length. Carrying on the lowering of the beam, the hook ends disengaging from the lifting lugs and the counter weight commands the opening of hooks, releasing the beam.

29.15. Recommended Materials

i) The material generally used for different parts of gate and associated equipment are given below in table. All the materials being procured shall be of tested quality, new, unused, and free from defects and of the grade designation/ classification envisaged in the designs and shall conform to latest relevant Indian Standards or equivalent standard/ make. The bidder should furnish the test certificates for each lot of material, if so required by the employer. Plates with laminations discovered during welding or during inspection shall be rejected. Materials not supplied according to the approved designs/ drawings shall be rejected at any time and needs replacement. Approval of employer shall not relieve the manufacturer from the responsibility of supply of suitable materials.

Decision regarding adopting particular equivalent standard/make shall be made by UJVN Limited or their authorized consultant and shall be binding on the bidder.

ii) Sectional weight

The difference between scale weight & sectional weight will be on the bidder's account and the bidder should consider this aspect while quoting the rates in the bid.

29.15.1. Orifice Spillway Radial Gate

As a general guidance materials used for various items of gates are given below.

Table 29.15-1 : Radial Gate

Components/ Parts	**Material specification/ Grade**	**Reference code (latest edition)**
Skin Plate (submerged gate)	Stainless steel -X04Cr19Ni9 (type AISI 304)	AISI304/IS 1570 Part 5
Structural gate parts-HGs, Arms,	Structural steel –Grade Designation E 350/410 Quality BR	IS 2062 -2011
Anchor rods for bracket	Forged carbon steel class 5 Designation 55C8	IS 2004
Trunnion Bracket	Structural steel –Grade Designation E 300 Quality BO	IS 2062-2011
Trunnion hub	Carbon steel casting Grade 340 -570 W	IS1030
Trunnion bush bearing	Self-lubricating plain bush bearing C 86300 (Lubron/ Ferolube/ Devaglide)	ASTM B22 Bronze Alloy
Trunnion axle/pin	Corrosion resistant stainless steel casting Grade Designation X20 Cr13 (420S1)	IS 6911
Guide roller	Carbon steel casting Grade 340 -570 W	IS1030
Seal seats for bottom, sides and top	Stainless steel plates (X04 Cr19 Ni9) (annealed)	IS 6911
Rubber seals	Natural or synthetic rubber/ Teflon cladded	IS 11855/IS15466

29.15.2. Stoplogs (Orifice spillway / Lower spillway)

As a general guidance materials used for various items of gates are given below.

Table 29.15-2 : Stoplogs (Orifice spillway / Lower spillway)

Components/ Parts	**Material Specification/ Grade**	**Reference Code (latest code)**
Structural gate parts- skin plate, horizontal girders, vertical girders, stiffeners & seal clamps.	Structural steel –Grade Designation E 350 Quality BR	IS 2062-2011

Components/ Parts	Material Specification/ Grade	Reference Code (latest code)
Embedded parts-sill beam, track base, side guides, seal seat bases & anchor bolts.	Structural steel –Grade Designation E 250 Quality A	IS 2062
Track plate	Corrosion resistant steel X20 Cr13 or X30 Cr30 (Q+T)	IS 6911
Seal seats for bottom, sides and top	Stainless steel (X04 Cr19 Ni9) (annealed)	IS6911
Guide roller	Carbon steel casting Grade 340 -570 W	IS1030
Sliding/Thrust pads	Aluminium bronze Grade AB2	IS 305
Rubber seals	Natural or synthetic rubber/ Teflon cladded	IS 11855/IS15466
Lifting beam hooks	Carbon forged steel class 4 Designation 45C8	IS 2004
Filling valve	Carbon steel seamless tube Grade B	ASTM A53
Stem	Corrosion resistant steel X20Cr13 or X30Cr13 *Q+T)	IS 6911
Spring	Spring steel	IS 6527

29.15.3. FIXED WHEEL GATE (UPPER SPILLWAY SERVICE GATE / INTAKE BULKHEAD Gate)

As a general guidance materials used for various items of gates are given below.

Table 29.15-3 : Fixed Wheel Gates (Upper Spillway Service Gate / Intake Bulkhead Gate)

Components/ Parts	Material Specification/ Grade	Reference code (latest edition)
Structural gate parts- skin plate, horizontal girders, vertical girders, stiffeners, seal bases & seal clamps.	Structural steel Grade designation E 350 Quality BR	IS 2062-2011
Embedded parts-sill beam, track base, side guides, seal seat bases & anchor bolts.	Structural steel Grade designation E 250 Quality A	IS 2062
Track plate	Corrosion resistant steel X20 Cr13 or X30 Cr30 (Q+T)	IS 6911
Seal seats for bottom, sides and top	Corrosion resistant stainless steel (X04Cr19Ni 9) (annealed)	IS6911

Components/ Parts	Material Specification/ Grade	Reference code (latest edition)
Wheel	Carbon forged steel or Carbon steel casting	IS 2004/ IS1030
Wheel axle/pin	Corrosion resistant steel Grade X20Cr13 or X30Cr13	IS6911
Wheel bush bearing	Self-lubricating bush bearings C93200 (Lubron/ Ferolube/ Devaglide)	ASTM B 271 Lubron/Devaglide/ Ferolube
Rubber seals **(Intake Bulkhead Gate)**		
a. Sides	Double Stem Music note type 44mm dia, Teflon cladded	IS 11855/IS15466
b. Bottom	Wedge type	IS 11855
Rubber seals **(Upper Spillway Service Gate)**		
a. Sides	Single Stem Music note type 44mm dia (hollow bulb), Teflon cladded	IS 11855/IS15466
b. Bottom	Wedge type	IS 11855

29.15.4. Butterfly Valve

As a general guidance materials used for various items of Butterfly Valve are given below.

Table 29.15-4: Butterfly Valve

Components/ Parts	Material Specification/ Grade	Reference code (latest edition)
Body, Disc	Ductile Iron	
Cover, End cover, Seal retainer ring	Stainless steel	
Key, Bolt, socket head, set screw, screw	Stainless steel	
Bearing	Steel, PTFE coated	
Spacer, Thrust Bearing	Bronze	
O-r ing, Gasket, disc seal	EPDM rubber	

29.15.5. Hydraulic hoist

As a general guidance materials used for various items of hoists are given below:

Table 29.15-5 : Hydraulic Hoist

Components/ Parts	**Material specification/ Grade**	**Reference code (latest edition)**
Hoist supporting frame and anchor bolts	Structural steel Grade Designation E 350 Quality BO	IS 2062-2011
Cylinder tube/shell	Cold drawn seamless steel tube Grade Designation E 410 Quality C/ st52	IS 2062 DIN-1629
Lower & upper Cylinder heads	Structural steel Grade Designation E 410 Quality C/st52-3	IS 2062 DIN-1629
Stem rod	Carbon steel with ceramic coating 250 microns minimum-42 Cr Mo4 or Corrosion resistant steel with chrome coating not less than 50 microns-Grade Designation X04 Cr18 Ni10 Ti	DIN 1.7225/EN 10083, DIN17440, Mat No. 1.4057 or any other eqvt. Material IS 6911
Piston	Carbon steel, 42 Cr Mo4	DIN 1.7225/EN 10083 IS 2062
Rod bearing (or guide)	Luytex C 320/ Bronze with PTFE	
Piston rings	Manganese bronze/ Synthetic PTFE	IS 318
Glands, Clevis Bushing	Manganese bronze/ Synthetic PTFE	IS 318
Bushings, bearings	Aluminium bronze	IS 305
Shafts & Keys	Corrosion resistant steel	IS 6911
Clevis pin	Corrosion resistant steel Grade Designation X04 Cr18 Ni10 Ti	IS 6911
Hydraulic seals (O rings, chevron seals)	Synthetic rubber	
Hydraulic piping	Cold drawn seamless steel tubes	AISI304L
Pipe fittings	Forged steel	IS 2004
Studs, bolts, nuts & washers	Carbon steel/ stainless steel	IS1367/ IS1570
Hydraulic oil	Mineral oil (class 8) V 32, VG 46, VG 68	NAS 1638
Hydrualic Power Unit	**Manufacturer**	
Oil tank	Stainless steel x04Cr19Ni9	IS 6911
Electric motor	Siemens/Kirloskar or equivalent	
Double gear pump	Rexroth or equivalent	
Hand pump (300 bar)	Rexroth/Dowty	
Flow control valve	Rexroth/Hydac/Yuken	

Components/ Parts	Material specification/ Grade	Reference code (latest edition)
Pressure relief valve pilot operated	Rexroth/Yuken	
Direction control valve	Rexroth/Yuken/Hydac	
Solenoid valve	Rexroth	
Check valve	Rexroth/Yuken	
Spherical shut-off valve	Hydac	
Neeedle valve	Hydac	
Pressure & return line filters	Hydac/Hydax	
Pressure switch	Rexroth/ Hyd.Air	
Oil level indicator	Hydac/Hydax	
Clogging indicator (Electrical)	Rexroth/Yuken	
Air breather	Hydax	

29.15.6. Rope Drum Hoist

As a general guidance materials used for various items of hoists are given below:

Table 29.15-6 : Rope Drum Hoist

Components/ Parts	Material specification/ Grade	Reference code (latest edition)
Hoist base frame, trestles, cross girders, stiffeners, bracings, base plates, anchors, etc.	Structural steel Grade Designation E 250/350 Quality BR	IS 2062-2011
Walkway platform	Chequered plates (min 8mm)	IS 3502
Hand railing and post	MS pipe (medium duty)	IS1239
Steel wire rope	6x 36 or 6x 37 Fiber main core, galvanized	IS 2266
Rope sockets	Drop forged steel	IS 2485
Rope Drum	Carbon steel casting Grade 340-570W	IS1030
Gears	Carbon steel casting Grade 340-570W	IS1030
Pinions	Carbon forged steel class 5 Grade 55C8	IS 2004
Pulleys	Carbon steel casting Grade 280-520 W	IS 1030

Components/ Parts	Material specification/ Grade	Reference code (latest edition)
Shafts	Carbon forged steel class 5 Grade 55C8	IS 2004
Bushings	Aluminium bronze Grade AB 2	IS 305
Plummer blocks	Cast iron	IS 210

29.15.7. Gantry crane/ Monorail crane & Lifting beam

As a general guidance materials used for various items of gantry are given below:

Table 29.15-7 : Gantry Crane / Monorail Crane & Lifting beam

Components/ Parts	Material Specification/ Grade	Reference code (latest edition)
Columns, gantry girders/ mono-rail crane, bracings, stiffeners, base plates, wheel bogies, etc and lifting beam structural parts	Structural steel Grade Designation E 250 Quality BR	IS 2062-2011
Walkway platform	Chequered plates (min 8mm)	IS 3502
Hand railing and post	MS pipe (medium duty)	IS1239
Steel wire rope	6x36 or 6x37 fiber core, galvanized	IS 2266
Rope sockets	Drop forged steel	IS 2485
Rope Drum	Carbon steel casting Grade 340-570W	IS1030
Gears	Carbon steel casting Grade 340-570W	IS1030
Pinions, Lifting hook, Latch plate	Carbon forged steel class 5 Grade 55C8	IS 2004
Pulleys	Carbon steel casting Grade 280-520 W	IS1030
Shafts	Carbon forged steel class 5 Grade 55C8	IS 2004
Lifting hook pin	Corrosion resistant stainless steel	IS 1570 part V
Bushings	Aluminium bronze Grade AB 2	IS 305
Plummer blocks	Cast iron	IS 210
Long travel track rail	Rail section (45 kg/meter length)	IS 3443

29.16. Instrumentation & Remote Control System

29.16.1. General

This chapter covers the complete instrumentation & control (I&C) equipment to be designed, supplied and installed by the Bidder.

Requirement specified within this section shall take precedence over other stipulated requirements.

Even if not specifically required by this specification, but required for the proper and efficient functioning of the equipment, the Bidder shall include supply and installation of such items.

The component of Remote Control System shall be of latest state of Art in technology.

29.16.2. Object and Limits of Supply

The Bidder shall supply and install all apparatus, terminal boxes, etc. necessary to make the distribution services to complete and ready for operation.

The main items of control & equipment to be supplied and installed under this section comprise the following:

A. **PLC based Remote Control System** complete in all respects consisting of one operating station located in Dam control room (DCR) to be supplied, installed and commissioned shall envisage the following control functions and indications:

- Individual control and operation of orifice spillway radial gates.
- Individual gate opening height indications of orifice spillway radial gates.
- Auto / manual operation indication.
- Gate opening / flash lamp indication with suitable alarm for orifice spillway radial gates.
- Gate closing and flash lamp indication with suitable audible alarm for spillway radial gates.
- Reservoir water level indication on continuous display mode in digital form with alarm where water level starts exceeding FRL and when water level starts receding. (Levels shall be decided during detail design).
- One uninterruptible power supply (battery backup) to provide back up (minimum 30 minutes) to the system in case of failure of main power supply to equipment.
- Two (2) sets of water level measuring and indication Equipment at dam area along with necessary alarms.

B. **Instruments not part of PLC system** shall also be provided at their respective locations complete in all respect:-

Differential pressure measurement and indication equipment across intake trash rack–One (1) set

Electronic measuring system to indicate achieving of balance head condition across:

- Orifice Spillway stoplogs : Two (2) sets
- Intake bulkhead gate : One (1) set

C. **Main distribution board & feeder pillar for all HM equipment**

- Main distribution board shall be provided at dam site near Diesel Generating Room for 415/230V AC power supply for Spillway gates, Automatic remote control system, Intake bulkhead gate. Feeder pillars shall be provided in the vicinity of respective local control panels of above gates. Cables between main distribution board and feeder pillar shall be in the scope of the Bidder.

- Additional contacts shall be provided in DCR for communication of status of gates (position indication) for spillway radial gates.

29.16.3. Design Criteria

The specified measuring system shall provide the data (reservoir level, gate position and spillway discharge) to determine the three above mentioned parameters by the main computer in the DCR (Dam Control Room).

Design data:

Rated voltage	230 V AV/110V DC
Maximum ambient temperature	37 degree
Degree of protection for panels	IP 54
Degree of protection for transducers	IP 67
Special treatment	Tropicalized
Transmitter output signal analog	4-20 mA (2 wire)

29.16.4. Equipment for Remote Control System

All the necessary transducers and instrumentation, terminals, contacts, cabling etc. for above at various locations shall be provided and incorporated in the control system.

Operator station shall include Operator's console consisting of PC of latest configuration CD writer and colour CRT (51cm) screen with push buttons for operation and video screen, which indicate the gate movement. The operator shall be able to view the gate positions or any gate status with the help of graphic display in the screen.

The Operator station shall have two controllers each backing up the other so that the failure of one of the controller shall not cause any discontinuity in the control system and shall ensure that no loss of data takes place during change over. The system shall also have a colour laser printer (minimum capacity 300cps) for printing various logs, instructions and reports. Interlocking shall be provided between Operator's station and local control panels.

All the input display from field including water level of reservoir shall be displayed at the CRT screen. The system shall continuously monitor the reservoir level and depending upon this level it shall be able to calculate the input discharge into the reservoir. In addition to this the gate opening of spillway radial gates should be displayed in the form of graphic display. The system shall be able to display the output discharge through spillway radial gates so that operation of spillway radial gates can be carried out in auto mode.

29.16.5. Video Screen Display (VSD)

Video Screen Display with at least 70-inches diagonal screen of resolutions at least 1400 X 1050 pixels having front access for the maintenance (without opening the screen) shall be provided. The VSD shall be fed by digital rear projector having rear projection and shall be connected to dedicated operator station (without monitor) in order to display any of the control system views. The VSD will have the hot swappable redundant lamp system to provide an uninterrupted image in case of lamp failure. The lamp life of VSD should not be less than 8000hrs (median). The concerned operator shall select the views from the available dam area gates control views from the workstation. The luminance shall not be less than 110 cd/m2 (typical) with screen having half gain angles of +450 vertical / horizontal. The contrast ratio will be 1600:1. The VSD shall be provided with necessary mounting frame.

29.16.6. Reservoir Water Level Measuring System

The Bidder shall design, supply and install best quality Level sensors at the following points.

Two (2) nos. Sensors of non-contacting micro wave type water level measuring equipment for dam area with electronic water level transmitter shall be provided. Sensors shall be multiple types to evaluate the water level from a minimum EL919.00 m to EL 980.50 m (0.5m above FRL), housed in a weatherproof enclosure, shall be provided one at the water level gauge well located at the right abutment of the spillway and other at the extreme left end of the Intake.

Reservoir levels shall be monitored from the two level transmitters at two different locations to obtain an average position of actual reservoir level. If any of the level sensors provided at any of the points falls defective or giving erratic reading, the other sensor shall govern the signals and Reservoir control and hence both the sensing units shall be compatible. Fault detection shall be displayed in the remote as well as local control panels.

The water level detector shall be of radar type water level measurement sensor and shall consist of necessary accessories.

The sensor shall be very sensitive to transmit the water level considering the fact that these sensors are to work under very heavy silt laden water.

The sensor shall be continuous monitoring type and shall have accuracy of +1cm or less.

The Reservoir water level signals shall be available in digital form at all respective control panels of spillway radial gates.

The signal shall be made available at remote operation panel at Dam Control Room. Facility should also be provided for tapping the water level signals along with gate level indication of the following equipment for further transmission to powerhouse control room with alarm signals by way of current signals at all respective control panels of spillway radial gates.

29.16.7. Screen Head loss Equipment

Two (2) set of screen head loss equipment for intake trash rack shall be supplied to detect head differences and be installed into 300 mm dia embedded pipes at the upstream and downstream side of the trash racks. The pipes shall be provided by the Bidder but fixing will be in the scope of civil Bidder.

The accuracy of the equipment shall be+1cm, or less.

All necessary instruments, interconnecting wiring, pipe work, housing, cabling, panel, etc., shall be provided according to the type of equipment proposed to supply in Tender and accepted in the Contract.

Screen head loss shall be measured by pressure difference between the upstream and downstream sides of the trash rack. This pressure difference shall be sensed by comparing with reservoir pressure at the upstream side of the trash rack versus pressure just behind the trash rack.

The indicator shall be provided at a remote panel mounted in the Dam control room and shall indicate from 0 to 2m head loss. At 0.5m head loss a flushing beacon shall be activated which shall continue to give visual alarm until the necessary remedial action has been taken. At 1.0 m head loss a klaxon shall be activated which can only be muted by an authorized operator inserting and turning a special key in the control panel. It must not be possible to withdraw the key in this position.

29.16.8. Gate Position Measuring System

Process Indicator and transducers shall be provided for gate position measuring and indication of spillway radial gates.

29.16.9. Tele-metering and Supervisory Control

The Bidder shall provide the digital transmitters and indications, and terminals strips via the bus system.

(a) Tele-metering Items

- Digital type gate position indicatorss.
- Digital type water level indicator.
- Digital type inflow measurement instrumentation
- Digital type computing system

(b) Supervisory Items

Dry contacts shall be provided for signal transmission to the DCR for all alarms and indications of gate mentioned above. These shall include, but not limited to, the following:

- A.C. fault
- Common Alarm
- O/L Trip
- Open
- Close
- Stop
- Remote/Local

29.16.10.Automatic Reservoir Measuring and Control System (ARMAC)

29.16.10.1. GENERAL

The ARMAC computing and control system shall be situated in the Dam control room (DCR) and shall be provided by the Bidder.

The local control and computing system for the spillway shall be able to calculate the actual spillway discharge depending from reservoir water level and gate opening. The system is to be mounted in the equipment control cabinet (ECC).

The local computing system shall be interconnected with the latest industrial grade computer with monitor not less than 51 cm sizes in the DCR, from which the command for the necessary discharge on the spillway shall be provided. All signals shall be sent and received to/from the DCR. Operating system shall be Windows 2013 or latest.

A PID-master controller shall define the required total gate opening. Indication of actual discharge passing through various gates (spillway radial gate) in cumecs, formula for single gate opening and the number of gates open shall be indicated for calibration. This indication shall be available on demand as well as at regular intervals for login. However to prevent hunting of hoist the deviation should be beyond the preselected tolerance band.

In a selection circuit the ‘open’ - instruction shall be transferred to the gate, which at the time of the comparison controls the smallest opening. Similarly, a ‘close’ - instruction shall be given to the gate controlling the largest opening.

For the gate selection, only the gates shall be considered, of which the manual switches are in the ‘Automatic’ position, and where no alarm signal has been received from, the ‘open’ or ‘close’- instruction shall remain with the selected gate, unless any of the following conditions is met:

- The required and actual openings agree and the positioner cancels the instruction, or
- The gate had previously reached its limit position, or,
- The max. Permissible deviation (pre-set difference in position between controlled gate and average of all gates available) has been reached previously.
- The selected gate is not in operating condition.

In the event of major changes in required size of opening, the gates shall be moved successively one step each, i.e. after re-setting all gates again agree within the pre-set margin in size of opening. After all available gates have reached their limit positions a corresponding signal shall be given.

At any individual gates shall be allowed to be switched over from the automatic mode to manual mode of operation, and vice versa, however the operation from the local panel cannot be overruled by the remote / automatic operation stage. Adjustments made manually are to be automatically compensated for with the other gates by the automatic control system.

Manually adjusted gates shall, when returned to automatic mode of operation, be adapted to their normal functioning in the automatic mode. The automatic system shall work independent of the number of available gates with the same characteristic. If all gates have been changed over to MANUAL, the master controller shall be reset so as to permit a smooth switching-over to AUTO operation.

The system is to be designed to monitor the duration of the instruction. The monitoring is to prevent, that an instruction is maintained over a period, that is longer than a pre-selected time, e.g. in the event of a malfunction of gate selected by the controller, if the monitoring system is actuated, the particular gate is to be cancelled from the group of the gates available for selection.

Following additional features shall also be incorporated/provided in ARMAC system:

- Cycle time of about 1.5 to 2 seconds for updating the data.
- Continuous monitoring and recording of reservoir level discharge through gate openings (height) etc.

- Complete surge voltage protection at remote due to isolation of inputs leads from the systems/Grounds.
- Real time clock and calendar.
- Runtime self-check features and system malfunctioning detection.

29.16.11.Discharge calculation

The discharge rate per gate is to be computed by electronic means. Water level measurement and measurement of the gate position and inflow velocity serve as input variables.

The necessary discharge rating curves shall be agreed with the Song Dam Drinking Water Project Resentative. The discharge rates shall be added and be displayed digitally as total water discharge rate, which shall also be recorded graphically.

29.16.12.Registration

Registration and recording of all available values shall be in the DCR (Dam Control Room).

29.16.13.Main distribution system Board

General

The 415 V board switchgear shall be metal enclosed indoor cubicles free floor standing type.

The cubicle assemblies shall be designed in accordance with the recommendations of IEC Publication 60439-1 with protection class IP 55 according to IEC Publication 60529. The assemblies must be built to suit the equipment shown on the single line diagram. Hinged doors and removable covers shall be provided wherever necessary to allow access to all equipment. The frame of the cubicles shall be sufficiently sturdy and the metal sheeting of sufficient thickness to ensure safe transport, mounting and operation without deformation or bulging. Natural ventilation as required shall be provided. Provision for future expansion of cubicles shall be made in end cubicles.

Continuous lifting angle or lifting hooks shall be provided to facilitate the installation of the cubicles.

Name plates

Each feeder shall be clearly identified with suitably located nameplate(s). Nameplates shall be furnished for all instruments, control switches, etc. Each section of an assembly shall have an identifying nameplate placed near the top edge.

Bus bars

The bus bars of Main distribution system shall have adequate continuous current carrying capacity. Bus bar conductors shall be made of copper. All connections shall be in accordance with the best modern practice.

Phase arrangements shall be R-Y-B from top to bottom, from back to front and from left to right when facing the front of the equipment. All bus bars shall be clearly marked by engraved letters.

Adequate provisions must be made for the expansion and contraction of the bus bars and other bus bar connections with variation in temperature. Bus bars shall be so arranged that they can be extended in length without difficulty.

29.16.14. Air Circuit Breakers

General

The air circuit breakers shall be designed in accordance with the recommendations of IEC Publications 60947.1 and 60947.2. All circuit breakers shall be of the draw out type, housed in individual metal-enclosed compartments. Each air circuit breaker shall be mounted on a carriage assembly with wheels running on tracks secured to the inside of the compartment.

The air circuit breakers shall be three pole electrically operated with motor driven stored-energy operating mechanism. The motor for operating the spring loading device shall be for 220 V D.C. supply. The closing and tripping coils shall be for 220 V DC.

The operating handle shall be located so that the air circuit breakers can be operated without opening the compartment door. A mechanical interlock shall prevent moving of the air circuit breaker from the connected position, while the breaker is closed, and prevent the access door being opened unless the circuit breaker is in test or withdrawn position.

Contacts

The main circuit breaker contacts shall be of the self-cleaning type, made from an arc resisting material and provided with auxiliary arcing contacts as a protection against burning during the operation of the breaker. All contacts shall be self-aligning, and shall be readily replaceable.

Main and secondary disconnecting contacts shall be silver plated with springs, which will ensure high-pressure contacts. Auxiliary contacts for position indication, control, interlocks, etc., showing whether the breaker is in open, closed or tripped position and whether the operating spring is locked, shall be provided and wired to terminals.

Protection

The air circuit breakers shall be equipped with adjustable magnetic short circuit over current and instantaneous trip mechanism/ relay, with auxiliary magnetic short circuit contacts for indication of tripped condition. The protection equipment shall be interchangeable.

29.16.15. Moulded Case Circuit Breakers

General

The MCCBs shall be designed in accordance with the IEC Publications 60947.1 and 60947.2. All MCCBs shall be manually operated and shunt trip type.

All MCCB shall be of the draw out type, housed in individual metal-enclosed compartments. Arrangement shall be provided for easy removal and handling of the units. ON, OFF TRIP position of MCCBs should be indicated.

A mechanical interlock shall prevent moving of the MCCB from the connected position, while the breaker is closed, and prevent the access door being opened unless the breaker is in withdrawn position.

Contacts

The MCCB contacts shall be of the self-cleaning type, made from an approved arc resisting material. All contacts shall be self-aligning, and shall be readily replaceable.

Main and secondary disconnecting contacts shall be silver plated, with spring, which will ensure high-pressure contact.

Current Transformers

The Contractor shall provide single-phase current transformers manufactured in accordance with IEC Publication 60044-1.

Required no. of single core current transformers for each main air circuit breaker coming from unit auxiliary transformers and Station service transformers for protection and measuring:

Accuracy class

Over current and E/F: 5P20

Interlocks

The breakers connecting the Board shall be interlocked mutually in order to prevent paralleling of the supply during normal operation. Interlocking scheme to prevent parallel operation of main supply and DG set supply shall also be provided.

29.16.16.Inspection and Shop Testing

Shop test

All equipment shall be checked by the Contractor in order to ascertain their correct functioning and shall be witnessed by the Project Authority Representative.

Field test

Tests to be performed shall include, but not be limited to, the following:

- Checking sensitivity of transducers, water level transmitters, shaft encoders etc.
- Checking of sensitivity of all Equipment.
- Checking of correct functioning and correct calibration of all Equipment.
- Automatic operation of the gates shall be tested "dry" by simulating various reservoir elevations at the level-sensing equipment.

29.17. Local Control System

It shall consist of complete set of local controls for all equipment near their installation.

All electrical equipment shall be designed for use in a tropical climate. In order to avoid operational errors and accidents, the hoisting equipment of all gates shall be equipped with an electrically operated emergency stop such that all operations of the machine are stopped on pushing of an emergency stop button.

Wherever, PLC based local control panel is provided, a parallel hardwired control shall also be provided for open and close commands for gate to cater emergency in case of PLC failure.

Complete wiring of the hoist/ gantry crane electrical equipment and the control device with all cables shall be included, under the scope of the Bidder.

Additional electrical equipment shall comprise the following:

- **A cable reeling drum with a junction box for the power supply and electrical control cables in case of moving gantry crane.**

- **A waterproof control box including a dehumidifying unit located on the hoist/ crane as specified.**

The control box shall house the following equipment:

- **A main selector switch (key operated) for the different modes of operation (local /remote and automatic).**
- **Controls comprising push buttons and relays (including overload and under voltage relays for motor) for manual/ remote and automatic as the case may be.**
- **A position indicator showing the exact position of the gate (in case of fixed rope drum hoist).**
- **A position indicator showing the exact position of the gate/ Stoplogs (in case of gantry).**
- **Various alarms to indicate the operating faults.**
- **A transformer for the control instruments with potential separation.**

In addition to above, necessary instrument required for control and measurement is to be provided by the supplier.

The following instruments but not be limited to, shall be mounted on or within the control cabinet:

- Incoming supply Moulded Case Circuit Breaker.
- Source voltmeter.
- Source pilot light.
- Load ampere meters.
- Starter for each motor.
- 230V-15A convenience outlets, from own transformer 415/230 V supply.
- "Gate fully raised" indicating light.
- "Gate fully lowered" indicating light.
- "Gate stopped at intermediate position" indicating light.
- "Raising" indicating light.
- "Lowering" indicating light.
- "Light test" push button for inspection of all indicating lights.
- Gate position indicator
- Space heater to prevent moisture condensation with hydrostat
- Moulded case circuit breakers to protect each motor circuit and other circuits.
- All other necessary transformers, relays, contactors, switches, push buttons and miscellaneous wiring components.

Following additional indications/equipment shall be provided for Gantry crane / Monorail Crane

- "Gantry crane / Monorail Crane traveling in left direction" indicating light.
- "Gantry crane / Monorail Crane traveling in right direction" indicating light.
- "Gantry crane / Monorail Crane stopped" indicating lights.
- "Trouble conditions" indicating lights.
- "Multi-step speed controller for traveling equipment.

29.18. Hydraulic Oil filtering unit

Oil purifier unit for spillway radial gate power packs shall be provided to purify the hydraulic oil. It shall be complete in all respect including oil hoses (of sufficient length and size) and hose connector etc. to connect the oil purifier to hydraulic power units (HPU). The hydraulic oil purifier shall be electrostatic liquid cleaner type. The capacity of purifier shall be 15-17 Liter/hr. After purification the size of the suspended particle should not be more than **5µm**. The oil may contain suspended impurities such as cotton, waste, welding slag and spatters, metallic chips, small sand particles, iron fitting pebbles, dust and scale particles. The oil may also contain grease and kerosene, which shall be required to be removed. The offered equipments shall not be damaged by the flow of oil containing these impurities. Unit shall be supplied along with **(1 set)** paper and other consumable required for 1 year of successful operation of machine.

One no. of Low vacuum dehydration & degasification unit for radial gate power packs shall be provided to remove water and dissolved gases from the hydraulic oil. The oil may contain free and dissolved moisture of the order of 500 to 600 ppm initially, which needs to be reduced in the range of **50 ppm**. The capacity of the vaporizer shall not be less than 50 liters and capacity of vacuum pump shall not be less than 50 liters/min.

One unit of contamination checking kit (for checking of contamination level) shall also be provided with the machine.

29.19. Mobile Power pack

One number petrol engine operated portable (trolley mounted) power pack capable of operating one radial gate at 25% of the rated operating speed from dam top shall be provided to operate radial gate in the event of mains power failure. The pumping set will be connected by hoses with quick connect/disconnect couplings to the main power pack tank and electrically to the local control panel. A battery of suitable capacity will be provided to start the engine when required and an inverter will be provided to provide 230 V supply to the local control panel for operating the solenoids of the power pack. Provision shall be made for charging the battery from normal A.C. mains to keep it in ready to use condition.

29.20. Mandatory Spares

All mandatory spares supplied shall be absolutely interchangeable with each other and with the parts for which they are intended to be replaced. The spare parts shall be treated and packed for long storage under the climatic conditions prevailing at site. Each spare part shall be clearly marked or labeled on outside of its packing with its description and tag number.

The spares are also liable to warranty clause and conditions as stipulated under General/ Particular conditions of contract. All the spares as per the price schedule 3, shall be handed over to the Owner only after completion of erection of equipments (gates, hoists, crane, etc) in all respects and prior to Commissioning of the project. The duration for warranty shall commence after handing over of all spares to the Engineer but not later than from the date of issuance of the Taking –over-certificate.

The Bidder shall check all the spares at site, in presence of the Engineer prior to handing over. The price for each listed spares shall be quoted individually in the Price Schedule 3 (Volume VI). If any additional spares are recommended by the Bidder, these shall be stated in quantity and description in the technical data sheets for each item. Orders for recommended spare parts shall be optional to Song Dam Drinking Water Project.

Table 29.20-1 : Mandatory Spares

Sl.No	Description	Quantity	Unit
1	**Orifice Spillway Radial Gates**		
	Rubber seals for one gate	2	set
	Seal fasteners for one gate	2	set
	Guide roller assembly for one gate	1	set
	Complete seal kit for hydraulic cylinder	2	set
	Bearing for cylinder eye end (both ends)	2	set
	Filter elements (pressure line & return line)	PL-4 RL-4	set
	Pressure relief valve	2	nos
	Pressure gauge	4	nos
	Limit switches for one hydraulic hoist	2	set
2	**Orifice Spillway Stoplogs**		
	Rubber seals for stoplog units	Biottom -1 Inter. -1 Top -1	Set each
	Seal fasteners for 3 stoplog panels	3	panels
	Guide roller assembly	4	nos
3	**Upper Spillway Service Gate**		
	Wheel assembly	1	no
	Grease nipples	1	set
	Rubber seals for one gate	1	Set each
	Seal fasteners for one gate	1	set
4	**Upper Spillway Stoplogs**		
	Rubber seals for stoplog units	Biottom -1 Top -1	set
	Seal fasteners for 2 stoplog panels	3	panels
	Guide roller assembly	4	nos

Sl.No	Description	Quantity	Unit
5	**Intake Bulkhead Gate**		
	Wheel assembly	1	no
	Grease nipples	1	set
	Rubber seals for one gate	1	set
	Seal fasteners for one gate	1	set
6	**Rope Drum Hoist for Upper Sillway Service Gate**		
	Contractor	1	no
	Starter	1	no
	Wire rope	1	no
	Brake liner	1	set
	Brake coil	1	set
	Hoist motor	1	no
	Limit switches	1	set
7	**Rope Drum Hoist for Upper Sillway Service Gate**		
	Contractor	1	no
	Starter	1	no
	Wire rope	1	no
	Brake liner	1	set
	Brake coil	1	set
	Hoist motor	1	no
	Limit switches	1	set
8	**Gantry Crane for Orifice spillway stoplog**		
	Wire rope	1	no
	Brake liner	1	set
	Brake coil	1	set
	Hoist motor	1	no
	Limit switches	1	set
9	**Monorail Crane for Upper spillway stoplog**		
	Wire rope	1	no

Sl.No	Description	Quantity	Unit
	Brake liner	1	set
	Brake coil	1	set
	Hoist motor	1	no
	Limit switches	1	set

29.21. Mandatory Tools and Tackles

The Bidder shall consider to provide the following tools and tackles including special tools required for maintenance, assembly and disassembly as per list detailed below:

A. Two (2) sets comprising of following items / instruments / equipments:

1. Torque wrench (0-150 inch pounds) 3/8 inch square drive.
2. Pipe wrench 12 inches
3. 3/8 inch to 1/2 inch square drive reducer.
4. Screw driver socket 1/2 inch square drive
5. Sockets 1/2 inch square drive
   a) 7/16 inch
   b) 9/16 inch
   c) 5/8 inch
6. Extensions 1/2 inch square drive
   a) 2 inches
   b) 5 inches
7. Combination wrench one end ring and one end open
   a) 7/16 inch
   b) 1/2 inch
   c) 9/16 inch
   d) 3/4 inch
   e) 7/8 inch
   f) 15/16 inch
8. Screw drivers
   a) 4 inches
   b) 6 inches
   c) 8 inches
   d) 12 inches
   e) 15 inches
9. Feeler gauge 4 inches long consisting of many strips
10. Nose plier – 150 mm
11. Circlip removing plier 200mm
12. Combination plier 200 mm
13. Cutting Pliers
14. Heavy duty insulated pliers
15. Tweezer (small)
16. Plastic hammer
17. Half moon spanner 3/8 inch * 5/8 inch
18. Allen key set
19. Ball-pein Hammer 2 lb
20. Hammer 5 lb
21. Mallet (Wooden Hammer)
22. D.E. spanner set 6mm to 32 mm
23. Ring spanner set 6 mm to 32 mm
24. Box spanner with handle
25. Adjustable spanner 12 inches

26. Adjustable spanner 6 inches
27. Socket spanner set 8 mm to 32 mm
28. Lineman's plier 8 inch
29. Spirit level
30. Soldering iron 15W
31. Wire stripper cum crimpling tool

All items 1 to 31, shall be of reputed make like Taparia / Jhalani.

B.One (1) set comprising of following items / instruments / equipments:

1. Digital clamp meter 500V AC/DC, 20Amp AC/DC including Continuity tester and line tester
2. D Sackle 1t capacity
3. D Sackle 2t capacity
4. Chain Pulley block 2t capacity
5. Chain Pulley block 5t capacity
6. Bearing puller

Item 1 shall be of Fluke / MECO / of reputed make and Items 2 to 5 shall be of reputed make and Item 6 shall be of SKF/ FAG/ reputed make.

C. Two (2) Nos. Tool boxes for above **A & B** shall be of good quality.

If any additional tools are recommended by the Bidder, these shall be stated in quantity and description in the technical data sheets for each item. Orders for recommended tools shall be optional to Song Dam Drinking Water Project.

29.22. Reference IS Codes

The following IS codes shall be referred for general guidance for design, fabrication/manufacture, shop inspection, painting, site installation, testing and commissioning of hydraulic gates and hoists.

Table 29.22-1: Reference Codes

Sl. No.	IS code number	Year	Title of the code
1	IS 28	1985	Specifications for Phosphor bronze ingots and castings (fourth revision)
2	IS 305	1981	Specifications for Aluminium bronze ingots and castings (second revision)
3	IS 318	1981	Leaded tin bronze ingots and castings (second revision)
4	IS 325	1996	Three-phase induction motors (fifth revision) (Amendments 3)
5	IS 456	2000	Code of Practice for plain and Reinforced concrete (fourth revision) (With amendment No. 1)
6	IS 800	2007	Code for practice for general construction in Steel (third revision)
7	IS 807	2006	Code of practice for design, manufacture, erection & testing (structural portion) of cranes and hoists (second revision)

Sl. No.	IS code number	Year	Title of the code
8	IS 808 (Part 3)	1989	Dimensions for Hot Rolled Steel Beam, Column, Channel and Angle Sections (third revision) (Amendment 1)
9	IS 1028	1987	Silicon bronze ingots and castings (second revision)
10	IS 1030	1998	Specification for carbon steel castings for general Engineering(fifth revision)
11	IS 1231	1974	Dimensions of three-phase foot-mounted induction motors (third revision) (Amendments 4)
12	IS 1239 (Part 1)	2004	Steel tubes, tubulars and others wrought steel fittings : Part 1 Steel tubes (sixth revision)
13	IS 1239 (Part 2)	1992	Steel tubes, tubulars and other wrought steel fittings : part 2 Steel tubulars and other wrought steel pipe fittings (fourth revision)
14	IS 1363 (Part 1)	2002	Hexagon head bolts, screws & nuts of product grade C : Part 1 Hexagon head bolts (size range M5 to M64) (fourth revision)
15	IS 1363 (Part 2)	2002	Hexagon Head Bolts, Screws and Nuts of product grade C : Part 2 Hexagon head screws (size range M5 to M64) (fourth revision)
16	IS 1363 (Part 3)	2002	Hexagon head bolts, screws and nuts of product grade C : Part-3 Hexagon nuts (size range M5 to M64) (fourth revision)
17	IS 1364 (Part 1)	2002	Specification for Hexagon head Bolts, screws and nuts of product grade A and B : part 1 Hexagon head bolts (size range M1.6 to M64) (fourth revision)
18	IS 1364 (Part 2)	2002	Specification for Hexagon Head Bolts, screws and nuts of product grade A and B : part 2 Hexagon screws (size range M1.6 to M64) (fourth revision)
19	IS 1367 (Part 1)	2002	Technical supply conditions for threaded steel fasteners : Part 1 introduction and general requirement of bolts, screws and studs (third revision)
20	IS 1367 (Part 2)	2002	Technical supply conditions for threaded steel fasteners : Part 2 Tolerances for fasteners , bolts, screws, studs and nuts – product Grade A,B and C (third revision)
21	IS 1367 (Part 3)	2002	Technical supply conditions for threaded steel fasteners : Part 3 Mechanical properties of fasteners made of carbon steel and alloy steel – Bolts, Screws and studs (fourth revision)
22	IS 1367 (Part 5)	2002	Technical supply conditions for threaded steel fasteners : Part 5 Mechanical properties of fasteners made of carbon steel and alloy steel – set screws and similar threaded fasteners not under tensile stresses.(third revision)
23	IS 1367 (Part 6)	1994	Technical supply conditions for threaded steel fasteners : Part 6 Mechanical properties and test methods for nuts with specified proof loads (third revision)

Sl. No.	IS code number	Year	Title of the code
24	IS 1367 (Part 7)	1980	Technical supply conditions for threaded steel fasteners: Part 7 Mechanical properties and test methods for nuts without specified proof loads (second revision).
25	IS 1367 (Part 9)	1993	Technical supply conditions for threaded steel fasteners : Part 9 Surface Discontinuities on bolts, Screws and Studs for general application (third Revision)
26	IS 1367 (Part 10)	2002	Technical supply conditions for threaded steel fasteners : Part 10 Surface Discontinuities on Nuts (third Revision)
27	IS 1367 (Part 12)	1981	Technical supply conditions for threaded steel fasteners : Part 12 phosphate coatings on threaded fasteners (second revision)
28	IS 1367 (Part 13)	1983	Technical supply conditions for threaded steel fasteners : Part 13 Hot dip galvanized coatings on threaded fasteners (second revision)
29	IS 1367 (Part 14)	1984	Technical supply conditions for threaded steel fasteners : Part 14 Stainless steel threaded fasteners (second revision)
30	IS 1367 (Part 16)	2002	Technical supply conditions for threaded steel fasteners : Part 16 Designation system for fasteners (third revision)
31	IS 1570 (Part 5)	1985	Schedule for wrought steels : part 5 stainless and heat resisting steel, (second revision)
32	IS 1608	2005	Metallic material – Tensile testing at ambient temperature (third revision)
33	IS 1875	1992	Carbon steel billets, blooms, slabs and bars for forgings (fifth revision)
34	IS 1893	1984	Criteria for earthquake resistant design of structures (fourth revision) (amendment 1)
35	IS 2004	1991	Carbon steel forgings for general engineering purposes (third revision)
36	IS 2048	1983	Parallel keys and keyways (second revision) (amendment 2)
37	IS 2062	2011	Hot rolled medium and high tensile structural steel (sixth revision)
38	IS 2223	1983	Dimensions of flange mounted ac induction motors (second revision) (Amendments 2)
39	IS 2266	2002	Steel, wire ropes for general engineering purpose (fourth revision)
40	IS 2291	1990	Tangential keys and keyways (third revision)
41	IS 2292	1974	Taper keys and keyways (first version)
42	IS 2365	1977	Steel wire suspension ropes for lifts, elevators and hoists (first revision)
43	IS 2485	1979	Drop forged sockets for wire ropes for general engineering purpose (first revision)

Sl. No.	IS code number	Year	Title of the code
44	IS 2595	1978	Code of practice for Radiographic testing. (first revision)
45	IS 2825	1969	Code for unfired pressure vessels (amendments 5)
46	IS 3177	1999	Code for practice for electric overhead traveling cranes and gantry cranes other than steel work cranes (second revision) (Amendments 2)
47	IS 3658	1999	Code of practice for liquid penetrant flow detection (second revision)
48	IS 3664	1981	Code of practice for Ultrasonic pulse echo testing by contact and immersion methods. (first revision)
49	IS 3681	1995	Gears – cylindrical gears – accuracies.
50	IS 3703	2004	Recommended practice for magnetic particle flaw detection. (second revision)
51	IS 4460	1995	Gears – spur and helical gears – calculation of load capacity. (first revision) (amendments 2)
52	IS 4622	2003	Recommendations for structural design of fixed wheel gates (third revision), Reaffirmed Oct 2013 & Amendment No.2
53	IS 4623	2000	Recommendation for structural design of radial gates (third revision), reaffirmed Oct 2013
54	IS 5669	1987	General plan for boundary dimensions for radial rolling bearings (first revision) (ISO Title : Rolling bearing-Radial bearing-Boundary dimensions-General plan) (amendment 1)
55	IS 5692	1988	Tolerances for radial rolling bearings (first revision)
56	IS 5932	1970	Boundary dimensions for thrust ball bearings with flat seats.
57	IS 5933	2002	Rolling bearing – thrust bearing – tolerances (second revision)
58	IS 6623	2004	High strength structural nuts (second revision)
59	IS 6911	1992	Stainless steel plates, sheet and strip-specifications
60	IS 6934	1998	Hydraulic design of high ogee overflow spillways, Reaffirmed March 2013
61	IS 6938	2005	Code of practice for design of rope drum and chain hoists for hydraulic gates (second revision), Reaffirmed May 2010
62	IS 7307 (Part 1)	1974	Approval test for welding procedures : Part 1 fusion welding of steel (amendment 1)
63	IS 7310 (Part 1)	1974	Approval test for welders working to approved welding procedures: Part 1 fusion welding of steel.
64	IS 7318	1974	Approval tests for welders when welding procedures approval is not required (part 1) fusion welding of steel.
65	IS 7396 (Part 1)		Criteria for hydraulic design of surge tanks

Sl. No.	IS code number	Year	Title of the code
66	IS 7718	1991	Recommendations for Inspection, testing and Maintenance of Fixed wheel and slide gate (first revision)
67	IS 8130	1984	Conductors for insulated electric cables and flexible cords (first revision)
68	IS 9349	2006	Recommendations for structural design of medium and high head slide gates, Reaffirmed May 2010
69	IS 10210	1993	Criteria for design of hydraulic hoist for gates, Reaffirmed Oct 2013
70	IS 13041	2013	Recommendations for inspection, testing and maintenance of hydraulic hoist (after erection) (First revision)
71	IS 11388	2012	Recommendations for Design of Trash Rack for Intakes
72	IS 11855	2004	Guidelines for design and use of different type of rubber seals for hydraulic gates (first revision), Reaffirmed Oct 2013
73	IS 15466	2004	Specification –Rubber seals for hydraulic gates, Reaffirmed Oct 2013
74	IS 13591	1992	Criteria for design of lifting beams, Reaffirmed Oct 2013
75	IS 13623	1993	Criteria for choice of gates and hoists. (amendment 1)
76	IS 14177	1994	Guide lines for painting system for hydraulic gates & hoists, Reaffirmed Oct 2013
77	IS 2062	2011	Hot rolled medium and high tensile structural steel

Other Standards

1	ANSI – B.1.1	Unified Inch Screw Threads.
2	ANSI – B16.11	'Steel Pipe Flanges and Flanged Fitting'.
3	ANSI – B16.11	'Forged Steel Fittings, Socket Welding and Threaded'.
4	ANSI – B31.1	'Power Piping'
5	ANSI – B93.18	'Non Integral Industrial Fluid Power Hydraulic Reservoir'
6	ANSI C1/NFPA 70	'National Electrical Code'
7	ANSI C 37.90a	'Standard Relays and Relays Systems Associated with Electrical Power Apparatus'.
8	ASME Code LOS – 5C1, ASTM–ASME	'Recommended Practices for the Flushing and Cleaning of Oil Systems for Lubrication and control of Hydro Electric Equipment'.
9	ASTM A – 27/A27M	'Specifications for Steel Castings, Carbon for General Applications
10	ASTM A –36M /A36M	'Specifications for Structural Steel'

11	ASTM A 153	‘Specification for Stainless and Heat Resisting Bars and Shapes.’
12	ASTM A 276	‘Specification for High Strength Bolts for Structural Steel Joints’.
13	ASTM A	‘Specification for Heat Treated Structural Bolts. 150 Ksi (1035 MPa) Tensile Strength’.
14	ASTM A572/A572M	‘Specification for High Strength, Low Alloy Columbium – Vanadium Steel of Structural Quality’.
15	JIC Standards	‘Hydraulic Standards for Industrial Equipments’.
16	NAS 1638	‘Cleanliness requirements for Parts used in Hydraulic Systems.’
17	NEMA MG1	‘Motors and Generators.’
18	ASTM A 668	‘Specifications for Steel Forgings, Carbon Alloy for general industrial use’.
19	EN10025:2004	European structural standard steel

30. SPECIFICATIONS – ELECTRICAL

30.1. Electrical Equipment

30.1.1. HT Switchgear

30.1.2. General

This specification covers the requirements of 11kV Switchgear complete with all accessories. Continuous current rating of the Switchgear shall be based on the name plate rating of the connected equipment with 20% margin, rounded off to the next higher standard rating. 11kV Switchgear shall be rated for short circuit withstand capacity of 26.3kA for 3 seconds.

Busbars, breaker and other componentsor continuous operation at rated current considering temperature inside the cubicle. The inside cubicle temperature shall be considered as design ambient temperature for maximum continuous operation rating of the equipment. For breaker control, 110 V DC supply shall be considered.

Each breaker module shall be provided with multifunction numerical relay for protection. Switchgear shall be provided with separate earthing trucks for cable earthing and bus earthing.

30.1.2.1. SWITCHGEAR CONSTRUCTION

Switchgear shall be indoor, single front, single tier, metal-clad, floor mounted, fully draw-out with VCB breaker. Design and construction shall be such as to allow extension at either end. Switchgear cubicle shall be so sized as to permit closing of the front access door when the breaker is pulled out to Test position. The working zone shall be restricted within 750 mm to 1800 mm as from floor level.

Circuit breakers, instrument transformers, bus-bars, cable compartment, auxiliary control devices etc., shall be housed in separate compartments within the cubicle. The design shall be such that failure of one equipment shall not affect the adjacent units. The circuit breaker and bus voltage transformers shall be mounted on withdrawable trucks. In case breaker truck rolls out on telescopic rails suitable trolley shall be provided. All relays, meters, switches and lamps shall be flush mounted on the respective cubicle door or on a control cabinet built on the front of the cubicle.

The trucks shall have distinct ‘Service’, ‘Test’ and ‘Isolated’ positions. The switchgear assembly shall be designed to achieve IP54 degree of protection, with the truck in any position ‘Service’, ‘Test’ and ‘Isolated’ and all doors and covers closed. Relaying and Metering compartment shall also have degree of protection IP54.

Enclosure shall be constructed with rolled steel sections / sheets of not less than 2mm. The switchgear shall be cooled by natural airflow. Forced cooling shall not be accepted. The Breaker and the auxiliary compartments provided on the front side shall have strong hinged doors. Breaker compartment doors shall have locking facility.

30.1.2.2. BUS AND BUS TAPS

Main buses and connections shall be of high conductivity aluminium, sized for specified current ratings with maximum temperature limited to 90°C. Maximum current density for Aluminium busbars shall be considered as 1.0 Amps/mm^2. The busbars shall be designed for a short circuit rating of 26.3kA for 3 sec. All bus connections shall be silver plated. Adequate contact pressure shall be ensured by means of two bolts connection with plain and spring washers and lock nuts. Bimetallic connectors shall be furnished for connections between dissimilar metals. Busbar insulators shall be epoxy cast resin type designed to withstand stresses due to maximum short circuit current.

Busbars and connection shall be fully insulated for working voltage with adequate phase/ground clearances. Insulating sleeves for busbars and cast-resin shrouds for joints shall be provided. Cross section of the main horizontal busbar shall be uniform throughout the switchboard and continuous in one transport unit. All buses and connection shall be supported and braced to withstand stresses due to maximum short circuit current and also to take care of any thermal expansion.

Busbars shall be colour coded for easy identification and so located that the sequence R-Y- B shall be from left to right, top to bottom or front to rear, when viewed from front of the switchgear assembly. The busbar chamber shall be provided with inter panel barrier with epoxy case seal-off bushings which the buses shall pass through so as to prevent fire from one panel to another.

30.1.2.3. CIRCUIT BREAKER

Circuit breaker shall be triple pole, single throw Sulphur Hexaflouride (SF_6) or Vacuum Circuit breaker. It shall be restrike free, trip free type. Breakers shall be suitable for switching transformers at any load. Rated operating duty shall be O-3min-CO-3min-CO. Short circuit withstand/interrupting capacity shall be 26.3kA. Circuit breaker shall have communication facility for communicating with the PLC/Control desk.

Circuit breakers shall be draw-out type, having SERVICE, TEST and DISCONNECTED positions with mechanical positive indication for each position. Operating mechanism shall be stored energy type. Circuit breakers of identical rating shall be physically and electrically interchangeable.

Each breaker feeder shall be provided with the following:

- An anti-pumping relay.
- Motor charged spring operating mechanism.
- Manual spring charging
- Mechanical indication of spring charge
- Mechanical position indicator (to show whether the breaker / contactor is ‘ON’ or ‘OFF’ in the service, test and disconnected positions)
- Closing coil (100% continuous rated)
- Shunt trip (100% continuous rated)

- Manual trip push button
- Operation counter,
- Locking facility to prevent breaker/contactor from being closed when it is open.
- Pressure relief device
- Safety shutters for power contacts
- Inter-pole insulators
- SF6 gas pressure low alarm/trip relay (In case of SF6 type Switchgear)
- Auxiliary Signaling contacts

For motor wound mechanism, spring charging shall take place automatically after each breaker closing operation. One open-close-open operation of the circuit breaker shall be possible after failure of power supply to the motor. SF_6 breakers shall be provided with SF_6 density / pressure switch with separate trip, alarm and blocking contacts.

Robust fail-safe mechanical and electrical interlocks shall be provided to prevent the following situations:

- Move the breaker unit from the service or disconnected position while the unit is closed.
- Move the breaker from the disconnected position to the service position while the earthing switch is closed.
- Close the earthing switch when the breaker unit is in service position or between the service and disconnected position.
- The operation of the circuit breaker while the truck is not properly installed in the service, test or disconnected position.

The closing coil and spring charging motor shall operate satisfactorily at all values of control supply voltage between 80 and 110 percent of the rated voltage. The shunt trip coil shall operate satisfactorily at all values of control supply voltage between 70 and 110 percent of the rated voltage. For breakers spring charging motor shall be provided with overcurrent protection. Motor windings shall be provided with class B insulation or better.

Circuit breaker shall not produce any harmful over-voltage during switching off induction motors. Surge protective devices to limit over voltage shall be included in the scope of supply for all motor feeders.

30.1.2.4. CURRENT TRANSFORMER (CT)

CTs shall be mounted on the switchgear stationary parts. CT secondary current shall be 1A. For metering separate core shall be provided. Core balance CT shall be provided for all the outgoing feeders. Accuracy class of the current transformer shall be:-

a. Class PS/ 5P20 for differential relaying and REF protection (Based on type of relay)

b. Class 5P20 for other relaying

c. Class 0.5 and ISF < 5 for metering

d. Class 0.2S for Energy Accounting & Audit meters

For metering separate core shall be provided. Core balance CT and associated relay combination shall be such as to ensure a pick up sensitivity of 10 A primary ground fault current for all the outgoing feeders. Facilities for easy shorting and grounding the terminals shall be provided at the terminal block. All terminal blocks shall be of stud type with marking strip.

30.1.2.5. VOLTAGE TRANSFORMER

Voltage Transformer shall be cast-resin, draw-out type and shall have an accuracy class of 0.5. Voltage Transformer mounted on breaker carriage is not acceptable. Rated secondary voltage shall be 110V. Accuracy class for metering core shall be 0.5, protection core shall be 3P and 0.2 for energy accounting & audit meters. High voltage windings of voltage transformer shall be protected by current limiting fuses. Fuse failure relay shall be provided on the secondary side of all voltage transformers to monitor failure of fuses.

The following over voltage factor shall be considered for PT.

- 120% for continuous duty.
- 150% for 30 sec (for 415V solidly grounded system)

High voltage windings of voltage transformer shall be protected by current limiting fuses. The voltage transformer and fuses shall be completely disconnected and visibly grounded in fully draw-out position.

Low voltage MCB's, sized to prevent overload, shall be installed in all ungrounded secondary leads. MCB's shall be suitably provided with auxiliary contacts. MCB's auxiliary contacts connected suitably through relay shall be provided on the secondary side of all voltage transformers to monitor failure or trip of MCB's. The relay shall initiate alarm and block the tripping etc. which shall operate in case of VT MCB trip or failure.

30.1.2.6. RELAYS

Numerical multifunction relays shall be provided for all feeders. Numerical relay shall have trip circuit supervision. All protective relays shall be of draw-out type, suitable for flush mounting and fitted with dust tight covers. All relays shall have built-in testing facilities. Small auxiliary relays may be of non-draw-out type and mounted within the cubicle. Relays shall have lock-out facility with manual reset. Each feeder shall be complete with necessary auxiliary relays, timers, etc., to meet the circuit requirement. Under voltage relays shall be provided in the bus PT circuit.

Relays shall be rated for operation on 110V VT secondary voltage and 1A CT secondary current. The switchgear shall be provided with DC fail relay and DC fail indication lamp for each DC control supply incomer. DC isolation switch for each feeder shall be provided with backup HRC fuse. Breaker auxiliary contacts used for interlocking purposes shall be multiplied using electrically latched relay.

Incomers and Outgoing transformer feeders shall have the following minimum protection relays.

- Numerical protection relay having Instantaneous over current protection (50) on all the three phases, IDMT Over current protection (51) on all the three phases, Instantaneous earth fault protection (50N)
- Instantaneous Ground fault protection through CBCT (50G)
- Backup earth fault protection connected to Transformer neutral CT (51N)
- Latched Lock out relay (86).

- Trip circuit supervision relay (95)
- DC Fail relay (80F)
- REF protection relay (For Transformers 2MVA & above)

Self-reset auxiliary relays with hand reset flag indicator shall be provided for contact multiplication (52X) of the following:

- Transformer winding temperature indicator alarm and trip contacts.
- Transformer pressure relief trip contacts.

Motor feeders shall have Numerical motor protection relay having as a minimum following protections.

- Instantaneous earth fault protection through CBCT (50 N).
- Latched Lock out relay (86).
- Under voltage protection
- Trip circuit supervision relay

30.1.2.7. CONTROL SWITCHES

Circuit breaker control switches shall be 3-position spring return to `neutral' from both close and trip positions. They shall have `Pistol Grip' handle.

The contacts shall be of silver plated, air break type. The continuous current and breaking capacity of the contacts shall be adequate for the duty involved.

30.1.2.8. INDICATING LAMPS

Indicating lamps shall be of the panel mounting, LED type. The lamps shall have escutcheon plates marked with its function, wherever necessary. Lamps shall have translucent lamp-covers of the following colours, as warranted by the application. Bulbs and lamp covers shall be easily replaceable from the front of the cubicles. Low Voltage Glow Prevention (LVGP) feature shall be provided for indicating lamps. The colour of indication lamps shall be as follows:

- GREEN : Breaker Open
- RED : Breaker Closed
- AMBER : Auto trip & all Alarm conditions
- BLUE : Spring Charged
- WHITE : For all healthy conditions (e.g. Trip coil healthy & Control supply healthy).

For each breaker feeder, Panel indication lamps shall be provided as follows:

- Breaker Open
- Breaker Closed
- Auto trip
- Motor Spring Charged
- Trip coil healthy
- Control supply healthy
- Breaker in service position

- Breaker in Test position
- Lockout relay healthy
- SF6 Gas Pressure Low (Alarm) (In case of SF6 type Switchgear)
- SF6 Gas Pressure Low (Trip) (In case of SF6 type Switchgear)
- Any other indication, as required

For incomer and Bus, indicating lamps for R, Y, B phase shall be provided.

30.1.2.9. METERS

All Indicating meters shall be digital type, 96 x 96 mm size, suitable for flush mounting with constant accuracy for the entire range of respective parameters with an inbuilt provision for calibration verification. The instruments shall have an accuracy class of 1.0. All Multifunction meters shall have digital display and communication port with true RMS measurement facility with minimum 1% accuracy level. All digital meters shall be with RS485 communication port.

For incomers following Meters and transducers shall be provided:

- Ammeter
- Voltmeter
- Current transducer on three phases
- Voltage transducer on three phases
- Multifunction meter with digital display and communication port for kW, kVAR, kWH and power factor measurement.

For outgoing transformer feeders following Meters and transducers shall be provided:

- Ammeter
- Current transducer on one phase
- Multifunction meter with digital display and communication port for kW, kVAR, kWH measurement.

For outgoing motor feeders following Meters and transducers shall be provided:

- Ammeter on one phase
- Current transducer on one phase
- Hour run meter

All the transducers shall have dual output of 4-20 mA range. For motor feeders, it shall be 4-20-24 mA to measure starting current also.

30.1.2.10. SECONDARY WIRING

The Switchgear shall be fully wired at the factory to ensure proper functioning of control, protection, transfer and interlocking schemes. Fuse and links shall be provided to permit individual circuit isolation from bus wires without disturbing other circuits. All spare contacts of relays, switches and other devices shall be wired up to terminal blocks. Wiring shall be done with flexible, 1100V grade, PVC insulated switchboard wires with stranded copper conductors of 2.5mm² for current circuits and 1.5 mm² for voltage circuits. Each wire shall be identified, at both ends, with permanent markers bearing wire numbers as per Contractor's wiring Diagrams. Wire termination shall be made with crimping type connectors with insulating sleeves. Wires shall not be spliced between terminals. All external cable terminations shall be accessible while the breaker is in service position.

30.1.2.11. TERMINAL BLOCKS

Terminal blocks shall be 1100V grade box-clamp type with marking strips. CT shorting links, Drop link type terminals shall be provided for CT secondary leads. Not more than two wires shall be connected to any terminal. Spare terminals equal in number to 20% active terminals shall be furnished. Terminal blocks shall be located to allow easy access. Wiring shall be so arranged that individual wires of an external cable can be connected to consecutive terminals.

30.1.2.12. CABLE TERMINATION

Switchgear shall be designed for cable entry from the bottom. Sufficient space shall be provided for ease of termination and connection. All provision and accessories shall be furnished for termination and connection of cables, including removable gland plates, cables supports and crimp type tinned copper lugs, brass compression glands with tapered washer and terminal blocks.

30.1.2.13. NAME PLATES

Name plates of approved design shall be furnished at each cubicle and at each instruments & device mounted on or inside the cubicle. The material shall be lamicoid or approved equal, 3 mm thick with white letter on black background. The material shall be held by self-tapping screws. Nameplate size shall be minimum 20 X 75 mm for instrument device and 40 X 150 mm for panels. Caution notice on suitable metal plate shall be affixed at the back of each vertical panel.

30.1.2.14. SPACE HEATERS AND PLUG SOCKETS

Each cubicle shall be provided with thermostat controlled space heaters and cubicle lamp with door switch suitable for operation from 240 V, single phase AC supply and 5A, 3 pin plug socket. The space heater shall be located at the bottom of each switchgear compartment. Cubicle heater, Motor heater, Plug/socket circuits shall have individual MCB units. In addition, motor feeder cubicle shall be wired-up for feeding the motor space heater through suitable rated breaker auxiliary NC Contact and/or contactor.

30.1.2.15. TESTING AND INSPECTION

Switchgear and all its components should have been type tested and proven type. Type test certificates shall be furnished for Purchaser’s review. Switchgear and its components shall be subjected to routine tests as per applicable Indian Standard. In addition, any special test required shall also be performed. Test reports shall be submitted for approval.

30.1.2.16. SPARES

Suitable number of commissioning and successful running for 2 years spares list shall be submitted for approval and spares as per approved list shall be supplied free of cost.

30.1.3. Transformer

This specification covers the requirements of 11/0.433 KV oil filled outdoor type distribution transformer complete with all accessories. The transformer shall be capable of operating continuously at its rated output without exceeding the temperature limits specified.

The transformers shall be suitable for connection to the system having short circuit level and short circuit duration as specified. The transformers shall be capable of withstanding without injury, the thermal & magnetic stresses caused by faults on any of the winding /through faults. Calculation shall be submitted along with the offer to prove that thermal as well as mechanical withstand capacity of the transformer is as per Indian Standards in the event of short circuit to the specified duration. Transformers shall be designed to withstand the thermal and dynamic stresses due to Short circuit at the terminals for 5 seconds duration with respect to fault level specified.

The impedance of the transformer shall not be less than as stated in Indian Standard at a reference temperature of 75^{O}C.

The transformers shall be capable of delivering the rated output at any particular tap without exceeding the specified temperature limits under the following operating conditions.

- Voltage variation of ± 10% of rated voltage of that particular tap.
- Frequency variation of +3% to -5% of rated frequency.
- Combined voltage and frequency variation of 10% (absolute sum).

The transformers shall be free from annoying hum and vibration when it is in operation, even at 110% rated voltage. The noise level at rated voltage and frequency shall be as per NEMA-TR1 standard.

The transformers shall be suitable for over-fluxing (due to combined effect of voltage & frequency) up to 10% on any tapping without injurious heating at full load condition. The maximum flux density in any part of core and yoke under such condition shall not exceed 1.9 Tesla.

Generally, the Transformer shall have total efficiency not less than 98% at full load condition. Transformer shall be fitted with diagram and rating plates. The diagram plate shall show the winding connections and tapings in tabulated form.

Salient parameters of the transformers are as follows:

- Nominal system voltage (HV / LV) : 11/0.433K V
- Vector group : Dyn11
- Temp rise in winding by resistance method : 50°C over 45°C ambient
- Parallel operation of transformer : Yes, only momentary
- Short circuit withstand duration : 2 seconds
- 11kV System fault level : 26.3kA for 3 sec
- 415V System fault level : 50kA for 1 sec

30.1.3.1. WINDINGS

Transformers shall be connected as specified in design requirements. The windings shall be of high conductivity copper and shall not be designed for excessive current densities. The insulation of transformer winding and connection shall be free from insulating composition liable to soften, ooze out, shrink or collapse and be non catalytic and chemically inactive to transformer oil during service. The windings shall be suitable for the highest system voltage and shall be concentrically wound on the core, and shall be braced to withstand shocks, which may occur through rough handling during transport, switching and other transient condition during service, and to reduce to a minimum the damage arising from stresses due to an internal fault. Coil clamping rings shall be of steel with suitable insulating material. Axially laminated material other than bakelised paper shall not be used.

30.1.3.2. CORE

Cores shall be built from best quality, low loss, cold-rolled, grain oriented electrical steel laminations conforming to relevant Indian Standard. All core sheets shall be designed to reduce the core loss to a minimum. All joints shall be interleaved and the core shall be securely clamped so as to ensure that the noise level and the vibration are maintained at a minimum. All clamps shall be adequately insulated. The supporting framework of the cores shall be so designed as to avoid the presence of pockets which would prevent complete emptying of the tank through drain valve or cause trapping of air during filling.

30.1.3.3. TEMPERATURE INDICATORS

For measuring hot spot temperature in the winding, 150 mm dia dial type winding temperature indicator (WTI) with adjustable potential free alarm and trip contacts, maximum reading pointer and resetting device shall be provided. Temperature sensing element shall be complete with image coil, bushing CT etc. Accuracy class of WTI shall be +/- 2□C or better.

30.1.3.4. BUSHINGS

All bushings shall be homogenous, non-porous porcelain type, uniformly glazed and free from blisters, burns and other defects complete with suitable terminal connectors of adequate capacity. Bushings located inside cable boxes / busduct flanges can be epoxy- molded types. Bushing CTs shall be provided as per system requirement. Secondary leads of CTs shall be wired upto-marshalling box. The arrangement shall be such that the CT can be removed from the transformer without removing the tank cover. Current transformers shall be cast resin type with Class E or better insulation.

30.1.3.5. TERMINAL ARRANGEMENT

Type of terminal connection shall be by Cables on both HV & LV side. The cable box shall be suitable for the working pressure of cable with which it is associated and shall have adequate clearances for the specified voltage and cable termination kits. For cable termination, terminals of transformer shall be brought out through side wall mounted bushings to a detachable cable box with disconnect link. The cable box shall be self-supporting, weatherproof, air filled type complete with all hardware such as undrilled gland plates, etc.

The design of the box shall be such as to preclude the access of water to the box. An adequate space shall be provided within the box so that the cable cores may be formed into the lugs without undue bending or stress on the lugs, and adequate clearance shall be preserved between live metal and frame such that the electrical pressure tests specified in Indian Standard are satisfied. Flexible links shall be provided between transformer terminals and cable lugs. Cable box shall have IP 55 degree of protection.

30.1.3.6. MARSHALLING BOX

Marshalling box shall be sheet steel enclosed with IP 55 degree of protection alarm & trip contacts of all the fittings & accessories and secondary leads of CTs shall be wired up to marshalling box. Cable gland plate shall be of removable type. The marshalling box shall have isolating switch & MCB for incoming power supply. Cubicle illumination lamp with door switch and space heater with thermostat and ON/OFF switch shall be provided. The marshalling box shall have 10% additional set of control terminals.

30.1.3.7. GROUNDING

Two grounding pads located on the opposite sides shall be provided for connection of station ground mat / overall earthing for each transformer. Grounding pads shall have clean buffed surface with tapped holes. M10 GI bolts, nuts and spring washers. Two ground terminals each shall be provided on marshalling box & cable box. For neutral connection, two ground copper conductors of specified size shall be provided, supported on pin insulators (provided on tank) from neutral bushing to the bottom of the tank for connection to station ground.

30.1.3.8. OFF CIRCUIT TAP CHANGER

Off Circuit tap changers shall be provided on HV winding with +/- 10% range of taps in steps of 2.5%. The tap changing shall be affected by an external 3 phase gang operated tap change switch. The operating handle shall be padlocked at any position. The mechanism shall be provided with a mechanical tap position indicator, mechanical stop to prevent over cranking of mechanism etc. A warning plate indicating 'For de-energised operation only' shall be fitted.

30.1.3.9. WIRING AND TERMINAL BLOCKS

All control cabinets, marshalling boxes, etc. shall be fully wired at the factory to ensure proper functioning of the control, protection and interlock schemes. All spare contacts of switches, relays and other devices shall be wired upto the terminal block.

Wiring shall be done with flexible 1100V grade HR PVC cables with stranded copper conductor of minimum size 2.5 sq.mm. Wiring shall be identified at both ends with ferrules bearing wire numbers as per approved drawings. Wire termination shall be made with crimping type connectors with insulating sleeves. Wires shall not be spliced between terminals.

Terminal blocks shall be of 1100 V grade suitable for terminating required cable size. Terminals for CT secondary shall have provision for shorting. Not more than two wires shall be connected to any terminal. 20% spare terminals shall be provided. All devices and terminal blocks within the panel shall have identification numbers as per schematic diagram.

30.1.3.10. NAMEPLATE

Each transformer shall be provided with a nameplate of weather-resistance material fitted in a visible position showing all the 'information and additional information' as per IS:1117.

30.1.3.11. FITTINGS & ACCESSORIES

Each transformer shall be supplied with the following as a minimum:

- Two nos. Stainless steel Rating & Diagram (Hindi & English), terminal marking and danger plates.
- 3 earth terminals per transformer, each suitable for earth conductors of size 2 numbers 75x10mm GI strip for earthing of the body of the transformer and its enclosure.
- Lifting lugs for complete transformer and Core-coil assembly
- 6 numbers PT100 RTDs with Winding temperature indicator (WTI) display
- 4 nos. Jacking Pads
- 4 nos. Bi-directional Rollers / flanged wheels with stopper arrangement to lock transformer in required position
- 4 nos.Cover lifting eyes
- Marshalling box
- Cable box
- 1 no. off circuit tap changer
- 3 nos. HV Bushings with terminal connectors
- 3 nos. LV Bushings with terminal connectors
- 1 no. LV Neutral Bushings with terminal connectors
- Platform mounting channel
- 1 set LV Neutral Bushing CTs
- 2 nos. Inspection covers
- 2 nos. supports for HV cable box
- 1 Lot Interconnecting cables

30.1.3.12. TESTING AND INSPECTION

Transformer and all its fittings should have been type tested and proven type. Type test certificates shall be furnished for Purchaser's review. Transformer and all its fittings shall be subjected to routine tests as per applicable Indian Standard. In addition, any special test required shall also be performed. Test reports shall be submitted for approval.

30.1.3.13. SPARES

Suitable number of commissioning and successful running for 2 years spares list shall be submitted for approval and spares as per approved list shall be supplied free of cost.

30.2. LT System

This specification covers the requirements of 415 V Power Control Centre, Motor Control Centre, Main Lighting Distribution Boards, AC Distribution Boards, Lighting / Welding Distribution Boards, Starters, Local Push button stations etc. complete with all accessories. The switchgear and its components shall be designed for design ambient temperature of 50^{O}C. Switchgear shall be designed for natural air cooling. No forced cooling is acceptable.

Auto/Manual/Planned Changeover scheme with synchronizing feature for various incomers and bus couplers shall be provided in Power Control Centre (PCC) / Motor Control Centre (MCC) for interlocking of Incomer breaker with upstream breaker. Incomer, bus-coupler & Outgoing breakers shall also be controlled from PLC in addition to Local operation from the panel.

 Short circuit withstands rating of the switchgear shall be as given in the attached SLD.

 415V normal system shall be solidly grounded. 110V DC system shall be ungrounded. Busbar, breaker and other components shall be designed for continuous operation at rated current considering temperature inside the cubicle. The continuous current rating of the bus bars, incomers, bus couplers of the MCC shall be the maximum load on the bus due to all the running auxiliaries during any operating condition plus 20% margin rounded off to the next higher standard rating. Maximum current density for Aluminium busbars shall be considered as 1.0 Amps/mm^2 and for Copper busbars as 1.25 Amps/mm^2.

Close & Open control of all the motors in PCC/MCC shall be provided in PLC in addition to Local Push Button Station (in the field) and from the panel. Local operation of circuit breakers shall be possible in "Test" position. Remote indications / alarms shall be provided in the PLC. The control / interlock schemes for various types of feeders shall commensurate with their application.

PCC & MCC shall be of draw out type for all the modules including breaker modules/ Starter module/SFU module. Distribution boards shall be of fixed type. All PCC/MCC/DB shall be single front type. 220V control supply shall be derived from 415/220V control supply transformer located in respective module. 240V AC space heater supply provision shall be provided for motors rated above 30 kW. For breaker operated feeders, control supply voltage shall be 110V DC.

At least 20% of feeder modules covering the range of motors used subject to minimum of one module in each bus section shall be provided as spare. Spare modules shall be completely wired up.

All motors shall have direct on line starter. 90kW and above capacity motors shall be fed from ACBs. Less than 90kW capacity motors shall be fed by MCCBs and contactors. However, the duty of the drive/application, i.e. high impact loading, etc. to be considered as criteria for selecting ACB operated motors even for rating < 90kW. Wherever applicable, priority shall be given to the use of Motor Protection Circuit Breaker (MPCB) with Contactor.

Operating height of the handles/switches shall be limited to a maximum of 1800 mm and a minimum of 300 mm.

For PCC changeover shall be provided. If there is an under voltage (dipped to 30-40% voltage) on any one of the buses, sensed through under voltage relays, the respective incomer breaker shall trip automatically and the bus coupler shall close, if the voltage is available on the other bus section, thereby establishing voltage at 415V motor terminals before motor reaches standstill condition. The auto changeover shall be blocked if any of the following condition exists:

- Any of the involved breaker is in the test or withdrawn position.
- Source voltage is not available.
- Source breaker is tripped due to bus fault.

No release is acceptable for Breaker feeders. Only CT operated relays shall be provided for protection. MCCB, Contactor and overload relay shall meet type-2 co-ordination as per applicable standard.

30.2.1. Design and Construction

30.2.1.1. PCC / MCC

415 V panels shall be of metal enclosed, indoor, floor-mounted, free-standing type. Switchboard frames and load bearing members shall be fabricated using CRCA sheet steel of thickness not less than 2.0 mm. Doors and covers shall also be of CRCA sheet steel of thickness not less than 1.6 mm. Thickness of gland plates shall not be less than 3.0 mm for sheet steel & 4.0mm for non-magnetic material. All switchboards shall be of dust-proof and vermin-proof construction and shall be provided with IP54 degree of protection. Outdoor switchgear enclosures should have minimum IP55 degree of protection for covered area and IP65 for uncovered area.

All switchboards shall be of uniform height not exceeding 2450 mm. Switchboards shall be easily extendable on both sides by the addition of vertical sections after removing the end covers. Module size of switchboards shall not be less than 200mm. Cable entry for PCCs/MCCs/DBs shall be from bottom.

Switchboards shall be divided into distinct vertical sections (panels), each comprising of the following compartments:

- Main busbar compartment:
- Switchgear / feeder compartment
- Cable alley
- Auxiliary busbar compartment
- Control compartment for relays for ACB feeder

The feeder compartment shall be sheet steel enclosed on all sides with the withdrawable units in position or removed. The front of the compartment shall be provided with the hinged single leaf door with captive screws for positive closure. All circuit-breaker panels shall be of single-front type. All single-front switchboards shall be provided with single-leaf, hinged or bolted covers at the rear. The bolts shall be of captive type. The covers shall be provided with “DANGER” labels.

All 415 V circuit-breaker modules and MCC modules shall be of fully draw-out type having distinct `Service' and `Test' positions. The equipment pertaining to a draw-out type module shall be mounted on a fully withdrawable chassis, which can be drawn out without having to unscrew any wire or cable connection. Suitable arrangement with cradle / rollers and guides shall be provided for smooth movement of the chassis.

30.2.2. Main Lighting Distribution Board (MLDB) / AC Distribution Board (ACDB)

MLDB shall be totally enclosed, sheet steel, indoor, dust tight, vermin proof and floor mounting type. The sheet metal thickness shall be 2mm. MLDBs shall be provided with separate chambers for (i) bus bars (ii) outgoing feeders (iii) incoming feeders (iv)cabling chamber. MLDBs shall have degree of protection of IP-54 for indoor and IP-55 for outdoor installation.

ACDB shall be totally enclosed, sheet steel, indoor, dust tight, vermin proof and floor mounting type. The sheet metal thickness shall be 2mm. ACDB shall be provided with separate chambers for (i) bus bars (ii) outgoing feeders (iii) incoming feeders (iv) Dry type transformer (v) cabling chamber. ACDB shall have degree of protection of IP-54 for indoor and IP-55 for outdoor installation. ACDB shall be provided with 415/415V, 3 phase dry type transformer of suitable capacity to obtain 3 phase, 4 wire system and to limit the fault level to 3KA. The capacity of the transformer shall be decided such that there is at least 20% margin over the total lighting load.

MLDB & ACDB shall be provided with one TPN MCCB for incomer feeder and required number of 3phase outgoing feeders with TPN MCB's and Spare feeders as per SLD. CT operated ammeters and Voltmeter and indicating lamps shall be provided for incomers.

30.2.3. Lighting Distribution Boards (LDB)/ Control Distribution Board (CDB)

Distribution boards shall be metal enclosed, fixed type, single front, and compartmentalized construction. The Distribution board frame shall be fabricated using CRCA sheet steel of thickness not less than 2.0 mm. The frames shall be enclosed by CRCA sheet steel of thickness not less than 1.6 mm. Suitable synthetic rubber gaskets shall be provided to make boards completely dust and vermin-proof with a degree of protection of IP54 for indoor and IP55 for outdoor installation. The handle of incoming switch shall be mounted on the door of the board, with padlocking facility in both 'ON' and 'OFF' positions. Cable entry facilities shall be provided with removable gland plates of suitable thickness. All incoming and outgoing cables shall be terminated on suitable terminal blocks.

For lighting circuits, Lighting Distribution Boards (LDBs) shall be provided and for welding receptacle circuits, separate Power Distribution Boards (PDBs) shall be provided.

30.2.4. Air Circuit Breakers

Air Circuit breakers shall be (three pole for motor feeders and TPN for other feeders), air break, horizontal draw-out type, and shall have fault making and breaking capacities as specified. These shall be microprocessor based with RS 485 communication facility. There shall be “SERVICE”, “TEST” and “ISOLATED” positions for the breakers. In “Test” position, circuit breaker shall be capable of being tested for operation without energizing the power circuits i.e. power contacts shall be disconnected, while the control circuits shall remain undisturbed. Locking facilities shall be provided so as to prevent movement of the circuit breaker from the “SERVICE”, “TEST” or “ISOLATED” position. It shall be possible to close the door in “Test” position.

Each breaker feeder shall be provided with the following as a minimum:

- Electrical anti-pumping feature
- Motor charged spring operating mechanism.
- Manual spring charging
- Mechanical indication of spring charge
- Mechanical position indicator
- Closing coil
- Shunt trip coil
- Manual trip push button
- Operation counter
- Phase barriers
- Shutter assembly
- Door interlock kit

The closing coil and spring charging motor shall operate satisfactorily at all values of control supply voltage between 80 and 110 percent of the rated voltage. The closing coil & shunt trip coil shall be rated for 100% continuous duty. One Open-Close-Open operation of the circuit breaker shall be possible after failure of power supply to motor. For breakers spring charging motor shall be provided with over current protection. Motor windings shall be provided with class B insulation or better. The shunt trip coil shall operate satisfactorily, all the values of control supply voltage between 70 and 110 percent of the rated voltage.

Circuit breaker of the same type and ampere rating shall be wired alike and shall be mechanically interchangeable.

All Air Circuit Breakers shall be provided with the following interlocks:

- Movement of a circuit breaker between “SERVICE” and “TEST” position shall not be possible unless it is in open position.
- Closing of a circuit breaker shall not be possible unless it is in “SERVICE” position, “TEST” position or in “ISOLATED” position.
- Once the closing springs are discharged, after one closing operation of circuit breaker, it shall automatically initiate recharging of the spring.

Telescopic trolley or suitable arrangement shall be provided for maintenance of circuit-breaker module in a cubicle. The trolley shall be such that the topmost breaker module can be withdrawn on the trolley and can be lowered for maintenance purpose. ACBs shall have CT operated relays for over current and earth fault protection.

Following shall be provided for each breaker feeders

- Electrical anti pumping feature (94)
- Hand reset High speed lockout relay (86)
- Trip circuit supervision relay (95)
- Aux relay for breaker contact multiplication (52X)
- Aux relays as required for contact multiplication
- Indicating lamps for ON, OFF, Auto trip, spring charged, Trip circuit healthy, DC supply fail etc.
- Breaker control switch
- Local / Remote / Test selector switch
- Test Terminal blocks

ACB incoming feeders for PCC from transformers shall be provided with the following as a minimum.

- TPN Air Circuit Breaker
- Current transformers for metering & protection
- Digital Ammeter & Ammeter transducer
- Fuse/MCBs for control circuits
- Voltage transformers, Digital voltmeter & voltage transducer
- Under voltage relay with timer
- Microprocessor based Multi-function meter with communication facility
- Numerical three phase overcurrent (instantaneous & IDMT) and earth fault relay

ACB Bus coupler for PCC from transformers shall be provided with the following as a minimum:

- TPN air circuit breaker
- Current transformer for protection & metering
- Fuse/MCBs for control circuits
- Numerical three phase overcurrent (instantaneous & IDMT) and earth fault relay

Unidirectional motor feeders rated less than 10 kW shall be provided with the following as a minimum:

- Triple pole motor protection circuit breaker (MPCB)
- Triple pole contactor
- Auxiliary contactors
- LOCAL/REMOTE selector switch
- Push buttons.
- Indicating lamps LED cluster type
- MCB for control circuit
- Interposing relays

Unidirectional motor feeders rated 10kW and up to 30kW shall be provided with the following as a minimum.

- Triple pole MPCB
- Triple pole contactor
- Auxiliary contactors
- LOCAL/REMOTE selector switch
- Push buttons.
- Indicating lamps LED cluster type
- MCB for control circuit
- Current transformer for metering
- Digital Ammeter
- Interposing relays

Unidirectional motor feeders rated above 30kW and less than 125kW shall be provided with the following as a minimum.

- Triple pole MCCB
- Triple pole contactor
- Auxiliary contactors
- LOCAL/REMOTE selector switch
- Bimetallic thermal overload relay with single phasing preventer
- Push buttons
- Indicating lamps LED cluster type
- Numerical Motor protection relay
- MCB for 240V AC space heater circuit
- MCB for control circuit
- Current transformer for metering
- Current transducer
- Digital Ammeter
- Interposing relays

Unidirectional motor feeders rated 125 kW and above shall be provided with the following as a minimum.

- Triple pole Air Circuit Breaker
- Current Transformer for metering & Protection
- Numerical Motor protection relay
- Fuse/MCBs for control circuit
- Indicating lamps LED cluster type
- MCB for 240V AC space heater circuit
- MCB for control circuit
- Current transducer
- Digital Ammeter

- Interposing relay

Bi-directional Motor feeders shall be provided with the following as a minimum. (Not applicable for Integral Actuators)

- Triple pole MCCB
- Triple pole mechanically interlocked, open / close contactors
- Auxiliary contactors
- Local/Remote/Test switch
- Bimetallic thermal overload relay with single phasing preventer
- Push buttons.
- Indicating lamps LED cluster type
- MCB for space heater circuit
- MCB for control circuit
- Interposing relays

30.2.4.1. MOULDED CASE CIRCUIT BREAKER (MCCB)

MCCB shall in general conform to IS: 13947 Part-2. MCCBs shall be provided with thermo- magnetic type release for over current and short circuit protection. These shall be microprocessor based with RS 485 communication facility. The setting of the thermal release shall be adjustable from 75% to 100% of the rated current. The MCCB shall have breaking capacity not less than 50kA. MCCBs used for incomers and Bus coupler shall be equipped with stored energy mechanism for electrical closing and tripping. All other MCCBs shall be manually operated. The operating handle should give a clear trip indication.

30.2.4.2. CONTROL AND SELECTOR SWITCHES

Control and selector switches shall be of rotary type, with escutcheon plates clearly marked to show the function and positions. Circuit breaker control switches shall have three positions and shall be spring return to “NEUTRAL” from “CLOSE” and “TRIP” positions and shall have pistol grip handles. Circuit breaker selector switches shall have three stay put positions marked `Test’, `Local’ and `Remote’, respectively. They shall have black spade handles. Selector switches for starter modules shall have ‘Test’, ‘Local’, ‘Remote’ positions as specified.

30.2.4.3. CONTACTORS

Motor starter contactors shall be air break, electromagnetic type rated for uninterrupted duty. Contactors shall be double-break, non-gravity type and their main contacts shall be silver faced. Direct-on-line contactors shall be of utilization category AC3. Reversing starters shall comprise of Forward and Reverse contactors mechanically and electrically interlocked with each other. These contactors shall be of utilization category AC4. The contactor shall operate satisfactorily from 85% to 110% of the rated voltage. The contactor shall not drop out at 70% of the rated voltage but shall definitely drop out at 20% of the rated voltage.

30.2.4.4. INSTRUMENT TRANSFORMERS

The CTs shall be mounted on the switchgear stationary parts. For metering separate core shall be provided. The CTs shall be of cast resin, bar primary type and of Class E or better insulation. CT secondary current shall be 1A. Accuracy class of Current Transformer shall be Class 5P20 for relaying and Class 0.5 and ISF < 5 for metering. CTs for current rating less than 50A shall be 'Wound primary' type and above 50A shall be 'Bar primary' type.

Voltage Transformer shall be cast-resin, draw-out type and shall have an accuracy class of 1.0. The bus VTs shall be housed in a separate compartment. All VTs shall have readily accessible fuse and MCBs on primary and secondary sides respectively.

30.2.4.5. INDICATING INSTRUMENTS

All Indicating meters shall be digital type, 96 x 96 mm size, suitable for flush mounting with constant accuracy for the entire range of respective parameters with an inbuilt provision for calibration verification. The instruments shall have an accuracy class of 1.0. All such meters shall be fed through suitable Current transformers for motors rated 10kW & above. All Multifunction meters shall have digital display and communication port with true RMS measurement facility with minimum 1% accuracy level.

30.2.4.6. PUSH BUTTONS

Push-buttons shall be of spring return, push-to-actuate type. Where specified push buttons shall be stay put type. Their contacts shall be rated to make, continuously carry and break 10A at 500 V AC. All push-buttons shall have two normally open and two normally closed contact, unless specified otherwise. The contact faces shall be of silver alloy. All push-buttons shall be provided with integral escutcheon plates marked with its function. All emergency push-buttons shall be stay put/latching type. To detach, master key provision shall be provided.

The colour of the button shall be as follows:

- Green for motor START, breaker CLOSE, valve / damper OPEN /CLOSE commands.
- Red for motor TRIP, breaker OPEN.
- Black for all annunciator functions, overloads reset and miscellaneous commands.

30.2.4.7. INDICATING LAMPS

Indicating lamps shall be of the panel mounting, LED type .The lamps shall have escutcheon plates marked with its function, wherever necessary. All indicating lamps shall be rated for continuous operation at 85% to 110% of their rated voltage. Low Voltage Glow Prevention (LVGP) feature shall be provided for indication lamps. Lamps shall have translucent lamp-covers of the following colours, as warranted by the application:

- Red for motor ON, breaker CLOSE.
- Green for motor OFF, breaker OPEN.
- Blue for Service
- White for Test, Spring Charged, Spring Discharged, Lockout Relay Healthy
- Amber for auto trip

30.2.4.8. CONTROL SUPPLY AND SPACE HEATER SUPPLY

The breaker operated PCC/MCC shall receive two nos. 110V DC feeder for the control supply and distribute to each panel. Auto changeover arrangement shall be envisaged between two supplies. Each panel shall receive control supply through bus wires and shall be tapped off through switch & fuse provided in the respective panel. It shall be possible to isolate any panel without disturbing the power supply to other panels. Each sub circuit shall have separate fuse. An under voltage relay to monitor control supply shall be provided. A contact of the relay shall be wired to the terminal for external use. `Control Supply Failed' indication shall be provided.

Each starter module of MCC shall derive 220V AC control supply through control supply transformer. The control transformers shall be of insulation class `B' or better. The sizing of control transformers shall be carried out by the contractor considering the actual load of power contactors, auxiliary contactors, indicating lamps and other equipment including remote auxiliary relays and lamps in the circuit.

For space heater circuits of motor rated more than 30kW and also for panel space heater, 240V AC supply shall be provided by tapping from the incomer before the main isolating switch/breaker. Necessary switch and MCB to isolate and distribute the supply to each panel shall be provided. For motor feeders, circuit for motor space heater shall be wired through NC contact of breaker/contactor and MCB.

Each panel of PCC/MCC/DB shall be equipped with the following as required:

- Thermostatically controlled space heater(s)
- Illumination lamp with door switch
- 5A 3pin socket with MCB protection

30.2.4.9. WIRING

All switchboards shall be supplied completely wired internally upto the terminals, ready to receive external cables. All internal wiring shall be carried out with 1100 V grade, HR PVC/ XLPE insulated single core, copper conductor of minimum 2.5 sq.mm for CT circuits and 1.5 sq.mm for other circuits. All internal wiring terminations shall be made with solder less crimping type tinned copper lugs. Insulation sleeves shall be provided over the exposed parts of lugs. Engraved core identification plastic ferrules marked to correspond with panel wiring diagrams shall be fitted at both ends of each wire. Number 6 and 9 shall not be used for wire identification.

Control terminal blocks shall be of 1100 Volts grade, rated for 10 Amps and in one piece moulding. It shall be complete with insulating barriers, clip-on type terminals and identification strips. Marking on terminal strip shall correspond to the terminal numbering on wiring diagrams. Terminal blocks for CT & VT secondary leads shall be provided with test links & isolating facilities. CT secondary leads shall be provided with short circuiting & earthing facilities. In all the panels at least 20% spare terminals for external connections shall be provided and these spare terminals shall be uniformly distributed on all terminal blocks.

30.2.4.10. POWER CABLE TERMINATION

Cable termination compartment and arrangement for power cables shall be suitable for heavy duty, 1.1 kV grade, stranded aluminium conductor, XLPE insulated, armoured and FRLS PVC sheathed cables. All power cable terminals shall be of stud type and the power cable lugs shall be of tinned copper solderless crimping ring type conforming to IS:8309. All lugs shall be insulated / sleeved.

30.2.4.11. NAMEPLATES AND LABELS

PCCs, MCCs, Distribution Boards, local push-button stations and local motor starters shall be provided with prominent, engraved identification plates. The module identification plate shall clearly give the feeder number and feeder designation. For single front switchboards, similar panel and board identification labels shall be provided at the rear also. All name plates shall be of non-rusting metal or 3-ply Lamicoid, with white engraved lettering on black background. Suitable stenciled paint mark shall be provided inside the panel/module for identification of all equipment, in addition to the plastic sticker labels, if provided. These labels shall be positioned so as to be clearly visible and shall have the device number, as mentioned in the module wiring drawings. Caution name plate “Caution Live Terminals” shall be provided at all points where the terminals are likely to remain live and isolation is possible only at remote end.

30.2.4.12. BUSBARS AND INSULATORS

Each PCC/MCC & DB shall be provided with three phase and neutral busbars. DC distribution boards shall have two busbars. All busbars and jumper connections shall be of high conductivity aluminium alloy for PCC/MCC and Copper for DB of adequate size. The cross-section of the busbars shall be uniform throughout the length of switchboard. Interleaving of PCC busbar arrangement shall be envisaged. All busbars shall be adequately supported by non-hygroscopic, non-combustible, track-resistant and high strength sheet moulded compound or equivalent type polyester fiber glass moulded insulators. All busbar joints shall be provided with high tensile steel bolts, belleville/ spring washers and nuts. All copper to aluminium joints shall be provided with suitable bi-metallic washers. All busbars shall have HRPVC sleeves and colour coded.

Contact surfaces at all joints shall be silver plated or properly cleaned and anti-oxide grease applied to ensure an efficient and trouble free connection. Suitable bimetallic connectors shall be used for dissimilar metal connections.

The continuous rating of the main busbars shall be same as that of the incomer breaker, and busbar shall carry this continuous current without exceeding the temperature of 90º C. For silver plated joints, temperature shall not exceed 105°C. All horizontal and vertical busbar joints shall be covered by insulating shrouds.

30.2.4.13. EARTHING

A copper/ Aluminium earthing bus of adequate size shall be provided at the bottom and shall extend throughout the length of switchgear. It shall be bolted to the framework of each panel and each breaker earthing contact bar. The earth bus shall be sized to withstand specified short circuit current. The truck and breaker frame shall get earthed while the truck is being inserted in the panel and positive earthing of the truck and breaker frame shall be maintained in all positions i.e., ‘Service’, ‘Test’ and ‘Isolated’ as well as throughout the intermediate travel.

All non-current carrying metal work of the switchboard shall be effectively bonded to the earth bus. All hinged doors shall be earthed through flexible earthing braid. VT and CT secondary neutral point earthing shall be at one place only on the terminal block. All metallic cases of relays, instruments and other panel mounted equipment shall be effectively bonded to the earth bus by independent stranded copper wires of size not less than 2.5 sq.mm.

30.2.4.14. LOCAL PUSH BUTTON STATIONS

The local push buttons stations shall be with FRP enclosure, suitable for outdoor mounting on wall or steel structures. The local push button stations shall be dust and vermin proof and shall have a degree of protection of IP55 as per IS: 13947 Part-1. Local push button stations shall comprise Start/Stop push buttons as per drive control philosophy. Emergency stop Push-buttons shall be stay put/Latching type, requiring master key for de- latching.

30.2.4.15. TESTING AND INSPECTION

Switchgear and all its components should have been type tested and proven type. Type test certificates shall be furnished for Purchaser's review. Switchgear and its components shall be subjected to routine tests as per applicable Indian Standard. In addition, any special test required shall also be performed. Test reports shall be submitted for approval.

30.2.4.16. SPARES

Suitable number of commissioning and successful running for 2 years spares list shall be submitted for approval and spares as per approved list shall be supplied free of cost.

30.2.5. 110V DC System

This specification covers the requirements of 110V DC Batteries 200AH, Chargers and DC Distribution Board. The function of the 110V DC Power Supply System is to provide the normal source of power to the 110V DC loads, such as Control Supply to Switchgears / Panels.

The duty cycle imposed on the battery shall include the following:

- Continuous loads (indicating lights, continuously energized coils, Control Panels, Relays)
- Momentary loads (switchgear operation (Trip coil/Closing coil), which exist for a period of less than 1 min period)

110 VDC Power Supply System shall be operated as an ungrounded system; that is, the negative terminal or ground reference terminal is not connected to the station ground grid. A DC ground monitoring system on the DC systems shall be provided and any DC ground fault shall be alarmed.

Batteries shall be sized in accordance with IEEE-485. The battery shall be sized with a 10% design margin and an ageing factor of 1.25. 110V DC Power Supply System shall consist of 2x100% 110V batteries, 2x100% 110V battery charger and one no DC Distribution Board. End Cell Voltage of Lead Acid Plate battery shall be considered as 1.85 V / Cell and for Nickel cadmium battery as 1.14V / Cell. During Normal operating condition, batteries shall be supplied from one (1) 100 percent battery charger. The chargers are supplied power from PCC/ MCC. The battery charger shall supply power to 110V DC loads and, at the same time, shall continuously float charge fully charged batteries. Both the chargers shall have dedicated incoming AC supply from MCC/PCC. During Emergency operation the battery shall supply the DC load when there is a loss of all auxiliary AC power supplies and/or a loss of power from the battery chargers. Batteries shall normally be permanently connected to the load in parallel with a charger and shall supply the load during emergency condition when AC supply is lost.

The Charger shall be float cum boost type suitable for float charging both the batteries and supply load simultaneously. Chargers shall boost charge fully discharged batteries in 12 hours. Design margin of minimum 20% shall be considered in charger sizing for either mode of operation. Charger protections such as DC-O/V & U/V, AC U/V, E/F, S/C protection etc. shall be considered.

30.2.5.1. CONSTRUCTION OF BATTERY

Lead Acid (Valve regulated) sealed maintenance free Plate type batteries shall be float charged at 2.15 to 2.20 Volts per cell and chargers shall also be capable of boost charging the associated DC battery up to 2.7 Volts per cell at the desired rate. Batteries shall be rated for 10 hour discharge rate (C10) as per manufacturer data. Containers shall be made of suitable glass fibre reinforced plastics or Polypropylene. Containers shall be robust, heat resistant, leak proof, non-absorbent, acid/alkaline resistant, non-bulging type and free from flaws such as wrinkles, cracks, blisters, pin holes etc.

Batteries shall have thick plates designed for maximum durability during all service conditions including high rate of discharge and rapid fluctuations of load. The separators shall maintain the electrical insulation between the plates and shall allow the electrolyte to flow freely. Separators should be suitable for continuous immersion in the electrolyte without distortion. The positive and negative terminals shall be clearly marked. Each cell shall be separately supported on porcelain insulators fixed on to the racks with adequate clearance between adjacent cells. Breathers/Vent plugs etc. shall be provided for each cell. It shall be anti-splash type and having more than one exit hole to allow the gases to escape freely but prevent the acid spray from the battery. Lead coated copper inter-cell connectors shall be used for connecting up adjacent cells and rows. Bolts, nuts and washers shall be effectively lead coated to prevent corrosion. All the terminals and cells, interconnections shall be fully insulated or have insulation shrouds/covers.

End take off connections from positive and negative poles of batteries shall be made by single core cables having stranded copper conductors and PVC/XLPE insulation. Necessary supports and lugs for termination of these cables on batteries shall also be supplied. All connectors and lugs shall be capable of continuously carrying the 60 minute discharge current of the respective batteries and through fault short circuit current which the battery can produce and withstand for the period declared. Anti-corrosive gel shall be applied at the Battery terminals.

Wooden racks shall be provided for batteries for multi-tier installation. These racks shall be made of good quality first class seasoned teak wood. They shall be free standing type mounted on porcelain insulators. Numbering tags, resistant to acid for each cell shall be attached on to the necessary racks. The bottom tier of the stand shall not be less than 150 mm above the floor.

Following accessories shall be provided with batteries.

- Syringe type Hydrometer: 2 Nos per Battery

Thermometer with specific gravity correction scale:		2 Nos per Battery
Cell testing voltmeter 3-0-3 volts	:	2 Nos per Battery
Acid resistant funnel: Acid resistant jug. : Rubber		2 Nos per Battery
apron and gloves : Spanners :		2 Nos per Battery
Wall mounted teak wood rack for above items :		2 sets per Battery
		2 sets per Battery
		2 Nos per Battery

Following maintenance spares shall be provided as a minimum

Inter cell connectors : Inter	10 Nos.
row connectors : Battery	2 Nos.
stand insulators : Cell	2 Nos
insulators : Nuts, bolts &	2 Nos
washers : Vent plugs :	10 pieces each
Spare dry cell :	10 Nos.
	4 Nos.

Fuse box for each battery shall be provided in the battery room and shall comprise the following:

- DP Fuse Switch unit
- HRC Fuses with striker pin & aux contact for remote alarm
- FRP enclosure.

Discharge resistor made of punched stainless steel grid enclosed in sheet steel enclosure shall be provided for discharge testing of Battery.

30.2.5.2. CONSTRUCTION OF BATTERY CHARGER CUM DCDB

During float charging, charger shall feed the respective DC Distribution board and as well as float charge its own batteries and maintain a DC voltage that shall pass the minimum current through the cells to keep them charged without overcharging. In case of mains failure to charger or charger failure, battery shall supply the full load. While boost charging of respective battery, DCDB shall be isolated from the Charger and shall be fed from other Charger. Each Battery charger should meet the Trickle requirement of both banks (under emergency) and boost requirement of each bank.

During boost charging, battery charger shall operate on constant current mode (when automatic regulator is in service). It shall be possible to adjust the boost charging current continuously over a range of 50 to 100 % of the rated output current for boost charging mode. During boost charging, the Boost charger shall recharge the completely discharged battery to full capacity in 12 hours.

When on automatic control mode during float charging, the charger output voltage shall remain within + / - 1% of the set value for AC input voltage variation of + / - 10%, frequency variation of + 3 / - 5%, a combined voltage and frequency (absolute sum) variation of 10 % and a continuous DC load variation from zero to full load. Uniform and step-less adjustments of voltage setting (in both manual and automatic modes) shall be provided on the front of the charger panel covering the entire float charging output range specified. Battery chargers shall have a selector switch for selecting the battery charging mode i.e. whether float or boost charging.

All Battery chargers shall be provided with facilities such as automatic voltage regulator (AVR) for both automatic and manual control of output voltage and current. The chargers shall be self-regulating, natural air cooled, static type provided with suitable double wound transformer, full wave thyristor type rectifiers, filter circuits, DC & AC Switchgear. Chargers shall be metal enclosed, fixed type, suitable for indoor mounting on floor. Panel frame shall be fabricated using cold rolled sheet steel of thickness not less than 2.0 mm. The frames shall be enclosed by cold rolled sheet steel of thickness not less than 2.0 mm. Suitable synthetic rubber gaskets shall be provided to achieve a degree of protection of IP54.

Rectifier transformer shall be continuously rated, dry type, class F insulation, epoxy resin impregnated, Air Natural (AN) cooling and with adequate number of taps. The rating of rectifier transformers shall correspond to the rating of the associated rectifier assembly.

All the Charger panels shall be provided with an illuminating CFL lamp, a 5 Amp socket and space heaters with thermostat. Toggle switches and MCB’s shall be provided separately for each of the above fittings. Space heaters “ON” indication to be provided. Two separate grounding pads shall be provided.

Locking facilities shall be for locking float / boost selector switch in the float position only.

Digital type Window annunciator shall be provided for alarm annunciation with acknowledge, test & reset push buttons and a buzzer for the following conditions:

- SCR fuse fail
- Battery / DC system under voltage
- DC system over voltage
- DC over load
- Output fuse blown
- AC supply fail
- AC under voltage
- Battery earth fault
- Filter fuse failure
- Battery on Float / Boost
- Charger fail/Battery on discharge
- Any other annunciation, as required

Remote alarm contacts for hooking up to PLC shall be provided. For each charger, current & voltage transducer shall be provided for remote monitoring of DC voltage and Current at PLC.

Protection features, indications, meters and alarms shall be provided for each charger. Protection features shall include the following as minimum.

- Overload Protection
- Phase failure protection
- Voltage unbalance protection
- Fuse failure protections for SCR and filter circuit

Suitable potential free contacts for remote indication of above abnormal conditions shall be provided. However the requirements / design shall be firmed up during the detailed engineering stage.

30.2.5.3. TESTING AND INSPECTION

Battery & Charger and all its components should have been type tested and proven type. Type test certificates shall be furnished for Purchaser's review. Battery & Charger shall be subjected to routine tests as per applicable Indian Standard. In addition, any special test required shall also be performed. Test reports shall be submitted for approval.

30.2.5.4. SPARES

Suitable number of commissioning and successful running for 2 years spares list shall be submitted for approval and spares as per approved list shall be supplied free of cost.

30.2.6. Power and Control Cables

Power cables shall be sized to satisfy the following Criteria:

- Short circuit withstand capacity for applicable fault current and duration.
- Full load current carrying capacity under installation conditions considering Site ambient temperature & site installation (Grouping) conditions based on Manufacturer's recommendation.
- Permissible voltage drop limits under steady state/transient state as applicable.

Power cables shall withstand fault current of the circuit for the duration not less than the maximum time taken by the primary protective system to isolate the fault. Cables shall be sized for the following short circuit rating.

- Outgoing cables from 11kV Switchboards: 26.3 kA for 0.16 sec.
- Incoming cables to 415V PCC (Breaker operated): 50 kA for 1 sec.
- Incoming cables to 415V MCC (Breaker operated): 50 kA for 0.5 sec.
- Incoming cables to 415V MCC/DB (MCB protected): Fuse cut-off current for 10m.sec
- Cables from 415 V MCC to Motors: 50 kA for 0.16 sec ACB operated
- Feeders from MCC/DB (MCB protected): Fuse cut-off current for 10msec

To maintain voltage at motor terminals / equipment end with in desirable limit, it is proposed to limit the voltage drop in the cables within the following limits:

- Steady state Voltage drop (Continuous running condition): 2.5%
- Transient state voltage drop (During Motor Starting): 10 %

All cables shall be suitable for laying on racks, in ducts, trenches with chances of flooding by water and shall also be suitable for directly buried installation. All the cables shall be flame retardant low smoke (FRLS) type designed to withstand mechanical, electrical and thermal stresses developed under steady state and transient operating conditions.

The minimum size of LV power cable shall be of 2.5 Sq.mm for Copper. Power cables shall have copper conductor for sizes up to 10 sq.mm. For higher sizes, aluminium conductor shall be provided. The minimum size of control cable shall be of 1.5 Sq.mm copper. For CT/VT circuits, minimum 2.5 sq.mm copper cable shall be provided. Conductor of Copper cables shall have plain annealed copper. All the conductors shall be multi-stranded.

Power cables shall be XLPE insulated. Control cables shall be PVC insulated. PVC insulation shall be suitable for continuous conductor temperature of 70°C and short circuit conductor temperature of 160°C. XLPE insulation shall be suitable for continuous conductor temperature of 90°C and short circuit conductor temperature of 250°C.

The cable cores shall be laid up with fillers between the cores wherever necessary. All the cables shall have distinct extruded PVC inner sheath. For single core armoured cables, armouring shall be of aluminium wire. For multicore armoured cables, armouring shall be of galvanised steel strip/wire as per applicable IS.
Outer sheath shall be of PVC black in colour having following FRLS properties.

- Oxygen index of not less than 29.
- Acid gas emission of max. 20%
- Smoke density of not more than 60%

The cables shall meet flammability test as per IEEE – 383. All the cables shall be protected against rodent and termite attack. Necessary chemicals shall be added in to the PVC compound of the outer sheath.

30.2.6.1. CONSTRUCTION

A) HT cables

Cables shall be XLPE insulated, screened, PVC inner sheathed (extruded), armoured, FRLS PVC outer sheathed, stranded aluminium conductor conforming to IS: 7098 Part-II. 11kV cables shall be suitable for unearthed system. The conductor screen and insulation screen shall both be of extruded semi-conducting compound and shall be applied along with the XLPE insulation in a single operation of triple extrusion process. The metallic screen of each core shall consist of copper tape with minimum overlap of 20% copper screen which shall be capable of carrying the system earth fault current for 2 seconds. Outer sheath shall be FRLS PVC.

B) LV Power cables

LV Power cables shall be of 1.1 kV grade, XLPE insulated, PVC inner sheathed (extruded), armoured, FRLS PVC outer sheathed, stranded aluminium conductor conforming to IS: 7098 Part-I.

C) Control cables

Control cables shall be of 1.1 kV grade, multicore, XLPE insulated, PVC inner sheathed, armoured, FRLS PVC outer sheathed stranded copper conductor conforming to IS:1554
Part-I. Up to 5 cores it shall be colour coded and above 5 cores shall be numbered.

D) Trailing cables (if applicable)

Trailing cables / Flexible cables shall be rubber insulated with copper conductor as per applicable standards. The minimum size of LV power cable shall be 4 Sq.mm for Copper.

30.2.6.2. CABLE IDENTIFICATION SYSTEM

In addition to manufacturer's identification on cables as per IS, following marking shall also be embossed over outer sheath.

- Cable size and voltage grade.
- Word `FRLS' at every 5 metre.
- Sequential marking of length of the cable in meters at every one metre.

The embossing shall be progressive, automatic, in line and marking shall be legible and indelible.

30.2.6.3. CABLE DRUMS

Cables shall be supplied in wooden or steel drums of heavy construction. The surface of the drum and the outer most cable layer shall be covered with waterproof layer. Both the ends of the cables shall be properly sealed with heat shrinkable PVC/rubber caps, secured by `U' nails so as to eliminate ingress of water during transportation, storage and erection. Wood preservative anti-termite treatment shall be applied to the entire drum. Wooden drums shall comply with IS 10418.

30.2.6.4. TESTING AND INSPECTION

Cables offered shall be of type tested and proven type. Type test certificates for test conducted earlier on similar rating shall be furnished. Routine tests, Acceptance tests and all special tests for FRLS properties shall be carried out for all the cables as per applicable standards. The sample shall be drawn at the rate of one per type and size for every lot offered for inspection.

30.2.6.5. SPECIAL TESTS

The following tests as applicable to FRLS sheathed cables shall be conducted as type tests on each size of each lot.

a. Oxygen index test

b. Temperature index test

c. Acid gas generation during fire

d. Smoke generation test under fire
e. Swedish chimney test for class F3 as per SS: 424-14-75

f. Under fire conditions for bunched cables as per IEEE std. 383 / 74

30.2.6.6. SPARES

Suitable quantity of commissioning and successful running for 2 years spares list shall be submitted for approval and spares as per approved list shall be supplied free of cost.

30.2.7. Lighting System

Plant lighting system shall comprise;

Normal lighting

Emergency lighting

Critical lighting

Aviation lighting (applicable for taller structure considering ICAO & DGCA guideline)

Normal and emergency lighting shall be fed by AC supply (415 / 240V, three phase four wire) while critical lighting shall be fed by AC UPS supply. Critical lighting in remote location (i.e. away from the substation or control room) shall be provided with aesthetically designed rechargeable 5 Watt LED lantern with dimmimg and SOS feature in selected areas of the plant during plant emergency conditions The emergency lighting load shall be fed from EDG supply.

The lighting load is fed from emergency bus of LT Switchgear through lighting transformer. The output of Lighting Transformer is fed to Main Lighting Distribution Board. A bus coupler is provided in bus section of MLDB. When EDG incomer is closed, the bus coupler breaker of MLDB is tripped and thus power is restricted to emergency bus of MLDB and power is supplied to emergency lighting bus and to Emergency Lighting Boards.

Dry type lighting transformers of voltage ratio 1:1 shall be provided for reducing fault level in MLDB. The single phase voltage level considered for lighting system & fixtures shall be optimally arrived to achieve energy efficiency without sacrifice in the illumination level. Lighting transformer tap range & tap step to be designed accordingly.

LED lamps shall be used as light sources in the lighting system.

Fixtures considered shall be energy efficient type with low loss & low harmonics (less than 10%) and with higher lumen / watt.

The lighting fixtures on various circuits shall be suitably interlaced so that failure of any one circuit does not result in complete darkness. All outdoor lighting shall be automatically controlled by means of photoelectric cell / synchronous timers with manual overriding control.

Normal lighting system shall provide enough illumination so as to enable plant operators to move safely within the accessible areas of plant to perform routine operation including reading of field instruments, operation of all valves etc. and to carry out all the necessary maintenance and adjustment to equipment.

Areas requiring AC critical lighting shall include, but not be limited to the following for the duration of one hour;

- Control rooms
- Substations and control room / exit lighting
- DG room
- Fire water pump house
- Emergency Escape corridor

Areas requiring AC emergency lighting shall include, but not be limited to the following;

- All Areas requiring critical lighting (mentioned as above)
- Strategic locations in process, utility areas where specific safety / shutdown operation are to be carried out.

The illumination lux level for normal and emergency lighting shall comply with the relevant standard. Lighting design shall conform to relevant International Codes and Standards, IES Hand Book and shall take into consideration the requirements from point of view of safety and ease in operation and maintenance.

LED lamps shall generally be used for outdoor plant lighting & indoor buildings. Also, AC critical lighting shall be with LED fittings. Tall structures shall have LED aviation obstruction lighting as per statutory requirements.

Lighting system shall consist of lighting transformers for reduction of fault level, lighting distribution boards (LDBs), lighting and power panels, fixtures, junction boxes etc. Depending on the nature of job activities carried out, the minimum illumination levels for various areas shall be as recommended by Indian Standard.

AC lighting fixtures and accessories shall be suitable for operation on 240 V AC, 50 Hz supply with supply voltage variation of ± 10%, frequency variation of +3% to –5% and combined voltage and frequency variation of absolute sum of 10%.

Lighting level design shall include a Maintenance factor as follows to account for lamp lumen depreciation, luminaries surface dirt and room surface dirt, etc.

Air conditioned areas :

Non-Air conditioned areas :

Dust prone outdoor Areas :

All receptacles shall be of high quality Polyamide P-6 body (shock proof, rust free, corrosion free, acid and chemical resistant, fire retardant, having high impact, made of halogen and silica free recyclable material) & terminals with Solid high-quality turned contacts made of copper alloy (Brass). All steel components (screws, springs etc) shall be Zinc plated & blue-chromed or nickel plated. For each contact double screws shall be available to give better cable strain relief. It shall be heavy duty type, IP67 suitable for fixing on wall/column and complete with individual switch.

In general the receptacles to be installed shall be of the following type:

Power Socket 6/16A, 230V, 3 pin type with third pin grounded, metal clad with gasket having 19 mm conduit entry and a metallic screwed cover tied to it with a metallic chain and suitable for indoor & outdoor installation in Control room building & Local Control rooms etc.

Power Socket - 6A, 230V, 5 pin type with third pin grounded, metal clad with gasket having 19 mm conduit entry and a metallic screwed cover tied to it with a metallic chain and suitable for indoor & outdoor installation in Control room building & Local Control rooms etc.

Welding Socket - 63A, 415V, 3 Ph, 4 Wire, 5 pin interlocked plug and switch with earthing contact to be used in transfer towers and along the Conveyor length. Welding sockets shall not be connected to lighting distribution board and shall get supply from feeders in the MCC/ACDB/PDB. For long conveyor feeders shall be provided from MCC/ACDB/PDB at head end (for 50% load) and from tail end (for 50% load) at interval of 100M.

Suitable number of 63 ampere, 3 phase, 415 volt AC welding receptacles shall be provided. Welding receptacles shall be placed near all major equipment and minimum 2 numbers on each floor in all the buildings.

6/16A and 6A 240V, Single phase convenience receptacle with switch shall be provided in all the rooms. The convenience outlets shall be spaced to provide access to any point with a 15 meter extension cord. Receptacles shall be served from an earth leakage circuit breaker (ELCB).

Welding sockets shall be fed from ACDB / PDB. Number of receptacles per circuit shall not be more than 2. Each welding receptacle unit shall have dedicated MCB installed adjacent to the receptacle with IP55 type enclosure.

The light fixtures shall be circuited so that adjacent fixtures are connected to alternate phases of a 3-phase circuit.Auto timed switching may be considered with manual bypass mode for indoor lighting system. The lighting for enclosed areas within the buildings shall be manually switched ‘on’ and ‘off’ at local light switches near personnel entrance doors. Wall mounted switches shall be provided at the entrance to battery room and equipment/office rooms.

Electric power to light fixtures located outdoors shall be switched with photoelectric controllers and timers. Outdoor lighting shall have auto/manual mode of operation. Provision shall be made to bypass the photoelectric controller and timer.

Switches shall be sized maximum of 80 percent of the light switch ampere rating with enclosures suitable for the location in which they are installed.

Load on each lighting circuit and single phase receptacle circuit shall be limited to 2000 W. For areas illuminated by more than one circuit, the adjacent circuit shall be fed from different phase. Load balance on all the 3 phases to be envisaged for lighting as well as 1- ph power distribution circuit.

Wiring for indoor lighting installation shall be carried with PVC insulated wire with following sizes laid in conduit.

- Lighting Panel to lighting Fixtures: 2.5 sq.mm copper
- Switch box to lighting Fixtures: 2.5 sq.mm copper
- Lighting Panel to Sockets: 4 sq.mm copper

For Area lighting, PVC insulated, PVC inner sheathed, armoured, FRLS PVC outer sheathed Aluminium conductor cables shall be provided.

Wiring for lighting circuits of Normal AC system and DC system shall run in separate conduits. Wiring for Lighting fixtures and receptacle units shall be fed from different circuits and shall run in separate conduits. Two different phase circuits shall not be laid in the same conduit.

All conduits shall be surface mounted in general. In Control room, conference room and offices conduit shall be concealed type. Conduit fill criteria shall be 40%. Conduits should have the minimum number of bends in their run with pull boxes at suitable locations. Conduits shall be sloped & drained to avoid water accumulation & draining into the equipment at its end. Conduits shall be galvanized steel except in corrosive areas, where it shall be epoxy painted.

30.2.7.1. RECEPTACLES

Power Socket - 6A, 230V, 5 pin type with third pin grounded, metal clad with gasket having 19 mm conduit entry and a metallic screwed cover tied to it with a metallic chain and suitable for indoor & outdoor installation in Control room building & Local Control rooms etc.

Power Socket - 15A, 230V, 2 pole, 3 pin type with third pin grounded, metal clad with gasket having 19 mm conduit entry and a metallic screwed cover tied to it with a metallic chain and suitable for indoor & outdoor installation in Control room building & Local Control rooms and outdoor areas.

Welding Socket - 63A, 415V, 3 Ph, 4 Wire, 5 pin interlocked plug and switch with earthing contact to be used in Control room building & Local Control rooms and outdoor areas. Welding sockets shall not be connected to lighting distribution board and shall get supply from feeders in the MCC/ACDB/PDB.

All receptacles shall be provided with matching plug-tops. All hardware shall be of Stainless steel type only including the mesh of well glass luminaries, nut, bolts, washers, etc.

30.2.7.2. STREET LIGHT POLES (FOR BOUNDARY WALL AND BARRAGE AREA))

Hot dipped galvanized poles with integrated in-built control box and lighting brackets is a preferred option to ensure long life of poles and to delay effect of corrosion. But in keeping view of energy efficiency the street and area lighting should be designed to keep lux level at lower limit specified in the standards. LED Streetlight system wattage 30W IP66 Multiple LED with Lens optics and Pressure die-cast aluminium housing for effective thermal management. Total system Lumen of 30W LED should be Lumen Efficacy >95 Lm/W, Power factor>0.95, CRI>70. Complete with Mounting Brackets & accessories as required with connections. It consist of GI pipe bkt of 3.5 meter length , 1 meter Tilted at 45 degree & 2.5 mtr straight with 3 nos of suitable size Clamp having MS plate 300 mm x 300 mm x 6 mm thick welded with bottom of pole and suitable hole with rectangle shape wiring of pole with 3 x 1.5 sq mm copper conductor FR wires, Bracket should be Painted from bottom and rest of pole with 2 coat of aluminium paint of superior quality of approved brand etc as required for boundary wall and Barrage Area.

30.2.8. High Mast Lighting System

30.2.8.1. GENERAL

High Mast at the proposed locations in the plant area shall have adequate height to achieve the required illumination. Top level of high-mast foundations shall be as per the approval from the Employer's Engineer. All High Mast of similar height shall be identical in construction to allow possible future relocation of High Masts within the area. A High Mast Switchboard is required to be installed at the base of each High Mast. The High Masts are expected to be fabricated out of steel.

The High Mast shall be designed for the number of light fittings determined by the Lighting Design based on the average 30 lux (with minimum 20 lux) of illumination plus two additional fittings to allow for possible future modifications/expansion. The High Mast shall be designed for the worst sail area resulting from the most adverse configuration. The High Mast shall be designed to withstand loads from fabrication, handling, erection, and for the dynamic loading outlined below.

30.2.8.2. DESIGN CRITERIA

The lighting design shall be in accordance with IS:3646. The selection of lamps and luminaire types shall be based on high efficiency, good glare control and illuminance level required. Luminaires, mast and brackets shall be selected to suit the harsh environmental conditions specified. Luminaires shall have high power factor (0.85 or higher) control gear. Any apparatus, appliance or material or services which may be necessary to make the system complete and perfect in all respects even if not particularly specified shall be furnished, without any additional expense to the Employer. Details not usually shown or specified, but necessary for the proper installation and operation of the work shall be included.

30.2.8.3. FITTINGS

Lighting fittings selected shall be LED type only. Lighting fittings shall be full cut off type to prevent stray light above 90 deg.

30.2.8.4. LIGHT SWITCHING PHILOSOPHY

Each High Mast shall be controlled from Main Lighting distribution board (MLDB). When there will be main power failure the high mast will automatically operate on DG supply.

30.2.8.5. LOCATION OF HIGH MASTS

High Mast locations shall be as shown in the Boundary Wall Drawing attached with these specifications. High Mast number, height and location are indicative, final details as per the detailed design shall be submitted to the Employer for approval. It is anticipated that the high mast positions as shown on the Drawings will provide sufficient coverage to obtain the specified illumination.

30.2.8.6. DETAILED LIGHTING PLAN

Detailed lighting distribution plans of the entire area along with Lux level plot plan shall be provided for approval of the Employer by the successful contractor.

30.2.8.7. HIGH MAST HEAD FRAMES

Each High Mast shall be fitted with a head frame, which shall be capable of being lowered and raised by means of a winch or other similar mechanical mechanism. The winch shall be able to be operated by use of a power tool. Each High Mast shall be provided with internal power tool complete with drive motor and drive assembly of suitable rating. The power for the drive motor of power tool shall be from the respective high mast switchboard. The head frame shall be of durable steel construction fitted with light and gear fixings and junction box. It shall be in single piece for maximum strength. The head frame shall also act as an electrical conduit with cable holes protected by grommets. The head frame shall incorporate arrangements to prevent damage to the galvanizing of the High Mast.

30.2.8.8. MECHANICAL ARRANGEMENT – LOWERING AND RAISING HEADFRAME (RING) SYSTEM

For installation and maintenance purpose, it is required that the headframe (ring) be able to be raised or lowered using a winch or approved lowering device to the base of the High Mast. The steel wire rope supporting the headframe shall be kept in balance and horizontal at all times. A device, suitably protected from corrosion, shall be incorporated to ensure that the tension rope cannot accidentally or manually be released without a service tool.

30.2.8.9. TOP PULLEY ASSEMBLY – LOWERING AND RAISING HEADFRAME (RING) SYSTEM

The pulleys for the lowering and raising of the headframe system shall be of non-corrodible material and shall run on self-lubricating bearings with stainless steel axles. They shall be of sufficient diameter so as to enable multicore flexible cables to be used. Arrangements shall be provided to ensure that the electric cables and steel wire ropes are separated before passing over their respective pulleys and close fitting guides shall protect the pulleys to prevent ropes and cables leaving the pulley grooves. It is intended that there will be 2 cables from the High Mast Distribution Board at the base of the High Mast to the junction box on the headframe. Individual cables will then run from the junction box to each light fitting. This cabling arrangement will need to be considered in the design.

The pulleys shall be housed in a chassis integral with a sleeve which slips over the top of the High Mast and is secured axially and in azimuth. Guides and stops shall be provided for locking the headframe and an anchor point shall be securely welded to the assembly to receive the safety maintenance equipment. The complete chassis assembly shall be hot dip galvanized after fabrication. The pulley assembly shall consist of safety brakes capable of immediate stopping of the raising and lowering device even in the extreme case of hoisting cables breaking.

The pulley assembly shall be protected by a galvanized steel/aluminium or other approved weatherproof cover.

30.2.8.10. WINCHES – LOWERING AND RAISING HEADFRAME SYSTEM

Winches shall be completely self-sustaining without the need for brakes, springs or clutches which require adjustment and shall be designed to be installed or removed through the door opening. Termination of the winch ropes shall not involve distortion or twisting of the rope structure. A minimum of four turns of the rope shall remain on the drum when the lantern carriage is fully lowered. Winch drums shall be grooved to ensure a tidy rope lay. A test certificate issued by an independent test house shall be supplied with each winch. The capacity and operating speed of the winch shall be clearly marked on each winch on an indelible label together with the Specification of the recommended lubricant. Each winch shall be supplied with a fitted canvas cover.

30.2.8.11. LIGHTNING PROTECTION AND EARTHING SYSTEM OF HIGH MAST

Each high mast shall be provided with lightning protection and earthing system which shall be installed and tested as per BS:6651, BS:7430 and TR7, ILE, UK, and IS:2309, IS: 3043 & IEEE:80-2000.

30.2.8.12. OPENINGS

Any openings in High Mast for feeding of cables/stainless steel rope in and out of the High Mast require coverings/cappings so as to prevent the intrusion of rain water into the High Mast.

30.2.8.13. DYNAMIC LOADING

All High Masts shall be designed for maximum reaction arising from basic wind speed of 180 km/hr and factors K1, K2, K3 as per IS:875 (Part III) for design wind speed. The minimum design life shall be 30 years. High Masts shall be designed in accordance with relevant Indian earthquake standard. The design shall be such that wind excited oscillations are damped as much as possible and an adequate allowance shall be made for the stress due to these oscillations. The method of damping shall be stated. Full calculations of the forces involved shall be submitted for approval. The analysis shall show the resultant loadings, deflection and stresses in all three principal axes at a minimum of 500 mm increments over the total length of the High Mast. In addition, High Mast structures shall have adequate strength to resist fabrication, handling and erection loads without becoming overstressed or deflecting excessively.

30.2.8.14. HIGH MAST CONSTRUCTION

All steel used in the construction of the High Mast, including welding shall comply with relevant Indian or British standards for Structural Steelwork. High Mast shall be constructed from mild steel plates, of grade and thickness as determined in the design. The minimum steel plate thickness shall be 6 mm. An appropriate corrosion allowance shall be used in the design. High mast shall be cut and folded to form a polygonal/circular section. Adjoining sections of the High Mast shall be joined by taper slip fit jointing. No site welded joints will be permitted.

All High Masts shall have a close fitting weatherproof door at the base with hinges and a heavy duty lock. The lighting distribution board shall be placed inside the High Mast base at this location. The size of the door is expected to be approximately 1.00 m x 0.50 m in size but may vary according to each design. The bottom of the door shall be located at a height of 0.50 m from the underside of the base plate of the High Mast. The door opening shall be reinforced where required to prevent buckling. The reinforcement being designed to suit the width of the door opening under the designing loading specified. Ten (10) sets of keys shall be provided for each type of lock.

The baseplate shall be free from laminations and the welded connection to the High Mast shall fully develop the strength of the section. In addition supplementary gussets shall be provided between bolt holes. On the completion of fabrication, all High Masts and headframes shall be hot dipped galvanized both internally and externally to a minimum thickness of 100 microns.

30.2.8.15. FOUNDATIONS

The design and layout of each type of High Mast shall be furnished. The design shall be based on the foundations not resting on bedrock & shall be carried to a depth of at least 2.0 m below final grade. Settlement shall not exceed 25 mm, unless specified otherwise and the structural arrangement and design shall be such as to withstand such settlements. The top level of the concrete pedestal shall be as per the approval of the Employer’s Engineer. The footings for the High Mast including holding down anchor bolts with nuts and washers shall be supplied and installed under this contract.

30.2.8.16. WIRE ROPES

Wire rope system shall be suitable for maintaining the lighting fixtures/control gear from the ground level in spite of crash barriers around the mast. Wire ropes shall be flexible stainless steel type. Thimbles and terminals shall be of compatible material. Ropes with hemp cores will not be permitted. In the event of failure of one rope the other rope shall hold the lantern carriage.

30.2.8.17. MATERIALS

All materials shall comply with relevant Indian or British Standards. All steel conduits, metal work, angle iron brackets, suspension rods etc. shall be hot dipped galvanized to a minimum thickness of 100 microns. Where galvanizing has been damaged this shall be repaired with an approved two pack zinc rich epoxy finish.

30.2.8.18. LUMINAIRES

Luminaires shall be standard industrial 4x400W LED type Lighting fixture shall be waterproof, dust proof and suitable for highly corrosive atmosphere. It shall be manufactured with die-cast aluminium, MBV treated reflector, electronically brightened and anodized, IP 67 degree of protection and confirm to relevant IS specifications. It shall be provided with stainless steel toggles, heat resistant & toughened glass cover. Hardware used to install the fittings, control gearboxes and for other purposes shall be of stainless steel. The luminaires shall be tested as per Indian Standard and shall be suitable for installation on high mast.

30.2.8.19. AVIATION LIGHT

LED type aviation light shall be provided at each mast.

30.2.8.20. POWER TOOLS

This is a geared motor with suitable torque limiter, industrial duty type. The motor is mounted on MS hot-dip galvanized plate inside the mast with a possibility of adjusting its position. However, the adjustment shall be so arranged that it cannot be altered easily during normal use of tool at site.

30.2.8.21. HIGH MAST SWITCH BOARDS (HMSB)

These boards shall be free standing pad mounted type. The boards shall be designed for the number of circuits as required. The boards shall include miniature circuit breakers/ELCB, Contactor, ON-OFF Control Switch and all other required accessories as required. The cubicle shall be designed for mounting over RCC pad of 300 mm thickness minimum and shall be capable of withstanding the vibrations normally experienced due to vehicular traffic. The top cover of the enclosure shall have slope to prevent accumulation of rainwater. A gland plate shall be provided at the bottom of the switchboard. A lamp shall be provided inside the switchboard, with door switches on both doors, so as to switch ‘ON’ when the door is open.

The circuit wiring shall be as required. System control panel shall be fabricated out of CRCA sheets – 2 mm thick for structural components and 1.6 mm thick for covers and doors & hot dip galvanized after fabrication. HMSB shall be fabricated out of stainless steel of grade 316 to prevent corrosion. HMSB shall be sized to allow for heat generated and design includes for dissipation of heat and shall be IP 65 degree of protection plus canopy, whereas system control panel shall have minimum IP54 degree of protection. Each board/panel shall be provided with hinged door with gaskets.

230V AC auxiliary and control supply aluminium bus bars shall be provided through control transformer of adequate capacity in HMSB. The Board/Panel shall have earth bus bar running through the whole length of the board. All equipment mounted in the board shall be directly connected to this earth bus.

30.2.8.22. WIRING

Wiring shall be complete in all respects so as to ensure proper functioning of control, protection and interlocking schemes. Control wiring shall be XLPE insulated stranded, copper conductor of 2.5 sq.mm cross section. Each control wire shall be identified at both ends with wire designations in accordance with the relevant Indian Standards. All wire terminals shall be with compression or clamp type connectors. Wires shall not be spliced or tapped between terminal points. Designation ferrules shall be interlocking type with designation engraved with indelible ink. Not more than two wires shall be connected to one terminal. Power and control wires shall be neatly bunched, separately and adequately supported so as to prevent sagging and strain on termination. Terminal blocks for power and control wiring shall be provided with adequate clearances.

30.2.8.23. COMPONENT SPECIFICATION OF HMSB

A) Contactors

Contactors for AC shall be 3 pole air-break electromagnetic type suitable for making and breaking locked rotor current of the motor which is equal to around six (6) times the full load current. Contactor shall have minimum 2 Nos. auxiliary contacts. Minimum rating of power contactor shall be 16 Amps. Contactors shall be suitable for uninterrupted duty as per IS 2959 and utilization category shall be AC3 as per IS:4064. The contact material of the contactors shall have anti-weld properties. Insulation class of the operating coils shall be class E or better. Operating coils of AC contactors shall be suitable for 240 V $\pm$10%, 50 $\pm$3% Hz, AC supply. The contactors in general shall not drop out at voltage on and above 65% rated control supply voltage.

B) Auxiliary Contactors

The auxiliary contactors and no volt relay will be provided as per circuit requirement. The contact rating shall be 10 Amp for AC. The auxiliary contactors shall have at least 8 contacts in contact combinations as per the requirement.

C) Control Terminal Blocks

Control terminal blocks shall be of 1100 volts grade, rated for 10 amps and in one piece moulding. It shall be complete with insulation barriers, clip on type terminals and identification strips. Marking on terminal strip shall correspond to the terminal numbering on wiring diagrams. At least 20% spare terminals for connections shall be provided and these spare terminals shall be uniformly distributed on all terminal blocks. All terminal blocks shall be suitable for terminating on each side, two (2) Nos. of 2.5 mm2 size stranded copper conductors. All terminals shall be numbered for identification and grouped according to the function. Engraved white-in-black labels shall be provided on the terminal blocks. Wherever duplication of a terminal block is necessary it shall be achieved by solid bonding links. Self-aligning, spring loaded, silver plated, sliding contacts for proven design shall be provided as control terminals for withdrawable / drawout modules. Detachable plug and socket type control terminals shall also be acceptable.

D) Indicating Lamps

The indicating lamps shall be panel mounting large industrial cluster LED type and shall be interchangeable. Indicating lamps shall be with translucent lamp covers. The lamp covers shall be mounted flush on the front panel door and shall be replaceable from the front of the cubicle.

30.2.8.24. INSTALLATION OF LIGHT FITTINGS

Mounting height of center-line of the various lighting equipment from FFL/Working platforms or finished grade level shall be as noted below unless otherwise specified in corresponding lighting layout drawings:

- Lighting panels/control gear boxes : 1500 mm
- Switch boxes : 1500 mm
- Receptacle boxes (Indoor) : 500 mm
- Receptacle boxes (Outdoor) : 1000 mm
- JB on poles/Masts : 750 mm

Lighting fixtures to be mounted on ceiling/platforms having considerable vibrations which can cause damage to the fixtures shall be suitably supported with rubber pads to limit vibrations in the fixtures. Where conduit wiring is adopted, an earth continuity conductor of 12 SWG galvanized steel wire shall be provided for earthing the lighting fixtures, switch boxes, etc. The earthing conductors shall be run along the entire length of the conduits and shall be securely connected and terminated at the junction boxes/control gear boxes/lighting panels. The earth connection shall be properly secured with bolts, nuts and washers. For outdoor lighting installations, an earth continuity conductor of atleast 25 x 3 mm galvanized steel flat shall be used for earthing the lighting masts/poles.

While designing the lighting circuit, the cables shall be sized such that the farthest loop from the supply receives no less than 95% of its nominal voltage, in addition it must be assumed that all the light fittings are energized while this design calculation is made. LED lights should be chosen & located carefully where they illuminate rotating shafts, so as to avoid stroboscopic effect. Fittings made from Aluminium and its alloys should be avoided because the oxide that invariably forms after a time is considered as a potential source of sparks caused by mechanical impact. All fittings shall be installed at a safe height for maintenance & effective illumination. All lighting controls shall be from a non-hazardous area, using double pole, switches, the supply neutral should be switchable along with the phase.

30.2.8.25. TESTING AND INSPECTION

Equipment of Illumination system should be type tested and proven type. Type test certificates shall be furnished for Purchaser's review. Equipment shall be subjected to routine tests as per applicable Indian Standard. Test reports shall be submitted for approval.

30.2.8.26. SPARES

Suitable quantity of commissioning and successful running for 2 years spares list shall be submitted for approval and spares as per approved list shall be supplied free of cost.

30.2.9. Cable Trays and Accessories

This specification covers the requirements of cable trays, support structures, cable laying, termination, earthing and lightning protection system.
While finalizing Cable routing layouts, consideration shall be given to the requirements of Safety, Reliability and Convenience of cable laying and termination. Where duplicate drives/auxiliaries are provided for reliability, cable routing shall be segregated to the extent practically possible.

In cable trenches, distance between bottom most tier and bottom of trench shall be 150 mm and clearance from top most tray to top of trench cover shall be 400 mm. Distance between two tiers shall be minimum 250 mm. PCC flooring of built-up trenches shall be sloped in longitudinal and also in transverse direction for effective drainage system. Cables should not be laid directly in the trench floor. Cables trenches should be provided with strong & effective covers with water & fire proof sealing arrangement at trench entry & exit points.

Other than cable vault & cable trenches, Cable trays shall be laid in vertical formation to avoid dust accumulation. In cable spreader room a clear access passage of at-least 800 mm wide shall be provided along the cable ways. Wherever passage is through cable routes, a clear height of not less than 2.0 M shall be provided.

Cables of different voltages shall be laid in separate racks. Minimum distance of 250 mm shall be maintained along the routes between various types of cables. In case of horizontal formation, the highest voltage cables shall be laid in the top most position in the tray stack followed by other grades as follows in the descending order.

- 11 kV Power cables (Top Tier)
- 1.1kV Power cables (Below HT Tier)
- Electrical Control Cables (Below LT Tier)
- Instrumentation/Signal cables (Bottom most tier)

On cable trays all the multicore power cables can be laid in touching formation. Single core cables shall be laid in trefoil formation with the spacing equal to twice the diameter of the cable. Control cables shall be laid in not more than two layers. Power & Control cables shall be laid on ladder type trays. Instrumentation & Signal cables shall be laid on perforated type trays. Cable trays shall be supported at an interval of 1500 mm approximately. Vertical runs shall be supported at an interval of 1000 mm approximately. Cable tray support system shall be site fabricated, welded and painted steel supports. Cable tray support system shall consist of ISMC channel as vertical support & ISA as horizontal arm. Horizontal arm is welded to the vertical support MS channel.

Cables shall be terminated using double compression cable glands suitable for the voltage grade of cables. Cable glands shall be heavy duty brass. Cable lugs for power and control cables shall be tinned copper solderless crimping type conforming to IS 8309. 11 kV cable terminations shall preferably be of heat shrinkable type kits.

Fire barriers/ Fire stops shall be provided for all fire rated wall and floor penetrations and for all direct cable entries into electrical Switchgear / Panels from Cable Vault. Fire barriers/ Fire stops shall provide a fire endurance rating of at least 2 hours. The fire sealing material shall be non-hygroscopic, mechanically steady, non-toxic and physically & chemically stable under fire conditions.

Fire barriers/ Fire stops shall be either of the following methods:

a) Panel sealing method comprising Encasing Panels, Cavity fill material & Sealant

b) Mortar Sealing method comprising Mixing Mortar curing with water

30.2.9.1. DESIGN AND CONSTRUCTION OF CABLE TRAYS

Cable trays shall be ladder/perforated type as specified prefabricated made of Fibre Reinforced Plastics (FRP) complete with matching fittings (like elbows, bends, reducers, tees, crosses, etc.), accessories (like side coupler plates, Tray cover etc.) and hardware (like bolts, nuts, washers, GI strap, hook etc.) as required. The size of the trays shall be selected on the basis of maximum 50% fill criteria. Cable trays shall be standard width of 150mm, 300mm, 450mm & 600mm. Thickness of side coupler plates shall be minimum 2.5mm and of tray covers shall be minimum 1.6mm. Cable Trough shall be required for branching out few cables from main cable route. These shall also be fabricated of FRP of minimum thickness 3mm. Troughs shall be of standard width of 50mm & 75mm and 25mm height.

30.2.9.2. DESIGN AND CONSTRUCTION OF CONDUITS/PIPES, FITTINGS & ACCESSORIES

Conduits/pipes offered shall be complete with fittings and accessories (like tees, elbows, bends, check nuts, bushings, reducers, enlargers, coupling caps, nipples etc.). The size of the conduit/pipe shall be selected on the basis of maximum 40% fill criteria. Hume pipes shall be of reinforced concrete conforming to class NP3 for road crossings as per IS: 458. GI pipes shall be of medium duty as per IS: 1239.

Rigid steel conduits conforming to IS: 9537 Part-I & II shall be suitable for heavy mechanical stresses, threaded on both sides and threaded length shall be protected by zinc rich paint. Conduits shall be smooth from inside and outside. Fittings and accessories shall also be hot dip galvanized.

Flexible conduits where required, near equipment terminations, shall be made with bright, cold rolled, annealed and electro-galvanized mild steel strips. Flexible conduits shall be supplied with suitable end coupler nipple and check nut. In corrosive areas, epoxy coated conduits shall be provided.

30.2.9.3. CABLING INSTALLATION

The work shall be carried out in the best workman like manner in conformity with relevant specifications / code of practices of the Bureau of Indian Standards. In addition, work shall also confirm to the requirements of latest editions / amendments of the following:

- Indian Electricity Act and rules framed thereunder
- Fire Insurance Regulations
- Regulations laid by the office of the Chief Electrical Inspector to Government
- Any other regulations laid down by the local authorities

Support system shall be so designed that it is able to withstand weight of the cable trays, Weight of the cables, concentrated load of 75 Kg between every support span without any permanent deflection. Factors of safety of at-least 1.5 shall be considered. Cable tray mounting structure shall be welded/bolted to the plate inserts or to steel structure and the type of welding shall be of fillet type of at least 6mm size.

All cable way sections shall have identification, designations as per cable way layout drawings and painted/stenciled at each end of cable way and where there is a branch connection to another cable way. Minimum height of letter shall be not less than 75mm. For long lengths of trays, the identification shall be painted at every 10 meter. Risers shall additionally be painted/stenciled with identification numbers at every floor. Tray covers shall be provided for overhead cable trays on top most tier. The cable risers or vertical raceways shall also be covered by cable tray covers upto 1.5 metres from respective floor for mechanical protection. The sheet cover shall be of removable type.

30.2.9.4. TESTING AND INSPECTION

Equipment offered shall be of type tested and proven type. Type test certificates for test conducted earlier on similar rating shall be furnished. Routine tests shall be carried out for all the equipment as per applicable standards.

30.2.9.5. SPARES

Suitable quantity of commissioning and successful running for 2 years spares list shall be submitted for approval and spares as per approved list shall be supplied free of cost.

30.2.10. 415 V Silent Diesel Generator Set

The output from the unit shall be 250 KVA (at alternator output), 415 volts, 3 ph, 50 Hz, 0.8 power factor. It shall cater to 50% indoor lighting and 20% outdoor lighting, Operation of Mitre, sluice and barrage Gates.

DG set shall be required to operate as standby unit under the following environmental conditions:

- Ambient temperature: 50°C
- Relative humidity: Above 90%
- Altitude: Sea-level

30.2.10.1. DIESEL ENGINE

The engine shall comply with the requirements of relevant BS 649/BS 5514. Engine shall be designed for maximum reliability ensuring uninterrupted operations. Engine shall be capable of delivering 10% overload for a period of one hour in any consecutive twelve (12) hour period. The values of rating, rotative speed and brake mean effective pressure (BMEP) for a specific engine design will not be accepted unless they are published as catalogue data.

Engine shall be heavy duty, industrial type four stroke delivering matching BHP at 1500 rpm, turbo charged radiator coded suitable for standby duty. Engine and auxiliary system shall be designed for safe start, stop and running on high speed diesel (HSD). Engine performance shall confirm to ISO:3046/BS:5574.

Engine Governor shall be electronic.
The set shall be capable of accepting at least 60% of rated load in a single step from an initial startup condition.

Filters of the replacement element type shall be provided on the engine for fuel oil, lubrication oil and air intake.

Engine Starting shall be 24 V DC battery system designed so that at least two separate attempts can be made, to prevent complete loss of starting capacity in one attempted engine start. Sizing of starting system should be in accordance with the engine manufacturer's recommendations, but in no case should the storage capacity be less than
30 seconds of cranking. An automatic static battery charger which possesses characteristics of "Zero-float" and positive charging shall be used. An engine-driven battery-charging generator is not acceptable. Batteries shall be maintained in a warm (20^{O}F to 110^{O}F) atmosphere to assist in quick starting. The battery system shall be of lead acid automotive type.

Flywheel Guards shall be provided as required.

An **engine control unit** free from vibrations comprising of the following devices with sensors (mounted at engine) shall be provided as minimum:

- Water temperature gauges for jacket water temperature
- Water pressure gauge
- Tachometer for engine speed
- Lubricating oil, pressure and temperature gauges
- Automatic shutdown and indication for low lubricating oil pressure, over crank, low coolant level, high cooling water temperature and engine over speed.

30.2.11. Engine Auxiliaries

30.2.11.1. COOLING SYSTEM

Cooling system shall be radiator type. Anti-freeze liquids and corrosion inhibitor as recommended by engine manufacturer shall be used to obviate the danger of damage occurring from the use of incompatible or improper liquids or inhibitors.

30.2.11.2. INTAKE AND EXHAUST SYSTEM

A) A residential type exhaust silencer of suitable size for exhaust run shall be provided complete with all support frames etc. to reduce engine exhaust noise. It should be kept as straight as possible.

B) Dry type air-inlet filter, exhaust manifold, mufflers shall be used. Type of filter selected shall be to fit the environmental conditions at the site.

C) Combustion air shall be taken directly from outside.

D) The air-intake and exhaust shall be so located as to preclude the contamination of fresh air with exhaust gases.

E) To dispose of the radiant heat given off by the exhaust pipe, sheet metal ductwork shall be supplied with 50 mm of space between the ductwork and the exhaust pipe.

30.2.11.3. FUEL OIL SYSTEM

A) The fuel-injection system shall be complete with PT fuel pump, injectors, fuel filters and self-contained piping.

B) The system shall generally comprise of

- Day tank capacity for 10 hour running at 75% load.
- Pumps required for conveying fuel from day tank to engine. Critical pumps should be provided in sets (1 working + 1 standby)
- The day tank shall also act as a relief and by-pass tank for fuel oil that is circulated to the injectors whereupon any excess fuel is by-passed back to the day tank.

30.2.11.4. FUEL FILTERING SYSTEM

The primary filtering system shall be located at day tank inlet. In addition the engine shall have secondary filtering system. Both filters shall be capable of absorbing water.

30.2.11.5. LUBRICATING OIL SYSTEM

The pressure lubrication system shall be used. The filter shall be of simplex type with paper element. The full flow lubricating oil filter can be mounted on the lubricating pump or remote mounted with flexible lines.

30.2.11.6. PIPING AND OTHER ASSOCIATED CONNECTIONS

All piping, flexible connections, flange valves, seals, fittings etc. shall be supplied by the Contractor for all the associated auxiliaries of equipment.

30.2.11.7. ALTERNATOR

Alternator shall be air cooled, brushless, 3 phase, fan ventilated, synchronous type fitted with heavy duty, long life ball or roller bearing with forced lubrication or lubricant packed for approximately 4000 hours of running without attention. The alternator shall be manufactured in accordance with BS 2613 IEE-341 or as per relevant BIS, ISO, DIN, NEMA, standard. The unit shall be horizontally mounted.

Enclosure shall possess minimum IP23 degree of protection.

Insulation throughout shall be class H, temperature rise by resistance. All windings shall be impregnated to allow operation in climatic conditions specified in this volume.

The Alternator shall be provided with following minimum accessories:

- Resistance temperature detectors
- Bearing temperature detectors
- Space heaters.

The basic ratings of the Alternator shall be as follows:

a) Rated voltage : 415 Volts

b) Speed : 1500 rpm

c) Rated power output : As specified (Continuous rating)

d) Frequency : 50 Hz

e) Number of phases : Three

f) Power factor : 0.8

g) Type : Brushless, synchronous, self-excited self-regulated

h) Neutral earthing : Solid grounding

i) Voltage regulation :+1% of rated voltage from no load to full load at any power factor between 0.8 lagging and unity

j) Type of cooling : Self cooled fan ventilated

30.2.11.8. METERING AND AMF CONTROL PANEL

This is intended for operation of DG set in auto mode. The panel shall be sheet steel construction and arranged for free standing, floor mounting and bottom entry with front and rear access. The interior wiring of the cubicle shall be looped and clipped and all wire ends are to be clearly identified. Any printed circuit boards shall be tropicalized.

Following metering and protection devices as a minimum requirement shall be included in each panel:

A) Metering Instruments (Digital)

- Voltmeter
- Ammeter
- Frequency meter
- KW meter
- Battery voltmeter
- Power factor meter
- Hours run indicator
- KWH meter
- KVAR meter
- Excitation current ammeter
- Excitation voltmeter
- Engine Speed Indicator

B) Push Buttons

- Engine start PB
- Engine Stop PB
- Lamp Test PB
- Reset PB
- Emergency Trip PB

C) Indication Lamps (Cluster LED type)

- DG set on
- Load on DG set
- Set running
- Mains available
- Mains failure
- Start failure
- Generator over current

- Generator high voltage
- Generator low voltage
- Earth fault
- High engine speed
- Low engine speed
- Low fuel level
- High fuel level
- Charge failure
- Generator winding temperature high
- High bearing temp
- Low lubricating oil pressure
- High lubricating oil temperature
- Engine jacket water temperature high
- Engine jacket water pressure low
- Reverse power
- Low fuel oil pressure
- Rotor diode failure

D) Protective Relays

- IDMT relay (Over current and earth fault)
- Over voltage relay
- Under voltage relay
- Reverse power relay
- Field failure relay
- Differential relay
- Phase failure relay

E) Multi-function Meter with Transducer

- Voltage – Ph-to-Ph & Ph-to-N
- Current – line to neutral
- Power – kW, kVAH, kVAR (Avg. & Ph. wise)
- Energy – kWH, kVAH, kVARH
- Power Factor – Average & Ph. wise.
- System frequency
- Import & export kWH & kVARH.
- RS 485 MOD BUS

30.2.12. Lighting Transformer

0.433 KV / 0.433 kV Lighting Transformers shall be dry type natural air cooled (AN) suitable for indoor installation. Detail of transformer shall be provided in respective specifications & datasheets. Transformer shall be housed in freestanding enclosure of welded sheet steel frames with expanded metal screens of suitable size or louvers backed by wire mesh. The transformer shall be double wound core type with cold rolled grainoriented silicon steel insulated laminations and clamped to minimise vibrations and noise. Core fastening bolts shall be insulated to reduce losses and to avoid hot spots. All the parts of the magnetic circuit shall be effectively connected to the earth system.

The winding shall be of copper and shall be designed for full load current and to withstand the thermal and electromagnetic stress arising due to the through fault current. The current carrying winding joints shall be electrically brazed. Transformer shall be of energy efficient level 2 as per IS 1180. Insulation shall be of cast resin type having class of insulation as H. Transformer shall have degree of protection as IP-42 for indoor Installation; however Marshalling box and cable termination box shall have degree of protection not less than IP-55. The percentage impedance of transformer shall generally be as per Indian Standards. However, the specified impedance rating while carrying out the electrical system study shall be informed later in the technical specification of the said equipment.

30.2.13. Grounding System

The Contractor shall make the design and the calculation of the whole grounding system of Control Building, Valve House and and other associated areas. The contractor shall supply all grounding conductors, grounding rods, connection material for the complete embedded grounding system which shall consist of underground earth mat. The installation of the embedded grounding system shall be done by the Contractor. The concreting of the embedded grounding system shall be done by the Civil contractor under the supervision of the Electrical Contractor.

The earthing system shall be such structured that breaking of a conductor at any point in the network shall not disconnect any part of the network from the earth. The earthing conductors shall be of MS Rods minimum diameter of 30 mm. The risers shall be of MS flat duly galvanized and minimum size of 70x10 mm. The mesh spacing of the ground mat shall not be greater than 3m x 3m. Earth conductor in ground shall be thermo welded to each other.

The earthing system shall provide:

- adequate protection of personnel against dangerous voltages, currents and arcs,
- Low earthing impedance for the transformer neutrals,
- The fault current shall flow through the earthing system,
- Limiting the induced or capacitively transformed voltages on electronic cables, circuits, panels and other equipment to low voltage, weak current.

30.2.14. Telephone System (EPABX)

30.2.14.1. GENERAL

The design shall be in accordance with the basic requirements described in the Tender Document and the best current engineering practice, together with the following general design requirements:

a) The essence of design shall be safety, simplicity and reliability in order to give long continuous service with high economy and low maintenance cost.

b) All equipment shall be designed to minimize the risk of fire and any damage which may be caused in the event of fire.

c) Care shall be taken so that materials and equipment are the standard Catalogued products of manufacturers regularly engaged in the manufacturer of such products and shall be of the latest standard designs that conform to the specification requirements. Design shall also be based on similar type of equipment supplied from one manufacturer, utilizing interchangeable parts, wherever practicable.

d) The design shall comply with relevant codes and regulations listed.

e) All apparatus, equipment and works shall be so designed that they provide satisfactory service and without any harmful effects for prolonged and continuous periods in the worst climatic conditions.

f) The reference design ambient temperature for all electrical equipment shall be taken as $50^{O}C$ and appropriate derating factors should be considered for equipment as applicable.

g) Suitable derating shall be applied based on published data against the most severe conditions encountered in the site, by reducing the permissible temperature rise above the ambient level.

h) Tentative number and location of the Telephone system is shall be decided during detailed engineering in consultation with the Employer.

30.2.14.2. MAIN EPABX

The proposed EPABX shall be 100% Non-Blocking, Electronic, ISDN native. The topology shall be totally distributed so as to support and configure the Remote Units flexibly as per the changing and evolving requirements on Optical Fiber as well as copper cable.

The system shall be based on High Speed, i3 CPU and with at least 2 GB RAM. It shall be equipped with Duplication of complete Control section (viz. CPU, Signalling circuits, Tone generators, Memory, Hard Disk – 1TB, RS232 ports, DTMF resources, conference circuits and other essential circuits) and common Power Supply & Ringer section in 100% Hot Standby mode. The system shall enable automatic changeover in case of failure in any of these without disrupting the existing calls in progress. The Operating system software shall be Unix based.

The system shall have RISC processor, RAM capacity of the system explicitly mentioned. It shall also specify the different control system elements duplicated in the offered system.

EPABX system shall be equipped with Ethernet port (30/100 Base T) and shall have provision to connect a TCP/IP LAN for management and metering application, which shall facilitate system management from any LAN node without using modems.

It shall be equipped with storage devices to save the data, as well as software necessary for its operation. For security reasons, these devices shall be of Flash ROM type, easy to duplicate and shall not cause any disturbance to the system. The Contractor shall specify whether information concerning variable data (forwarding, screenings) is automatically saved in real time, so that if the system goes down and comes up for any reason it doesn't loose data integrity.

30.2.14.3. TRUNK INTERFACES

The EPABX shall have all the following types of Interfaces:

- Analogue Interface to PSTN lines
- Interface to Leased Lines
- Paging System Interface
- Interface to VSAT Equipment
- BR and PR interface to Public ISDN Network
- Digital Interface for DID
- IP FOR VoIP & Data transfer

30.2.14.4. EXTENSIONS

A) Analogue Extensions

The system shall be compatible with both Pulse & Tone Dialling Instruments.

Contractor shall clearly specify the DTMF receivers available on the system whether they are centralized or distributed, if they are centralized. Contractor to mention number of such receivers on each board. The number of DTMF Receivers shall be 50% of the ultimate capacity to handle peak traffic conditions. The Contractor shall specify the number of such boards equipped in the system offered.

B) Digital Extensions

The Digital phones shall have an Alphabetic Keyboard with "Dial by Name" facility from the central database of the PABX system and a user-friendly operation of the PBX internal services and of the services provided by the ISDN trunk. These terminals, as well as lower- range terminals shall be equipped with keys, which can be directly programmed by the user. The keys enable the user to change several functions (for example: call forwarding code + external number, etc.)- An option shall allow the number of keys on certain terminals to be extended. It is desired that all programming information on digital sets to be centralized and saved in the PBX to enable simple replacement.

The Contractor shall offer his range of digital terminals giving detailed specifications of their features:

- voice sets
- voice and data sets for ISDN & VoIP..

For each type of terminal, the Contractor shall specify the following characteristics:

- type of terminal,

- remote power supply or not,
- maximum distance of connection on 0.5mm cable (min. 1000meters)
- number of pairs necessary for the distribution,
- capacity of data transmission,
- interface for ISDN & VoIP,

The features, which have to be systematically accepted by digital terminals, are:

- connection of VDU terminals
- additional ISDN services
- IP services

The Digital telephone sets with Display panels and Dynamic Soft keys as a part of this display panel shall be quoted. These shall be equipped with Text Messaging facility. The digital telephones shall have keys along with LCD display with associated icons / LEDs.

30.2.14.5. ATTENDANT CONSOLE (OPERATOR)

The operator console shall have the following features:

A) General

The attendant shall provide call presentation, chaining process, call-back shall be entirely managed by the PBX. However, it shall be possible to put certain calls on individual hold on keys that have been reserved to that effect. The capacity of the various queues shall have to be unlimited. The information displayed on the terminal shall have to be explicit enough to facilitate unambiguous call handling and shall give maximum details about the communication (normal call, urgent call, queue status, name of the internal called-party, status of the telephone set etc.).

B) Supervision of the Installation's Stations

An add on unit with attendant console shall be provided to enable single touch dialling and to supervise the status of certain extensions and trunks. A minimum of 48 terminals shall be supervised.

C) Manual or Automatic Answer

The operator shall be able to modify the call answer mode from his/her attendant console. In "automatic answer", calls must be presented and connected without any intervention from the operator.

D) Calling Internal or External Correspondents by Name

To facilitate the operation of attendant consoles, operators shall be able, whatever their communication position (direct call, transfer), to call internal and external circuits according to surname, first name or initials. To assist searches, the system shall be equipped with a spelling and phonetic approximation utility program. User-friendliness being a requirement, the user shall access the service via an alphanumeric keyboard, either integrated or external to the attendant console. The Contractor shall describe in detail the access modes and the number of subscribers serviced.

E) Text Messaging

The system's telephone application shall enable the operator on transfer call status to send a text message to a selected internal subscriber. The operator shall have the choice between sending the message immediately onto the display panel of the subscriber if his/her line is engaged or sending it to a text mailbox linked to the terminal, whether the latter is free or busy. This service shall only be provided if the internal subscriber's terminal is compatible with the service (digital terminals with text messaging feature). To facilitate the operation of this service, the operator shall have the choice between several types of messages:

- Pre-programmed messages to answer most common cases (example call back the switchboard, a visitor is waiting for you in reception etc.),
- pre-programmed messages to be completed (example: call back number XYZ),
- free messages to be composed entirely by the operator.

The Contractor shall describe clearly all the characteristics of the service and the size of messages, which can be sent in the various communication positions.

F) Hands-free and Amplifier

The operator can freely modify the operating mode of the attendant console and answer calls either in hands-free with the amplifier or with the telephone handset or headphones. When using the latter, the user can operate the amplifier with volume adjust.

G) Ringing levels

The operator shall be able to modify the melody and the ringing volume of the attendant console.

H) DTMF Frequency Transmission

The operator shall have the possibility to use servers controlled by Q23 coded frequencies.

I) Withdrawal of an Attendant Console

There must be a simple procedure to withdraw an attendant console from the group and
switch it into a "night service" position. The status of his/her terminal should be clearly indicated to the operator. Calls shall be forwarded to a particular station or a group distributed within the premises.

J) Automatic Transfer of Calls to Attendant Consoles

Then the attendant consoles that are present do not answer calls, the system should, after a time delay, automatically switch to "night service" mode. Calls must be routed towards dedicated stations, the status of the installation shall be clearly indicated to the operators and a simple procedure should enable return to normal situation.

K) Routing Calls to Individual Operator

Incoming calls on Specific trunks shall be possible to route to a particular operator or extension.

L) Additional Services

Attendant consoles enable the user to manage some operation parameters of the system, in particular the following points:

- Create, change or delete a subscriber's attributes,
- Manage service classes (automatic dialing and call transfer etc.)
- Manage the external abbreviated dialing.

All of these operations shall have to be protected by a password programmable by the head administrator.

30.2.15. Telephone Features

30.2.15.1. GENERAL

Following features shall be available without restriction to all the subscribers or freely programmable:

- Routing of an external bundle on a group or individual user,
- Calling an attendant console,
- External call barring,
- Local calls,
- Simultaneous 6 party Conference
- Consult a pending call,
- Broker's call
- Recording and transmission of external numbers
- Transit function,
- Bundles of external lines,
- Call pick-up,
- Call pick-up: group,
- Put on hold,
- Abbreviated external numbers - Minimum 200 numbers,
- Directory database in the system - minimum 1000 numbers,
- Call parking,
- Direct Outgoing Dialling (DOD),
- Direct Outgoing Dialling per cost center,
- Direct seizure of external line,
- Dedicated incoming station,
- Dedicated outgoing station,
- Station with direct routing to another station, to an abbreviated number, to an attendant console,
- Station with delayed routing,
- Protection against intrusion,
- Automatic call-back to a busy or free station
- Appointment call-back,

- Storing last dialed number,
- Last number redial,
- Call forwarding - no answer, busy, no answer/busy, fixed
- External call forwarding
- Remote call forwarding
- Night answering service,
- Call diversion on ringing,
- Moving service - without any intervention by the maintenance people, subscriber must be able to move to a new location and by dialing codes at the new locations, he should retain his existing number.
- Padlock with password protection
- Substitution -to temporarily avail all the features of the subscriber extensions at another extension.
- PIN dialing - Each extension should have a PIN dialing, through which one could make calls from a different extension and the metering must be made to the subscriber's extension.
- Call ID on Analogue Extension

30.2.15.2. PUSH BUTTON TELEPHONES

A) Features

- Feather touch push buttons for quick and sure dialing.
- Memory storage, upto 22 digits for purposes of redialing.
- Facility for redialing the last number called by pressing the repeat
- push button just once.
- Ringing facility with adjustable volume.
- Digital pulses during dialing to be muted to eliminate harsh sounds.
- Compatible with P&T network.
- Built in automatic gain control.

B) Specifications

1. System voltage : 48V DC + 10 %
2. Pulse Rate : 10PPS
3. Break make rates : 66:33/60:40
4. Inter-digit pause : 800m secs. (minimum)
5. Loop resistance from the exchange : 1 K ohms (maximum)

The push button telephones must confirm to CCITT standards.

The telephone offered shall be approved by the TRO for interface with P&T network. A copy of the certificate shall be enclosed.

C) Following Additional Features shall be built-in the System:

Multi Line Digital Stations

This function shall enable a user to simultaneously establish, from a station answering only one number, several outgoing or incoming communications. Only one communication is active at a given time, the other engaged communications being on hold; the user shall be clearly informed of the status of the pending communications.

Each key on the station can be allocated to a different call number, hence allowing differentiation of the calls. Contractor to mention how many multiline numbers can be programmed on one digital set.

Multiple Keys and Number Stations

Combining the two previous functions, each directory number can have several keys. The Contractor shall specify the number of manageable keys per station, a minimum of 6 keys which can be allocated to the multiple key / multiple number function would be desirable.

Executive/Secretary sets

- Call Filtering - Certain calls on the Executive set should be programmed to reach directly, whereas all other calls shall be routed to the secretary.
- Real time diversion without picking-up the call, Work Groups

Status to be supervised (Visual and audible) on a digital set by associating a key to an extension and monitor for the following status:

- free station
- busy station
- station receiving a call (ringing)

Hunt Groups of stations - sequential / cyclical / parallel

Utilization of ISDN Additional Services

The Contractor shall submit the list of ISDN additional services to be used on proprietary stations. The main requirements are as follows:

- Identification of an ISDN Caller

Some external subscribers must be identifiable by their name or the name of their company upon display of the calls on the attendant console or on proprietary stations. The caller's name shall be maintained after pick-up and shall reappear during all communication modes (back-and-forth, conference, and transfer).

- List of unanswered calls upto 8 calls

Automatic forwarding to Night-mode

Night-mode shall be automatically activated by the clock system and it is required to have night service based on the time of the day.

Additional Features
Following features shall be available with the EPABX system in addition to the above.

Music-on-hold

The system shall be equipped with in-built music-on-hold device that shall have a capacity of 10-15 seconds and shall have good acoustic quality.

Automatic Attendant

The proposed telecommunications system shall be equipped with 4 port P.C. "automatic attendant" feature allowing, the reception of external calls and offering to direct them interactively to a pre-defined service or subscriber. The interactive dialogue shall be based on DTMF. Errors (incorrect codes) shall be handled by an information message and return to the current message. If no Q23 code is received, the call shall automatically flow over to a dedicated number, after a pre-set delay.

Computer Telephone Integration

CT1 shall support for following computer environment- Digital, IBM, Microsoft, etc.

The physical interfaces supported shall be on V.24, RS232, SO, TCP/IP. Both first party and third party CTI solutions shall be supported.

IP Components

The EPABX shall have in-built interface for IP functionalities. The Contractor shall enclose the detailed implementation schematic for VoIP and shall quote price for 10 VoIP users. It shall support the following:

- Connection of a server via LAN-LAN router and LAN-WAN (ISDN)
- Voice over IP and Frame Relay.

30.2.15.3. SYSTEM ADMINISTRATION - MANAGEMENT TERMINAL

The proposed system should

- offer GUI based windows software with user-friendly access to the various proposed services,
- be protected by an overall access code and offer several secondary access levels,
- enable overall management of the system,
- provide menus in English, without obligation to answer questions with hexadecimal characters or mnemonics. A Windows-compatible application would be desirable.

30.2.15.4. MAIN DISTRIBUTION FRAME

The main distribution frame for Field side and Exchange side shall be housed in a metal cabinet and shall be equipped with Krone modules for 8 Pair terminations. An Intermediate Distribution Frame shall also be provided for 8 Pairs with Over-voltage and over-current protection for all the Trunk lines. The interconnection between MDF and IDF shall be done using Jumper Wire. The Contractor shall do all termination of cables and jumpering at the MDF.

30.2.15.5. POWER SUPPLY

A) FCBC

The Float cum Boost Charger shall be sized to supply power to the PBX for the required capacity and it shall simultaneously allow re-loading of the battery within 10 hours maximum. FCBC shall also be provided for the Remote units also.

B) Battery

Sealed Maintenance Free Lead Acid battery shall ensure automatic standby for the PBX in case of failure of the electric power supply or the rectifier. A minimum back-up of 6 hours is required.

30.2.16. List of Approved Makes

S. No.	Equipment / Component	Preferred Makes
1	HT Switchgear	Adlec (Schneider) / SPC Electrotech (L&T) / RISHA (L&T) / NITYA (Siemens)
2	LT Switchgear/Control desk	Adlec (Schneider) / RISHA (L&T, ABB) / SPC Electrotech (L&T) / Vidhyut Control (L&T) / NITYA (Siemens)
3	Distribution Boards	SPC Electrotech (L&T) / NITYA (Siemens) / RISHA (L&T, ABB) / Adlec (Schneider)
4	Distribution Transformer	Areva / Crompton / BHEL / Voltamp / Bharat Bijlee / Kirloskar
5	HT Power cables	Havells / Gemscab / Gloster / Unistar cables / CCI / KEC
6	LT Power cables	Havells / Gemscab / Gloster / KEC / Unistar / CCI
7	Control Cables, Wires & Flexible cables	Havells / Gemscab / Gloster / KEC / Unistar / CCI
8	Copper Wires PVC FRLS	Skytone / Echo Cables / National / Finolex / Polycab
9	Cable Glands/Lugs	Jainsons / Dowells / Gripwell / SMF
10	Cable Trays (FRP)	Ercon / Indiana / Sumip Composites / Sintex
11	Capacitor Panel with Banks and other related accessories	L&T / Epcos / Schneider / ABB / Asian / Havells
12	Battery	Exide / Amco / Amara Raja / Chloride / HBL
13	Battery Charger with DCDB	Chhabi Electricals / Caldyne / Mastek / DB Electronics / HBL
14	Diesel Generator Set	Powerica / Jakson / Sudhir/ Greaves
15	Alternator	Crompton Greaves / Kirloskar / Stanford
16	Lighting fixture with street light poles	Bajaj / Philips / GE Lighting / Havells / Wipro
17	High Mast	Bajaj / CGL / Philips

18	Aviation Light	Avaids Technovators Pvt. Ltd.
19	Plate-Switches & Sockets, Boxes	MK / Crabtree (Havells) / Anchor / ROMA
20	GI Conduit with accessories	BEC / AKG / SENCO / Jindal
21	VCB	Siemens / L&T / ABB / Schneider
22	ACB	Siemens / L&T / ABB / Schneider
23	MCCB	Siemens / L&T / ABB / Schneider
24	MCB / ELCB / RCB / MPCB	Siemens / L & T / MDS / Schneider / Havells
25	Fuse/Link	Siemens / L&T / Alstom / Schneider / C&S / Areva
26	Switch Fuse Units	Siemens / L&T
27	Contactors	Siemens / L&T / ABB / Schneider
28	Indicating Lamps / Push buttons	Siemens / Schneider / Teknic / Kaycee / L&T / Essen / Vaishnav / BCH / C&S
29	Push button stations	Siemens / Schneider / Teknic / Rishabh / L&T / BCH / Control Group
30	Meters (digital) MFM	Schneider (Conzerv) / L&T / Secure
31	Voltmeter / Ammeter / PF Meter / Frequency Meter/ KWH Meter	AEI / IMP / MECO / INDCOIL / Enercon / L&T / Rishab / Siemens / Industrial Meters
32	Selector Switch	L&T / Siemens / Schneider / Kaycee / Salzer / C&S / Vaishnav
33	Auxiliary Contactors/ Relays	L&T / Siemens / BCH
34	Overload Relays (Hand Reset Type)	L&T / Siemens / BCH / Telemachanique
35	Protective / Auxiliary Relays	Areva / Schneider / Siemens / EasunReyroll / ABB / Telemechanique / L&T
36	Time Delay Relays	BCH / Siemens / L&T / English Electric
37	Power Contactor with 2NO+2NC	L&T / Siemens / Telemechanique
38	Timer	Siemens / L&T / BCH / Schneider
39	Terminal Blocks	Elmex / Connect Well
40	Current Transformer/	AE / Kappa / L&T / Siemens / Pragati
	Potential Transformer	
41	Plugs & Sockets	Hensel/Menneks
42	PVC Conduit and accessories	BEC / Polypack / Precision /AKG
43	Cable Termination Kits & Straight Through Joints	Raychem / M-Seal (3M)
44	Motors	BHEL / Kirloskar / Crompton / Siemens / Havells

45	Chemical Earthing	Ampere Protection / JK Earthing / JMV/OBO
46	Exhaust Fan	Bajaj/Orpat/Havells
47	Air Conditioners	Samsung / Blue Star / LG / Hitachi
48	EPABX	Panasonic / Coral

NOTE: - Makes like 'or equivalent' are not acceptable. Other makes proposed shall be submitted to the Employer with back-up documents and PTR (Proven Track Record) for prior approval.

30.3. Controls and Automation Works

30.3.1. System Description

A Central Control System is proposed as shown in the **Drawing SCADA Architecture** to ensure safe and reliable operation of Spillway Gates, valve and other facilities. At the highest level - the Management Network shall include network servers, PC work-stations, printers, communication and data interfaces, software(s) etc., to provide planning, inventory management, data acquisition/communications and other management functions. The operator console shall assist the operator for an easy operation of the entire system. It shall also allow to print out and show on the video displays all relevant signals, events, alarms, status, status change, abnormalities, history data and plant conditions on request or immediately in case of alarm.

The Control Network shall be used for providing automation functions, Opening & Closing of spillway gates and valve etc and monitoring and supervisory functions from Control Room. The following displays shall be applicable:

- Overview display shall present a survey of different parts of the process ie single line of the station,
- Group displays shall represent information about the objects in group,
- Object displays shall represent all information that are available about single object. Objects shall be oriented in groups corresponding to process section.

At the lowest level of automation System, the individual drive motor controllers for spillway gates, valve with their associated control devices (limit switches, sensors, local control devices, local control panel and other sub-systems and Control Architecture shall be controlled in groups or individually by the PLCs.

The core of the system shall consist of a central SCADA Server station, Operating cum programming station (all the computers shall be latest version of the Industrial PCs as on the date of bidding) with printer receiving data from each location and along with real time redundant PLC system (One online and the other in hot standby excluding I/O modules).

The individual control system would incorporate all safety interlocks to ensure complete safety to operating personnel and to avoid any damage to equipment due to mal-functioning.

The control system shall generally be based on the following principles:

i) To start equipment in either of the two modes i.e. 'Local' or 'Remote'.

ii) To trip off minimum equipment in the desired sequence during abnormal operating conditions, leaving all the other equipment running, which may safely be permitted to continue the operations.
iii) To annunciate the fault which has tripped equipment along-with the cause for tripping
iv) To prevent restarting of the equipment until safe conditions have been restored.
v) To retain maximum flexibility of operation consistent with safety.
vi) To prevent mal-operation of equipment on interruptions.
vii) To stop all the running equipment simultaneously by pressing Emergency Stop Push Button.
viii) To stop running equipment in the reverse order with time lag during normal stop.

CDB's (Control Distribution Board) shall be furnished, manufactured and installed for feeding power supply to the field instruments/CCTV.

30.3.2. Equipment Specification

Equipment Specification shall strictly adhere to the following general guidelines:-

i) The makes and the specifications of every aspect and in totality of the Server, LED Displays (Large), Operating Terminals, LED monitors, Network Printer (A3/ A4), PLCs (including CPU, Communication Processors), DI/DO, AI/AO and RTD modules), Uninterrupted power supplies and all Network Components and accessories including Managed Network Switches, Media Converters, Cat5e (STP), Multicore Cables for Field Instruments etc. shall be of the latest available make and shall conform to applicable industry standard. The type, make and model of all bought out items supplied shall be subject to approval during detail engineering stage.

ii) The enclosures for Control equipment i.e. PLCs placed in control room shall be of IP- 54/55 and IP-66/67 standard for the ones placed in Fields.

30.3.2.1. SERVER

The Servers should be configured in a way that each location is equipped with a Hot-redundant PLC with SCADA System for local control. The Central Control Room shall be equipped with SCADA with Redundant Server to receive data from individual locations in line with the System Architecture attached with Tender specifications.

The central SCADA Server shall be redundant & of industrial grade with high computing power, suitable for communication equipment networking and industrial automation. The SCADA servers should communicate with the Redundant PLCs over a single fault tolerant redundant network so that any single fault / failure on media / network should not affect the network & operation. Standard keyboards, mouse controllers shall be included, with CD/DVD read/write drives, and tape backups.

Servers shall be commercial class with efficient computing power in order to maximize memory through unprecedented capacity and bandwidth for maximum performance, suitable for high speed communication equipment networking and industrial automation. Independent expansion of processors, memory, networking and storage I/O on the samescalable platform shall be possible.

Technical Data

Processor	Intel Xeon Quad Processor/4 GB, 1 TB HDD
Clock Speed	2.8 GHz
Cache Memory Size	35 MB Cache
Memory Types	DDR4-1333 MHz
Hard Drive	1 TB (2X500GB) HOT PLUG SAS (with flexible hot-swap storage with up to 8 HDDs or up to 16 SSDs)
Communication Ports	Parallel Port-1 Serial Ports (Universal)- 3. USB Ports-8
Power Source	240 V AC,50/60 Hz
Permissible Humidity	20%-80%
Design Ambient Temperature	45^{O}C
DVD	Min. 4.7 GB DVD RAM (R/W) drive
DAT	Min. 4 GB DAT as software media and storage

30.3.2.2. THE LED (VDU)

Shall display all gates, pump motors & instruments data and sub-systems represented individually in approved manner. Each position/level shall be indicated. Other data/information as required (Selection, fault Indication, outputs, equipment locations and other information required shall be shown or displayed on demand in different colors. The graphic displays shall be subject to the approval of the Employer but shall be field programmable. The video graphic display unit shall be suitably placed in the Control room. The VDU shall be capable to display graphics or pictures in 1080p high-definition resolution, with the highest level of quality and reliability.

LED screen shall be used for displaying operation of gates & pumps mimics, with full high definition capability and using the latest in display technology. They shall have the highest level of quality, reliability and resolution.

Technical Data:

Power Source	240 V AC,50/60 Hz
Display Type	Compensated TN, Full color LED Luminance :400 cd/m2
Resolution	At least 1920*1080
Size	32 inch Diagonal
Operating Condition	Temperature: 0ºC - 50ºC Humidity : 20% - 80%
Contrast Ratio	5,000,000:1
Viewing Angle	140ºH, 140ºV
Safety Standards	UL6500/C-UL

30.3.2.3. DATA TERMINAL COMPUTERS

Data Terminal CPU shall be of Industrial grade having high computing power, suitable for communication equipment networking. They shall be complete with standard keyboards, 21 inch LED colour monitors, mouse controllers, CD/DVD drives, network cards.

Data terminal computers shall have high computing power, suitable for communicating equipment networking. They shall also include compatible standard keyboards and standard mouse and licensed operating system and other necessary licensed software.

Technical Data:

Processor	Intel Xeon i5, 3.00 GHz 12 MB cache
Random Access Memory	4 GB- DDR4, 1333 MHz
Hard Drive 1 Optical Drive	1000 GB SATA CD/DVD R/W
Operating System	Windows Server 2008
Communication Ports	Parallel Port: 1, Serial Ports (Universal): 3, USB Ports: 8
Power Source	240 V AC,50/60 Hz
Permissible Humidity	20%-80%
Design Ambient temperature	50^{O}C

30.3.2.4. LED MONITORS

LED monitors shall be used for wide range of digital applications, with full high definition display technology. They shall have the highest level of quality, reliability and resolution.

LED monitors shall be used for wide range of digital applications, with full high definition capability and using the latest in display technology. They shall have the highest level of quality, reliability and resolution.

Technical Data:

Power Source	240 V AC,50/60 Hz
Display Type	Compensated TN , Full 1080p Display
Resolution	At least 1040*768 (NI)
Size	21 inch Diagonal
Operating Condition	Temperature : 0ºC - 50ºC Humidity : 20% - 80%
Contrast Ratio	10M:1 Dynamic contrast Ratio
Viewing Angle	140ºH, 140ºV

Safety Standards	UL6500/C-UL

30.3.2.5. NETWORK PRINTER

At Control room, Scheduling and Planning Terminals shall be suitable for large work groups, and for high-quality, high volume printing. The printers shall enable high-speed color or monochrome printing of up to 40 pages per minutes for optimal productivity and shall have the capacity to print high-quality, complex documents quickly. Large work groups shall be able to produce professional, impressive-looking documents every time. Printers shall be equipped with paper feeders and paper cassettes for at least A3 and A4 paper.

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Technical Data:

Power Source	240 V Ac,50/60 Hz
Printer Type	Color Work Group Laser printer
Operating Condition	Temperature : 16ºC-50ºC Humidity : 8% -80%
Print Quality	Selectable up to 1200x1200 dpi
Communication Port	USB
	10/100 Base Ethernet Port
Processor	300 MHz processor
Memory	64MB (320 Max)

30.3.2.6. THE PROGRAMMABLE LOGIC CONTROLLERS PLCS

PLC's shall be Redundant and of rugged design and quality to meet the functional requirements, capable of withstanding/bypassing high electric noise, electromagnetic interferences, vibrations etc. The microprocessor based systems shall be of modular design and suitable for mounting in standard racks.

It shall be equipped with latest Processor modules, Communication Modules, Data processing software, Logic Implementation software, and other required interfaces complete with all accessories. It shall have adequate functional capacity for handling the I/O Unit's, external interfaces and data bus interfaces. It shall be enclosed in IP-54 degree of protection panels.

The microprocessor based systems shall be of modular design and suitable for mounting in standard racks. Each module including rack/mount base shall be individually metal enclosed dust and vermin proof for withstanding worst environmental and ambient conditions etc. Remote input/output cabinets shall be suitable for mounting on walls/columns.

CPU shall be battery less. No battery backed up CPU allowed. Data shall be saved in internal Flash memory on power off and should not be lost.

The execution cycle of the PLC shall meet the functional requirement of plant. The memory capacity of the PLC shall be adequate to perform the required functions satisfactorily and with 100% spare capacity for use in the future. Redundancy (100% hot standby) shall be provided in the PLC's such that in case of failure of any of the processors, the hot standby processor shall take over automatically. The changeover shall be bumpless. Primary & secondary controller shall be located on two separate racks and Redundant Rack power supply (no bulk power supply) shall be provided at each controller rack i.e. two sets of rack power supply shall be used in each rack

The PLC Processor must have an embedded web-server to provide CPU diagnostics, including detailed information on Ethernet system networking. The Embedded web server must be customizable by the user to display application variables and advanced diagnostics features (rack viewer, alarm buffer, complete PLC application)

The PLC processors should be able to communicate with SCADA over DNP 3.0 & IEC 60870-5-101/104 protocol as per telemetry standards to provide a reliable means of communication. This shall ensure that no events are lost & 100,000 timestamped events can be stored in case of communication failure.

Each CPU shall be complete with required number of modules, main power supply unit, marshaling box, interconnection cables etc. and shall have screw type terminals for I/O connections.

A processor failure condition shall be indicated in the control room and change over to redundant systems shall also be indicated. Extensive diagnostics shall be available for all intelligent modules of the system. The processor shall execute the programs for the plant operation at very high speed. Signals to each remote interface unit shall be transmitted by means of the network.

PLC power supply units must have self-test facilities for detecting under voltage and also must be able to give alarm and switch over to UPS mode in case the output voltage is + 20% above the normal value.

The status indications for power `ON', control supply healthy, overloads, by means of LED's should be available on the power supply unit. The equipment must be capable of accepting wide voltage fluctuations + 10% voltage + 3% frequency.

Power Supply module must give extensive diagnostics, including the real time load, temperature, number of power up/down, and expected remaining life time.
The PLC Processor must provide cyber-security features, such as real-time memory integrity control and access control. It must also be compliant to IEC-62443 & Achilles Level-2 standard for Cyber Security. The Contractor shall furnish the power load details of his system and shall keep 30% spare capacity in the power supply excluding allowances for transformers, cable losses etc.

Three Wire RTD signals shall be processed in the PLC through an analog input/RTD module which will be programmed for alarm and tripping the relevant motor in case of abnormal temperature of any RTD. Winding temperature shall also be available on color monitor VDU (in the fault window) and in mimic panel of the control desk, when required by the operator.

Each Controller shall be complete with required number and type of modules, main power supply unit, marshaling box, interconnection cables etc. and shall have screw type terminals for I/O connections.

Input/output units shall be capable of accepting discrete, analog, RTD, digital input and output devices. If the number of slots for input and output modules in the controller rack is not sufficient expansion units shall be connectable to the CPU by means of interface modules. Signals to each remote interface unit shall be transmitted by means of the network.

I/O modules shall have status indications to indicate the proper functions of the modules and scanning of signals by the processor. Each Input and Output module shall be electrically isolated through opto-couplers or isolation transformers and shall withstand severe voltage transients without damage or adverse effect on the controller. Output modules shall incorporate self-contained damping networks and voltage limiting devices to prevent false triggering of outputs and to suppress line voltage spikes. Each output card shall have fuses to protect its circuitry from over current and overloads. PLC power supply units must have self-test facilities for detecting under voltage and also must be able to give alarm and switch over to UPS mode in case the output voltage is + 20% above the normal value. The status indications for power `ON', control supply healthy, overloads, by means of LED's should be available on the power supply unit. The equipment must be capable of accepting wide voltage fluctuations + 10% voltage + 3% frequency. The Contractor shall furnish the power load details of his system and shall keep 30% spare capacity in the power supply excluding allowances for transformers, cable losses etc.

The Contractor shall provide separate grounding system for the PLC based automation system equipment supplied with independent earth pits and earth grid of 8 SWG G.I. wire with PVC sleeve.

Digital and Analog Input Output Modules which shall be required for future expansion of the gates shall be procured at that time by the Contractor.

The PLC control system is envisaged to control all navigation lock, sluice and Barrage gate operations from the control desk located at the control room on the top floor of the control room building.

(i) All the major equipment shall be controlled from the PLC and Remote I/O Panels(located in Local Control Panel rooms) such as

a) LCP Barrage Gates- PUSH BUTTONS UP/DOWN

b) LCP Valve House- PUSH BUTTONS – OPEN / CLOSE

c) LCP Upper Spillway Gates- PUSH BUTTONS – OPEN / CLOSE

(ii) The PLC and remote I/O panel (at Local Control Rooms) shall also have provisions for various indications / status of various equipment such as:

a) All Gates LED OPEN / CLOSE

b) Valve LED UP / DOWN

c) All Other Drives LED OPEN / CLOSE

The system shall consist of all the required panels, components, inter-connection cables, field sensors on all the equipment, junction boxes etc. to achieve the required functions. Basic interface of PLC, RIOs with field devices is shown on SCADA Architecture Drawing.

30.3.2.7. REMOTE INPUT OUTPUT (RIO)

Remote Input Output shall accept the command from main PLC; also it shall send and receive the data from Control Room PLC over the Ethernet protocol. It shall also have provision to connect over Modbus RS-485/TCP-IP protocol. It shall have communication interface with necessary signal/baud rate converters. No redundancy required for I/O modules. The input modules circuit voltage shall match with Power control centre voltage PCC's (MV Switchgear). It shall also have DI, DO, AI, AO and RTD etc. modules of suitable channel density, numbers and with appropriate spare channel capacity, Supply Voltage Rating, Current input/output is 4-20mA DC for AI/AO .Voltage input/output of 24V DC and/or 240V AC for DI/DO to suit the functional requirements. Also include appropriate spare capacity on I/O rail/rack.

It shall be an intelligent Remote Input/output unit and shall have communication processors / interfaces to communicate with PLC system. It shall send and receive the data from PLC. It shall have Mod-bus-RTU, RS-485 port interface to communicate with Local Control Panels. It shall have communication interface with necessary signal/baud rate converters. The input modules circuit voltage shall match with Power control center voltage PCC's (MV/LV Switchgear). They shall be suitable for field mounting with IP 55 degree of enclosure protection inside transfer towers or at outdoors.

A) Digital Input Module

Technical Specifications:

Supply Voltages	24 VDC Reverse Polarity Protection
Current Consumption	3 mA
Isolation	Isolation should checked with 1500VAC (isolation by opto-couplers)
Dimensions (Max)	As per standards
Operating Condition	Temperature : 8ºC-60ºC Humidity : 8% -95%
Input Voltage For signal "1"	110 VAC Or other approved to meet the operational requirements
Input Current	5mA to 50 mA
No. of Channels	64/32/16 per module

B) Digital Output Module

Technical Specifications:

Supply Voltages	24 VDC Reverse Polarity Protection
Short circuit protection of the output	As recommended per channel
Isolation	Isolation should be checked with 1500V DC (isolation by opto-couplers)
Dimensions (Max)	As per standards

Operating Condition	Temperature : 8ºC-60ºC Humidity : 8% - 95%
Output Voltage For signal “1”	110VAC or any approved to meet the operational requirement
Output Current For signal “1” max For signal “0” residual current, max	2 A 3 mA
No. of Channels	64/32/16 per module

C) Analog Input Modules

Technical Specifications:

Supply Voltages	24 VDC Reverse Polarity Protection
Current Consumption	225 mA
Isolation	Isolation should be checked with 1400VDC
Address space per module	4 byte
Dimensions (Max)	As per standards
Operating Condition	Temperature : 8ºC - 60ºC Humidity : 8% - 95%
Measurement Type/range	4 to 20 mA / 0 to 24 VDC
Overflow / underflow	Disable/enable
Resolution Temperature errors	13 bit or more + 0 to 2% K
No. of Channels	16/8 input channels
Status information/alarms/ Diagnostics	Process alarm (yes)
Scan time (all channels)	25 ms

D) RTD Modules

Technical Specification:

Supply Voltages	24 VDC Reverse Polarity Protection
Current Consumption	150 mA
Isolation	Isolation should be checked with 1400VDC
Address space per module	4 byte
Dimensions (Max)	As per standards
Operating Condition	Temperature : 8ºC - 60ºC Humidity : 8% - 90%
Overflow / underflow	Disable/enable

Resolution Temperature errors	13 bit or more + 0 to 2% K
No. of Channels	8 Channel RTD
Temperature Sensor	2/3/4 wire RTDs (PT 100 type)
Scan time (per channel)	50 ms

30.3.2.8. THE UPS

The panels for UPS system shall be of floor mounted, free standing, metal enclosed and vermin proof type having hinged door for front access and suitable for indoor use.

UPS shall have 100% redundant configuration with dual redundant battery. UPS system shall be sized to take care of the crest factor of the load current. The UPS shall be provided with fault diagnostic unit.

UPS system shall include a set of storage batteries, rectifier transformer, rectifier-cum-charger, inverter, set of filter circuit, static switches, bypass transformer, facility for manual transfer between inverter supply and bypass line, facility for bypassing inverter and static switch for maintenance, AC Distribution board and other associated accessories.

Under normal conditions, the rectifier-cum-charger shall feed the inverter and charge the battery set. In case of mains failure, the battery shall supply the necessary power to the inverter. The inverter in turn shall feed the load through the static switch. If the inverters malfunction or get overloaded, the load shall be instantaneously transferred to the bypass line through the static switch. Normally, the inverter shall be operated in synchronized mode with the bypass line and manual forward transfer or manual reverse transfer shall be affected without any break. Automatic forward transfer, in case of inverter malfunction shall be affected with a break not exceeding 4 milliseconds.

Each UPS shall have at least 10% spare capacity to meet future requirements. Each branch circuit of the UPS distribution system shall have fused disconnect switch. The fuse shall be fast clearing type and the fuse rating shall be coordinated with the rating of the UPS system. Normally the largest branch circuit load shall not exceed 25% of the system rating.

The status of UPS shall be indicated at CR-VDU/CCR-VDU.

Technical Specifications:

Rated output power	Minimum 10 KVA
Input	415 Volts, AC + 10% at 50 Hz + 5%
Output	240/110 Volts, AC, 50 Hz
Static Output Tolerance	+ 1 %
Dynamic Output Tolerance	+ 5 % (without Battery)
Design Reference Ambient Temperature	$50^{O}C$

30.3.2.9. ETHERNET SWITCHES

Ethernet Switches should be of managed industrial-grade type that provides very high speed Fast Ethernet and Gigabit Ethernet with Copper and Fiber Optic media connectivity for deployment in harsh environments (if required). They should be able to operate in environments suitable for industrial networking.

The Ethernet Switch shall allow expansion of network securely. It shall be optimized for maximum system availability, with fully redundant stacking, redundant power options. Network security shall be provided through IEEE 802.1Q VLANs, IEEE 802.1x port authentication, access control lists (ACLs), denial-of-service (DoS) prevention, and MAC- based filtering. Web-based configuration shall be secured using SSL.

30.3.2.10. THE ETHERNET UTP CABLE

Shall meet the EIA/TIA-568/569 and shall be suitable for use in noisy environment. It shall be of Cat5e/Cat6 type.

30.3.2.11. FIBER-OPTIC CABLE

As required, shall be 8 core Single Mode / MM Cable as required in line with the layout provided with tender specifications. FO Cable should be internally wrapped with dielectric tape and corrugated steel tape armoring and shall be suitable for outdoor laying.

30.3.2.12. CONTROL AND INSTRUMENTATION CABLE

Shall be suitable for laying in perforated trays, pipes, ducts, closed trenches and directly buried underground. All cables shall be armoured type. Cables shall be provided with additional overall Shielding with Aluminium Mylar tape with 100% coverage and 25% overlap on laid up cores for shielding against static/ electromagnetic interference. The voltage rating shall be 1100V with an ambient temperature of 50^{O}C. The conductor shall be of plain annealed high conductivity copper stranded wires which before stranding shall be generally circular in section, smooth, uniform in quality and free from scale spills, splits and other defects. The conductors shall confirm to relevant IS specified. The insulation shall be chemically cross linked polyethylene XLPE conforming to the physical, electrical and ageing properties as required to relevant IS specified. Armouring shall be arranged over the inner sheath for the cable consisting of two or more cores. The armour of cables shall be either of galvanized steel wires or galvanized steel strips. A tough outer sheathing of PVC insulating material in standard colours shall be provided over the armouring to offer a high degree of mechanical protection against abrasion. Additional compound shall be applied under and over each layer. In order to prevent adhesion, a coating of lime wash or other suitable material shall be applied to the outside of the cable. Outer sheath shall be FRLS.

30.3.2.13. THE RS485 STP CABLE

RS 485 Cable shall be shielded twisted pair copper cable with minimum of four cores. These cables shall be insulated and PVC sheathed FRLS cables for serial data communication purposes.

30.3.2.14. OTHER CONTROL SUBSYSTEMS

The Different Local Control Panels, RIOs Panels for Gates & Pump motors with required Cabling and Accessories shall be provided by the Respective Contractors and shall be integrated with the Main PLC Control System.

30.3.2.15. NETWORKS

The automation network shall be real-time Open universal network, requiring long time continuous operation. During normal operations, the system cannot be shut off and it shall be possible to replace the components without shutting off the power. It shall be feasible to program the system online.

The management network shall be full duplex with full redundancy. Proper care should be taken in the data transfer in order to achieve quick response while transmitting control and management information. The response time should not be more than one millisecond. The network system shall have fault clearance functions, secure transmission of data through error checking routines on all data transmitted. The networks shall use open systems technology, support multiple industrial standards, allow a combination of multiple communications agreements, and shall have the capability to join wider networks in the future.

The networks shall use MODBUS RTU RS 485 Cable to connect PLC to RIO Panel. In general fiber optic cable shall be used for distances greater than 500 meters. The data cable shall be suitable to communicate between RIO (Remote Input Output Panel), other Control Subsystems like LCP's shall be connected to the Central Control Operator (PC/PLC) station to meet the functional requirements. The baud rate or transmission rate shall be 10/100 Mbps. It shall be a high-speed data access control type capable of handling critical time functions. This network shall be used up to 32/64/128/256/1024-devices. Redundancy in the control network shall ensure that at all times signals shall be available to all interfaced components. The management network shall exchange plant related information between various information and data terminals (PC consoles) and Control Room/Master Control Unit. Redundancy in the management/control network shall ensure that at all times signals shall be available to all interfaced components.

30.3.3. Software

30.3.3.1. GENERAL

Software provided shall be based to the maximum extent on standard packages to minimize complex programming tasks and facilitate support, maintenance and upgrading. Software shall be "user friendly".

The development of the application software shall be done in consultation with the Employer's Engineer in a number of stages (requirements definition, functional specifications, design, implementation and testing, maintenance and training) with each stage to the Employer's Engineer's approval. The final version of the software will be subject to the approval of the Employer.

The software shall meet the requirements of this specification for all of the management and control system functions and operations, and it shall be possible to develop it in further detail on site to meet the management and operating needs of the Employer.

Programs shall be rationally structured, well readable, easily revisable, and with man-machine interfaces displayed in English.

The software shall be suitable for use with multiple methods of English character

input. Manuals shall be provided for all software in English

Proprietary software packages forming part of the software provided will include permanent run-time licenses. If any part of the software requires annual license fees, the cost of such fees will be indicated in the bid.
In any case the Employer shall have the right to freely develop, modify, maintain the application software, and shall provide the source code and all relevant manuals and information needed for this purpose.

Utility program's shall be included in the software supply, including network management, multi-level password protection, on-line help, virus protection, and back-up and archiving, word processing, statistics, simulation and data communication (like MS Office, Recommended (McAfee/Trend Micro/Windows one live) Antivirus, Adobe Reader). Whenever an operator input data, a text window will be prompted on the display.

The Software's that are required for different field devices shall be provided by the respective vendors, and it shall be the responsibility of the Contractor to install third Party software's in respective Terminals.

30.3.3.2. CONTROL SOFTWARE

The control software shall be used mainly to:

- Control the process flow operations
- Process operating instructions
- Control operating cycles and interlocking sequence logic
- Collect data automatically on equipment status and fault indication
- Collect and process data in real-time
- Transmit data and communicate with RIO's/ Subsystems/associated control devices
- Automatically diagnose faults in the complete system
- To provide a human interface for the operators on SCADA
- Update the software programs.

The PLC programming language **(IEC-611311-3)** shall be of ladder type, functional block description, or other approved standard type. It shall be possible to program the system on-line. Facilities shall be provided to monitor the system on-line in addition to programming, using either mounted on PLC hardware or separately through a programming workstation so that forcing of I/Os, changing of timer/counter values, contact monitoring, error analysis etc are possible. The PLC/PCs shall read or write data from/to the RIO's, workstations, associated control devices indicated on the Control Architecture Drawing and elsewhere in this specification.

All displays shall be dynamic and updated continuously, irrespective whether they are actually shown on the screens or not at the time. All page/graphic displays shall be programmable so they can be changed at any time to add additional information needed by a software engineer at the site off-line.

The software shall display the fault and alarm status of the plant components and shall be available in the data base at all times. The fault and alarm status shall be transferred to maintenance operator automatically.

The data base and data formats in the control system shall be identical to the management system databases.

Control Room and Related Rooms

The Control Room shall be housed on the First floor of Control Building which will house the canteen, office room and conference Room.

In Control room the following equipment will be installed:

- Server Station;
- PC Operating Cum Programming Terminals;
- PLC and associated control equipment
- Printers;
- Network Video Recorder for CCTV;
- CCTV Monitoring Terminal
- UPS;
- Third Party Control Systems for Field Instruments (VDU, Total Station and Automatic Data Acquisition System)

The consoles shall be low profile, laid out ergonomically in an arc shaped pattern, to accommodate the equipment and the operators to permit efficient operations with a minimum of fatigue. The layout will be subject to the approval of the Employer's Engineer. Appropriate non-glare lighting shall be provided in the Control Room, which shall be fully air conditioned and shall have sound absorbing panelling ceilings and walls.

The control equipment room will house equipment such as PLC panels, I/O panels, distribution panels, control power panels. The computer room will accommodate the network file workstations, network devices; system engineers work stations and printers. The batteries will be in a separate room. The Control Room First Floorr will be air conditioned. False floors shall be used in the Control Room First Floor to accommodate cabling and connections. The Contractor shall supply four revolving, ergonomic office chairs, media storage, bookcases for manuals, and filing cabinets for Control room.

30.3.3.3. SCADA SOFTWARE

The Central SCADA software shall consist of a redundant server with SCADA software package, an HMI software package, I/O interfacing software (communication drivers), operating systems, servers and industry standard networking hardware.

The SCADA software will read and write data to PLC controllers and provide graphics screens and reports so that operators, supervisors and maintenance personnel can quickly and easily maintain and operate the system.

30.3.3.4. PERFORMANCE

Based on the configuration, graphical display call-up time of one second maximum could be achieved for all graphics. Display refresh update time of one second for tags from multiple PLCs could also be achieved on a single display.

Total time to call up a graphic display (displaying 100 variables from a total of 5000 tags anywhere in the system) shall be between one and two seconds, complete with well-defined current data read from the field device(s).

30.3.3.5. SCALABILITY

The software shall be scalable such that the user can start with a small system and expand the database to any size simply by upgrading the license. Client systems shall be able to be added to the system simply by adding licenses and configuring the station. No changes shall be required to commissioned stations, or to the project configuration, to support new ones. The present system shall be suitable for unlimited tags.

30.3.3.6. ARCHITECTURE

The SCADA software should consist of an operator interface subsystem(s) and various server subsystems for centralized processing. As a minimum, this includes:

- I/O Communications Subsystem(s)
- Monitoring, alerting, distribution and acknowledgement of alarms
- Collection, storing and distribution of historical trends
- Processing, storing and distribution of reports

Subsystems shall run as separate threads / processes such that a failure of one subsystem does not negatively impact the operation of any other subsystem, and the failed subsystem can be reset and recover without shutting down the SCADA application or the computer.
This is to provide high reliability as well as to reduce duplication of processing, network bandwidth and field device processing, as well as to achieve high performance. Finally the SCADA software need to enable that all historical data is retained in a centralized repository for ease of maintenance and backups.

If required, the system shall support casual web browser clients so that personnel on the WAN with the appropriate security settings can have access to the system. The web browser clients shall support view and control capabilities, controlled by both login security and license types. The web browser client shall provide identical functionality to the standard client software including but not limited to graphics displays, trend pages, alarm pages and system security. The web browser client shall not require any additional engineering or specialized software, nor the exporting of configuration. The standard graphics pages, alarm pages and trend pages used for operator client stations shall be available via the web browser clients without any additional development effort. Browser clients shall support page changes of under 2 seconds.

The SCADA software shall be configurable as a single global database regardless of the number of stations in the system. It shall be possible to make configuration changes to the global database at any station on the system in a manner that is completely transparent to the user. Each SCADA station shall have the option of either hosting the database locally to reduce network traffic or accessing the database remotely in a file serving environment on networks with high bandwidth capabilities.

The SCADA software shall be able to be configured as a series of projects for ease of maintenance and commissioning and be easily linked together (or included) to run as a single global database.

Software licensing should be based on the number of users concurrently using the software, not the total number of stations or installs on the network.

30.3.3.7. SECURITY

Security shall be fully integrated into the SCADA software and access to any individual part of the system only to users with appropriate security levels. Security must be checked on the server side and passwords must be encrypted.

The software shall be able to group the users into Roles. Roles shall be able to be configured with clearly defined privilege levels and clearly defined plant areas.

The software shall support large number of users. For each user, it shall be possible to define a password and a role for that user. Passwords shall be hidden both in the configuration and the runtime environment to ensure that other personnel cannot access another account.

30.3.3.8. OPERATOR DISPLAYS

The number of graphic displays possible shall not be limited by the software. Graphic display pages shall be capable of a minimum of 2000 analog tags, with updates of an average one second (for all data to appear or change on the page).

Graphics pages shall be automatically re-sized to match the screen resolution of the given computer, irrespective of the resolution the pages were developed in or configured for, without shutting down the SCADA software, without recompiling, and without having multiple copies of graphics pages for different resolutions.

The graphics system shall support full 32-bit (65 million) colors and be capable of displaying images imported from third party packages for use within the SCADA displays, including animating and color flooding the image.

The software must support Historical Trend Graphs as part of a graphic display, with a minimum of 8 tags available per graph. The number of trend graphs per page shall not be limited and it shall be possible to lay trend graphs on top of each other to provide comparisons.

The software shall have the capability to provide pop-up windows for trends, loops, device status pages or any other graphical display purpose. To minimize operator confusion, pop-up windows shall be capable of being configured so that multiple copies of the same pop-up cannot be opened on the same computer at the same time. The software shall be able to support up to 100 simultaneously open windows. The software shall have the capability to define the maximum number of windows that can be opened at any one time between a minimum of one and a maximum of 100.

Each display object shall support keyboard entry that will allow adjustment of any tag in the system. When an operator wants to enter a value, the object should be selected then the operator input shall be displayed as the input is typed (such as a tooltip adjacent to the object). The system shall check the value entered is in an approved range before sending it to the field device.

The software shall support full screen, live camera video images and video from disk (MPEG, AVI) concurrently with screen displays and no interruption to data collection. Refresh rates of display windows shall not be affected.

If communications to a particular I/O tag fails for any reason, then wherever that data is displayed the software shall post a visual indication that the tag is not valid.

The software must be designed with the ability to make changes to the graphics while the system is running. Shutting down the system shall not be required to make these changes.

The user shall be able to navigate around the graphics system utilizing a variety of navigation methods:

- Hot keys shall be available to provide quick links to specific graphics pages from the Windows keyboard
- Windows style navigation menus shall be provided allowing access to any configured page in the system from any other page
- The graphical displays shall be configured with “hot spots”, where a user can click on the area and drill down into a detailed view (if available) of the plant area

The Windows style navigation menus shall be configurable in runtime, and shall be saved and restored with the project backup/restore utility.Trend and Alarm grouping assignments shall be configurable in runtime, and shall be saved with the project configuration for inclusion with the Backup and Restore utilities.

30.3.3.9. ALARMS & EVENTS

For alarm events (both digital and analog) that are time-stamped by the field controller for increased accuracy, the SCADA software shall support using that time-stamp for the event rather than its own time-stamp. The SCADA software shall support millisecond precision for this time-stamp.

30.3.3.10. ALARM ACTIONS

It shall be possible to configure alarm actions that are unique to each individual alarm category group for when alarms within the group transition into and out of alarm state. These actions shall be capable of performing any macro or code function available in the SCADA system, including reading and writing to I/O data, displaying graphics, sound annunciation or running complex SCADA functions.

30.3.3.11. ALARM DISPLAY

With appropriate privileges, it shall be possible to display or acknowledge any alarm and/or the most recent alarm on any page.

The software shall provide multiple levels of alarm priority or category. The priority of an alarm shall be identifiable by the color and font settings of the alarm message on the screen. The color coding of prioritized alarm messages shall be configurable by engineers. The system shall support at least 10000 categories of alarms, and up to 255 priorities of alarms.

Sound indication for each alarm category shall be configurable. This must be possible at each station. It shall be possible to have the alarm sound either by internal or external speaker.

The software shall have a standard alarm display page that can be modified for the project. The standard alarm page shall have the facility for scrolling through multiple pages of alarms and to acknowledge and disable individual alarms.

It shall be possible to display the following information for each alarm as it appears on an alarm display page:

- Alarm Tag Name
- Alarm Description
- Value of the Tag
- Trip limit
- Alarm Status - Disabled, Acknowledged, Unacknowledged
- Alarm Category
- Alarm Priority
- Time & Date in International Formats
- Privilege
- Category
- Operator Comments
- Value of any Tag or result of any calculation

It shall be possible to display each alarm category in a different font and color (including flashing colors) dependent on whether the alarm is Active Unacknowledged, Active Acknowledged, Acknowledged Cleared, Unacknowledged Cleared or Disabled.

The alarm display shall support both proportional and fixed fonts, with all alarm fields displayed in properly aligned columns.

It shall be possible to disable alarms on an individual basis by page, alarm category or for all alarms. When an alarm is disabled, the alarm will be displayed on a separate disabled alarms page so every user of the system can easily determine which alarms have been disabled.

30.3.3.12. ALARM SORTING

It shall be possible to sort (ascending and descending) active alarm displays by one or more alarm fields without grouping restrictions. Alarm fields that can be used for sorting include:

- Tag
- Name
- Category
- Priority
- Area
- Privilege
- State
- OnTime
- OffTime
- AckTime

30.3.3.13. ALARM DELAY

It shall be possible to set a time period on individual alarms such that the alarm must be active for the time period before it is annunciated to the operator. The time stamp of the alarm must be the time when the alarm first became active, not at the completion of the time delay.

30.3.3.14. ALARM LOGGING

For each alarm category it shall be possible to define a different method of logging alarms. It shall be possible to define if alarms are to be logged when the alarm transitions into ON, OFF or Acknowledged state. The alarms shall be able to be logged to a designated printer, disk file or database with alarm text, time and date labels. Alarms shall be printed or filed in a user-configurable format.

The SCADA software shall allow logging to any printer on the network. The software shall be able to redirect printing to another printer while the system is online.

Alarms that are logged to disk shall be available for viewing while the system is online or offline without causing any interruption to data collection. The number of alarms logged to disk shall not be limited by the software. The alarm logging function shall be capable of logging an instantaneous burst of at least 4000 alarms received in a single scan without losing a single alarm.

30.3.3.15. TREND DISPLAY

Trend displays shall comprise line graphs with time on a linear, continuous horizontal or vertical axis and the trended value on the vertical or horizontal axis. Resolution of each graph shall be to within 0.1% of full scale. Where more than one tag is graphed, the graph of each tag and associated information shall be displayed in a different color.

Trend displays shall support both analog and digital pens on the same graph. Trend pen assignments shall be user definable and retrievable in runtime to allow easy creation and management of favorite trend groups.

Each trend graph shall be capable of displaying up to 32 pens with adjustable time-base to one second samples and reporting up to 10000 points with user-specifiable time ranges, using the standard software. The graph shall be capable of viewing the entire archived trend history for a group of pens on a single display.
It shall be possible to trend multiple pens or multiple plots of the same pen over various time spans. Each pen shall display individual ranges and engineering units. Each pen shall be scalable for display purposes independently of other pens displayed on a page.

The software shall include the capability to pan backward and forward within a selected time range to read the exact value of any displayed tag, by selecting a point on the graph or chart. The system shall display historical information as far back in time as desired, with all information being displayed on average of 1 second.

The trend display shall have a slide wire that can be moved over the page that will provide indication of the date, time and value at the intersection of the slide wire and the trend tags.
The trend display shall be dynamic, scrolling through time, with the capability to ‘replay’ or scroll through historical time as well as current time. There shall also be the capability to stop the automatic scrolling of the trend for detailed analysis of a point in history. Pens on the same pane shall be able to be separated both in the time axis and the range axis.

The user shall be able to toggle the trend display between Local time and UTC time. When in Local time, the trend display shall clearly indicate periods of daylight savings transition.

The software shall provide "zoom" and "pan" facilities for both the trended tag range and the time axis range. The "zoom" facility shall allow an operator to compress or expand the axis range whilst the "pan" facility shall allow an operator to shift the origin of the axis. The software shall allow a user to define any zoom area by dragging a mouse across the trend.

30.3.3.16. HISTORICAL ANALYSIS

Process operations are a continuous interaction of various signals, including analog, discrete and alarms. To fully understand these interactions it is important to be able to analyze all of these types of signals on a single display. Therefore there shall be the provision in the SCADA software to display alarm states in parallel with the analog and discrete trend pens on a timeline chart. This chart shall support all the trend requirements described above, in addition to those described below.

The alarm pen shall clearly indicate the active/inactive/acknowledged state of the alarm through visual cues, as well as providing detailed information at any point which the operator selects. For example, High High or Deviation states should be shown upon operator interrogation.

The alarm pens shall scroll similarly to trend pens to provide a real-time view of the alarm state. The operator shall be able to select which alarm pens to monitor with which trend pens to build up a complete ‘view’ of a particular process unit or area on the historical display.

When accessing historical data, the alarm pens shall display their historical states on the historical display in parallel to trend pen histories. The operator shall be able to make a single request for a specific date and time for historical display and all pens configured for display, both alarms and trends, shall be retrieved for that time.

30.3.3.17. REPORTS

The SCADA software shall perform all report generation, scheduling and management internally and shall not require a third party package to perform these functions. With the exception of very high speed accumulators, no long-term data or accumulators shall need to be programmed in the PLC sub-system to deliver data to the SCADA for reporting purposes. The SCADA shall have functions available for this purpose and shall not require scripting to achieve such functionality.

The software shall permit reports to be scheduled for a specific time of day, on a periodic basis, upon operator request, or event initiated (such as an alarm condition or end of batch).

The software shall support printing to the designated report printer. The software shall also have the capability to log all reports to a disk file or database (SQL, ODBC and DBF) or to a Web Server in a rich text file format such as HTML.

The software shall have the capability to display all reports on the screen, in user definable fonts and colors.

The software shall permit reports to be defined based on archived data. Single point in time reporting (online and historical) and time-range reporting are both essential, as is the ability to report on an unlimited number of tags in one report.

Reports shall include extensive calculations on both instantaneous and historical data, and any other data from the system. Reports shall have the ability to write to any tag in the system during the execution of the report.

Reports are to be automatically sent to a designated report printer. The software shall provide for on-screen reporting. It shall also be capable of interfacing to third party report generation packages, and importing data from or exporting data to external databases.

30.3.3.18. DATABASE INTEGRATION

The SCADA software, or an integrated and bundled package, shall be capable of logging key SCADA data to a relational database, including MS SQL server and Oracle. The software shall support logging of snapshot (real-time) data, historical data in tabular format, and alarm histories in list formats, to the database.

Configuration of the logging shall be via point-and-click configuration and shall not require any scripting to achieve this functionality. The destination database shall be a full-license version of the database and allow the end-user all normal data access, data manipulation and reporting options.

Where redundant SCADA servers or clustered SCADA servers exist, the database logging shall seamlessly collect data from the currently active servers as required to facilitate a successful transfer.

The SCADA shall provide interface to retrieve data from an ActiveX Data Objects (ADO) data source (such as SQL Server, Oracle, etc.). The data retrieval shall operate in an asynchronous manner such that a long running query or slow connection shall not impact other SCADA functionality.

ADO data shall be able to be accessed either as a connected or a disconnected data set. The SCADA shall provide a display of ADO data on a graphics page.

30.3.3.19. EQUIPMENT CONFIGURATION

The software shall include an integrated development package utilizing menu-driven, fill in forms style to configure the equipment.

Equipment can be defined in SCADA to represent the layout of the production process. Each piece of equipment can be defined within a hierarchy that defines a parent/child relationship between the items. This can be used to define a plant model that can enable an ISA-95 compliant structure.

The equipment shall be integrated with the scheduler.

30.3.3.20. ONLINE CHANGES

It shall be possible to add, modify and replace alarms, trends and reports online without restarting the server.
It shall be possible to modify the Alarm, Trend and Report servers without restarting the server. It will be possible to add new configuration, recompile and then, deploy the change, by simply reloading the appropriate server.

Only the changes shall be reloaded. Any unchanged alarms, trends or reports shall continue to function without interruption.

30.3.3.21. DATA QUALITY

Variable tags shall have a collection of functional elements, each of which contains value, quality and time-stamp information.

It shall be possible to manually set the value shown by the variable tag by overriding the value received from the field. It shall be possible to protect system information by disabling the ability to write to specific variables.

30.3.3.22. VIDEO INTEGRATION

It shall be possible to integrate video cameras to allow viewing of live video. It shall be possible to operate user friendly controls like Pan, Tilt, Zoom (PTZ), Brightness and Contrast. It shall be possible to program additional features such as pop-up displays for motion/intrusion detection and linking of events with video functions.

30.3.4. Network Components & Accessories

30.3.4.1. ETHERNET SWITCH

Ethernet Switches should be of managed industrial-grade type that provides very high speed Fast Ethernet and Gigabit Ethernet with Copper and Fiber Optic media connectivity for deployment in harsh environments. They should be able to operate in environments suitable for industrial networking.

The Ethernet Switch shall allow expansion of network securely. It shall be optimized for maximum system availability, with fully redundant stacking, redundant power options. Network security shall be provided through IEEE 802.1Q VLANs, IEEE 802.1x port authentication, access control lists (ACLs), denial-of-service (DoS) prevention, and MAC- based filtering. Web-based configuration shall be secured using SSL.
For Power over Ethernet (PoE), automatic load sensing in the power-control circuitry detects PoE on the end device before providing power. For safety, each port shall have independent overload and short-circuit protection, along with LED indicators to show power status. The switch shall provide PoE power on up the Ethernet ports for powering PoE-enabled wireless access points.

It shall integrate into Supervisory Control and Data Acquisition (SCADA) systems, and any other facilities. The switches shall have industrial-grade components, a compact form factor, convection cooling, and relay output signalling to extend intelligent services such as enhanced security, high availability, and advanced quality of service (QoS). A large number of protocols supported make sure that the system will interoperate with other Ethernet- enabled devices and IP applications and enables integration between business office applications and industrial equipment.

It shall have device manager software which allows users to easily configure and monitor the switch using a standard Web browser. Customers can easily initialize the switch with Web-based set up. In addition a standalone network management application shall be provided so that operator can simultaneously configure and troubleshoot multiple switches. The bundled software shall reduce the cost of deployment by enabling less- skilled personnel to set up switches quickly.

Technical Specification

No of Ports	As required by system architecture
Managed	Yes
Power inputs	240 VAC at 50 Hz
Industry Specifications	IEEE 1588 Precision Time Protocol, IEC 61850-3 (substations), ODVA Common Industrial Protocol, IEEE 1588v2, NEMA TS-2 (ITS)
Mounting	DIN-rail, wall, rack mount option, desktop and Stackable
Intrusion protection rating	IP 20
Operating temperature	32 to 113ºF (-40 to 70ºC)
Operating relative humidity	10 to 95% (condensing)

30.3.4.2. PATCH PANEL

Patch panel shall provide ultra-high density connection while facilitating cable routing and patch cord management. They shall be of Rack-mount and Wall-mount they should be totally modular and scalable to accommodate future fiber build-out.

Patch panel unit housings shall be of 1U, 2U and 4U or small, medium and large (depending on whether it is rack or wall mounted) size (as per the number of terminations), in titanium color. The front patch cord tray and rear cable tray shall be removable for easier access during the installation.

Technical Specification

Rack Mount	No of Adaptor Strips
a) 1U Rack Mount	2
b) 2U Rack Mount	4
c) 4U Rack Mount	8
Splice Trays	
a) 1U Rack Mount	1 x 8 in.
b) 2U Rack Mount	2 x 8 in.
c) 4U Rack Mount	4 x 8 in. or 4 x 12 in.
Wall Mount	
No of Adaptor Strips	
a) Small Wall Mount	2

b) Medium Wall Mount	4
c) Large Wall Mount	8
Splice Trays	
a) Small Wall Mount	1 x 8 in.
b) Medium Wall Mount	2 x 8 in. or 2 x 12 in.
c) Large Wall Mount	4 x 8 in. or 4 x 12 in.

30.3.4.3. MEDIA CONVERTER

Media converters shall be installed for use in optical field-bus networks. They shall allow the conversion of electrical interfaces (RS-485 level) into optical interfaces and vice versa. The modules shall be integrated in existing field-bus networks with the known advantages of optical transmission technology. A complete field-bus network shall be set up with modules in a linear (bus), star or preferably ring topology as well as any combination of these topologies. To increase the reliability of the field-bus network in case of failure, redundant ring wiring topology shall be supported.

Technical Specifications

Number of Ports	Device/Network Dependent
Operating voltage	24 V DC safety extra low voltage
Current consumption	Max. 200 mA
Output voltage for bus termination RS-485 (D-sub jack, pin 6)	5 V DC+5/-10%,
Signaling Contact Function	floating contact, opens in case of error
Signaling Voltage	Max. 50 V DC/30 V AC safety extra low voltage
Signaling Current	max 1.0 A
Signal transmission rate	Network dependent
Transmission rate setting	Device/Network Dependent
Electrical channel type	RS-485
Electrical channel voltage	-7 V... +12 V
Optical channel wavelength	Device/Network Dependent
Maximum Distance Transmitted	Device/Network Dependent
Connector	BFOC/2.5
Safety	IEC 60950
Hazardous Locations	ANSI/ISA-12.12.01-2000 compliant (up to CLASS 1, DIVISION 2, GROUPS A, B, C AND D, T4)
Operating temp	-25 °C...+60 °C

Storage temp	-40 °C...+70 °C
Relative Humidity	<95% non-condensing
Protection class	IP 42
Enclosure material	stainless steel
Installation position	Vertical
Mounting	DIN Rail Mounted/Rack Mounted

30.3.4.4. JACK PANEL

- Performance should meet EIA/TIA 568.
- Highly compact with 24 information outlets.
- 19’’ Rack mountable.
- Size of Jack Panel should be 1 U.

30.3.4.5. UTP CABLE (ETHERNET CABLE)

- Should meet the EIA/TIA-568/569 Category 6.
- Should meet the category 6 standard.
- Must be in minimum 4 pair, unshielded twisted pair cable.
- Suitable for use in factory (noisy) environment.
- Suitable tested till 600Mhz

30.3.4.6. UTP PATCH CORDS

- Unshielded twisted pair 100ohms multi standard and highly flexible.
- Should meet EIA/TIA 568 Category6.
- RJ-45 connectors with Resistance of 20 mega ohms.
- RJ-45 connectors are three piece two layer design connectors.
- Size of patch cords should be 2 meters

30.3.4.7. UTP TO OFC CONVERTER

- Converters to be directly connect to the 10/100 Mbps L-2 Switch.
- L-2 side connection is RJ-45 port and OFC with SC Port.
- UTP to OFC converter should suitable for the 19” rack mounting.
- Input power supply 240 VAC, 50 Hz also vendor can suggest with 24 VDC supply.

30.3.4.8. OFC CABLE

Fibre optic cable shall be Single Mode / MM armoured. These cables shall be perfect immunity to noise. These cables shall be suitable to communicate between Field Interface and PLC terminals to meet the functional requirement.

The core in fibre-optic cable shall be made from a combination of highly purified silicon and germanium. The cladding shall be made by pure silicon. Surrounding the cladding is a buffer material which acts as a shock absorber to protect the core and cladding from the damage. The outer jacket shall protect against abrasion and environmental damage. The fiber optic cable shall be armored.

The manufacturer shall be identified throughout the length of the cable by manufacturer's name or trademark and year of manufacture of the cable indented or embossed on the cable. The indentation or embossing shall be done only on the outer sheath.

Fibre optic cable shall meet all the functional and technical requirements in this specification

Technical Specifications for Single Mode Fibre optic cable:

Fibre Size	9/125 micro meter
Maximum Length	5km
Fibre Material	Glass
Permissible Temperature	-20°C to 60°C
Permissible Humidity	75% on average
Outer Sheath	Poly Ethylene
Bend Radius (Long Term)	10D
Bend Radius (Short Term)	20D
Tensile Load	2500N
Operating Wavelength (nm)	1310/1550
Jacket Type	Loose tube
Max Attenuation (db/km)	0.35/0.25
Zero Dispersion Wavelength (nm)	1312±12
Cable Cut off Wavelength (nm)	≤.1260
Polarized Mode Dispersion (PMD)	≤ 0.2
Mode Field Diameter (MFD)	9.2±0.4/10.4±0.6
Number of Fibers	8
Strength Member	Aramid yarn / Steel music wire
Armour	Steel
Buffer	Gel filled and PBT tube

Compliance standards	TIA/EIA-568-C.3 IEC 60793 IEC 60794
Colour Code Standard	TIA/EIA-598-B

30.3.4.9. OFC PATCH CORD

- Should meet EIA/TIA 568.
- Patch cord should suitable for single/multimode fiber application.
- Plastic molded plug or metallic body connectors.
- Fiber patch cord SC-SC type duplex.

30.3.4.10. UTP INFORMATION OUTLETS

- Information Outlets should be of dual points.
- Surface mount box should fit single or dual information outlets.
- Should meet EIA/TIA 568 Category 6.
- Should have insulation resistance of 500 M-ohms minimum and contact resistance of 20 M-ohms max.
- Information Outlets should have cable entry points on all 4 sides and one in the center.

30.3.5. Associated Control Devices/Sub-Systems

The Contractor shall be responsible for the interconnection of all such associated devices/ sub-systems with the control system under this specification and their integration with the software supplied by the Contractor. Please note that the interconnections shall be such that the status of all devices/sub-systems shall be transmitted to the control network irrespective of whether a motor is in the “local” or “auto” mode. All third parties interface shall be hooked to Control Room in RS-485 Port /Optical Data highway link (as applicable) compatibility.

30.3.5.1. CONTROL WIRING INSTALLATION

Control wiring shall be done by Flame Retardant Low Smoke (FRLS) insulated stranded copper conductor wires. Terminals emanating from various control devices of conveyors like pull cord, belt sway, belt speed, belt take up limit switches, Local Control Station etc. shall be brought to a junction box by PVC insulated, control cables.

One ‘NC’ contact of all switches shall be interconnected in series by 2.5 sq.mm copper cables and brought to the junction box mounted at an interval of 200 M i.e. at crossover points for long conveyors or at head/tail end of the conveyors.

Also one `NO' contact of all switches shall be interconnected in parallel and brought to the above referred junction box.

Similarly, control terminals (intended for sequential interlocking and/or indication in Control Room) emanating from each of the other system such as winches, dust control, belt-weighers, metal detector, magnetic separators, hoist, level detectors/controllers etc. shall be brought up to their respective junction boxes located suitably and terminated therein.

It is to be noted that individual cores from each safety device mentioned above shall be connected in the junction box properly identified by interlocking ferrules and no looping is permitted in this junction box.

The cables shall be laid over ladder type/pre-fabricated GI cable trays, which shall be mounted on short posts all along the conveyor.

30.3.5.2. LOCAL CONTROL PANEL

The local control panels shall be mounted adjacent to the equipment and exposed to normal ambient environment and shall have IP65 degree of protection.

This panel shall house the essential monitoring instruments. Alarm/annunciation system, command station like control switches, start/stop push buttons, indicating lamps, ammeters etc. required for start-up operation/maintenance of the equipment/sub-system/system locally.

All panels shall be of free standing welded construction and shall be robustly constructed of cold-rolled sheet steel of thickness not less than 2 mm.

All panels shall have (left off type) doors, capable of being opened through 180 deg. A pocket shall be provided on panel door for cable termination charts which are also in the Contractor's scope. All doors shall be supplied with built-in locking facility. All doors, removable covers and plates shall be gasketed all around with 4 mm neoprene gaskets. The enclosure shall be vermin-proof, dust-proof and weather-proof.

The interior of each panel shall be suitably illuminated through fluorescent lamps operated by a panel door-switch.

Panel heaters suitable for 240 V, single phase, AC shall be provided on each panel bottom to prevent moisture condensation. Heater should be designed to maintain panel temperature 5^{O}C above the ambient. Suitable miniature circuit breaker and thermostat for the heater shall be provided.

All panels shall be supplied complete with foundation and removable lifting eye bolts along with the panel base-frame for foundation.

Wiring, fuses, switches and terminal boards shall be properly color coded, routed and neatly run in insulated cleats/trays if required in such a manner that wherever practical it can be checked against the wiring diagrams. Wire sizes and layout shall conform to the relevant standards and to Employer's approval.

AC and DC bus-wires shall be kept separate from all other wiring and DC wirings shall be segregated from all other circuits. Supply to various equipment shall be directly tapped, from a through bus-bar and looping for the same shall not be used.

All wires shall be properly numbered and identified with ferrules at both ends to Employer's approval. Incoming and outgoing wires shall be suitably segregated wherever possible as per **relevant IS.**

One piece moulded 1100V grade terminal blocks complete with insulated barriers terminal studs, washers, nuts and identification strips shall be used. Terminal blocks may be of clip- on or insertion type. Individual terminals shall be suitably insulated and spaced apart to enable access to the same and preferably of Elmex/Jyoti make. Terminal blocks shall be numbered for identification and grouped according to function. Minimum clearance between rows should be 100 mm. In case terminal blocks are mounted vertically suitable slanting shall be provided for ease of termination. At least, 20% spare terminals shall be provided in each row of terminals, after all cable cores, including spare cores have been terminated. For incoming AC and DC supplies, separate terminal blocks shall be provided. These terminals shall be suitably shrouded.

Panel internal wiring shall be done with 1100V grade PVC insulated copper wire of size not less than 2.5 sq. mm. Insulation of wiring shall be flame retardant type and shall not deteriorate at ambient temperatures.

All wires shall be suitably terminated with solder less crimping type tinned copper lugs which firmly grips the conductor and insulation.

Tapping/jointing of wires is not permitted and looping of wires shall be avoided to the maximum. In no case, the number of wires per terminal shall exceed 2. All accessories such as packing glands, crimping type tinned copper lugs, supporting clamps and brackets etc. shall be supplied by the Contractor.

Undrilled cable gland plates and cutout covers for cable and pipe entry shall be provided. Cable entries shall be suitably sealed with an approved non-inflammable seal material. Cable gland plates shall be at least 250 mm above floor/ground. Necessary number of cable glands shall be supplied fitted on this gland plate and the same shall be specified by the Employer during detail engineering stage.

Suitable isolating switches and fuses, preferably HRC cartridge type mounted on plug-in- type fuse bases (both made out of moulded insulating material) shall be provided for incoming power supplies to the panel. It should be possible to change fuses with the circuit alive

Each electrical drive motor shall have two modes of operation; ‘Local’ and ‘Auto’, manually selectable by a three position selector switch “Local-Off-Auto’ Each heavy duty selector switch shall be located close to and within view of each drive motor (except in the case of the multi motor for which see below). Start-Stop, Forward-Reverse push button shall be provided next to or integrated with each L-O-A as required. It shall be feasible to lock the L-O-A switch in the ‘Off’ position, so that the locking key can be retained by maintenance staff for working on the driven equipment in safety.

A maintained contact emergency stop switch shall be provided near the other drive motor(s). The emergency stop switch shall have at least three sets of NC/NO potential free contacts rated 10amp at 110V AC in an IP-65 protected enclosure. A red mushroom type of actuator shall be used. There shall be two cable entries suitable for double compression glands (or better) for up to 10 x 2.5 sq mm copper conductor armored control cable. Earthing terminals shall be provided on the enclosure.

30.3.5.3. CONTROL DEVICES

“Control devices” generally consist of sub-systems complete with:

- Individual control panels (usually at or near the sub-system),
- Internal control logic,

- Internally wired components

These units shall be integrated with the Control System and shall be connected and interfaced to the System by the Contractor. Physical installation of such devices or sub-systems, their internal electrical connections. However, the interconnecting cables between the control panels of such sub-systems and the components of the control system supplied under this specification shall be the Contractor's responsibility. The Contractor shall coordinate with the suppliers of such control devices/sub-systems to ensure that the functional requirements are fully satisfied. In the case of such sub-systems as for rail and truck loading, the Contractor shall ensure smooth transmission of data to and from the workstations PLC or Controller / PC's supplied. These shall be interface/interlocked/ integrated with the control system through Modbus - RTU/hardwired Mode, etc.

30.3.6. Cables and Wires

30.3.6.1. CONTROL CABLES

This specification covers the requirements for Voltage Grade 1100 V armoured, multi core XLPE (cross linked polyethylene) insulated and PVC sheathed, FRLS cables for control purposes.

All cables shall be designed and manufactured such that no damage occurs during transportation, installation and operation of the cables under stipulated conditions.

The cables shall be suitable for laying in trays, pipes, ducts, closed trenches and directly buried underground. All cables shall be armoured type.

Cables shall be provided with additional overall Shielding with Aluminum mylar tape with 100% coverage and 25% overlap on laid up cores for shielding against static/electromagnetic interference.

System Particulars

- Voltage: 1100 V grade
- Ambient Temperature: 50^{o}C.

30.3.6.2. CONDUCTORS

The conductor shall be of plain annealed high conductivity copper stranded wires which before stranding shall be generally circular in section, smooth, uniform in quality and free from scale spills, splits and other defects. The conductors shall confirm to relevant IS. The stranded conductor shall be clean and uniform in size and shape and its surface shall free from sharp edges.

30.3.6.3. INSULATION

The insulation shall be chemically cross linked polyethylene XLPE conforming to the physical, electrical and ageing properties as required by relevant IS. Only natural unfilled compounds shall be used for insulation of cables. The insulation shall be free from micro voids and shall be heat resistant.

30.3.6.4. INNER SHEATH

For all cables having two or more cores, the individual cores shall be laid up and then be surrounded by common covering applied either by extrusion or wrapping or filling material containing a thermoplastic material. A proofed or plastic tape may be applied over the common covering when a wrapped common covering is employed. It must be ensured that the circularity of the cable is maintained.

30.3.6.5. ARMOURING

Armouring shall be arranged over the inner sheath for the cable consisting of two or more cores. The armour of cables shall be either of galvanized steel wires or galvanized steel strips.

30.3.6.6. OUTER SHEATH

A tough outer sheathing of PVC insulating material in standard colours shall be provided over the armouring to offer a high degree of mechanical protection against abrasion. Additional compound shall be applied under and over each layer. In order to prevent adhesion, a coating of lime wash or other suitable material shall be applied to the outside of the cable. Outer sheath shall be FRLS.

30.3.6.7. COLOUR SCHEME FOR IDENTIFICATION OF CORES

Cores shall be identified by colour scheme of PVC/ XLPE insulation. The following colour scheme shall be adopted:

 Up to five cores- Red, Yellow, Blue, Black and Grey.

For cables having more than five (5) cores, two adjacent cores (counting and directional) in each layer may be coloured blue and yellow respectively and the remaining cores may be light grey.

30.3.6.8. MANUFACTURER'S IDENTIFICATION

The manufacturer shall be identified throughout the length of the cable by manufacturer's name or trademark, voltage grade and year of manufacture of the cable indented or embossed on the cable. The indentation or embossing shall be done only on the outer sheath.

30.3.6.9. SERIAL DATA CABLE (RS485)

These shall be shielded twisted pair copper cable with minimum of four cores. These cables shall be insulated and PVC sheathed FRLS cables for serial data communication purposes.

All cables shall be designed and manufactured such that no damage occurs during transportation, installation and operation of the cables under stipulated conditions.

30.3.6.10. JUNCTION BOXES

All the JBs (Junction Box) shall be metal enclosed, suitable for mounting on wall (or) sheet structure in material dust laden atmosphere. The enclosure shall be made of high quality Polycarbonate (shock proof, rust free, corrosion free, acid and chemical resistant, fire retardant, having high impact[IK 08],totally insulated [class II] made of halogen and silica free recyclable material), UV resistant, having high grade gasket made of Polyurethane, should withstand glow wire test at 9600c in accordance with IEC 60 695-2-11, should be flame retardant, self-extinguishing the Junction box should have test certificate in accordance with IEC 60 670-22 The JBs shall be dust and vermin proof and shall have IP- 66/67 degree of protection as per relevant code. The JBs shall be suitable for both top & bottom cable entry and shall be provided with removable undrilled gland plates or knockouts. Clip-on type/screw terminal shall be mounted on the base chalked in the JBs. The base channel shall have space for accommodating another 20% extra terminal. Two numbers of earthing points suitable for 12 SWG GI wire shall be provided on the body of the JBs.

30.3.6.11. PACKING AND MARKING

The cable shall be wound on a wooden drum and packed as per the requirement of relevant IS. The ends of the cable shall be sealed by means of non-hygroscopic sealing material.

The cable shall carry the following information either stenciled on the drum or contained in a label attached to it:

- Reference to Indian Standard
- Manufacturer's name or trade-mark
- Type of cable and voltage grade
- Number of cores
- Nominal cross-sectional area of conductor
- Cable code
- Length of cable on the drum
- Number of lengths on the drum (if more than one)
- Direction of rotation of drum (by means of an arrow)
- Gross mass
- Year of manufacture.
- Dispatch

The cables shall be dispatched in suitable drums with weatherproof packing.

30.3.7. CCTV Surveillance System

30.3.7.1. GENERAL

Surveillance CCTV system is required to ensure surveillance of required locations as well as create secured record for post event analysis. The system shall provide an online display of video images on LED monitors located at different locations of Valve house and Dam area. The System shall facilitate viewing of live and recorded images and controlling of all IP cameras by the authenticated/authorized personnel. The core of the surveillance system shall be NVR servers. System shall also have operating systems, appropriate software, networking equipment and other essential components.

The communication between the cameras and the Camera Control Room shall take place to ensure the maximum availability, Real time Delivery of the Datagrams and further maximize determinism. In addition to the Wireless, Backbone of the network an additional fiber optic as optional backbone has to be built in order to ensure the failsafe working of the CCTV surveillance in the event of unexpected failure of the system components such as wireless routers etc.

System shall have expansion possibility with the available hardware (system shall have the facility of additional camera installations beyond the originally planned capacity). It shall be an open standard based integrated system with IP network aimed at providing high speed automatic operation for best performance. It shall use video signals from various types of outdoor cameras installed at different locations. Joystick and mouse-keyboard controller shall be used for Pan, Tilt, Zoom, and other functions. System shall have a combination of Digital colour video cameras with individual IP address. It shall also have raid backup device of recording, application software, colour video monitors and keyboards.

Camera server shall be NVR server based with appropriate Audio and Video Management System backup system and software. Each camera server shall handle 60 or more cameras. CCTV system shall ensure that once recorded, the video cannot be altered; ensuring the audit trail is intact for evidential purposes. System shall provide sufficient storage of all the camera recordings for a sufficient period. The recording resolution and frame rate for each camera shall be user programmable.

30.3.7.2. EQUIPMENT SPECIFICATIONS FOR CCTV SURVEILLANCE SYSTEM

A) NVR Server

The NVR shall have enterprise class reliability with a RAID 6 hard drive configuration and the option for redundant power supplies. In addition, both the hard drives and the power supplies shall be hot-swappable for online repairs. The NVR shall have upto 10 TB effective recording capacity that is expandable using a storage expansion unit. Quality Video Resolution: 640 x 480, 320 x 240 (default), 192 x 144. The Image Quality shall be of JPEG (favour clarity, standard, and favour motion) and MPEG4. It shall support a Frame Rate of 30 frames/sec (640 x 480, 320 x 240 or 192 x 144).

It shall support IPv4/v6 Dual Stack Supported Network Protocols. It shall support Simultaneous Viewing with simultaneous accesses with Image Transfer via E-Mail (SMTP) or FTP, SMTP, FTP, and HTTP etc. It shall be complete with standard keyboard, 21 inch XVGA LED colour monitor, mouse controller, CD/DVD drives, network cards.

B) Workstations

Data terminal computers shall have high computing power, suitable for communication equipment networking. Each processor should have its own independent system bus to reduce data bottle necks while maximizing processing throughput and multitasking. They shall be complete with standard keyboards, 21 inch XVGA LED colour monitors, mouse controllers, CD/DVD drives, network cards.

Processor	Intel i5 processor,
Clock Speed	3.6 GHz
Random Access Memory	4GB- DDR2-ECC-SDRAM Clock Frequency = 1667MHz
Hard Drive 1 Optical Drive	320 GB SATA CD/DVD read write
Communication Ports	Parallel Port-1, Serial Ports (Universal)-3, USB Ports- 8
Power Source	240 V AC,50/60 Hz
Network card	Additional Gigabit/10/100 MBPS Ethernet PCI-E Network Card (in total 2 network connections)
Permissible Humidity	20%-80%
Design Ambient temperature	50^{O}C
Operating System	Windows 7/ 8/ 10
Power Source	240 V Ac,50/60 Hz
Display Type	Compensated TN , Full colour TFT LED Luminance :1150cd/m2
Resolution	At least 1280*1024 (NI)
Size	21 inch Diagonal
Operating Condition	Temperature : 0ºC-40ºC Humidity : 20% -80%
Contrast Ratio	30000:1
Viewing Angle	140ºH, 140ºV
Safety Standards	UL6500/C-UL

C) Optical Fibre Cables

Multimode/Single mode (depend upon the distances), armoured optic cable standard cable shall be used. It shall have rugged design for industrial applications indoors and outdoors. It shall have high immunity to noise and electro-magnetic fields and shall be Tap-proof and radiation shall be limited to applicable standards. It shall also be silicon free and free from varnish-moistening substances.

D) Ethernet Cable

Category-5e /Cat 6 cables shall be built tough enough to withstand the harsh environmental conditions and mechanical stresses. The cable shall also provide more stable electrical performance with less attenuation and greater resistance to EMI/RFI.

E) Cameras

All the cameras shall be IP based. They shall have an enclosure of minimum of IP-67 while outdoor cameras to be of IP-67. They shall also be outdoor ready with day/night functionality

36x (Optical Zoom) PTZ Camera and an Image Sensor with CCD sensor, approx. with wireless capability with advanced digital Signal Processing Capability, High Horizontal Resolution, Day and night Type, 360 degree continuous Pan Rotation with complete power supply and accessories.

Image Device	Better format CCD sensor
Optical Zoom	36 X or better
Number of pixels	1280X960 or above
Scanning system	PAL
Pan Travel	360º continuous
Tilt travel	0 - 90º continuous
Iris Control	Auto
Focus	Auto
White Balance	Auto
Electronic shutter	Auto
S/N ratio	>= 40 dB
Frame Rate	PAL – up to 30 frames per second in all resolution
Operating Temperature	- 10 º to 60 º C.
Operating Range	Up to 190 meters
Mounting Frame	Aluminum (or any which suits weather conditions)

F) Mounts

All the cameras shall have appropriate mounts based on the camera design and the functional requirement of the same.

G) Enclosures

All the cameras shall have IP-67 appropriate dust tight enclosures ready for use in small Particle and dusty environments it shall also include Heater, Blower, Air Funnel Kit, Sun Shield and Sun Visor depending on the mounting location and requirement.

H) Video Management Software

Processor	Intel Xeon i5 processor
Clock Speed	3.86 GHz
Cache Memory Size	12 MB Cache L3 1333 MHz front side bus
Random Access Memory	8 GB DDR4 Clock Frequency: 1333 MHz

Hard Drive 1	10 TB (7,200rpm) SAS
Hard Drive 2	6 TB GB SOS
Communication Ports	Parallel Port-1, Serial Ports (Universal)-3. USB Ports-8
Power Source	240 V AC,50/60 Hz
Network card	Additional Gigabit Ethernet PCI-E Network Card (in total 2 network connections)
Permissible Humidity	20%-80%
Design Ambient Temperature	$50^{O}C$
Operating System	Windows

The software shall be IP-Surveillance software that works with the network cameras to provide video monitoring, recording and event management functions. It shall enable recording of video continuously, on schedule, on alarm and/or on motion detection. The software shall have multiple search functions for recorded events. Remote viewing and playback shall also be possible with the use of the client software.

30.3.8. Recommended Equipment/Component Vendor List

Make of the equipment under supply items shall be selected as per the following list. Employer, however, reserves, the right to select the particular make during detailed engineering for uniform design and inventory. Approval of makes for items not mentioned in this list shall be obtained from Employer/Employer's Representative Engineer before initiating procurement action.

ITEM	**RECOMMENDED VENDORS**
Servers	Hewlett Packard / IBM / Dell
LED (32")	Samsung / Sharp / Panasonic / LG / Sony
Workstation Terminals	Hewlett Packard / Dell / IBM
LED Monitors (21")	Sony/Samsung / LG / AOC/ Hewlett Packard
Network Printers	Hewlett Packard / Canon / Epson / Samsung / Lexmark
UPS	APC / Eaton /Toshiba/Best Power /Emerson Hi-Rel
PLC	Siemens / Allen Bradley /ABB /Schneider/ Honeywell / Yokogawa / GE
CCTV	Honeywell/ Bosch
Network Components And Accessories	
Jack Panel	Molex / Signamax /Brand-Rex
Cat5e Cable (UTP)	Amp / D-Link / ADC
Cat6 Cable (UTP)	Amp / D-Link / ADC
UTP To OFC Converter	Moxa / D-Link

LIU (Light Guide Interconnect Unit)	D-Link / Moxa
Ethernet Switches	D-Link / Cisco / Moxa / Siemens / Nortel
UTP Patch Cords	AMP / ADC / D-Link
UTP Information Outlet	D-Link / Molex / ADC
Instrument Cable	Cords Cables / KEI / Associated Cables / Universal Cables
Panel/Cabinets	Rittal / ICA / Pyrotech
JB/Cable Gland/Plugs	Hensel / Rittal / Emiter
OFC Cable	Molex / D-Link / Finolex / RPG Cables Ltd. / Sterlite Industries
Other Equipments	
RTD	Pyroelectric Equipment/General Instruments / A.N. Instruments
Relays	Omron / OEN / Jyoti

NOTE: - Makes like 'or equivalent' are not acceptable. Other makes proposed shall be submitted to the Employer with back-up documents and PTR (Proven Track Record) for prior approval.