

EPC Execution of Civil and HM works of Heo H. E. Project (240MW), Shi- Yomi district, Arunachal Pradesh	 ISO: 9001, 14001, & 45001	Bid Document Vol-IV: Employer's Requirements
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VOLUME – IV: EMPLOYER’S REQUIREMENTS



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1. EMPLOYER'S REQUIREMENTS

1.1. INTENDED PURPOSE OF THE WORK

The intended purpose of the work is to execute Civil & Hydro Mechanical works required for implementing the Heo Hydro Electric Project (240.MW) near Hiri Village, in the Shi-Yomi District of Arunachal Pradesh for harnessing a part of the hydroelectric power potential of the river Yarjep.

1.2. SCOPE OF WORK

- i) The Scope of Works shall include but not limited to Design & Engineering, instrumentation, quality assurance, acquisition of all permits, approvals & licenses, construction, manufacture including procurement, delivery, installation, testing, commissioning of Civil, Hydro Mechanical and part of Infrastructure and Utility Works of the project. This shall also include overall and detailed review of the planning of the Project, review of all statutory, regulatory and legal compliance done so far, assessment of additional investigations and tests and provide required services and works for filling up gaps therein, if any found.
- ii) All document, data and information related to the Project and available with the Employer shall be furnished to the Contractor without charge. The Employer may without obligation give such assistance for obtaining of any additional data and information as may reasonably be requested by the Contractor.
- ii) The Contractor shall be deemed to have scrutinized the Employer's Requirements and shall be responsible to comply with the same.
- iii) Overall, the requirement of the Employer is that the contractor shall carry out review of planning and investigation and additional investigation as required, detail design & drawing, preparation of specification, construction, supply and

erection, integration, testing & commissioning and handing over the structures, installations, facilities and Plant and Machineries in fully functional, safe and acceptable condition complying all statutory, regulatory and legal requirements within the stipulated time.

Description of the Employer's general requirement in the form of salient activities and deliveries to be made by the EPC contractor is stated below.

- a) As per TEC stipulations, further geotechnical investigations are required to be done. The Employer has taken up the Exploratory Drilling works as stipulated in TEC. The exploratory drifting works including in-situ stress measurement are to be carried out by the Contractor. The minimum size of drift shall be 1.80 m (W) x 2.10 m (Height).
- b) Plate Load test (TEC) at Power House Site to be carried out by the Contractor.
- c) Additional Geotechnical investigations, laboratory and field testing as required by the contractor;
- d) Review and preparing summary of all tests and investigations;
- e) Confirmatory topographic pre-construction/construction survey;
- f) 3D Physical hydraulic model study for Barrage, spillway, under sluice & Intake;
- g) Preparing Design basis report and finalizing/deciding design inputs/parameters;
- h) Prepare Detailed Design calculations and document;
- i) Prepare detail specification of work and supplies;
- j) Prepare Good for Construction Drawings;
- k) Report on construction methods, Plant and equipment to be used in the works;
- l) Procurement and delivery Schedule for all Plant & equipment;
- m) Plans for operation of borrow areas and muck disposal areas;
- n) Processing & Production of construction raw and intermediate products;
- o) Quality Control and Quality Assurance plans and procedures for Construction;

- p) Health, Safety and Security plans;
- q) Execution of all construction, supplies, erection and commissioning of all structures, installation and equipment within the scope of the contract;
- r) Carry out all load test and equipment performance test;
- s) Facilitate Employer to witness onsite and off-site tests of work, material & equipment;
- t) Prepare Operation and Maintenance Manuals;
- u) Prepare Training Manuals for Operation & Maintenance of the commissioned Hydraulic structures and Hydro Mechanical equipment and machinery of the project;
- v) Handing over the commissioned Civil and Hydro Mechanical works

The list is tentative and it covers only salient components of the scope of work. Any other component/activity which is essential to complete the delivery of commissioned Civil and Hydro Mechanical works required for the proposed Power Plant is deemed to be included therein.

In this document the words “Employer” and “Owner” has been used interchangeably with the intention of meaning same i.e “Employer” for both the words.

1.3. COMPONENTS OF THE PROJECT

Salient key components of the project are envisaged as stated below. All subcomponents, interfacing and minor components that shall be required to make the key installations fully functional in safe and acceptable manner are to be worked out by the contractor.

A. Civil work

- i. Diversion barrage
- ii. Power Intake
- iii. Head race tunnel and Adits
- iv. Surge Shaft
- v. Valve house
- vi. Pressure shaft
- vii. Surface Powerhouse complex

- viii. Tail Pool
- ix. GIS & Pot Head yard.
- x. Instrumentation
- xi. Drainage
- xii. Permanent road network
- xiii. Utilities

B. Hydro-Mechanical work

- i. Spillway radial gates with and without Flap and Hydraulic hoist
- ii. Spillway Stop logs and gantry crane
- iii. Under sluice gates with hoist
- iv. Intake Trash rack and TRCM.
- v. Intake Service and Emergency gates with hoists
- vi. Draft tube gates with hoists
- vii. Penstock steel liner with specials
- viii. Instrumentation and remote control

C. Electro-Mechanical work:

Execution of Electro Mechanical works is not included within the scope of the work.

1.4. MODEL STUDY, INVESTIGATION, TEST & SURVEY

1.4.1. Preparatory Work

As a part of the study of all documents provided by the Employer as well as collected by the contractor on his own, it is required but not limited to it, that the contractor carry out the followings, which ideally be performed at pre-bid stage to avoid any ambiguity at execution stage

- i. Review of available geological and geotechnical data as a basis for a programme for additional investigations to be carried out, if any, deemed necessary by the Contractor.
- ii. Review of available topographical information as a basis for a programme for additional detailed surveying to be carried out, if any, deemed necessary by the Contractor.
- iii. Review of technical parameters for Civil Works, Hydro mechanical Works and Electro mechanical works except the fixed parameters.

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1.4.2. Investigations, Tests

Following activities are required to be carried by the contractor in such a manner that the construction activities can be started timely to complete and commission the project as per over all completion schedule provided in the contract.

- i. Additional geological and geo-technical investigations as required by the contractor.
- ii. Confirmatory topographical and control survey as required by the contractor
- iii. 3D physical hydraulic model study for verifying hydraulic parameters of the Barrage, spillway, under sluice and Intake.
- iv. Extraction of Coarse and fine aggregate from designated quarries and conducting tests of all associated construction materials for deriving optimized mix designs for various grades of concrete & shotcrete

The Contractor shall include these activities including associated sub-activities in the project schedule. The contractor shall timely notify the Employer these tests in advance and facilitate to witness it.

1.4.3. Survey

The contractor shall carry out all survey necessary for preconstruction and construction works. Employers requirement of surveying process, setting control points, precision level etc. are stated in **Annexure-4.01**.

1.5. PLANNING AND DESIGN

- 1.5.1. The Contractor shall provide engineering services for planning and detailed design of the Works complying all relevant Indian standards and other accepted standards and fulfilling Employer's requirement as stipulated herein and as per requirement of Electro-Mechanical works.
- 1.5.2. There will be a design monitoring, review and approval process which is intended

for ensuring fulfilment of Employer's requirement. In this process the contractor would submit all design documents, specifications and processes statements and the Employer would verify and approve the same prior to its implementation. Such approvals, however, shall not relieve the contractor from ensuring the delivery of the stipulated end product as stated herein. The Employer shall engage one Project Management Consultant (PMC), who will, in stages monitor, review and comment on the contractor's submittals on planning and design and other submittals and will monitor its implementation subject to approval by the Employer including approval by statutory authority viz. CWC/CEA, etc. where ever it is essential/statutory. This procedure shall include, but not limited to scheduled and urgent design co-ordination meetings, witnessing onsite and offsite tests and inspections, supervision, monitoring milestones and making communications. Planning and detail design shall generally include the followings:

- a) Assumptions and design procedures adopted, design criteria, loads, load cases used and the safety factors;
- b) General Arrangement and layout and design load and load combinations of Power house and Penstock protection valve house caverns and Adits and ducts fulfilling the requirement of Electro-Mechanical works
- c) Description of adopted methods of analysis, computer programs, software, etc. used;
- d) Calculations and principal results of the detailed design analyses and validation of results by physical/numerical/mathematical model studies as per requirement;
- e) Good for construction drawings of structures, installations & utilities and specifications for its supply & construction;
- f) All other inputs necessary for construction and completion of the Works;
- g) Any geological issue during construction phase, which shall have to be vetted/approved by the Employer and/or appropriate authority of GSI as and when required;

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- 1.5.3. The design of all structures, Equipment, installations and utilities shall conform to all relevant Indian standards irrespective of whether it is expressly mentioned or not elsewhere. In case of non-availability or lesser elaboration of any design aspect in Indian Standards, International standard like ASTM, BS, DIN, JIS, ISO, IEC, etc. shall be adopted with Employer's consent. Reports of recognized engineering professional bodies/ authorities like ICOLD, ISRM, ASCE, AFTES etc. may also be referred wherever required and agreed by the Employer.

It is mandatory for the bidders to refer Vulnerability Atlas of India (prepared by Building Materials and Technology Promotion Council under Ministry of Housing and Urban Affairs, Government of India and available at their website www.bmtpc.org) for multi-hazard risk assessment and include there relevant hazard proneness specific to project location while planning and designing the project in terms of:

- i. Seismic zone (II to V) for earthquakes,
- ii. Wind velocity (Basic Wind Velocity: 55, 50, 47, 44, 39 & 33 m/s)
- iii. Area liable to floods and probable max. surge height
- iv. Thunderstorms history
- v. Number of cyclonic storms/severe cyclonic storms and max sustained wind specific to coastal region
- vi. Landslides incidences with Annual rainfall normal
- vii. District wise Probable Max. Precipitation

Henceforth, this stipulation on design standards, codes & documents applicable for the contract shall be collectively referred interchangeably in short by the terms **“Standards”** or **“Indian Standards”** or **“Indian and International standards”**, which instead of its literary meaning shall explicitly mean the above stated stipulation.

A tentative list of Standards applicable to material, design, construction and instrumentation of various components of Civil and Hydro Mechanical works is enclosed as **Annexure-4.02**. This list is no way exhaustive and the contractor shall ensure inclusion of all applicable Standards to make it complete.

- 1.5.4. The structures, plant & equipment, installations and utilities delivered by the contractor shall at least meet the following requirements:



- a) It shall perform to give out put with desired serviceability accommodating the requirement of Electro-Mechanical works seamlessly as required by the Employer.
- b) It shall remain stable during and after completion of construction for it's operation/use throughout its service life with appropriate factors of safety under all stipulated loads and combinations as specified in the relevant Indian and International Standards;
- c) Stresses in structures and foundation medium shall be within permissible limits;
- d) Displacement. deformation and settlement in structure, installations, foundation medium etc. induced by imposed loads shall be within permissible limit and it shall not impair structural stability and serviceability;
- e) Seepage rate and uplift pressure in foundation shall be restricted within permissible limit to prevent internal erosion, piping and/or uplift that could cause instability;

1.5.5. Prior to proceeding with detail design, the Contractor shall submit Design Basis Report (DBR) for approval of the Employer. The DBR shall include the following including any other point that may be entailed by these points.

- a) Design considerations to be adopted including the aspects of physical/numerical/mathematical model studies
- b) Indian and International standards corresponding to each component
- c) Type and class of material and their properties
- d) Basis for arriving at overall dimensions including minimum dimensions where ever envisaged
- e) Geo-technical test reports interpretation and Geo-technical inputs to be considered in design
- f) Program for submission of design report and drawings
- g) Program for submission of material & equipment specification, construction and supply and fabrication & erection specification

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- h) Onsite and offsite tests of works, material and equipment to be witnessed by the Employer

The submitted programs shall be of Level 2 and Level 3 nature and conforming to the overall completion schedule as referred in the GCC and PCC of the contract.

Whenever necessary, DBR shall be reviewed on the basis of decisions taken during finalizing and approving DBR, revelation of facts and encountering situation not envisaged earlier or change in statutory stipulations.

- 1.5.6. Time line for the design review and approval process shall be as follows.

Submission of first DBR:	30 days from Letter of Intent
Comment/ Approval of DBR:	15 days from the date of submission
Submission of detail design reports:	In line with the approved Project Schedule
Comment/Approval of design report:	15 days from the date of submission
Submission of construction drawing:	In line with the approved Project Schedule
Comment/Approval:	15 days from the date of submission
The Contractor shall successively submit design and drawings aligning it with the construction schedule.	

When the Employer comment on any submittal, the contractor shall endeavor to attend it and resubmit as early as possible or at any date mutually agreed so as to conclude it and proceed to next step.

In case the contractor does not receive any response from the Employer within the stipulated time, it may be considered that Employer has reviewed it and has no comment to offer and the contractor can proceed to next step of the process after intimating the Employer.

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For the details of transection and format of submission of documents, the clause “**Contractor’s document and submittals**” included hereunder shall be referred.

1.6. FIXED PARAMETERS

The immutable fixed geometric, hydraulic, hydrological, seismic and Generation & Transmission parameters of the project are furnished herein.

- i. Hydrological parameters:

Probable Maximum Flood:	3900.00 Cumec
Standard Project Flood:	3200.00 Cumec
Glacial Lake Outburst Flood (GLOF):	820.00 Cumec
25-year Non-monsoon flood i.e. from November to May:	1148.00 Cumec
- ii. Seismic parameter

Seismic design parameters shall be as per the following documents

 - a) Design site specific seismic parameters approved by NCSDP for the project (Refer Volume II - Project Profile for details).
 - b) “Guidelines for preparation and submission of site-specific seismic study report of water resource project to National Committee on Seismic Design Parameters” Second revision June 2024, issued by Central Water Commission, Govt. of India.
- iii. Component wise hydraulic & geometric parameters:

Barrage	
Location	Longitude: 94°16’ 31” E Latitude: 28°32’20” N
HFL	1400.00 m
FRL	1400.00

Spillway	
Type	Gated
No. of Bays	Minimum 5 No.



Design Discharge	Standard Project Flood + GLOF
Size of Gate	As per design requirement but not less than 11.5 m(Width) x 12.0 m (Height)
Type of Gate	Radial Gates
Energy Dissipation arrangement	Stilling Basin Type
Under Sluice	
Type	Gated with breast wall
No. of Bays	2.0 No
Size of Gate	As per Design Requirement but not less than 3.5 m(Width) x 3.5 m (Height)
Type of Gate	Vertical gates
Energy Dissipation arrangement	Stilling Basin Type
Intake System	
Length	Minimum 31.0 m
FRL	EL 1400.0 m
MDDL	EL 1398.0 m
Number of Trash Rack & Size	Minimum 6 number and size each not less than 4m width x 15 m height
Numbers of Intake Gates & Size	Service and emergency gates 2 numbers each Size not less than 9.0 m width x 6.5 m height each
Type of Gates	Vertical lift gate
Head Race Tunnel	
Shape (Finished)	Circular/Modified Horse Shoe

Lining	PCC lined except in low cover zone/shear zone. RCC/Steel liners to be provided in low cover zone/shear zone as per design requirement.
Diameter	Minimum 6.5m
Design discharge	130.25 Cum/ Sec
Adits	
Shape & lining	D-Shaped and concrete lined
Finished dimensions of Adits	
Adit-1 to HRT	As per requirement.
Adit-2 to Bottom of Surge Shaft	As per requirement.
Adit-3 to Top of Surge Shaft	As per requirement.
Connecting Adit to Valve House Bottom	As per requirement.
Connecting Adit to Valve House Top	As per requirement.
Connecting Adit to bottom of Pressure Shaft	As per requirement.
Surge Shaft	
Type & lining	Restricted Orifice, RCC lined & Underground
Finished Shaft Diameter (m)	Minimum 13.5m
Penstock Protection Valve House	
Number & Internal Diameter of valve	1(One), 5.75m $\pm$ 0.25m
Type	Underground cavern
Clear distance between inner finished face of upstream and downstream Crane beam column	9.0m $\pm$ 0.5m
Clear length of Valve house including service bay	19.50m $\pm$ 1.50m

Height of Top level of E.O.T Crane beam from Service bay finished floor level	11.0m $\pm$ 0.25m, Finished floor level of service bay is bottom level of Penstock body $\pm$ 0.10m
Height of Spring level of Roof arch from the Top level of E.O.T Crane beam	3.50m $\pm$ 0.25m
Depth of finished floor level of trench below the penstock	1.80m $\pm$ 0.25m
Valve foundation	RCC pedestal with required block out for Valve anchor bolts, Servo motor and counterweight etc.
Shape & Clear Size of Entrance Adit at Service bay floor level	D Shaped 7.50m wide x 8.0m high ($\pm$ 0.25m for width & height)
Capacity of EOT Crane	200MT / 32MT ($\pm$ 10 %)
Construction Adit at Valve house roof level	6.0m x 6.0m or as decided by the contractor
High Pressure Tunnel	
Number	1
Type	Underground Steel Lined
Internal Diameter	Minimum 5.75 m
Thickness	Varies from 16 mm to 46 mm as per design requirement.
Grade of Steel	ASTM 537/517
Unit Pressure Shaft/penstock	
Number	3
Type	Underground Steel Lined
Internal Diameter	Minimum 2.75 m
Orientation	Orthogonal to C-Line/D-Line of Power House
Thickness	Varies from 24 mm to 50 mm as per design requirement
Grade of Steel	ASTM 537/517
Power House, GIS & Pot Head yard	



Location	Longitude: 94°18' 43" E Latitude: 28°32' 32" N
Type	Surface
Distance from A line to B line	4.40m $\pm$ 0.5m
Distance from D line to B line	19.60m $\pm$ 1.5m
Distance D line to E line	15.0m $\pm$ 0.5m
Length of machine hall	85.5m $\pm$ 1.50m
Length of gis & transformer hall	85.5m $\pm$ 2.50m
Number of Units and Capacity	3 nos. (80 MW each)
Type of Turbine	Vertical Francis
Elevation of Machine Center Line	El 1184.8 m $\pm$ 1.0m
Machine centre line elevation to DT liner bottom elevation	8.0m $\pm$ 0.5m
Machine centre line elevation to Generator top/ Service bay floor elevation	8.5m $\pm$ 0.5m
MIV centre line elevation to MIV gallery floor level elevation	4.0m $\pm$ 0.25m
Service bay floor elevation to Crane beam top elevation	11.0m $\pm$ 0.5m
Clear height of bottom chord of roof truss from EOT Crane beam top elevation	4.5m $\pm$ 1.0m
Number of floors between MIV floor level and Generator floor	2
Total number of floors in Machine hall	4
Size of draft tube Gate	As per Design Requirement but not less than 7.0 m(Width) x 3.95 m (Height)
Type of Draft tube Gate	Vertical gate
Length of DT gate floor along a line	51.0m $\pm$ 1.5m
Elevation DT gate floor	Same as service bay floor elevation



Tail Pool	
Walls top elevation	El 1194.3m $\pm$ 0.5m
Floor elevation	El 1177.5 m $\pm$ 0.5m
Invert elevation of Bell mouth of exit to Tato-I head race duct	El 1180.0m $\pm$ 0.5m
Width at top elevation across flow direction on upstream side	56.0m $\pm$ 2.5m
Minimum clear width at bottom across flow direction on upstream side	44.0m $\pm$ 2.5m
Minimum clear length at bottom along the flow direction from d.t pier face	22.5m $\pm$ 1.0m
Duct size of exit to Tato-I Head race duct	
Height	5.0m
Width	13.5m
GIS & Transformer Building	
Length	85.5m $\pm$ 2.5m
Width	15.0m $\pm$ 0.5m
First storey floor elevation	Same as service bay floor elevation
First storey height	9.5m $\pm$ 0.5m
Second storey height	12.0m $\pm$ 0.5m
Bench & floor at upstream of E line	
Length	Length of GISs & Transformer building + clearance required for DG set shed on left side of the building
Width	12.0m $\pm$ 0.5m
Elevation	Service bay floor level $\pm$ slope for drainage

iv. Salient Electro-Mechanical works:

Scope of Electro-Mechanical works is not included in the Bid.

Supply and erection of all embedded parts, Earthing element, foundation bolts of equipment, EOT Cranes and Transformer Rails etc. required for erection and operation of E&M component shall not be within the scope of this bid.

All civil works of providing structure, enclosure, access, drainage, foundation, block out, grouting etc. for installation and housing E&M component shall be within the scope of work.

The bidder is expected to have experience of design and execution of civil works of a Hydro Electric Project including Power house and Auxiliary building and detail requirement of the interfacing between civil design and construction with E&M works.

Description of the E&M works in the Power House complex and Penstock Protection Valve House alongside indicate layout is given hereunder to indicate the extent of requirement of civil works therein in.

Turbine:

There shall be three (3) sets of vertical shaft Francis Turbines, each having a rated net head of 201.80 metres output not less than 81.20 MW at guide vane opening not more than 85%.

The rated speed of the units shall be 300.00 rpm in a clockwise direction when viewed from top

Maximum gross head i.e FRL-NTWL= 211.0m

Minimum gross head i.e MDDL-NTWL=209.0m

Estimated Total Head loss in the WCS including loss in the MIV = 9.20m

Estimated Head loss in the MIV = 1.36M

Estimated Head loss up to upstream of MIV = 7.87M

Rated Net Head = 201.80m

Minimum net head = 199.80 m

Spherical type Main Inlet Valves and all the turbine generator units shall be accommodated in a single Building. The penstock entry into the building shall be provided at an angle of 90 Degree to the longitudinal centre line of Power House. The spiral casing shall be arranged and laid to suit this orientation.

The design the turbine shall be such that disassembly and assembly of the upper/ lower draft tube cones, guide vanes, bottom ring, runner, guide vane bearings etc. can be done from below the turbine without disturbing the generator components and the runner can be removed from the bottom without disturbing the bottom ring and guide apparatus arrangement.

The runner, after dismantling from the turbine shaft, shall be lowered and clamped on the runner handling cart for which suitable arrangement shall be provided. The runner handling cart shall be taken out through runner removal gallery to MIV floor on the rails embedded for this purpose. The runner shall be lowered or lifted by the EOT crane in the machine hall and shall be taken to the service bay for erection or maintenance.

In each unit suitably oriented Gallery for removal of the underwater components and runner shall be provided in the machine foundation below spiral casing at MIV floor level.

3 nos. of Main Inlet valves (MIVs) of Spherical type shall be provided at inlets of the 3 nos. of Francis turbines. The valves shall be of 2750 mm $\pm$ 250mm nominal diameter and shall have oil servo motor and counter weight. The maximum static head on the valves shall be 215.2 m $\pm$ 1.0m and the transient head when being closed against full load shall not exceed 291 m $\pm$ 2.0m.

Transient pressure rise shall not be more than 35% of the static head at full reservoir level of EL.1400.00 m and speed rise shall not be more than 45% of the synchronous speed.

Generator:

There shall be 3 (Three) no Vertical shaft & alternating current synchronous Generators having rated Output 80MW, 3 phases, efficiency 98.5% (approx.), Power Factor 0.85 lagging, continuous overload capacity of 10%, 10 pair of poles, synchronous speed of 300 rpm and rated Terminal Voltage between Phases 11 kV or any other voltage provided by the Manufacturer.

The generators shall be capable of safely withstanding maximum stresses during normal operation, runaway-speed conditions, two phase and three phase short circuit conditions, single phase earth fault, 180 degree and 120 degree out-of phase synchronization, magnetic unbalance with 50% of the

poles short circuited with the speed up to 1.3 times the rated speed, brake application etc.

The thrust bearing and its bracket shall be capable of carrying in addition to generator loads, the maximum hydraulic thrust loads and weights of rotating parts of turbine including turbine-shaft and runner. The generator pneumatic brakes shall be supported on the lower bracket.

The generator shall have a combined thrust and guide bearing located above the rotor and a guide bearing below the rotor. Alternative offer with one guide bearing below the rotor and thrust and guide bearing above the rotor may be furnished by the supplier if otherwise found suitable.

Reaction on civil foundations due to all Turbine and Generator forces shall be provided in due course by the Equipment manufacturer for consideration in detail design of on the Civil foundation.

The maximum runaway speeds shall be provided by the Equipment manufacturer in due course. The generating unit shall be designed to withstand the forces and stresses occurring at maximum runaway speed condition for a period of at least Fifteen (15) minutes without any damage and to safely withstand any transient over speeds. The runaway speed test shall be conducted at site and shall be considered successful if, after undergoing the test for two minutes, no injury/damage is apparent to the Machine as well as civil foundation and Power house structure.

E.O.T Crane:

Required capacity EOT crane shall be used for lifting T-G equipment, MIV etc. with a long travel extending through entire length of Machine hall and Service bay.

Colling water system:

Cooling water system comprising 4(Four) nos 150 KW Centrifugal pump, 3 (three) sets of filters and network of pipe line of size 450mm to 250mm supported on concrete pedestal. Suction line shall be laid through the A Line wall for drawing water from Tail pool at suitable points and levels.

Drainage gallery, Drainage and dewatering sump:

There shall be a Drainage gallery of D shaped duct of size 2.0m high x 2.0m wide ($\pm 0.5M$) extending through the entire length of Machine hall between C – Line and MIV centre line with bottom level at least 1.50m below the lowest level of Draft tube. This duct shall be connected to the Draft tube and all drains in the machine hall for carrying drained water to the Drainage and dewatering sump.

There shall be drainage sump and dewatering sump each of size 4.0m x 2.50m $\pm (0.5m)$ on right hand side end wall pf machine hall. There shall be slab at suitable level in the sumps and trenches in floor for supporting and laying drainage dewatering pumps and suction & delivery pipe lines. The bottom finished level of the sumps shall be located at least 3.50m below the lowest level of Draft tube.

Delivery pipes from the pumps shall be routed up to the Tail pool through trenches, block outs etc. in floors and walls.

Firefighting system:

There shall be network of pressurized water pipe lines of assorted sizes in the Machine hall and GIS & Transformer building at both storey for firefighting purpose.

A Carbon di oxide cylinder bank and network of gas pipe line in the Machine hall and GIS & Transformer building shall be installed for firefighting.

Compressed Air system:

There shall be 2 sets of HP compressor, 2 sets of Air Drier, 1 set of LP Air compressor with equal quantity of Air receiver tanks and all accessories and network of compressed air pipe line laid in the Machine hall.

Heating, Ventilation & Air conditioning unit:

There shall be 3(three) sets of fresh air blower, 3(three) sets of Air handling units, required quantity of split Air conditioners and a network of fresh air and return ducts between the HVAC units and the machine hall floors, control room, GIS hall, battery room, LT & HT switch gear room etc.

Cable tray:

Power and control cables shall be routed between various Panels and equipment in the Machine hall and the GIS & Transformer building and DG

set etc. Cable trays suspended from the floors at various levels and erected on walls shall be installed for supporting and carrying the cables.

There shall be block outs in the Machine hall floors for lifting and lowering of various equipment with location and clear opening size as follows which shall be covered with Steel framed panels clad with chequered plate

- Above MIV of all Units 5.20 m x 4.0 m $\pm$ (0.25 m)
- Above the end point on D-Line side of runner removal rail track at all Units 3.50 m x 4.0 m $\pm$ (0.25 m)
- Drainage dewatering sump 2 nos 1.25 m x 1.25 m $\pm$ (0.25m)
- High pressure oil reservoir at all Units 2.0m x 1.50 m $\pm$ (0.25m)
- Panels at all units at Downstream of Barrel 1.25m x 3.25m $\pm$ (0.25m)
- Cooling water pump & accessories 2.0m x 1.50 m $\pm$ (0.25m)
- Any other miscellaneous item as per detail station layout

These block out shall be provided on each floor located above the concerned equipment/ item so that the same can be lowered and lifted up to the service bay floor level by the EOT crane.

In addition to these covered block outs, there shall be block outs without cover for routing water & oil pipe lines, cables and miscellaneous equipment components through various floors and walls.

Block outs without cover shall be required below the panels to be installed in the control room, machine hall, LT & HT Switch gear and Unit auxiliary panels in the second storey floor of GIS & Transformer Building, Unit control panels in Generator floor etc.

Block out in Machine hall floor at Service bay level and the D-Line wall shall be required for routing Bus ducts from the Units to Generator Transformer. Block outs in the upstream side wall in the second storey of the GIS & Transformer building shall be required for routing GIS ducts to roof top Pot Head yard.

An electrical workshop is to be located in the power house to meet the requirements of powerhouse O&M works. This workshop shall be equipped with all general measuring, testing, calibrating tools and devices

Stair case at two ends of the Machine hall from Service bay floor level up to the MIV floor level shall be provided.

GIS & Transformer Building:

The GIS & Transformer building shall be a 2(two) story building to be provided at the service bay elevation at the upstream of D-Line of the Powerhouse.

- In the first story of the followings shall be accommodated:
- Ten (10) number of Single-phase generator transformers
- GIS loading bay with block out of clear size 3.5m x 5.5m on the floor slab of second storey.
- Lift shaft accommodating lift car of 8 (eight) passenger capacity for vertical travel from Control room floor level to MIV floor level.
- stair case to second story
- Any other miscellaneous item as per final plant layout

For connecting the Lift shaft from various floors in the Machine hall, Drift of finished dimension 2.0m wide x 2.50m height may be driven to avoid increase in open excavation and backfill concrete.

For gravity drainage of seepage water collected at the base support chamber at the lift, lowest level of lift shaft opening may be suitably adjusted.

Drift of suitable dimensions for routing Cables between the Machine hall and the GIS & Transformer building may have to be provided at required locations.

Outside the GIS & Transformer building and on upstream side of the building followings shall be placed

- 1(One) no. 220kV, three phase, OFWF/ODWF cooled, indoor, 25 MVAR switchable Shunt Reactor.
- 1(One) No. 5 MVA; 220 / 33 kV, 3 phase, 50 Hz, Oil type Station service
- One additional transformer bay for spare Generator Transformer
- Any other miscellaneous item as per detail layout.

Network of 90 LB Rail track system for shifting and placing these transformers and Reactor shall be laid from the Service bay up to locations of the equipment.

The Transformers and the Reactor shall be placed on Rail mounted beam/ wall provided inside a Stone filled Oil collection pit of depth not less than 1.0m from the floor level.

2 (two) nos. Covered Oil collection sump of size 6.0m x 4.0m x 3.0 m deep (approx..) shall be provided on either side of the GIS & Transformer building and these sumps shall be connected to each of the oil collection pits.

In the second storey the followings shall be accommodated

Ventilated room for 245 kv Gas Insulated Switch Gear (GIS) comprises of three (3) Generator Transformer Bay, one (1) bus coupler Bay, one (1) station service transformer bay, two (2) Outgoing Bay & One (1) Shunt Reactor Bay with the related LCC.

10.0 MT Capacity E.O.T crane for handling GIS components with long travel extending entire length of the building across the flow direction.

LT and HT Switch gear, 415 V Switchgear (Station Service Board MSSB), 33 kV Switchgear (Station Service Board: MVSSB), Unit Auxiliary Boards, Auxiliary Transformer etc.

DC System comprising of 220 V DC & 48V DC battery & battery charger including switching and metering instruments/ devices and the main D.C distribution boards

Protection system comprising protection equipment comprising protective relays, auxiliary relays, metering, panels etc.

A Control room housing Station Control System at suitable location for automatic control of all the units and comprehensive supervision of all units, EHV-switchgear and plant auxiliary equipment i.e. ventilation system, fire protection system, oil pressure & air compressor system, auxiliary AC & DC supply system etc. shall be provided.

Toilet and Pantry shall be provided adjacent to the control room.

Any other miscellaneous item as per final plant layout.

On the roof of the GIS Building there shall be Pot head yard in addition to a head room for access stair and Lift hoist.

The pot head yard shall accommodate the followings for two 220KV lines (i.e. 6 phases).

Post Insulator mounted Isolator with Earth switch, CVT, Wave trap per phase for each line (3 phases) there would be a lattice type steel structure consisting of 4(four) towers, One Gantry for stringing three conductors, girders and bracings connecting all the towers.

The Centre line of Gantry for stringing conductors shall be at $7.5\text{m} \pm 0.5\text{m}$ above the Tower base elevation i.e. roof of the GIS & Transformer hall building. Tentative pull per conductor may be considered as $\pm 8.15\text{MT}$ in horizontal direction orthogonal to the Gantry alignment. The tower shall be extended by $3.50\text{m} \pm 0.25\text{m}$ above the Gantry top for stringing Earth wire which shall be tensioned with a pull of $\pm 2.50\text{MT}$.

Diesel Engine generator:

1(one) No. 800 kVA Diesel Engine Generator with all accessories and Panels shall be installed outside the GIS & Generator Transformer building at the Service Bay floor level. The DG set shall be provided with roof and enclosure and covered access from adjacent building for protection from rain.

Penstock Protection Valve house:

A $5.75\text{m} \pm 0.25\text{m}$ I.D Butterfly Type Valve shall be provided in an underground cavern located between the Surge shaft and bifurcation of Penstock.

The valve shall be operation hydraulically with Servomotor where a counter weight shall also be provided for emergency closure.

Electric operation and control panels, Hydraulic oil pump unit, dewatering pump units with accessories shall be installed in the Valve house.

One EOT crane and a Service Bay shall be provided for erection and maintenance of the Valve.

For regular drainage of seepage & leakage water and occasional dewatering of the WCS, there shall be a drainage pipe line routed to outside the access Adit.

The construction Adit may be used for routing cable duct and ventilation ducts.

1.7. MINIMUM DESIGN, FACILITY, UTILITY AND FINISHING IN CIVIL WORKS

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While fulfilling the overall requirement as stated in preceding clauses, the contractor shall also ensure fulfilment of the minimum requirement of design, facility, utility and finishing as stated herein. This minimum requirement is in respect of key components of civil works only and it neither exclude the necessity of fulfilling the overall requirement in respect of these components of work nor relieve the requirement of any other component which shall be required to fulfil the overall requirement under the contract.

1.7.1. Excavated Slope:

Slope stability analysis shall be carried out by Limit Equilibrium and Finite Element method and judicious decision shall be taken by comparing the result of the two approaches.

For excavated slopes in rock, Kinematic analysis of stability shall be carried out. In overburden/ terrace material potential sliding plane may be a slip circle passing though the toe of the slope or at the contact plane of dissimilar material.

The slopes shall be checked both for various construction stages & operation condition (when some part of the slopes is covered by backfill/structure) including judicious consideration of water table and seismic load.

Where the slope does not have adequate factor of safety, Geo-Technical Support measures like Shotcrete, wire mesh, rock bolts, cable anchor, retaining structure of RCC/PCC/Cratered boulder shall be provided as per requirement.

Irrespective of the result of stability analysis of slope which would remain exposed/ over ground, minimum slope treatments as stated hereunder shall be provided at Powerhouse, Intake and barrage site and any other vital location which is critical for the safety and Operation and maintenance of the Project:

- a) For slope and berm in rock
 - 100mm thick Shotcrete of minimum grade M25 with wire mesh/chainlink and pattern rock bolt 25mm dia. and 3.0m long at a spacing of 2.0m X 2.0m.

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- Pattern drainage holes of 75mm diameter with 65mm diameter perforated PVC pipe and length 5.0m at a spacing 3.0m x 3.0m, 48mm dia x 0.3m deep weep holes at a spacing 3.0m X 3.0m.

A toe wall comprising of a combination of RCC/PCC/stone masonry/Cratered boulder at the contact of overburden and rock with two rows of grouted rock anchor/anchor bolt at a spacing of 2.0m C/C.

b) For slope and berm in overburden/ terrace material

- 25mm dia and 4.0m long Soil nail/ Self drilling anchor at a spacing of 2.0m X 2.0m
- Chain link wire mesh anchored with soil nail/self-drilling anchor
- Geo-membrane/ Stone Rip rap with filter bed at the locations where seepage/ fine grained soil is encountered.

Bench height of slope in rock shall not be more than 12.0m with a berm width not less than 2.0m where longitudinal drain shall be provided. Drain may be lined or unlined depending on the rock condition to ensure free and loss free flow of surface runoff.

In overburden/terrace material the bench height shall not be more than 5.0m with a berm width not less than 2.0m where lined longitudinal drain shall be provided. Necessary slope treatment for arresting progressive erosion of slope material by surface run-off shall be duly implemented.

For validation of the slope design for its long-term performance observation of the excavated/treated slopes at Power house and barrage site covering the Intake shall be carried out regularly as follows in presence of the Employer

(a) Monitoring 3D co-ordinates of reflecting targets fixed at a suitable grid on the slopes.

- (b) Monitoring change in inclination of boreholes by Inclinator. Boreholes of size compatible with size of Inclinator and lined with PVC tube shall be bored up to a depth and at a spacing which shall be adequate to capture any global movement in the slopes of concern.

In case of detection of movement in the slope beyond the anticipated level estimated by Finite element analysis etc., measures for strengthening the slope shall be taken up to timely avoid hindrance/damage to works.

In the slopes excavated in overburden/terrace material at other locations except temporary haul roads and contractor's temporary installation sites, irrespective of requirement of retaining structure required as per slope stability analysis, minimum retaining structure consisting of toe wall of height 2.0 m founded 0.50m below ground level/drain top level and base width of 1.5m using stone masonry/ PCC/cratered boulder depending on location specific suitability of the material shall be provided.

1.7.2. Drainage

The catch water drains/ditches and culverts for roads and Power house perimeter are required to be designed for 15-minute storm with a return period of 50 years.

Relevant latest Indian Meteorological Monograph Hydrology shall be referred for adopting design storms.

Peak Discharge shall be obtained by using Rational formula for peak runoff from catchment.

Size of drain will be worked out for the designed discharge by using Manning's formula and adopting appropriate inputs. Drains shall be rectangular or trapezoidal in section with a minimum base width suitable for periodic cleaning.

1.7.3. Power House:

The Powerhouse complex shall accommodate (but not limited) Turbine and Generator, MIV, Service Bay, Auxiliaries, Control building, Transformers, GIS, Pot Head Yard Draft Tube & Tail pool etc. in two buildings namely Machine Hall building and the GIS and Transformer building

Layout of the power house shall accommodate the Electro-Mechanical & Hydro-Mechanical GA and ensure convenient and safe erection, operation & maintenance of the Plant comparable with contemporary plants in the country. Detail layout of Power House and Penstock Protection Valve house shall fulfil all E&M requirement.

One special feature of the Tail pool is that it is seamlessly connected to the fore bay of the Downstream project namely Tato-I HEP (186MW). The downstream wall of the Tail pool shall be given hydraulically smooth profile for training the machine discharge to the Tato-I HEP approach channel. A sump may be provided on the Tail pool floor for dewatering and sludge removal. On the right side (river side) wall of the Tail pool, the feeder channel from Tato-I HEP Trench weir Intake shall join the Heo HEP Tail pool where required block out shall be provided to accommodate and support the same. The contractor shall fulfil all the requirement of interfacing activities to smoothly integrate the work with the adjoining project.

Grades of concrete in first stage concrete in foundation raft and all structural component shall be of grade M25. All second stage concrete and the concrete in the machine foundation and barrel shall be M30.

Maximum Vertical and Lateral deflection in Crane beam in the Machine hall under maximum load (DL+LL+EL) shall not be more than Span/1000 and Span/400 respectively. This shall have to be demonstrated by carrying out load test after commissioning of the EOT Crane in presence of Employer.

The power house building shall be made of RCC structure up to crane beam top level. RCC wall provided at outer periphery of the Power house and auxiliary building up to service bay floor level shall have a thickness not less than 300 mm at any section.

Roof structure above the crane beam top elevation may be made of steel structure. Structural steel works shall be made of Indian Standard rolled sections or built up sections and the sections shall be designed as semi compact class. The roof structure and its maximum height shall be so decided that it should not encroach the ground clearance provided to the Transmission lines connected to the Pot head yard.

Roof purlins spacing shall not be more than 1.60M c/c. Maximum vertical & horizontal deflection of steel Purlin and wall stringer under DL+LL shall not be more than Span/300. Vertical deflection of steel bracings under self-load shall not be more than Span/200.

Dynamic analysis of the TG Foundation and super structure shall be carried out for ensuring adequate separation of the natural frequency of the machine foundation and the structural components from the range of operating frequencies of the machines and containing amplitude of foundation and structural vibration within permissible limit as per Indian and International standards. The achievement of frequency separation and amplitude control shall be demonstrated at the time of commissioning the units in presence of the Employer.

For vibration isolation all Unit bays, Service bay, Machine hall and GIS/ Auxiliary building shall be separated by providing 25mm wide expansion joint. The joints shall be provided with PVC water stop and bitumen impregnated sheet fill material and Poly-sulphide sealant to prevent ingress of water. On tail pool side and at substructure special care shall be taken to prevent entry of water, where multiple layers of PVC water stop to be used.

For reducing earth pressure and possibility of water seepage, outer walls in substructure shall be back filled with M10 concrete up to the adjacent levelled ground level or foundation level of structure, if any founded above it. In order to facilitate seepage free construction area, this backfill may be placed first up to a suitable height prior to placing reinforcement and structural concrete.

Routing and installation of various utility like HVAC ducts, fire-fighting water pipe lines etc. shall be made in a manner that would not impair aesthetics and ergonomics of the plant.

There shall be at least two stair cases from the lowest level to the highest floor level inside the Power house building at opposite side for convenience of movement and speedy evacuation in case of any emergency. This shall be in addition to one Industrial class lift inside the building.

Emergency escape route comprising gang way, foot path bridge etc. from service bay floor level to adjacent ground at a level not less than 10.0M above on two sides of the power house building shall be provided.

There shall also be access to the roof of the Power house and GIS & Transformer building.

Above crane beam level there shall be sufficient area of fixed glazed windows for natural illumination of the inside of the building.

The levelled area around the power house and auxiliary building shall be covered with a combination of CC pavement and Concrete Pavers block at a level slightly lower than the service bay floor level and with suitable slope to drain surface run off to peripheral drains.

Rest rooms for male, female and especially abled person containing European and Indian water closets, urinals, bath rooms and wash basin shall be provided inside or in extension of the power house building. Rest rooms for executive and worker shall be located separately ensuring convenience.

Total number of required facilities shall be as follows

- | | |
|--|--------|
| a) Water closet: | 7 nos. |
| b) Wall mounted Urinal pot with partition: | 7 nos. |
| c) Bath room: | 4 nos. |
| d) Wash basin with soap tray & towel rail: | 6 nos. |
| e) Mirror: | 6 nos. |

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f) Exhaust fan and water heater of required nos.

Septic tank and soak pit for 50 users shall be provided outside the Power house building with protection against entry of drain water/surface runoff.

One pantry with dining space shall be provided with in or in extension of the P.H building as follows which shall be set up maintain adequate space and agronomy.

- i. Cooking platform 2.5m x 0.6m excluding sink and 1 no 450mm exhaust fan
- ii. Wall mounted cabinet 100 litre storage capacity
- iii. One kitchen sink 600mm size
- iv. Dining space with dining table and chair for 12 users
- v. Reverse Osmosis type water filter of 30L capacity with external pre-filter.

Required concealed water uPVC, CPVC water supply pipe line and effluent drain of adequate size with all required fittings shall be provided.

A water supply system shall be provided as follows for supplying potable water for consumption from an approved perennial water source.

- a) Submersible/surface Water pump with necessary support, suction and delivery pipe line with all fittings up to filtration plant.
- b) A 2000 LPH water filtration plant of approved brand for removing iron, suspended material, bacteria and odor.
- c) Arrangement of pipe line with or without pump depending on location of the filtration plant for transferring filtered water to overhead storage and distribution tank.
- d) 2 nos. 2000 Litre capacity polyethylene water tank with required staging and pipe lines with fittings for supplying water under gravity to rest rooms, pantry and another two points out side power house for general purpose.

Walling in the Power house, auxiliary and GIS/ GT building shall be as follows

Location	Requirement
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From service bay floor level up to Crane beam top level in P.H building:	230mm brick masonry or concrete block masonry with 200mm thick RCC bands at a spacing of 2.0m vertically or 200mm thick
Location	Requirement
	RCC wall with nominal reinforcement on both faces.
Above Crane beam top level up to roof in machine hall:	As above or 0.8mm thick Pre-Painted Galvalume I Roofing sheet (PPGL) with stringers. Steel columns for roof support shall be encased in RCC if masonry or RCC walling is done
At all levels in GT/ GIS building:	230mm brick masonry or concrete block masonry with 200mm thick RCC bands at a spacing of 2.0m vertically or 200mm thick RCC wall with nominal reinforcement on both faces.
Internal partition walls in Power house machine and auxiliary bay:	-Do-
Internal Partition wall in Rest room and pantry	115mm thick brick or concrete block masonry with 150mm thick RCC band at a spacing of 2.0M vertically.
Periphery and partition walls at Generator Transformer, Station service transformer and Reactor bays	Walls compatible for the statutory fire safety rating not less than two-hour fire resistance capacity.

If PPGL is adopted for walling, steel frames shall be provided for fixing glazed windows where wall cladding shall be properly overlapped and fixed with frame to leave no gap.

Glazed walling from floor to ceiling level and glazed doors and windows shall be provided as per requirement at the following locations but not limited to it for ensuring better visibility, aesthetics and convenience in operation & maintenance

- a) Control room
- b) GIS bay
- c) Pantry

In rest room door and door frame shall be of High-density WPC material with S.S. fixtures. Common door, window and ventilator shall have frosted glass for better natural illumination and aesthetics.

At the battery room, store room, work shop, back side personnel exit etc. prefabricated steel doors of brand like Tata Pravesh shall be provided.

The sizes of doors and windows shall be adequate for the intended usages.

At the control room, rest room and Pantry suspended false ceiling at a height acceptable for intended purpose of the spaces shall be provided.

At the main entrance to P.H/ Service bay one motorized sliding or rolling shutter type door shall be provided. The door opening shall be enough for movement of the largest item that shall pass through it during erection and subsequent O&M stage. One similar door shall also be provided at the opening leading to the Reactor yard at backside. Rolling shutter of larger width are found to be susceptible to deformation under high wind and uneven movement due to various reasons leading to jamming and dysfunction. To overcome this difficulty, one intermediate removal guide shall be provided for Rolling shutters. Rolling shutter strips shall be 18 Gauge thick sheet and this including end clips and all fasteners shall be hot dip galvanized.



One partly glazed metal door for personnel entrance shall also be provided separately alongside each of the above stated two entrances.

Floorings/ floor finishes in the power house shall be as follows

Location	Flooring
Service bay floor	CC flooring with metallic floor hardener
Machine hall Generator floor and skirting	Epoxy flooring
Location	Flooring
Machine hall turbine floor and skirting	CC flooring with metallic floor hardener
Machine hall MIV floor	CC flooring with metallic floor hardener
Stair case step, landing and skirting	Black granite with anti -skid strip
Control room and GIS room floor	Vitrified tile of approved shade
Battery room	Acid resistant tile on floor and wall up to door opening height
Rest room	Mat finished vitrified tile on floor and vitrified tile on wall up to door height
Pantry	-Do-
Generator transformer and Reactor bay	CC Flooring

Roofing in the Machine hall and Auxiliary/GIS building and drainage shall be as follows.

- a) In machine hall Steel roof truss with 0.8mm thick Pre-painted Galvalume (PPGL) roofing with self-drilling screw shall be provided. Expansion joints of the roof shall be treated by expandable overlapping of sheets overlain by tacked bituminous water proofing sheet.
- b) In the RCC roof over GIS/Auxiliary bay multi course roof treatment with bituminous sheet shall be provided after adequate grading the roof.
- c) Slope of roof over machine shall have to be sufficient for self-cleansing as it is not accessible for regular inspection. Therefore, the slope shall not be flatter than 1V: 4H.
- d) PPGL Gutters discharging to UPVC down comer pipes extending up to service bay floor level at a spacing similar to roof columns shall be provided in the machine hall roof for draining rain water. Similar Down comer pipes shall also be provided at the GIS/ auxiliary building.
- e) No gap shall be left between wall and roof and any other location in the machine hall to prevent entry of bird, rain water etc.

Hand rails at stairs and at the edge/boundary of permanent openings excluding covered hatches shall be provided. Railing material shall be Stainless steel.

The Power house and auxiliary building should be free from seepage or sweating on walls and floors due to ingress of ground water/moisture or any other source. Special care like concreting of underground wall and columns and floors in water free condition, providing keys in lift and vertical construction joints, minimizing vertical construction joints in underground part of the PH structure etc. shall be taken. In case seepage or any sweating occurs in the PH building, this shall be treated by applying proprietary seepage control grout product of Xypex.

Surface finish and painting on the wall and ceiling of PH building shall be as follows:

- a) All finished Concrete and plastered surface inside and outside the PH and auxiliary building wall shall be of the highest finish grade.

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- b) All cemented visible and accessible wall surface shall be applied with best quality cement-based wall putty of Birla/J.K brand or equivalent to make surface even and smooth with sand papering for subsequent finishing/painting with primer and two or more coats of Acrylic exterior and Acrylic multi surface Interior paint to obtain full and even shade of the paints. Shades of paints shall have to be approved by the Employer.

Surface of all structural steel items shall be cleaned and applied with zinc rich primer coat and one coat of paint prior to erection. After erection touch up primer/paint coating and final coats of painting shall be applied ensuring full and even shade of paints. Paint on ferrous surface shall be premium quality synthetic enamel / epoxy / chemical resistant / fire proof paint of approved brand as per requirement.

Fire proof paint shall be applied on the surfaces in the fire hazard area complying statutory requirement.

Application procedure and rate of paint quantity to be applied shall be as per the published recommendation of the paint manufacturers.

One RCC Security booth of size 3.0m x 3.0m with windows on all sides shall be provided at entrance to Powerhouse area. General building specification, flooring & finishing works, door & windows etc. shall be same as specified for the Power house building.

Security fencing around the Power house and tail pool with one mechanized drop barrier gate and one manually openable hinged/roller slided 4.0mx1.75m high heavy steel gate shall be provided at the main entrance. The fencing shall be terminated at natural barrier like steep hill or river bank.

Filed/laboratory geotechnical tests to ascertain bearing capacity, dynamic modulus, rock to concrete friction co-efficient etc. at machine foundation level shall be carried out as per requirement.

1.7.4. Barrage, Intake and Temporary Stage Diversion of River:

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The fixed hydraulic, hydrological parameter for design of the barrage and Intake and the layout are provided in the clause “**Fixed Parameter**”.

Large depth of river born deposit on the river bed necessitates founding the barrage on permeable river bed material.

Construction of the barrage may be carried out in two seasons by diverting river water in stages. The contractor shall make detail planning and engineering for the stage diversion and construction of the barrage in stages in a manner that match the schedule of construction of interfacing works and commissioning of the project. Seasonal variation of flow in the river alongside the specified diversion flood needs to be duly considered in planning the stage diversion and construction of barrage to manage the risk of damage to work by flood or any consequential reason. Construction method, equipment selection, mobilization of material and equipment, contingency measures etc. shall be decided accordingly for safe execution of the work.

The composition of river bed material is not yet ascertained fully, but it can be fairly guessed that it may contain rock fragments of size varying over a wide range with infills of finer material. The composition of river bed material is not conducive for conventional sheet piling for installing cut off.

Further, any single method of grouting may not be found sufficient to create curtain for temporary stage diversion of water in the river for construction of the barrage. Thus, the contractor has to make careful planning and engineering for making water tight temporary barrier for stage diversion of river water.

Intake structure dimensions shall be decided considering feasibility of construction of underground opening for providing transition from intake gate ducts to the Head race tunnel.

Physical 3D scaled model study shall be performed through approved agency to confirm followings along with other associated parameters, which shall be witnessed by the Employer

- a) Spillway discharge capacity of the barrage and the inflow through Intake at various Reservoir water level and performance of the under sluice for effective silt flushing,
- b) scouring at upstream and downstream impervious floor of the barrage at various levels of discharge.

Bearing capacity and permeability of foundation material considered in deciding upstream and downstream impervious bed length and thickness shall be verified by conducting field tests.

Number/location of contraction joints provided in the barrage shall be decided on the basis of field tests conducted to ascertain variation/homogeneity in bearing strength/compressibility of foundation material.

Geo membrane and Geo textile may be provided for enhanced performance of the barrage floors against seepage at upstream and piping of finer material through the drainage holes in downstream. At contraction joints double layer water stops of stem length 300mm or more shall be provided forming closed loops.

The spillway shall be designed as a free flow broad crested structure with crest elevation, trunnion elevation etc. as per model study and detail design. Two bays of under sluice shall be provided. The under-sluice bays shall be designed to flush silt and pebbles collected upstream of Intake.

The barrage shall be designed for design basis earthquake (DBE) and shall be checked for maximum credible earthquake (MCE) as per seismic parameters provided by the Employer.

In the Barrage and Intake minimum grade of concrete M-25 shall be provided for the structural concrete and M15 grade for mass concrete. High Performance Concrete of grade M60 and thickness not less than 500mm shall be provided on spillway profile.

Divide wall at upstream and downstream of the under sluice shall be mandatory for isolating the Intake from flow through spillway to prevent cross circulation of

water/silt at upstream and facilitating formation of hydraulic jump for energy dissipation at the downstream respectively.

Abutment wall on right and left bank shall be extended up to full length of upstream and downstream impervious bed of the barrage. Combination of return wall and Wing wall shall be provided for a minimum distance of 25.0M from the upstream and downstream end of the abutment wall. The return wall & wing wall shall have to be founded at a level below scour depth.

Single layer of 1.50m X 1.50m X 1.0m thick M20 grade CC block laid on a 600mm thick layer of inverted filter shall be provided up to a distance of 12.0M from the downstream cut off for the full width of the barrage. These blocks shall be interconnected with 12mm thick galvanized steel wire rope passing through preformed holes in each of the blocks in both along and across the flow direction. Ends of the ropes shall be anchored with appropriate wire rope joint and 12mm thick epoxy painted M.S bearing plate. At downstream of the CC block apron, a stone layer of 1500mm thick and 12.0m long for the full width of the barrage shall be provided. Minimum weight of stone shall be as per Indian standards.

RCC deck bridge to provide 3.75 m carriage way of IRC load class 40R and an additional bay for travel of Gantry for handling Spillway stop logs shall be provided. Span/joint of the bridge shall be decided on the basis of position of contraction joints in the barrage.

Deck level of bridge shall be decided by ensuring adequate clearance from the bottom level of bridge girder to HFL and afflux.

Maximum Pier height and length shall be decided on the basis of Hydro Mechanical requirement.

Intake structure deck slab shall have adequate capacity to support loads from gate elements, vehicle and equipment for erection and O&M.

RCC/Structural steel safety railing shall be provided on the bridge, Abutments and Intake platform. All railing shall be finished with paint. At vital locations fluorescent paint shall be applied.

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Effective Sediment management shall be formulated for implementation:-

One RCC control room comprising the followings shall be provided at suitable location as close as possible to the barrage.

- a) Two office rooms of total floor area not less than 30.0 sqm with 3 sets medium size and 1 set of large size table and chair and file cabinet.
- b) One instrumentation SCADA/panel room of size required for installing panels with minimum clearance of 1.50m around/in between panels. This room shall be attached with the office rooms.
- c) One restroom with two water closet, two urinals, one bath room and Septic tank and sock pit for 20 users.
- d) Building specification, flooring & finishing works, door & windows, Air conditioning and ventilation, Items and quality of sanitary and water supply items shall be same as that specified for Power house.
- e) External and Internal electrification in all rooms shall be provided.
- f) 2 X 1.50 Tone capacity window type AC units shall be provided in the office rooms.
- g) One pantry with dining space shall be provided with in or in extension of the office building as follows which shall be set up maintain adequate space and agronomy.
 - i. Cooking platform 2.5m x 0.6m excluding sink and 1 no 450mm exhaust fan
 - ii. Wall mounted cabinet 100 litre storage capacity
 - iii. One kitchen sink 600 mm size
 - iv. Dining space with dining table and chair for 6 users
 - v. Reverse Osmosis type water filter of 20L capacity with external prefilter.

Building specification, flooring & finishing works, door & windows, Air conditioning and ventilation, Items and quality of sanitary and water supply items shall be same as that specified for Power house.

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A water supply system shall be provided as follows for supplying potable water for consumption from an approved perennial water source.

- a) Submersible/surface Water pump with necessary support, suction and delivery pipe line with all fittings up to filtration plant
- b) A 500 LPH water filtration plant of approved brand for removing iron, suspended material, bacteria and odour.
- c) Arrangement of pipe line with or without pump depending on location of the filtration plant for transferring filtered water to overhead storage and distribution tank.
- d) 2 nos. 500 Litre capacity polyethylene water tank with required staging and pipe lines with fittings for supplying water under gravity to rest rooms, pantry and another two points out side power house for general purpose.

The Gate local control/ Power pack units of Radial gates shall be housed in RCC rooms. Mechanized drop barrier gate and RCC Security booth of size 3.0m x 2.50m with windows on all sides shall be provided one on each bank of the barrage at suitable locations. General building specification, flooring & finishing works, door & windows etc. shall be same as specified for the Power house building.

Elaborate Illumination arrangement comprising lamp post of height not less than 4.50m from ground level shall be provided on both sides of the bridge over the barrage, around intake, office and one side of 100.0m length of approach roads. Local spot illumination at all gates, gate operation/control rooms, two nos. water level gauge shall be provided.

For monitoring of water levels, silt, structural & hydraulic performance to facilitate Operation & Maintenance of the barrage, instruments and equipment as stated below but not limited to it shall be provided.

- (i) 2 nos. Reservoir Water level scale at prominent and visible location on piers
- (ii) One Radar type automatic water level recorder.
- (iii) Automatic & continuous silt concentration monitor with recorder

- (iv) One automatic weather station
- (v) Two strong motion sensors, one at barrage top and another on one bank. These sensors shall be properly housed in RCC or masonry enclosure.
- (vi) 10 nos. piezometers placed and distributed below the upstream and downstream impervious floor of the barrage.
- (vii) 10 nos. settlement points distributed on piers and divide walls.
- (viii) 2 no flood warning electric sirens of db level not less than 100db mounted on 6.0M high lattice pole with access facility for periodic maintenance.
- (ix) One Public address system covering the barrage and control room.

Output from all digital sensors shall be routed to the control room and integrated with the SCADA system for gate operation and control.

All shrub and tress in the entire reservoir area from river bed level to Maximum RWL shall be cleared in addition to site clearance required for construction of barrage and appurtenances.

Lined Drains & Cross drains for arresting and diverting surface run off from entering the barrage approaches on both banks, abutments, office and security booths shall be provided.

Minimum 10 numbers of Information and Warning sign boards, with painting and lettering made of steel sheet fitted in steel frame of size 1.5mx1.0m x 2.5m high above ground shall be installed around the reservoir and the barrage with CC pedestal foundation.

Security fencing around the barrage covering office, security booth, heavy duty Iron gate and drop boom/barrier gates covering road width and extension of fencing for its termination at nearest natural barrier like Reservoir rim and hill slope.

1.7.5. Water conductor system, Underground excavation and lining:

Hydraulic transient analysis of the water conductor system shall be carried out by the contractor to verify and confirm maximum & minimum water head in the

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Head race tunnel, surge shaft and High-Pressure Tunnel for use in the detail design.

The contractor shall also workout head losses in the Water conductor system and shall make necessary modifications if required to contain maximum head loss in steady state condition in the WCS from the Intake at Reservoir up to the Upstream of Main Inlet Valve of P.H Units within 7.87M and this shall have to be demonstrated while commissioning the Units in presence of the Employer.

It is envisaged that underground excavation will be done by using conventional drilling and blasting method with full face or heading and benching approach depending on the encountered ground condition.

Design of support will be carried out/verified using elastoplastic FEM program considering boring done by adopting NATM, phases of support installation and rock support interaction including estimate of stress and displacement.

Required inputs like field stress, ground water head, rock properties, support stiffness, phasing of loading etc. for use in the analysis shall be worked out judiciously.

The Design will be checked using empirical method given by the Q system. Where adverse foliation is predominant empirical method of support system based on RMR system shall also be referred. The analysis and design shall also be checked with respect to the recommendation of Indian standards to adopt a judicious support design.

For working out support requirement and estimation of stress & deformation levels in underground caverns in Surge shaft and Valve house, 2D and 3D numerical model study shall be carried out by the contractor.

In case of any disagreement between the contractor and the Employer in regard of field evaluation of rock mass properties, analysis & design of underground excavation and support, the matter shall be referred to authority/expert viz GSI, NIRM, CWPRS or any IIT depending on their availability and the nature of the issue. The contractor shall arrange for expeditious resolution of any such

difference and the opinion so obtained shall be binding to both the contractor and the Employer. The Employer shall in no way be responsible for the time taken and its consequences whatsoever it may be, in resolving such issue in this manner.

Plain/SFR Shotcrete, steel wire mesh, anchor bolt, Steel rib support, lattice girder, fore pole, steel canopy support, etc. shall be considered for providing support as per requirement.

In very poor rock strata, pre-grouting pipe roofing may have to resorted to expedite progress of work.

Measurement of convergence and stress on support elements shall be concurrently continued to validate the adequacy of support design. Convergence measurement stations comprising 5 points per station shall be placed at a not more than 10.0M to closely monitor and capture deformation in the excavated opening. Multipoint borehole extensometer shall also be provided at mutually agreed frequency for capturing time history of rock deformation at locations away from underground opening surface. All such measurements shall be carried out in presence of the Employer. If strain (opening closure/width or height) exceeds 1-1.5% or the estimated strain or support elements are overstressed, the support system for the corresponding rock strata shall be revised and the already installed concerned supports shall be adequately strengthened.

Time history of convergence at each measurement station shall be recorded. It is desirable that ground deformation cease to continue prior to placement of final lining.

In the underground shaft and caverns appropriate Drift shall be excavated first for acquiring geological/ geotechnical information required for deciding support design. Stages of excavation in caverns shall be decided on the basis of numerical model analysis which shall have to be supported by Deformation/convergence measurement.

All Adits shall be provide with a gradient to ensure expedient flow of water for drainage/dewatering under gravity through the Adit portals.

Finished dimensions and alignment of the underground cavern Adit shall be adequate for transporting plant and equipment intended to be installed therein.

Lining of tunnel shall be preferably PCC of grade M25. The excavated size of tunnel shall be so adjusted that the minimum thickness of final lining shall be 300mm.

RCC lining shall be restricted to only extremely poor strata/shear zones in tunnel. In roof and walls of underground cavern RCC lining shall be provided.

Minimum grade of RCC in such lining shall be of grade M25A20 and grade of reinforcement shall be Fe500.

Steel liners in HPT shall be backfilled with PCC of grade M20. Overt and invert of all Adits shall be lined with PCC of grade M20. Adequate lined side drains shall be provided in the invert of all Adits on both sides.

In low cover zones, where the vertical cover or half of horizontal or half of diagonal cover is less than the maximum pressure head in the tunnel, RCC or steel lining to withstand both internal and external pressure shall be provided.

Concrete lining will be designed for the full formation water pressure acting on the outside face. Wherever the internal operating water pressure is greater than the formation water pressure, the external water pressure shall be considered equal to the internal water pressure.

Timing for placing final lining shall be decided on the basis of deformation analysis and field measurement to ensure stabilization of rock-support interaction and cessation of continuation of deformation with time to an acceptable level.

A permanent dewatering arrangement consisting of high carbon steel seamless 250mm dia. pipe with Gate valve of durable appropriate pressure class shall be

provided at the Adit of Surge shaft. The out let of drainage pipe shall be extended to outside the Adit portal for discharge of water into natural or constructed lined drain for its safe dissipation on the hill slope.

All Adit exits shall be provided with fully cladded hinged and locked heavy duty Iron gate for security.

At underground cavern Adit a permanent false portal of length 10.0m made of structural steel shall be provided. The false portal should be adequate to withstand and divert sideways any unforeseen rock fall/slide on the slope above portal without collapsing.

Requirement of finishing, painting of all inner surface and flooring in underground cavern shall be similar to Power house.

Drainage around the Entrance of all Adits shall be developed by providing lined and unlined drains to ensure drainage of surface runoff and seepage water away from the Adit entrances and safe dissipation into adjoining natural drains or hill slopes.

1.7.6. Instrumentation in Civil Works:

The contractor shall be responsible for providing instrumentation to monitor various load, deformation and performance of excavated medium, support structures and validate the adequacy of design and construction fulfilling the Employers requirements as stated herein.

Type, location and quantity of Instruments installed shall be site and structure specific and as per standard and good practices. Specification of the Instruments, data collection provisions, Cabling and its interim and final termination shall be so planned that collection of real time data can be started immediately from the time of installation of the Instruments and finally it can be continued through an automatic data acquisition system in designated control centres as stated hereunder.

Collection and monitoring of the reading of the Instruments installed at the Barrage and Power house site shall be continued after completion of work through automatic data acquisition system installed at respective control rooms.



Collection of reading of the Instruments installed at Surge shaft roof and Valve house shall be continued after completion of work from suitably located Data loggers by using Portable Read out Units.

Collection of readings from the Instruments installed at the HRT, Surge shaft and Penstock shall be discontinued on completion of construction of final lining and backfilling.

While the contractor shall be responsible to fulfil over all requirement of Instrumentation, the quantity of Instruments provided shall not be less than as stated hereunder.

Location & Instrument	Quantity
Barrage & Intake	
Stand pipe piezometer	8
Uplift pressure meter	13
V.W Piezometer	13
Tilt meter	9
Group strain meter	7
Rebar strain meter	16
Radar type Automatic water level recorder	2
MPBX 6.0m long 3 point	20
Hole for Inclinator	8
Portable Inclinator	1
Automatic Weather station	1



Location & Instrument	Quantity
Radar type automatic water level recorder	2
Strong Motion Equipment	2
Head Race Tunnel	
Bi reflex Target	140
MPBX 6.0m long 3 point	70
V.W Piezometer	70
Convergence measurement station	140
Rock bolt & Steel support Load cell	140
Adits	
Bi reflex target	70
Convergence measurement station	35
Surge shaft	
MPBX 4 point 18.0m long	29
Anchor bolt Load cell	29
Bi reflex Target	32
Valve House	
MPBX 4 point 18.0m long	12
Anchor bolt Load cell	12



Location & Instrument	Quantity
Bi reflex Target	21
Penstock	
Bi reflex Target	10
MPBX 6.0m long 3 point	3
Convergence measurement station	15
Power house	
Hole for Inclinator	8
MPBX 18.0m long 4 point	6
MPBX 6.0m long 3 point	12
Re bar strain meter	12
Group strain meter	12
VW Piezometer	12
Automatic Weather station	1

1.7.7 Permanent Road:

Construction of the following permanent roads shall also be within the scope of the contract.

Sl. No.	Name of the Permanent Road
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2	Approach Road from the Tato-Mechuka Road to the Right Abutment of the Bridges at U/s & D/s of the Heo Power House / Tato-I Weir
3	Approach Road from Heo Barrage site to the Right Abutment of the Bridge at U/s of Adit -1
4	Approach Road from the left abutment of the bridge at U/s of the Heo Barrage to the Heo HRT Intake
5	Approach Road from the Left Abutment of the Bridge at U/s of the Heo Power House to the Heo Power House
6	Approach Road from the Left Abutment of the Bridge at u/s of the Adit-1 to the Adit-I
7	Approach Road from the Power House to Valve House and Surge Shaft

Geometric requirements of these roads are as follows

- (i) Single lane carriage way width: 3.75M
- (ii) Minimum Formation width: 7.75M
- (iii) Maximum vertical gradient: 1 in 15
- (iv) Vertical Ruling gradient: 1 in 20
- (v) Minimum Radius of curvature: 20.0M

Detail Geometric design shall be done as per IRC manual for hills road.

Minimum composition of the pavement shall be as follows

- (i) Sub grade to be treated and compacted up to 500 mm depth in formations in ordinary soil
- (ii) Sub base 200mm thick granular sub-base
- (iii) Base 200 mm thick Wet mix macadam & 50 mm thick Bituminous macadam
- (iv) Wearing coat 30mm thick bituminous concrete

Detail specification of construction shall be as per the Ministry of road transport & Highways (GOI) Specification.

Lined road side drains on hill side shall be provided where the formation in ordinary soil & weathered rock. In hard/compact rock drain may be left unlined.

RCC culvert of clear width and depth of 1.5M x 1.5M shall be provided at a spacing not more than 250M. Out let of the drains in ordinary soil shall be protected against erosion by providing stone pitching and gabions. Bituminous wearing coat shall be continued over the culverts.

Masonry Parapet or Galvanized metallic crash barrier shall be provided on valley side where the berm edge from carriage way edge is less than 4.0M.

Road edges shall be marked with paint and Information and statutory road signs shall be provided as per requirement.

Construction of the roads shall be scheduled in such a way that it does not hinder progress of other works. To avoid damage by construction equipment, timing of laying bituminous layers shall be decided judiciously. Timing of laying the wearing coat shall be so decided that at the time of handing over the project it's surface finish remain intact.

Maintenance of the roads including patch repair of damage, if any to pavement throughout the construction period shall be within the scope of the contract.

1.8. SPECIFICATIONS OF CIVIL WORKS

The contractor shall prepare exhaustive detail specification for all material, construction, fabrication & erection of all works, equipment, instrument, utilities and installations for completing entire works under the contract as per Employer's overall requirement stated hereunder.

Detail specification shall be prepared in a format followed by Indian Standards by giving reference to all applicable Standards and avoiding detail descriptions which can be directly read from referred Standards. Detail specification for the following items as stated herein shall be prepared and implemented by the contractor after obtaining approval of the Employer.

† Site Installations and Services

† Materials for Construction



- † Explosives and Blasting
- † Open Excavation
- † Underground Excavation
- † Structural Steel
- † Rock Supports: Bolts, Anchors, Shotcrete, Wire mesh
- † Steel Reinforcement
- † Formwork
- † Drilling and Grouting
- † Cement Concrete
- † Dewatering, Drainage and Pumping
- † Rock Mechanics Tests and Instrumentation
- † Environment Protection Measures
- † Penstock
- † Brick Work
- † Safety Precautions
- † Quality Assurance
- † Commissioning
- † Road Works
- † Metal works

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- † Water stops and joints
- † Building and architectural works
- † Miscellaneous and ancillary works
- † Slope protection
- † Instrumentation and Monitoring
- † Service water supply, Sewerage system and Sanitary Installations
- † Others specifications, if any, required for completion of the works in totality.

Employer's minimum requirement in respect of some of the implied materials and items of work are enclosed as **Annexure-4.03**. The contractor shall ensure fulfilment of these requirement too in addition to the overall requirement of preparing and implementing detailed specifications in respect of all items of supply, works etc. to be implemented under the contract.

1.9. DESIGN & SPECIFICATION OF HYDRO-MECHANICAL WORKS

1.9.1. Intended Purpose of the Works

The Employer's Requirements for various items related to the HM works are to be provided according to the stipulations of the Contract. Hence, the instructions given herein form an integral part of and are applicable to the Bid Documents issued for the Works.

Certain performance requirements, materials, features and design requirements are specified herein. It is not the intention in these requirements to specify in complete detail of the various equipment of the HM Works. This is left to the experience and practice of Contractor who shall furnish equipment, which shall meet, in all respects, the specified requirement in regard to performance, durability and satisfactory operation.

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1.9.2. Scope of Works:

The scope of work shall include but not limited to Planning, Design & Engineering, instrumentation & Remote Operations, quality assurance, manufacture including procurement, fabrication, shop assembly, painting, testing, transportation, supply, erection, site testing and commissioning of the following equipment at site complete in all respects.

1.9.3. Spillway Radial Gates and Hoist:

Radial Gates for clear opening including embedded part(s), anchorage, dogging arrangement, twin cylinder hydraulic hoist(s) with independent power pack for each gate, controls and hoist supporting structures, in-built in the hydraulic circuit oil dehydration and particle cleaning system for removal of moisture, humidity and oil impurities in the oil reservoir of power pack units, hydraulic & electric control and its related power components suitably interconnected to enable the operation of the hoist cylinders of one gate with the hydraulic power unit of any other gate, electrical control panels and terminals in the electrical control cabinet for its connection to the remote control panel as well as from centralized/computerized automatic control for operation of these gates, mandatory spares etc., complete in all respects. One set of petrol engine driven portable power pack to operate one gate at 25% of rated speed shall also be supplied.

An auxiliary power equipment comprising a diesel generator set of capacity 150% of hoisting requirement of two hydraulic hoist plus dam illumination load shall be supplied and commissioned. The auxiliary power equipment shall be pressed into service in the event of failure of firm power source.

1.9.4. Flap Radial Gate Hoist:

Flap radial gate dogging arrangement, hinge supports suitably spaced, twin cylinder hydraulic hoist (downstream side), in built oil dehydration and particle cleaning system in the hydraulic circuit for removal of moisture, humidity and oil impurities in the oil reservoir of power pack unit, electrical control panels and suitable terminals in the electrical control cabinet for its connection to the remote control panel as well as from centralized/computerized automatic control for operation of these gates, mandatory spares etc., complete in all respects.

1.9.5. Stoplogs for Radial Gate and Gantry Crane:

One set of stoplog units for maintenance of radial gates (capable for servicing all bay of spillway) including embedded parts (for all bays of opening including storage bays), anchorage, dogging & storage arrangement, lifting beam, gantry crane with longitudinal & cross travel arrangements, rails, mandatory spares, water level measuring system to indicate balanced water head condition etc., complete in all respect.

1.9.6. Under Sluice Service Gate and Hoist:

Under Sluice Service Gates for flushing of silt including embedded part(s), anchorage, dogging arrangement, independent rope drum hoist with EM & EHT brakes, gate position indicators (digital & analogue), hoist supporting structure, mandatory spares etc., complete in all respects.

1.9.7. Under Sluice Emergency Stoplogs and Hoist:

Under sluice emergency stoplogs for maintenance of service gate including embedded part(s), anchorage, dogging arrangement, hoisting arrangement, gate position indicators (digital & analogue), hoist supporting structure, water level measuring system to indicate balanced water head conditions, mandatory spares etc., complete in all respects.

1.9.8. Trash Racks & TRCM(s) for Power Intakes

Trash rack(s) to cover intake area including embedded parts along with Hydraulic trash rack cleaning machine with a provision of trash rack panel lifting & lowering mechanism, hydraulic grappler with adequate horizontal reach to cover entire trash rack, prime mover operated self-unloading trash disposal vehicle and rail track with required embedded parts, mandatory spares etc., complete in all respect. The machine shall be capable of lifting and removing trash rack panels and floating debris with adequate turning/swinging mechanism for loading and unloading on vehicle/trolley parked behind the TRCM. The minimum capacity of Grappling Hook shall be 2.0 MT.

1.9.9. Intake Service Gate and Hoist:

Intake Service gates including embedded part(s), anchorage, dogging arrangement, rope drum hoist with EM & EHT brakes, gate position indicators (digital & analogue), electrical control panels and suitable terminals in the electrical control cabinet for its connection to the remote-control panel as well as from centralized/computerized automatic control for operation of these gates, hoist supporting structure, mandatory spares etc., complete in all respect.

1.9.10. Intake Emergency Gate and Hoist:

Intake emergency gates including embedded part(s), anchorage, dogging arrangement, rope drum hoist with EM & EHT brakes, gate position indicators (digital & analogue), electrical control panels and suitable terminals in the electrical control cabinet for its connection to the remote-control panel as well as from centralized/computerized automatic control for operation of these gates, hoist supporting structure, mandatory spares etc., complete in all respect.

1.9.11. Draft Tube Gate and Hoist:

Draft tube gates including embedded part(s), anchorage, dogging arrangement, independent rope drum hoist with EM & EHT brakes, gate position indicators (digital & analogue), hoist supporting structure, water level measuring system to indicate balanced water head conditions, mandatory spares etc., complete in all respects. Independent gate & hoist for each machine shall be provided.

1.9.12. Penstock Steel Liner:

Steel Liner for penstocks including bends, bifurcations, stiffener rings, thrust collars, anti-percolation ring etc. complete in all respects. The design of bifurcations shall be got validated by the contractor through model studies/3D FEM analysis and report of the same shall be appended with the design documents.

1.9.13. Mandatory Spares and Tools & Tackles:

Spare and Tools & tackles shall be supplied by the Contractor as per list enclosed as **Annexure-4.04**.

1.9.14. Cables:

All type of cables and cable trays (including power supply panel and Master control panel) to HM control panels & further to HM equipment are in the scope of Contractor. HM Works agency shall intimate total power requirement at power supply panel and details of Master Control Panel for integration by E&M Works agency with SCADA system.

1.9.15. Additional Control Panels

a) Dam Control Room

1 (One) no. control panel for radial gates & flap gate, one no. control panel for intake gates, 1 no. control panel for Under Sluice gate at dam control room. The control panels shall be equipped with min. 55" LCD display (with audio plus recording facility showing different position of the gates, with cables and cable trays.)

b) Power House Control Room

1 (One) no. control panel for draft tube gates and 1 nos. control panel for radial gate in power house control room. The control panels shall be equipped

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with min. 55" LCD display (with audio plus recording facility showing different position of the gates, with cables and cable trays.)

1.9.16. Design Criteria:

Planning, Engineering and Design of the HM Works shall conform to the Employer's requirements and in absence of any of the parameters not included in the Employer's requirements, the Bureau of Indian Standard shall be followed. In absence of Indian Standards, reference/guideline of internationally accepted standards and other references shall be adopted. The Contractor shall provide various national/international references, when required by Employer, to substantiate his design.

The earthquake effect shall be considered while designing the HM Plant and the seismic coefficient of the project.

The 1st stage concrete shall be M25 and 2nd stage concrete shall be at least one grade higher than 1st stage concrete and shall not be less than M-30 Grade.

Battery limit for penstock shall be 1 (one) meter from the edge of D-line wall of Power House.

1.9.17. MINIMUM DESIGN INPUTS IN HM WORKS

While fulfilling the overall requirement as stated in preceding clauses, the contractor shall also ensure fulfillment of the design inputs as stated herein. This requirement is in respect of key components of HM works only and it neither exclude the necessity of fulfilling the overall requirement in respect of these components of work nor relieve the requirement of any other component which shall be required to fulfill the overall requirement under the contract.

a) Spillway Radial Gate:

i.	Type	Radial Gates
ii.	No. of Gates	refer "fixed parameters"



iii.	Full reservoir level	refer “fixed parameters”
iv.	Free Board	300mm to take care of wave effects
v.	Operating criteria	Unbalanced water head conditions capable for reservoir operations
vi.	Operation	Twin Cylinder Hydraulic Hoist of sufficient capacity provided with independent power packs. Power packs shall be interconnected in such a manner that power pack of any of the gate shall be capable to operate any of the radial gate.
vi.	Design Head	Water head corresponding to FRL
vii	Hoisting Speed	Minimum 0.5 m/minute
viii	Cushioning speed	0.1 m/minute

b) Flap Gate:

i.	Type	Radial Gates
ii.	No. of Gates	One
iii.	Free Board	300mm to take care of wave effects
iv.	Operating criteria	Unbalanced water head conditions
v.	Operation	Twin Cylinder Hydraulic Hoist (Double Acting) of sufficient capacity provided with independent power packs.
vi.	Design Head	Water head corresponding to FRL
vii	Hoisting Speed	Minimum 0.5 m/minute

c) Spillway Stoplogs:

i.	Type	Fixed wheel type
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ii.	No.	One set comprising of suitable interchangeable elements
iii.	Free Board	300mm to take care of wave effects.
iv.	Functional Requirement	Maintenance of Radial Gate, Flap Gate and its accessories
v.	Operating criteria	Balanced water head conditions to be achieved by crack opening of top elements
vi.	Operation	Gantry Crane mounted with Automatic Engaging and Disengaging type lifting beam.
vii	Design Head	Water head corresponding to FRL
viii	Hoisting Speed	Minimum 1.5 m/minute
ix	Gantry Travel	Minimum 6 m/minute
x	Length of travel of Gantry	It should cover all the openings including storage bay with a reserve travel of 1 m.
xi	Cross travel	To be decided as per requirement

d) Under Sluice Service Gate:

i)	Type	Fixed wheel
ii)	Operating criteria	Regulating under flowing water
iii)	Operation	Independent Rope Drum Hoist
iv)	Hoisting speed	Minimum 0.5 m/min.

e) Under Sluice Emergency Stoplog:

i)	Type	Slide Type
ii)	No	One set comprising of two elements

iii)	Operating criteria	Operation under balanced head conditions
iv)	Operation	Monorail Crane
v)	Hoisting speed	Minimum 0.5 m/min.

f) Intake Trash Rack & TRCM:

i)	Trash rack panel	refer “fixed parameters”
ii)	Trash Rack Cleaning Machine(s) cum Gantry crane	Trash rack cleaning machine cum Gantry crane with trash rack panel lifting & lowering arrangement along with hydraulic grapples.

g) Intake

Service Gate:

i.	Type	Fixed Wheel Type
ii.	No.	refer “fixed parameters”
iii.	Functional Requirement	Inspection and Maintenance of HRT
iv.	Operating criteria	Non-Regulating type. Normally operated under flowing water condition.
v.	Operation	Independent Rope Drum Hoist of sufficient capacity
vi	Design Head	Water head corresponding to FRL
vii	Hoisting Speed	Minimum 0.5 m/minute

h) Intake Emergency Gate:

i.	Type	Fixed Wheel Type
ii.	No.	refer “fixed parameters”
iii.	Functional Requirement	Maintenance of Intake Service Gate

iv.	Operating criteria	Non-Regulating type. To be operated under balanced head condition created by a bye pass system. However, gate should be capable of lowering in flowing water condition
v	Operation	Independent Rope Drum Hoist of sufficient capacity
vi	Design Head	Water head corresponding to FRL
vii	Hoisting Speed	Minimum 0.5 m/minute

i) Draft Tube Gate:

i.	Type	Fixed wheel
	Functional Requirement	For maintenance of machine
ii.	Operating criteria	Lowering under unbalanced and raising under balanced water head conditions
iii.	Operation	Independent Rope Drum Hoist
iv	Hoisting speed	1m/min.
v	Design Head	Water head corresponding to Normal TWL
vi	Location of Skin Plate	Tail Pool Side
vii	Location of Rubber Seal	Machine Side

j) Steel Liner for Penstocks:

i	Full reservoir level (static condition)	refer "fixed parameters"
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ii.	Size of penstocks	refer “fixed parameters”
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1.9.18. Material for main components of HM Works:

a) Radial Gate and Flap Gate:

Sl. No.	Component	Recommended Materials	Reference
1.	All Structural members such as, Skin plate, horizontal girders, arms, bracings, vertical stiffeners, hoist brackets, dogging device, seal seat bases, wall plates, and seal clamps etc.	Structural Steel	IS: 2062
2.	Guide rollers, trunnion hubs	Cast steel or forged steel	IS:1030/1875
3.	Trunnion pins, roller pin, lifting pins etc.	Corrosion resistant Stainless steel with 50 micron Chromium plating	IS: 1570 (Part -5)
4.	Trunnion Bearing	Self-lubricated bronze with solid lubricant	Deva glide / Lubrite or Standard make
5.	Seal seats & guide roller track	Stainless steel	IS: 1570 (Part -5)
6.	Seals	Natural or synthetic rubber	IS: 11855/ 15466
a.	Side seal	Music note type	
b.	Bottom seal	Wedge/Flat type	
c.	Screws/bolts for seal	Stainless steel	

b) Stoplogs:

Sl. No.	Component	Recommended Materials	Reference
1.	Structural members of the stoplogs, such as skin plate, stiffeners, horizontal girders & vertical girders etc.	Structural steel	IS: 2062
2.	Lifting brackets, guideshoes, etc.	Structural steel	IS: 2062
3.	Track bases, seal seat bases	Structural steel	IS: 2062
4.	Anchor plates and anchorages, etc.	Structural steel	IS: 2062
5. a.	Track plates	Corrosion resistant steel plates (BHN of wheel track should be more by min. 50 points than that of wheel)	IS: 1570 (Part -5)
b.	Seal seats	Stainless steel	IS: 1570 (Part -5)
6. a.	Wheels for stoplogs	Cast/Forged Steel	IS: 1030/ IS: 1875
b.	Wheel Pin	Stainless steel	IS: 1570 (Part -5)
7.	Slide block	Aluminium Bronze	IS:305
8.	Seals	Natural or synthetic rubber	IS: 11855
a.	Side and top	Double stem type	
b.	Bottom	Wedge/Flat type	



9.	Screws/Bolts for seals	Stainless steel	IS: 1570 (Part -5)
10.	Bearings	Spherical roller, self aligning bearings of SKF or equivalent make	

c) Vertical Lift Fixed Wheel/Slide Gates for Under-Sluice/Intake/Draft Tube

Sl. No.	Component	Recommended Materials	Reference
1.	Skin plates, Stiffeners	Structural Steel	IS: 2062
2.	Main horizontal girder, vertical girders etc.	Structural Steel	IS: 2062
3.	Seal bases, track base seal seat bases, clasp guide shoes	Structural Steel	IS: 2062
4.	Anchor plates & anchorages etc.	Structural Steel	IS: 2062
5.	Side guide tracks	Structural Steel	IS: 2062
6.	Seal seats	Stainless Steel	IS: 1570 (Part -5)
7.	Wheel track	Corrosion resistant Stainless steel plates	IS: 1570 (Part -5)
8.	Wheel	Cast steel/Forged steel	IS: 1030 IS: 2004 IS 1875
9.	Wheel pin	Stainless steel	IS: 1570 (Part -5)
10.	Bearings		



	a. Bearings in Wheels	Spherical Roller self aligning (SKF or equivalent)	
	b. Bush bearing	Aluminum Bronze	IS: 305
11.	Seals		
	a. Side Seals	Natural or synthetic rubber Music note type (fluorocarbon cladded wherever necessary)	IS: 11855/15466
	b. Bottom Seal	Natural or synthetic rubber Wedge type	IS: 11855/15466
	c. Top Seal	Natural or synthetic rubber Music note type (fluorocarbon cladded wherever necessary)	IS: 11855/15466
12.	Screws/bolts for seals	Stainless steel	IS: 1570 (Part -5)

d) Hydraulic Hoist

Sl.No.	Component	Recommended Materials	Reference
1.	Hoist Cylinder	Boiler quality plate Forged steel	IS: 2002 Gr. 21 IS:1875
2.	Upper- & Lower- Cylinder head	Boiler quality plate Cast steel	IS: 2002 Gr. 21 IS:1030
3.	Piston	Forged steel/Cast steel	IS: 2004 / IS:1030



4.	Piston Rod	Solid bar of corrosion resistant steel.	IS: 1570 (Part - 5) DIN 17440 Type x 20 Cr. 13
		Outer surface of the piston rod shall be hardchromium plated with a minimum plating thickness of 75 microns after machining. The chrome plating shall be done in at least 2 stages. The thickness for each stage shall not exceed 0.05mm.	(15) or ASTM A 276 Type 316
5.	Piston rings	Lead Tin Bronze	IS: 318
6.	Piston glands	Cast Manganese bronze	
7.	Clevis Pin	Corrosion resistant steel	IS: 1570 (Part 5) ASTM A-276 Type 316 or ASTM A-564 Type 630
8.	Piston seals & Piston Rod seals	Chevron Type Packing Seals	



9.	Bearings for Cylinder Mountings	Self-lubricating bushing on corrosion resistant pins	Reputed make
10.	Bush bearings	Lead tin Bronze	IS: 318
11.	Shafts	Carbon steel	IS: 1570 C-40
12.	Studs, bolts, nuts & washer	Mild steel	IS: 1367
13.	Support frame	Structural steel	IS 2062, IS: 808
14.	Pipe flanges, & fittings	Stainless steel	DIN-17440/8 DIN-17458 BS-3604
15.	Seals	Synthetic	Buta -N (NITRILE)
16.	Piping	Seamless Stainless-Steel tube	DIN-17440/8 DIN-17458 DIN -2462 BS-3604
17.	Steel pipe flanges and flanged	Stainless steel	
18.	Hydraulic oil tank	Stainless steel	

e) Electrically Operated Rope Drum Hoists/Monorail/Hoist Bridges/Lifting Beam/Gantry Crane

Sl.No.	Component	Recommended Materials	Reference
1.	All Structural members	Structural steel	IS: 2062
2.	Rope drum	Structural steel Cast steel	IS: 2062 IS: 1030



3.	Wire rope	Improved plough steel- fibre core (Ungalvanised)	IS: 2266
4.	Hook	Forged steel Structural steel	IS: 1875 IS: 2062
5.	Gears	Cast steel	IS: 1030

6.	Pinions	Forged steel	IS: 2004/IS1875
7.	Shafts	Structural steel/ forged steel	IS: 2062/IS: 1875
8.	Sheaves/pulleys/ Couplings/Roller	Cast steel	IS: 1030
9. i.	Bearing (sleeve)	Phosphor Bronze Tin bronze Aluminum bronze	IS: 28 IS: 318 IS: 305
ii.	Anti-friction bearing	SKF or equivalent	
10.	Keyways and Keys	Mild Steel	IS: 2048/2291/ 2292
11.	Motor		IS: 325/900
12.	Cable and conductors		IS: 9968/813
13.	Conduits		IS: 9537
14.	Switch gear		IS: 1822/5124/ 2147
15.	Equalizer bar and turned buckles	Mild steel	IS: 2002/2065

16.	Gate position indicator	Non-rusting metal or enameled plate	
17.	Cover	Cast Iron Mild Steel	IS: 210 IS: 2062
18.	Wire rope socket	Forged Steel	IS: 1875
19.	Bolts and nuts	Mild steel	IS: 1363, 1365, 1367, 2389
20.	Pedestal	Mild steel	IS: 2062
21.	Wheel	Cast steel	IS: 1030
22.	Axles and pins	Forged steel Corrosion resistant steel	IS: 1875 IS: 1570 (Part -5)
23.	Rail Track		Rail of suitable size not less than 45 kg/m

f) Penstock Steel Liner, Bend, Bifurcation, stiffener rings. Anti-percolation rings and others appurtenant work:

The steel material shall be pressure vessel grades conforming to ASTM 537 CL-II Grade/ASTM A517 Gr. F shall be used for penstock works.

1.9.19. Documents to be submitted for review of Employer:

The Contractor shall submit the following documents to the Employer for review in editable format (.xls, .dwg, .doc, etc. format). The Employer shall furnish comments within 45 days of date of submission.

1.9.20. Technical Specifications:

Draft specifications shall be submitted to the Employer for review. Specifications reviewed by the Employer shall be adopted as final specifications.

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1.9.21. Schedule of Submission of Documents:

The Contractor shall submit a schedule for submission of design calculations, fabrication drawings, O&M Manuals, As Built Drawings and other documents etc., to the Employer for review.

1.9.22. Drawings & Design Calculations:

The Contractor shall submit detailed drawings (component wise) and detailed design calculations supported by catalogues/technical literature of all bought out items with selection criteria and characteristics to the Employer for review.

1.9.23. As-Built Documents:

Prior to the issue of Taking-Over Certificate, the Contractor shall supply to the Employer a Design report, which shall include all the as-built drawings along with Design criteria and calculations. Contractor shall also submit two (2) copies of asbuilt drawings on polyester film.

1.9.24. Installation, Operation and Maintenance Manuals:

Four (4) sets (2 hard copies and 2 soft copies) of installation, operation and maintenance manuals containing drawings, catalogues and brochures, service manuals for each bought out item, handling procedure for assembly & subassemblies of all Gates, Hoists, Cranes and associated equipment etc.

1.9.25. Samples:

All material used for equipment manufacture including castings and forgings, etc. shall be of tested quality as per relevant codes/standards. Details of results of the tests conducted on samples to determine the mechanical properties; chemical analysis and details of heat treatment procedure recommended and actually followed shall be recorded on certificates and time temperature chart. Tests shall be carried out as per applicable material standards.

1.9.26. Inspection, Testing & Maintenance:

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The guidelines/recommendations for inspection, testing and maintenance of Gates, Rope Drum Hoists/cranes/hydraulic hoist as contained in the relevant Indian Standards viz. IS-7718, IS-10096, IS-3177 and IS- 13053 (Latest Revision) etc. but not limited to, shall be applicable at different stages of the work viz. at the manufacturing stage, at the time of erection as well as after the erection. The Employer's representative shall have full access to the workshop during works.

1.9.27. Workshop Assembly, Inspection and Tests:

The Employer will depute his representative(s) for witnessing tests and carrying out inspection during manufacturing stage and final complete assembly/ testing of Gates/ Hoists/cranes/lifting beams etc. for issue of Material Dispatch Clearance Certificate (MDCC). The Contractor shall make necessary arrangement of stay and local transport for Employer's Inspectors/ Engineers at or near the place of work, if so, requested by Employer.

The sub-assemblies and parts shall be assembled and tested in shop to ensure that parts are correctly fabricated and properly aligned.

1.9.28. Gates/Stoplogs (Wheeled/Slide)

Each Gate shall be completely assembled in the shop for inspection and to ensure that all parts fit properly and that dimensions, clearances and tolerances required in the specifications and drawings have been achieved. The Gates/Stoplogs shall be assembled in a vertical position and holes for field connections carefully drilled or reamed. Connections which have to be disassembled for shipment/transportation shall be made by the use of erection pins, one size less in diameter than the designed size or temporary machine bolts. The shop assembly must also be checked for correctness in all respect, such as quality or workmanship, freedom from defects, free rotation of roller etc. The surfaces of seals on sides and top shall be in same vertical plane.

1.9.29. Rope Drum Hoists

The contractor shall assemble the Hoist completely and shall conduct tests in his workshops to ensure that all parts fit and function properly and the dimensions and tolerances are as per the drawings for the parts and assemblies for its proper performance. The Hoist shall be completely assembled and run under no load in shop to ensure that all parts fit accurately at site when erected. The Hoist under such tests shall run smoothly, without vibration, noise, chatter or undue friction.

1.9.30. Hydraulic Hoist

The contractor shall assemble the hoist completely and shall conduct tests in his workshops to ensure that all parts fit and function properly and the dimensions and tolerances are as per the approved drawings for the parts and assemblies for its proper performance. The hoist shall be tested for a pressure 150% of the design pressure, by applying the oil pressure to move the piston.

1.9.31. Gantry Cranes

The cranes shall be completely assembled, inspected, operated and tested in shop. The gantry tracks shall be centered & supported by two parallel & level rails to form the run way after accurately aligning all shaft couplings, bearing & gears. They shall be dowelled with pin & straightened by shear blocks if necessary. The hoist and gantry drive shall be operated by power to check the operation of the gearing. The hoist shall be operated for 15 to 30 min. to demonstrate that the equipment has been designed for continuous duty. The gantry shall be made to travel for a distance of about 20 meters, if space permits. The deflection test shall be carried out with the safe working load at rest. The measurement shall not be taken on the first application of the load.

1.9.32. Monorail Cranes

The EOT crane shall be completely assembled, inspected, operated and tested in shop. The crane tracks shall be centered & supported by two parallel & level rails to form the run way after accurately aligning all shaft couplings, bearing & gears. The crane shall be operated for 15 to 30 min. to demonstrate that the equipment has been designed for continuous duty.

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1.9.33. Overload Test in Shop

After the above tests but before the Rope Drum Hoists/EOT Crane/Gantry crane are put into service, these shall, with overload relays appropriately set, be tested to lift and sustain a minimum test load of 125 percent of the working load.

1.9.34. Operational Test (Dry Test)

a) Gates/stoplogs

Operational tests in dry conditions shall be carried out as soon as possible after completion of erection when all controls and permanent power supply have been connected. The tests shall include at least two complete traverses from the maximum raised position to the full closed/seating position 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/stoplogs seal and seal seats shall be checked and pre-compression ensured by viewing the contact surface against the light source. The operation of the hoist/crane shall be smooth without any undue noise/excessive friction and without excessive vibration in the gate/stoplog and supporting structure

b) Test for Rope Drum Hoists and Cranes

After the Hoist/crane has been erected, adjusted, lubricated and otherwise made ready for operation, it will be operated through cycles of placing and removing of the gate/stoplogs. The hoist/crane shall raise, lower, held in any position the Gate/stoplogs at rated speed. Before conducting any field trial or tests, complete procedure for the tests shall be drawn and submitted by the contractor to the Employer for review.

After erection but before the hoists/cranes are 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.

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c) **Operational Test (Wet Test)**

These tests should simulate the actual operating conditions. At least two complete traverses will be made from the fully closed position to the normal raised position as follows:

- i) When Gates/stoplogs/ is closed, Gates/ stoplogs is raised to their normally open position in steps and observe the performance including vibration etc.
- ii) Lower the Gates/stoplogs to the fully closed position in steps and observe the performance of the Gates/stoplogs including vibrations etc.
- iii) Check for proper operation of the filling valves.
- iv) Checkup of proper operation of limit switches.

1.9.35. Leakage Tests

Leakage tests shall be carried out with the Gates/stoplogs closed. Before measuring the leakage, the Gates/stoplogs shall be raised and lowered several times by a few inches or so in order to dislodge any debris that may have lodged in the seal seats. The leakage shall then be measured and recorded. The permissible leakage should be as per relevant IS code.

1.9.36. Rope Drum Hoists and Cranes

After the supply has been connected and before the complete hoist/crane installation is put to commercial service, tests shall be carried out to prove the following:

- v) The satisfactory operation of each control switch, contactor, relay and other control devices and in particular the correct operation of all limit switches under the most unfavorable conditions.

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- vi) The correctness of all circuits and interlocks and sequence of operation. vii) Satisfactory operation of all protective devices.
- viii) The satisfactory operation of each motion of the hoist/crane.
- ix) The compliance of the hoist/crane with the specified performance requirement.
- x) Tolerances on specified speeds on full load shall be within 10%.

1.9.37. Field Test and Acceptance of Gantry Crane/Monorail crane

After the gantry/EOT crane has been erected, adjusted, lubricated and otherwise made ready for operation, it will be operated through cycles of placing and removing the stoplog units. The crane shall raise, lower, held in any position and transport the stoplogs unit at rated speed.

1.9.38. Tests for Penstocks

a) Radiographic examination

- i) All longitudinal joints of Penstock Steel Liner including bend, reducers and bifurcation shall be subjected to 100% radiographic examination.
- ii) All shop Circumferential Joint shall be subjected to 100% radiographic examination.
- iii) Other circumferential joints shall be spot radiographed to 10%.
- iv) In addition to the above, 100 mm of circumferential joints on either side of longitudinal joints shall also be tested radiographically.
- v) All circumferential welds of bends shall also be subjected to 100% radiographic examination.

- vi) All radiography shall be performed and supervised by the experienced personnel qualified or trained for the job from the institutes of national repute.
- vii) 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 at least 1.5 percent or better. All radiography shall be conducted using lead intensification screens. The acceptance standard for radiography shall be as follows:
- † Any type of crack, or zone of incomplete fusion or penetration;
 - † Any elongated slag inclusion which has length greater than $1/3 t$, where 't' is the thickness of the weld;
 - † Any group of slag inclusions in line that have an aggregate length greater than 't' in a length of $12t$ except when the distance between the successive imperfections exceeds $6L$ where 'L' is the length of the longest imperfection in the group;
 - † Porosity or rounded indications in excess of that specified by the acceptance standards given in Appendix-IV of ASME Boiler and pressure vessels code section-VIII Div.1.
 - † Radiographs shall not be taken until 24 hours after welding has been completed.
- viii) Prior to making radiography, identification marks shall be placed adjacent to the weld intended to be radiographed. The images of such markers shall clearly appear in the radiographs. It shall be ensured that actual weld and its radiographs are mutually identifiable up to completion and acceptance of the work. The marker shall not be removed until all the welds have been accepted.

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- ix) The contractor shall provide at his own expense all materials including radiographic films and all consumables, equipment etc. necessary for radiographic examination and shall perform all radiographic examination in accordance with the requirements.
- x) Defective welds shall be arc air gouged or chipped out, re-welded, re-X-rayed and the cycle repeated until satisfactory results are obtained.

b) Ultrasonic examination

- i) All field welds, wherever not spot radiographed or such joints, which are difficult to be radiographed, or inaccessible to radiographic examination shall be subjected to ultrasonic examination.
- ii) The circumferential field joint of Penstock steel liners, including those of specials such as bends, bifurcations shall be tested ultrasonically to 100%. Ultrasonic examination shall be performed in accordance with the Article-5 of ASME-V.
- iii) ASME Boiler and pressures vessels code Section V. The relevant references from ASTM specification E-164-74 shall also be 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. The records in such case shall be furnished and the same shall be the property of Employer.
- iv) All indications which produce a response greater than 20% of the reference level shall be investigated to the extent that the operator can determine the shape, identity and location of all such reflectors and evaluate them in terms of the acceptance standard given below:

- † Discontinuities shall be unacceptable if the amplitude exceeds the reference level and discontinuities have length which exceeds $1/3t$ where 't' is the thickness of the weld being examined.
- † Where discontinuities are interpreted to be crack, lack of fusion or incomplete penetration, they shall be unacceptable regardless of discontinuity or signal amplitude.
- v) Defective welds shall be arc air gouged or chipped out, re-welded, re tested and the cycle repeated until satisfactory results are obtained.

c) Magnetic Particle Examination:

- i) All field Circumferential joints shall be subjected to 100 % MPE. The procedure for the Magnetic Particle examination, the acceptance standards for welds etc. shall conform to the relevant articles of ASME Boiler and pressure vessel Code-Section-V.
- ii) All weld metal build-up shall be examined over the full surface of the deposit by MPE.
- iii) All permanent hold down logs or devices welded to the steel penstock shall be examined by MPE. Removal of temporary lugs and devices tack welded to the penstock and steel liner section and subsequent dressing shall be followed by MPE of the connection area. The procedure and acceptance standards for the methods shall conform to the relevant articles of ASME boiler and pressure vessel Code -Section-V.

d) Hydrostatic Testing:

- i) Hydrostatic shop testing shall be conducted in shop. The testing of ferrules shall be done using test jigs& test beds etc. and shall be properly designed.
- ii) All the pipe shells, bends, wye pieces, taper pieces etc. shall be in general

subjected to test pressure equal to 150 percent of the design pressure producing stress not exceeding 90 percent of yield stress in shell.

- iii) In the case of extra high tensile steel liner using ASTM-517 Gr. F or equivalent, a test pressure which produces a hoop stress in pipe shall be equal to $\frac{1}{2}$ the minimum UTS of the materials or $\frac{3}{4}$ yield point of the materials, whichever is less, shall be adopted.
- iv) During Testing, each piece shall be subjected to a test pressure as indicated on the drawings.
- v) Suitable vent(s) shall be provided at a high point to vent possible air pocket while the Pressure shaft shells, bends, bifurcations etc. are being filled.
- vi) 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.
- vii) 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.
- viii) The test pressure shall be applied three times successively increasing and decreasing at uniform rate but not lowering the pressure below 0.75 times the operating pressure and shall then be held at the specified test pressure for such a time as is considered sufficient for inspection of plates, all welded joints and connection and all regions around openings but the period shall in no case be less than ten minutes.
- ix) 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 satisfactory repaired and re-tested.

1.9.39. Quality Assurance

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All materials, components and equipment covered under scope shall be procured, manufactured, erected, commissioned and tested at all the stages (onsite & offsite), as per a comprehensive Quality Assurance Programme agreed mutually.

Manufacturing Quality Assurance Plan and Field Quality Assurance Plan shall be submitted by the Contractor to the Employer for review.

1.10. DOCUMENT AND SUBMITTALS

The Contractor shall submit all documents, drawings, suggestions, information for necessary acceptance/approval of the Employer.

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 and approval by the Employer.

All submittals shall be in Digital form as well as hard copies in the prescribed number. 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

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

Documents for DBR and detail design comprising 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 related information suitably collated and indexed. Similar format shall be used for submission of other important and voluminous documents.

In the submittal formats, the contractor shall keep token space for review and approval by the Employer.

The Employer/PMC shall review all drawings, design, data or any other information submitted by the contractor. Employer may forward any of the such submittals to authorities like CWC/CEA/GSI etc. whenever required for fulfilling statutory requirement or obtaining authoritative comment, if needed.

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

- a. "Approved"
- b. "Approved with comments".
- c. "Revise and resubmit".
- d. "Rejected".

When submittals are returned marked with either "Revise and re-submit" or "Rejected", the Contractor shall make such revisions and/or corrections and resubmit the drawings or other material in the manner as specified. Time of submission, review and approval of documents by the contractor and the Employer shall be mutually decided at the time of submission and approval of Design basis report in a manner that supports expeditious and timely completion of the contract in line with the stipulations made herein and the construction schedule of the project.

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

Five (5) copies of approved Good for construction drawings shall be furnished to the Employer not later than 14 days before commencement of related construction/ erection activity.

Tentative list of design document and drawings to be submitted by the contractor for Civil and HM Works is enclosed as **Annexre-4.05**.

1.10.1. AS-BUILT DRAWINGS, INSTRUMENT DATA AND TEST RESULT:

The Contractor shall provide five (5) copies of detailed "as-built" drawings for the entire Civil and Hydro-Mechanical works. These are to be based on the "approved" drawings and field information.

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

Geological drawings with geo-technical information of encountered geology during construction of the underground and surface project components shall also submitted.

An abstract of the instruments installed, data recorded throughout the construction period and its interpretation shall be submitted by the contractor.

1.10.2. COMMISSIONING REPORT:

A compiled report on tests of all material, work and equipment including gates & hoists, power house building vibration and crane beam load test result, WCS leakage and head loss test, Maximum and minimum pressure in the WCS in load throw off test, grouting efficacy test etc. establishing satisfactory execution, completion and commissioning Works in a comprehensive manner shall be submitted by the contractor prior to handing over the commissioned works to the Employer.

1.10.3. INITIAL RESERVOIR FILLING MANUAL:

Prior to the filling of reservoir, Contractor shall finalize the Reservoir Filling Manual in consultation with the Employer.

1.10.4. INITIAL WATER CONDUCTOR FILLING MANUAL:

Manual for initial filling of the Head race tunnel, High pressure tunnel and the Tail pool filling shall be submitted for approval of the Employer prior to proceeding for the initial filling.

1.10.5. RESERVOIR SILT MANAGEMENT MANUAL:

A manual for monitoring and flushing silt from the reservoir shall be provided by the contractor for implementation in the project.

1.10.6. OPERATION AND MAINTENANCE MANUAL

O&M manual of all gates, equipment and Hydraulic structures including the Reservoir shall be provided by the contractor at the time of handing over the commissioned works.

1.10.7. COMPLETION REPORTS:

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

1.11. CONSTRUCTION MANAGEMENT:

The Contractor shall commence construction of any project component only after receipt of approval of the Employer for respective Good for construction drawings. Execution of all supply, works, fabrication, erection and services shall be strictly as per approved drawings and technical specifications complying QAP, safety etc. of the project.

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The contractor shall manage and carry out the construction of the Works and ensure its expeditious and timely completion in accordance with the terms and provisions of the Contract. The Contractor shall inspect, facilitate inspection by the Employer, all materials and equipment to be incorporated in the Works and shall reject those items found 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 discharging 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 them and the construction work carried out by their Sub-Contractors

1.12. 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 subcontractor's labour, 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 Contract warrants that all such items shall be new and of the good quality, reliability and performance as 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.

1.13. STANDARDS, LAWS & DISRUPTION TO PUBLIC UTILITY:

As stated herein, the design and construction of the Works shall be in accordance with the Indian and International standards. Should any provision in statutory

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local laws and ordinances exceed the requirements of Indian Standards, the former shall be complied.

All applicable laws and regulations of the Union and concerned State Government and local laws and ordinances shall be complied.

The Contractor shall make all necessary arrangements for notifying the service authorities of required connections, removals and relocations of all public utilities and services and roads, 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.

1.14. PROGRAM AND PROGRESS REPORT

a) Program:

The Contractor shall submit the proposed program for the design, supply and execution of the Works in accordance with relevant clause of the General Conditions of Contract in a format and media required by the Employer. 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 and PERT/CPM 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 Employer on the work section, activities, sub-activities, interface and other critical dates, which the Contractor has to identify

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in the programme. Upon agreement by the Employer, the proposed overall Program shall become the Project Baseline Program based on which the Contractor shall complete the Works and progress shall be monitored. This overall Works Program shall not be changed unless agreed by the Employer.

The Detailed Working Program shall also define times for submittals of Contractor's documents and approval by the Employer.

In respect of planning & design program it is stipulated that in first stage within 30 days from the commencement Date the Contractor shall submit Design Basis Report (DBR). Within 15 days of the submission, a design review meeting shall be held between the Contractor, the PMC and the Employer in order review and discuss the DBR. To expedite detail design of works, review and approval may be given to independent sections of the DBR separately in stages.

Based on the approved DBR, in the second stage the contractor shall submit detailed design report in full or component wise as per the program agreed in the DBR for review and approval. The Contractor shall also submit a schedule of all inspections and tests required to be carried out and a list of drawings and documents together with a schedule for submission of same. Drawings and documents shall be submitted in a logical sequence and in a structured manner for review and comment.

b) Progress Reports:

The Contractor shall submit monthly report on an agreed day. in a format and media approved by 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 obtain approval of the Employer before implementing progress control procedures.

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

Monthly progress meetings will be held with the Employer and the PMC for discussing progress, highlighting or bottleneck/hindrance, if any, and finding way out to resolve it. Special meetings will be held as and when required.

c) Photographic Records:

In the monthly progress report the contractor shall submit photographs in digital format in support of the reported progress of work.

1.15. QUALITY ASSURANCE PLAN & 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 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 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 (NCRs) where ever necessary and procedure for addressing it for remedial action shall be part of the Quality assurance plan.

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Formats of Quality Assurance Plan for Civil and HM works are enclosed as ***Annexure-4.06.***

1.16. TEMPORARY SITE INSTALLATIONS/FACILITIES:

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

On completion of the Project, after obtaining consent of the Employer 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.

Employer's requirement in regard to temporary site installation and use of site by the contractor, environmental obligations & safety precaution is enclosed as ***Annexure-4.07.***

1.17. SITE OFFICE & ACCOMMODATION FOR EMPLOYER:

The Contractor shall provide and maintain fully furnished Site Office, accommodation compound, Canteen and other necessary facilities for 35 nos. of users belonging to the Employer and the PMC.

Site Office shall be provided with: 5 (five) Closed Cabins, 7 (seven) Work Station Cubical, 13 (thirteen) Work Stations, all with desks and lockable drawers and adjustable level padded chairs: one meeting/conference room with tables, chairs and Video Conferencing/Projector arrangement for 25 people. Filing cabinets of suitable capacities shall also be provided for document control and secretarial use

Accommodation shall be provided with'

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- 7 (Seven) fully furnished Family Quarters (2 BR, 1 LR, 1 Kitchen, 1 Toilet/Bathroom); kitchen appliances, TV and cold/hot water shall be provided.
- 28 (Twenty-Eight) Double Bed Rooms with and attached Toilet/Bath facilities. Double Bed Rooms should have minimum required kitchen appliances, TV and cold/hot water.

All above mentioned facilities shall be properly airconditioned and ventilated.

On completion of the works, these facilities shall be handed over to the Employer on as is where is basis.

1.18. BORROW AND DISPOSAL OF MATERIALS

a) Excavated surplus materials:

The contractor shall disposed-off all excavated surplus materials and spoils to muck disposal areas designated by the owner and indicated in the bid document. Usable excavated materials shall be stacked separately for subsequent extraction and use.

b) Borrow Pits and Stockpiles

The Contractor shall submit management plan for acquiring, processing and stockpiling stone/ sand material from designated quarry/ borrow pit area indicated in the bid document for the Employer's approval.

If required the Contractor shall be responsible for locating and acquiring additional borrows pits and stockpiles, in addition to the designated quarries/ borrow pits and stockpiles. Whether the Contractor obtains materials from the designated or their 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 for the work. The Contractor shall pay all necessary costs towards, leases if any, fees, taxes, levies or royalties to the appropriate parties/agencies/authorities and follow all relevant regulations. The Contractor shall keep the borrow pits free from ponding water and shall carry out

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necessary erosion protection and other mitigation measures as acceptable to the Employer.

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. Wherever required the Contractor shall provide a drainage ditch around the stockpile to prevent the ingress of water or other measures acceptable to the owner.

The Contractor shall also be responsible for disposal of surplus materials to designated places as approved by owner. The muck disposal area shall be duly prepared and protected to prevent spillage of muck beyond designated area. Mucks shall be compacted progressively by the passage of muck hauling vehicle and construction equipment. The slope of muck dump shall be protected against erosion. On completion of work all muck disposal area shall be restored by laying top soil layers and growing vegetation.

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.

1.19. PROJECT SIGNS

The Contractor shall supply, erect and maintain good quality aesthetic Information and statutory signs in sufficient numbers prominently displaying at the project installations for general information, safety and security.

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

1.20. ENVIRONMENTAL COMPLIANCE

- i) Reference is made to the environmental requirements given in:

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- a) The Law and Regulation of Government of Arunachal Pradesh/India and relevant Standards.
- b) Employer's Requirements for Environmental Compliance.
- c) Sub-clauses of General and Particular Condition of Contract and any other clause or sub-clause related to Environment
- d) Local traditions and customs of Project area.

ii) Environmental Compliance & Miscellaneous:

Within one month from commencement Date the Contractor shall appoint/ designate one official as an Environmental Officer for the Works, whose broad responsibility shall be to guide the construction personnel on environmental matters and ensure complying all environmental stipulations specific to the project, to communicate and to make liaison on behalf of the contractor with the owner, statutory and local authorities. The Environmental Officer will submit a Monthly Environment Report incorporating monitoring, evaluation and institutional measures to be taken for complying statutory and project specific environmental stipulation. The report format shall be as required by concerned statutory authority and the Employer.

iii) Photographic Records:

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

1.21. HEALTH, SAFETY AND SECURITY

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 owner 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.

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

The contractor shall provide and maintain fencing, warning signs and watch & ward, when and where necessary or required by the owner or by any duly constituted authority, for the protection of works or for the safety and convenience of the public or others.

The contractor shall 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.

Employer's requirement of safety procedures to be complied by the contractor is enclosed as **Annexure-4.07**.

1.22 Sharing of Risk of variation in Geology and extraordinary geological incidence

Notwithstanding the provisions of GCC and PCC, the Owner shall share risk of variation in Geology, occurrence of extraordinary geological incidence and consequences thereof as stated hereunder.

The quantum of Geotechnical investigation carried out for preparing the Detail Project Report may not be adequate to prepare an exhaustive Geological Base Line Report for the work. The bidder shall have to duly assess the risk of occurrence of variations in the geology and its implications likely to be encountered during execution. Keeping this in consideration the bidder shall prepare Geological models of underground and surface excavation & structures which shall be verified at final design and construction stage by undertaking required geo-technical investigation. Irrespective of the encountered geology or any difficulty and its consequences, the contractor shall be fully responsible except the risk to be shared by the Owner as expressly stated herein, to deliver all structures and installations in acceptable, safe and fully functional condition as stipulated in the contract and within the stipulated completion time and quoted amount.

Risk shall be shared by the Owner in respect of physical difficulties that may arise on account of any variation in encountered geology in the underground and surface excavations and the Owner's sharing shall be limited to the extent as stated herein. Sharing of risk by the Owner in such event shall be done in the form of extension of completion time and admitting additional Payments over

and above the stipulated completion time and the quoted amount subject to the extent of limits as stated hereunder. This shall be subject to execution of the work s as per approved design, drawing, methodology and specification.

For grant of Extension of completion time, the impact of an incidence on the work cycles shall be evaluated on the basis of assessed impact and mutually agreed micro level work program unless otherwise specified hereunder and if it happens to affect the critical path of the project, then Extension of time limited to the extent of the impact excluding any overlapping with other eligible extension of time shall be granted.

A. Underground excavation:

A.1 Variation in the Rock support class:

Rock support classes in the HRT and penstock tunnel (excluding the Shaft) are envisaged as follows

Rock mass quality Q- Value	Support class	Estimated Length (m)
HRT		
10-40	Class –II	1917.0
4-10	Class –III	745.0
1-4	Class – IV	639.0
0.1-1.0	Class – V	249.0
Penstock Tunnel*		
10-40	Class –II	63.3
4-10	Class –III	95.94
1-4	Class – IV	19.20
0.1-1.0	Class – V	13.43
*At upstream of Bifurcation/ Trifurcation excluding Penstock Shaft		

The Owner's share of Risk of variation in the encountered geology and resulting variation in Support class wise length of tunnel shall be limited to admitting additional payment in proportionate manner at the below stated rates and manner and extension of completion time.

- i) Support class wise estimated shared cost considered towards excavation and all primary support

Support class	Estimated Length (m)	Considered Rate Rs / M tunnel length	Amount (Rs)
HRT			
Class –II		1,17,200	
Class –III		1,43,000	
Class – IV		1,62,300	
Class – V		3,74,500	
Penstock Tunnel*			

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Class –II		1,09,899	
Class –III		1,30,191	
Class – IV		1,48,369	
Class – V		3,24,644	
		Total estimated amount (Rs) (X)	
*At upstream of Bifurcation/ Trifurcation excluding Penstock Shaft			

- ii) Support class wise shared cost to be considered towards excavation and all primary support as per execution

Support class	Executed Length (m)	Considered Rate Rs / m tunnel length	Amount (Rs)
HRT			
Class –II		1,17,200	
Class –III		1,43,000	
Class – IV		1,62,300	
Class – V		3,74,500	
Penstock Tunnel*			
Class –II		1,09,899	
Class –III		1,30,191	
Class – IV		1,48,369	
Class – V		3,24,644	
		Total amount as per execution (Rs) (Y)	
*At upstream of Bifurcation/ Trifurcation excluding Penstock Shaft			

If the amount as per execution exceeds the estimated amount, then additional payment shall become due and its amount shall be the difference of the amounts i.e. (Y) –(X).

For deriving the additional payment, if any be due as above, the HRT and Penstock tunnel at upstream of bifurcation or trifurcation shall be considered together.

Extension of completion time for sharing Risk of variation in support class wise length of Tunnel and Penstock shall be worked out on the basis of the variation in executed Support class wise lengths from the respective estimated lengths and the cycle time of excavation and support erection in various Support classes as stated hereunder.

Support class	Cycle Time (Hour Per RM)
HRT	
Class –II	4.08
Class –III	5.16
Class – IV	5.85
Class – V	7.62
Penstock Tunnel*	

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Class –II	3.79
Class –III	4.80
Class – IV	5.42
Class – V	7.00
*At upstream of Bifurcation/ Trifurcation	

If the total executed length of the HRT and the Penstock tunnel increase over the above stated estimated length, the Support class wise executed length shall be reduced proportionately so that the adjusted total length is equal to the estimated length.

Such additional payment and time extension towards Risk sharing by the Owner shall not be admitted for the Surge shaft, Penstock shaft, Adits and the portions of Penstock tunnel at downstream of Bifurcation/ Trifurcation.

A.2 Geological overbreak:

The Contractor is required to perform the excavation works in such a way that the final excavation surface is located between the minimum excavation line (A-Line) and the hypothetical line (B Line) which is located at a distance of 150mm from A-Line. The B-Line is considered to take care of inherent limitation in precision of excavation by drilling and blasting and irregular breakage of rock. Excavation beyond the B line is defined as Overbreak. The “Overbreak Line” is a line outside the B- Line, determined by measurement.

Overbreak due to occurrence of any or all of the incidences viz sudden loose fall, cavity formation and chimney formation may be accepted as geological overbreak when each of the following four conditions are simultaneously fulfilled:

- Overbreak extends beyond the B line,
- The overbreak occurs above the overt of the tunnel,
- The Owner is immediately informed and given an opportunity for inspection while both the cause and the extent of the overbreak are clearly visible,
- It occurred, in the opinion of the Owner, even though the contractor was using proper working methods or was otherwise not negligent, and it could not have been prevented by prompt and appropriate installation of supports and in view of the Owner, the occurrence is solely due to geological reasons.

The Owner’s share of Risk of occurrence of Geological overbreak and its tackling shall be limited to admitting Additional payment for the following items of works at the specified rates and extension of completion time.

(I) Overbreak removal:

Measurement of overbreak material to be removed shall be based on the in situ solid volume of all excavated material outside the B-line based on cross sections at 1.0 m intervals.

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Additional payment towards loading, unloading, transportation and dumping at the designated muck disposal area shall be restricted up to 7% of the B Line volume above tunnel overt or spring line of cavern and within the sections where overbreak occurred.

Rate of overbreak removal is stated in Para C (I) hereunder.

(II) Backfilling:

In order to tackle the sections where overbreak occurs the contractor shall decide appropriate and approved support system keeping in view the backfilling requirement and its optimisation. In order to avoid the challenge of placing concrete and releasing trapped air, the backfilling of overbreak spaces outside the minimum excavation line shall be done prior to placing the final lining or backfilling behind steel liner as the case may be. The backfill material shall be concrete, shotcrete or sand cement grout. The grade of backfill material placed outside the minimum excavation line shall not be lower than M15 grade concrete.

Backfilling of geologically accepted overbreak shall be measured in the manner of measuring overbreak removal and it would be segregated into two parts viz

- (i) the backfilling volume within 7% of the volume of excavation within B Line above tunnel overt and the chainages where the overbreak occurred and
- (ii) the backfilling volume in excess of the above, if any.

Additional payment towards tackling backfill of geologically accepted overbreak shall be limited to the following items of work depending on the approved methodology, technical specification and execution.

- a) backfilling quantity within 7% of the B Line volume as described herein.
- b) backfilling quantity in excess of 7% of the B Line volume.
- c) drilling hole for grouting
- d) grouting
- e) Structural and rebar steel for providing forepoling and canopy.

Method of measurement and Rates of these items of work are stated in the Para C (I) hereunder.

A.3 Squeezing:

Excavation dimensions, support systems and sequence of its installation and measures for ground improvement shall be decided duly considering the encountered rock mass property, estimated support pressure and estimated deformation. The adequacy of the support systems shall be validated by continuous observation of stress and deformation in rock and support system and carrying out strengthening or revision of support design as per requirement as stipulated in the tender.

If despite of taking all measures as agreed and approved by the Owner convergence of the tunnel exceeds substantially then necessary re-work for re-mining, re-erection of support etc. shall be done as per approved design, drawing and specification. for restoration of excavated section and accommodating the specified minimum thickness of final lining.

The Owner's share of Risk of squeezing and the its consequences as stated above shall be limited to admitting additional payment for the following items of work at specified rates and extension of time. The quantities of these items shall be as per approved design & drawing for re-works.

- a) Dismantling and Re-excavation
- b) Removal of excavated muck
- c) Permanent steel support including all associated items of steel work/ lattice girder
- d) Drilling, supply and installation of rock bolt
- e) Providing and placing Shotcrete
- f) Supply and installation of steel wire mesh
- g) Supply and installation of RCC lagging
- h) Providing and placing backfill concrete

The additional payment towards the above stated items of work shall be made as stated hereunder

- a) Payment for dismantling damaged support elements and Re-excavation of rock for providing the required minimum excavation profile shall be analysed by considering the following cost components
 - i) Cost of Manpower and machinery directly engaged in the work as jointly recorded by the contractor and owner
 - ii) Hourly use rate of machinery to be worked out as per CWC guideline where the cost of POL shall not be more than the actual consumption
 - iii) Wage of workmen shall be as per minimum wages notified by the state government
 - iv) Cost of consumables
 - v) Over Head and Profit of 10 % on total direct cost
 - vi) Applicable taxes
- b) Rates of all remaining items of work at sl (b) to (h) are stated in the Para C (I) hereunder.

A.4 Ingress of water:

If the inflow of water within 100m distance from Heading face exceeds 4000 litre/ minute, the Owner's share of Risk of Ingress of water and its consequences shall be limited to admitting additional payment towards following items at specified rates and extension of completion time. The quantities of these items shall be as per approved design & drawing tackling Ingress of water.

- a) Chemical grouting for arresting water ingress
- b) Cement sand grouting
- c) Dewatering by pumping

The additional payment towards the above stated items of work shall be made as stated hereunder

- a) Payment for Chemical grouting shall be made in the manner same as stated under para A.3 (a).
- b) Method of measurement and Rates of all remaining items of work at sl (b) to (h) are stated in the Para C (I) hereunder.

A.5 Occurrence of hot water, harmful gas:

In case of occurrence of below mentioned incidences extension of completion time shall be granted.

- a) Encountering water spring with water temperature equal to or more than 60 degree Celsius
- b) Encountering release of Methane gas with concentration equal to more than 10000ppm.

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B. Surface Excavation:

B.1 Open excavation slope at Barrage, Power House and Adit Portals:

Slide or slumping in open excavation may be accepted as geological overbreak when each of the following four conditions are simultaneously fulfilled:

- i) The slide or slumping extends beyond the final excavation line as per approved construction drawing,
- ii) The Owner is immediately informed and given an opportunity for inspection while both the cause and the extent of the overbreak are clearly visible,
- iii) It occurred, in the opinion of the Owner, even though the contractor was using proper working methods or was otherwise not negligent, and it could not have been prevented by prompt and appropriate installation of supports and in view of the Owner, the occurrence is solely due to geological reasons.

If during carrying out open excavation as per approved drawing, specification and method there is occurrence of overbreak then re-work for restoration of slided slope to new approved profile shall be done as per approved design and drawing. The Owner's share of Risk of Geological overbreak in open excavation during excavation stage shall be limited to admitting additional payment towards the following items of work at specified rates and extension of completion time. The quantities of these items shall be as per approved design & drawing for re-works.

- a) removal of the geological overbreak
- b) excavation in soil and soft and disintegrated rock
- c) excavation in hard rock

If any excavated slope in rock deforms beyond serviceable limit or yields despite of carrying out excavation and installation of supports as per approved drawing, specification and methodology and the cause of its occurrence is accepted as geological reason, then the Owner shall share the cost towards re-work for restoration of the rock slope by re-excavation, re installation of supports and surface treatment etc. as per approved drawings. The Owner's share shall be limited to admitting additional payment towards the following items of work at the specified rates. The quantities of these items shall be as per approved design & drawing for re-works.

- a) excavation in soil and soft and disintegrated rock
- b) excavation in hard rock
- c) supply and installation of rock bolt and anchor
- d) supply and installation of welded wire mesh/ GI chain link mesh
- e) Providing and laying shotcrete
- f) Supply and installation of drainage pipe

The method of measurement and item rates are stated in Para C (II) hereunder.

B.2 Construction of permanent approach road:

The contractor shall be responsible for planning, design, construction and maintenance of all permanent roads and its handing over in finished and undamaged condition to the Owner at the time of completion of the entire work as stipulated in the contract. The contractor shall plan construction

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of the roads in such a manner as to mitigate the risk of damage to the permanent road due to traffic, high rainfall, geological reasons etc.

If in any stretch after construction of formation, pavement and appurtenances, formation of the road is damaged partially or fully due to slide and this qualifies as geological overbreak as per the stipulations stated at Para B.1, then the Owner shall share the cost of restoration and reconstruction of the damaged work. The Owner's share shall be limited to admitting additional payments towards the following items of work at the specified rates. The quantities of these items shall be as per approved design & drawing for re-works.

- a) Excavation in ordinary soil and soft and disintegrated rock
- b) Excavation in hard rock

The item rates are stated in Para C (III) hereunder.

C. Items and rates

Sl	Description of Item	Unit	Rate in INR
I	Underground work		
1	Removal of overbreak in all classes in all underground excavation including all lead and lift.	Cum	1120.00
2	Backfilling overbreak using M15 grade concrete up to 7% overbreak	Cum	6900.00
4	Backfilling overbreak using M15 grade concrete in excess of 7% overbreak	Cum	6069.00
5	Backfilling overbreak using M25 concrete up to 7% overbreak	Cum	8210.00
6	Backfilling overbreak using M25 concrete in excess of 7% overbreak	Cum	7225.00
7	Providing and placing Shotcrete M25 grade	Cum	11662.00
8	Providing and placing welded steel wire mesh 100mm x 100mm x 5mm	Sq.M	300.00
9	Supply and installation of permanent steel support using cold bend rolled structural steel bend, plates etc. including all accessories	MT	100536.00
10	Providing and placing forepoling of canopy of miscellaneous structural steel and rebar including drilling	MT	130380.00
11	Providing and placing RCC lagging of M25 grade concrete	Cum	13136.00
12	Steel for reinforcement & Lattice girder	MT	100536.00
13	Drilling hole for grouting with hole size not smaller than 32mm	RM	428.00
14	Grouting with cement	Bag of 50kg	972.00
15	Dewatering by pumping including all incidental works	KWH	68.00
II	Surface excavation		
1	Removal of overbreak including all lead and lift	Cum	125.00
2	Excavation in ordinary soil & soft & disintegrated rock	Cum	219.00
3	Excavation in hard rock	Cum	607.00
4	Supply and installation of rock bolt including drilling		
a	25mm dia	RM	872.00

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Sl	Description of Item	Unit	Rate in INR
b	32mm dia	RM	1082.00
5	Providing and laying Shotcrete M25 Grade	Cum	10885.00
6	Providing and placing welded steel wire mesh 100mm x 100mm x 5mm or Galvanised chain link wire mesh 50mm x 50mm x 3mm	Sq.M	300.00
7	Providing and laying 65mm dia. PVC perforated drainage pipe including drilling in rock/ soil	RM	1285.00
III	Road works		
1	Excavation in ordinary soil & soft & disintegrated rock	Cum	165.00
2	Excavation in hard rock	Cum	485.00

The specification of the items of work shall be same or equivalent to the detail specification of the item of works approved for the work.

The item rates are the unit price of respective items shared by the Employer and it is deemed to be inclusive of all material, consumable, labour, machinery, incidental costs and taxes shared by the Employer.

D. Method of measurement:

The method of measurement for making payment towards the items at Para C shall be as per Indian standards unless specifically mentioned hereunder.

- a. Overbreak removal and Excavation: The measured volume for payment shall be the Solid or bank volume of excavation derived by section measurement done with spacing of section grid not more than 1.0m centre to centre in underground excavation and 3.0m centre to centre in surface excavation respectively.
- b. Backfill concrete: The measured volume for payment shall be derived from the sectional measurement done as stated above for measurement of overbreak/ excavation and the theoretical minimum excavation line i.e A Line.
- c. Providing and placing welded wire mesh/ GI chain link wire mesh: The measured area for payment shall be the derived by measuring the curved length and width with section grid not spaced more than 1.0m centre to centre in underground works and 3.0m centre to centre in surface works. Any overlapping shall not be measured for payment.
- d. Permanent steel support: The measured weight shall be inclusive of the weight of erected bent, support and joint plates, bolts, stringers and tie members connected to the bent. Nominal sectional weight shall be used to workout in deriving the measured weight.
- e. RCC lagging: Reinforcement for RCC laggings shall be measured and paid separately. The item rate is inclusive of cost of shuttering.
- f. Dewatering: Electric power consumed by dewatering pumps shall be measured by installing calibrated energy meter near the pumps.
- g. Shotcrete: The curved surface area where shotcrete is applied shall be measured with section grid not spaced more than 1.0m centre to centre in underground works and 3.0m centre to

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centre in surface works. Volume of shotcrete shall be derived by multiplying the measured surface area with the measured average thickness of shotcrete laid on the surface.

END OF THE CHAPTER EMPLOYER'S REQUIREMENTS

