NAVI MUMBAI MUNICIPAL CORPORATION

DEVELOPMENT OF RENEWABLE ENERGY PROJECT FACILITIES OF HYDRO ELECTRIC POWER PLANT OF 1.5 MW AND FLOATING SOLAR PV POWER PLANT OF 100 MW

AT

"MORBE DAM"

TECHNICAL SPECIFICATIONS - PART - 1

Contents

SECTION – A – TECHNICAL SPECIFICATIONS OF HYDRO POWER PLANT 3

SECTION – B – TECHNICAL SPECIFICATIONS OF FLOATING SOLAR PV POWER PLANT 190

SECTION – C – A – TECHNICAL SPECIFICATIONS CIVIL WORKS 306

SECTION – C – B – TECHNICAL SPECIFICATIONS CIVIL WORKS 422

SECTION – D – TECHNICAL SPECIFICATIONS: SUBSTATION AUTOMATION SYSTE (SAS) 582

SECTION – E – TECHNICAL SPECIFICATION FOR EHV LINES 673

SECTION – F – GIS SUBSTATION SPECIFICATIONS 828

SECTION – G – PROJECT MANAGEMENT REQUIREMENTS 888

SECTION – H – PREFERED VENDOR LIST 943

SECTION – A – TECHNICAL SPECIFICATIONS OF HYDRO POWER PLANT

PROCUREMENT ID -

CLIENT NAME-

PROJECT NAME-

SECTION –

TECHNICAL SPECIFICATIONS

CONTENTS

Sub-Section	Description	Page No.
1	Scope, Project Information & Technical Requirements of the Project	5-35
2	Technical Specification of Hydraulic Turbines, Governing Equipment and Auxiliaries	36-51
3	Technical Specification of Synchronous Generators and Auxiliaries	52-63
4	Transformer	64-69
5	Switchyard Equipment	70
6	Switchgear	71-74
7	Control Panels	75-76
8	Miscellaneous Items	77-88
9	Erection, Testing & Commissioning	89-90
10	Gates and Hoists	91-128
	SCHEDULES	
Schedule-1	Indicating & Recording Instruments	129-134
Schedule-2	Guaranteed & Technical Particulars	135-158
Schedule-3	Price for turbine, generator etc.	159
Schedule-4	Price for materials, dimensions etc.	160
Schedule-5	Auto Control System	161
Schedule-6	Mandatory Spares	162-164
Schedule-7	Deviations	165
Schedule-8	Proposed Tests	166
Schedule-9A	Maintenance Tools & Plants	167-168
Schedule-9B	Dimensions & Weights	169
	SCHEDULE OF REQUIREMENTS	170-180
	BILL OF QUANTITIES	181-188
	GUARANTEE	189

SECTION- : TECHNICAL SPECIFICATIONS

SUB-SECTION : 1 SCOPE, PROJECT INFORMATION & TECHNICAL REQUIREMENTS OF THE PROJECT

1.1 SCOPE

1.1.1 The Contractor shall quote for the scope specified in the Contract including the Schedule of requirements and shall include in the scope all the equipment and services required for the project in full and complete shape even though some equipment and services are not specifically mentioned (or) detailed here or elsewhere. The Contract envisages generation and evacuation of power on a water to wire concept and accordingly, the Contractor shall perform all such work and/or supply all such items and materials not specifically mentioned in the Contract but that can be reasonably inferred from the Contract as being required for attaining completion of the project as if such work and/or items and materials were expressly mentioned in the Contract.

Hydro Power house building architectural plan and aesthetic appeal shall be for the facade which shall be prepared by renowned architect for the power house design and industrial buildings and approved by NMMC. if concessioners fails to submit and approved the design and architectural plan , it shall attract penalty of INR 5.00 (Five) Cr. and it shall be mandatory for concessioner to execute the work based on revise design provided by NMMC.

1.1.2 The Facilities and Services shall meet the stipulations of the Technical Specifications and other requirements of the Contract.

1.1.3 The final destination for “Facilities” to reach is:

Morbe Dam, District Raigad, Maharashtra State
Latitude: 18° 55' 32.78" N
Longitude: 73° 14' 46.29" E

1.1a SCOPE OF SUPPLY

The Scope includes manufacture, testing, supply, transit insurance, packing shipment, delivery to project site, complete erection, testing & commissioning of two sets of vertical generating units coupled with appropriate turbines for Morbe Dam generally comprising of the following:

- Two (2) nos. requisite turbines with associated auxiliary and ancillary equipments in complete set to develop rated output of each machine 750 kW at rated net head & rated discharge and capable of delivering a continuous maximum output of 860 kW at generator outplug from both the turbines at rated net head and maximum

discharge in complete sets. The auxiliary and ancillary equipments include governing equipment (electronic governor), main inlet valve, equipment for auxiliary systems such as compressed air, cooling water system (tapping from penstock), oil pressure system, station drainage & dewatering system, centralized grease lubricating system, oil, water and air piping with valves and fittings, instrumentation, control and safety devices (as required), spares for five (5) years trouble free operation of the plant, special tools etc. have to be provided as described and detailed in the Technical Specifications (Section -) and listed in the Schedule of Requirements.

- Two (2) nos. 750 kW rated output, 11 kV, 0.85 pf, 428 rpm, 50 Hz, with 15 % overload horizontal shaft synchronous generator with instrumentation, brushless excitation, AVR, Automatic power factor controller etc. in complete set directly coupled to the two turbines with accessories, fittings and instrumentation, controls, auxiliaries such as excitation system, Voltage regulating equipment, neutral grounding, generator terminal equipment including CTs, PTs, Surge Protection equipment, Power factor controller installed, Voltage reduction at frequency reduction, Roller bearings with grease lubrication and re-greasing system with grease regulation, in accordance with DIN / VDE 0503 and IEC Standards including mandatory spares for five (5) years trouble free operation of the plant, special tools and testing devices, as described and detailed in the Technical Specifications, Section- and listed in the Schedule of Requirements.

- Equipments for 11 kV / 132 kV or 11/ 220 kV Outdoor switchyard adjoining the powerhouse and interface equipments at the 132 or 220 kV MSETCL 132KV/ 220KV Sub-Station receiving end sub-station or with LILO injection point , in at location which is near by the proposed powerhouse location; control panels and associated equipment for the safe and efficient supervisions, protections, control, metering, annunciation and operation of E&M and auxiliary equipment as described and detailed in the Technical Specifications, Section- and listed in the Schedule of Requirements.

  - One set of Governing system for each unit with OPU and its accessories necessary for fitting.

  - One set manual and conventional control system Protection, Metering, Synchronizing equipment, annunciation and alarm system for the plant, and one set of PLC based Control, Supervisory Control And Data Acquisition (SCADA) System for the units, feeders, common auxiliaries, hydro mechanical equipment etc. and programming and training console with necessary communication links in addition to manual control.

  - Electrical auxiliaries of powerhouse including auxiliary transformer, control cables, Power cables & LT Cables, station batteries & battery charger; LT switchgear (AC & DC) power and D.C lighting system, earthing & A.C. lighting system, internal communication etc.

- Mechanical Auxiliaries of the Powerhouse including EOT Crane of 75/15 T capacity.
- Main Inlet Valves (MIV) of Butterfly type, two (2) nos. of adequate diameters hydraulically operated along with By-Pass Arrangement and Dismantling Joint, necessary piping etc. – one for each machine, matching to the system.
- Two (2) nos. 11 / 132 kV, or 11/ 220 kV 15000 kVA, ONAN, 3 phase, 50 Hz outdoor step-up transformers complete with OLTC, bushings, under-carriage, off load tap changer and all accessories/ fittings, Cooling medium as mineral oil and earthing HV Neutral solidly Earthed, Standard fittings & accessories.
- CTs, PTs, LAs, Isolators, Switches etc. complete as per Single Line Diagram and Schedule of Requirements.
- One set of special Tools & Tackles required for Erection, Testing and maintenance of the equipment.

Note : *The above is only a general description; for complete details refer Schedule of Requirements and the Single Line Diagram (SLD) supplied with these Tender Documents.*

1.1b SCOPE OF WORK

- Design, Material Selection, Fabrication, Testing in the Workshop prior to dispatch, Transport to the Site including Marine Cum Erection Insurance, Unloading & Storage at Site including watch and ward, Erection, Testing at Site as per IEC Standards, Commissioning and Commercial production of power including conducting efficiency & performance tests to the satisfaction of the authorities appointed by the NMMC / Govt. of India.
- All site consumables required during erection / commissioning including lubricating oil & greases for flushing and first filling.
- Spares for five (5) years trouble free operation
- The Contractor shall be responsible for operation & maintenance of all Electro-mechanical equipments (facilities) for a period of Ninety (90) days. During the above period, the Contractor shall also impart necessary training to the designated personnel of the NMMC in the running, operation & maintenance of the facilities.
- Any items of work not covered in the Contract documents but are considered necessary for the verification / checking of optimum efficiency, synchronization with the grid and correct operation of the facilities by the NMMC or Govt. Authorities (such as IIT Bombay) or both shall be deemed to be included in the Contract price.

1.1c FOUNDATION BOLTS, EMBEDDED ITEMS, GROUTING

All necessary foundation bolts, lugs, nuts and washers, packing and other like material required for mounting and securing the Equipment shall be supplied by the Contractor.

Pouring of secondary concrete and grout shall be carried out by the Contractor after a thorough checking of the dimensions, centre to centre distances, depth of trenches, layout of embedded pipelines and other embedded parts etc. or their blockouts to the requirements and under his supervision and as directed by the Engineer.

Foundations of all equipments shall be as per specifications of Civil Works.

1.2 INTRODUCTION

1.2a LOCATION

Morbe Dam Toe Hydraulic Project shall be constructed at the tow of Morbe Dam constructed across Dhavari River (about 35 km from Navi Mumbai) in District Raigad, Maharashtra State.

1.2b PROPOSED INSTALLED CAPACITY & NUMBER OF UNITS

It is proposed to provide 2 nos. appropriate Turbines coupled directly to horizontal Axis Synchronous Generators to give 2 x 750 kW output at generator plug. Each machine shall be capable of running continuously at 15% overload.

1.2c RATED DISCHARGE

The rated (design) discharge for the machines of 750 kW output is with 15% continuous overload

1.2d EVACUATION

The generation voltage shall be 11 kV which will be stepped-up to 132 kV or 220 kV and evacuated to the 132 kV or 220 kV MSEDCL/MSETCL sub-station nearby location & LILO line injection, Length of transmission line from the switchyard adjoining the powerhouse up to proposed MSEB sub-station is approximately 10 -15 km.

1.3 LAYOUT DRAWINGS

The Contractor shall submit along with his Bid, drawings showing plans at different levels, longitudinal section and cross section of the powerhouse indicating all the equipment. The drawings shall contain following details:

i. Bottom most elevations to which the area of powerhouse and tailrace duct have to be dug and the width and lengths at various elevations.

ii. The equipment loads (including the points of their application) due to turbine, generator and other auxiliary equipment in dry and wet conditions.

iii. While arriving at equipment loads, the forces acting due to static loads, torque loads, axial thrust loads, short circuit torque loads and any other loads acting in both dry and

wet conditions shall be considered and indicated on the drawings.

iv. The direction of load and its resolved X and Y components and distance of force at which it is acting from a reference point shall be indicated.

v. One composite layout plan of the powerhouse and switchyard adjoining the powerhouse.

vi. Charts / Shell curves showing performances including Discharge Vs turbine output and turbine output Vs turbine efficiency; Power output Vs efficiency of Turbine; Head Vs efficiency and power output of Turbine

vii. Values of critical sigma as determined from cavitation model tests as per IEC 173A in the form of curves for different heads of operation.

viii. Plant sigma curves as recommended by the Contractor clearly showing the safety margin available.

ix. General layout and assembly drawings showing overall dimensions of the generators indicating stator, rotor, shaft and bearings and positions of main and neutral terminals, main and neutral grounding cable boxes etc.

x. Description of Generator Bearing Oil Lubrication System, if required.

xi. Graphs showing predicted characteristics of the generator viz. Output Vs efficiency, power factor

xii. Drawings for connection of winding temperature detectors and bearing temperature detectors

xiii. Schedule of tests to be performed – both at the Vendor's Workshop as well as after erection at site.

1.3.1 DATA / DRAWING

In general, following technical documents shall be supplied by the Contractor after Award of Work :

- Drawings and catalogues of all the equipments as specified in respective Technical Specifications,
- Design calculations as per requirement of the specifications/Engineer,
- Operation and Maintenance Manuals,
- Installation and Commissioning Manuals,
- Quality Assurance Plan for Manufacturing Works,
- Quality Assurance Plan for erection and commissioning,
- Quarterly Progress Reports during design & manufacturing,
- Monthly Progress Reports during erection & commissioning

The NMMC reserves the right to request the Contractor for additional documents free of cost

as may be required for proper understanding of constructional & operational features of the equipment.

All documents to be supplied shall be submitted in accordance with the agreed programme so that any comment and change requested by the Engineer can be taken into account before starting of the manufacture in the workshop and/or erection at the site. The Contractor shall not be relieved of his responsibility towards quality and guaranteed performance of equipment even after drawings and calculations have been approved by the Engineer / Consultant.

1.3.2 DRAWINGS

The Contractor shall submit the drawings as per technical specifications of individual equipment for approval and reference within the stipulated period and in number and format as specified.

Following drawings of all works will necessarily be submitted for approval:

- General arrangement drawings, layout drawings and foundation drawings,
- Assembly drawings of all major components,
- Electro-Mechanical schematic drawings,
- Electrical / electronic control schemes block diagrams, logic diagrams, schematic diagrams and single line diagrams.
- All other drawings required for construction / installation, testing and commissioning of equipments.
- Profile drawing for runner blades

1.3.3 LISTS AND SCHEDULES

Following lists and schedules shall be supplied:

- Cable Lists / Interconnection Lists
- Alarm Lists
- List of Final Control Elements

1.3.4 CALCULATIONS

The Concessioner shall, along with his Technical Bid, submit detailed calculations made by him for the turbine speed offered by him.

The Concessioner shall, along with his Bid, submit detailed calculations for GD^2 of the generator offered in the Bid. The calculations shall be made with respect to the permissible pressure & speed rise, taking due care about penstock diameter & length and machine overload conditions. The calculations shall be submitted in accordance with applicable Indian / IEC standards. Further, photocopies of the references used shall be submitted along with the calculations. The calculations shall be submitted in open Excel Files giving all formulae for checking & verification of the NMMC. If GD^2 of the generator offered by the Concessioner

falls short of actual requirement, the Concessioner shall provide additional fly wheel to make up for the deficiency and even in this case, calculation showing the combined GD^2 of the generator & fly wheel shall be submitted for verification of the NMMC.

The Concessioner shall submit to the NMMC all relevant calculations for determining the main sizes, stress levels, dimensions and operational characteristics clearly indicating the principles on which the calculations are based. The computer calculations shall be supplemented with base line information such as derivation of the calculation method, applied formulas, definition of variables and constants, explanation of abbreviations etc. The calculations shall be submitted in open Excel Files giving all formulae for checking & verification of the NMMC.

The short-circuit calculations shall be performed in accordance with VDE Standard 0102, Part I / IEEE 242 and 399 and submitted to the Engineer for approval. These calculations shall also be submitted in open Excel Files giving all formulae for checking & verification of the NMMC.

1.4 TRANSPORT LIMITATIONS

The powerhouse of the project being located 35 Km from Navi Mumbai, and it is alongside of SH 38, 103, practically there are no transport limitations for transporting the E&M equipment for Morbe Dam. Weight of each package shall be such that it can be handled by the proposed lifting and hoisting arrangements.

The Concessioners are, however, strongly advised to visit the site to have detailed information about roads, railways and bridges enroute the project site.

1.5 INTERCHANGEABILITY

All similar component parts of similar equipment supplied shall be interchangeable with one another.

1.6 APPROVAL OF DRAWINGS

(i) Concessioner shall submit all relevant drawings for fabrication along with design calculations of components of E & M equipment within 3 weeks from the issuance of Notification of Award of contract, for approval. The approval of the drawings shall be accorded within 2 Weeks of receipt of the drawings. After approval of the drawing by the NMMC, each drawing becomes contract drawing and such 5 copies of approved drawings shall be sent within 1 Week of receipt of approval to commence manufacture of the Facilities. The Contractor shall not depart from contract drawings except by the written permission of the NMMC. The NMMC will maintain secrecy and confidentiality of all Proprietary Drawings provided by the Contractor.

(ii) Any manufacture performed prior to the approval of drawings will be at the Contractor 's risk.

(iii) When revised drawings are submitted for approval, the changes from the previous

submitted drawings shall be clearly identified on the drawings, with every revision made during the life time of the Contract shown by number, date and subject in a revision block and its notation shall be given in the drawing margin. The drawings shall be clear and legible in all respects.

(iv) The drawings shall be clear, facilitating easy identification of all parts with part number for ordering of spares by the Owner without referring to Contractor.

(v) Approval of the drawings will not relieve the Contractor of his responsibility for the correctness of the design and construction of the plant, guarantees and warrantees on the performance of the Facilities as per the terms and conditions of the specifications.

(vi) One set or reproducible shall be supplied with all correspondence. All drawings must be prepared on AutoCAD format and supplied in CD also along with five prints for each drawing.

1.7 DEVIATIONS FROM SPECIFICATIONS

(i) Should the Contractor wish to depart from these specifications, he shall submit a complete and itemized list of such departures together with full particulars of the reasons for the departures in a separate schedule with reference to section and paragraph numbers of these tender specifications. (Schedule-4 of Technical Specification)

(ii) Unless this is done the Facilities offered shall be deemed to comply in every respect with this Bid document. The statement of departures shall be made as a separate Schedule to the Tender.

1.8 STANDARDS AND CODES

All material and equipment shall comply in all respects with the requirements of the relevant Indian Standards, International Electro Technical Commission (IEC) Standards, British Standards, American Standards Association (ASA) or ATM or NEMA or DIN Standards or any other equivalent standards. The standard applicable and code number of the standard shall be given for all the equipment. It is however understood that the Facilities offered shall comply with one consistent set of standards except in so far as they are modified by the requirements of these specifications.

1.9 MANUFACTURING STANDARDS

The Contractors are requested to tender for their own standard equipment as far as possible provided the same complies with the requirements of these specifications. However, should the Contractor wish to depart from the provisions of these specifications either on account of manufacturing practice or for any other reasons, he shall draw the attention of the Owner to the proposed points of departure and shall submit full information, drawings and specifications as well to enable the relative merit of his proposal to be fully appreciated.

In the event of these specifications, or a part thereof and the Contractor 's drawings, specifications etc. being found to disagree during the execution of the Contract, these specifications shall be held as binding unless, the departures have been duly approved in

writing by the Owner.

1.10 ELECTRICITY RULES

All works shall conform to the rules in force under the Indian Electricity Act and latest Indian Electricity Rules 2003, Central Electricity Regulatory Commission (Terms and Conditions for Tariff determination from Renewable Energy Sources) Regulations, 2020 dated 23rd June 2020 and other applicable legislation.

1.11 NAME PLATES

All shipments shall have metal nameplates fixed at a suitable position, with full technical particulars and the standards adopted.

1.12 NOISE

All rotating machinery shall be desired to work without undue noise and limiting the noise levels as specified in Technical Specifications. Special precautions shall be taken to provide machines that shall run smoothly.

1.13 BALANCING

All revolving parts of the machinery shall have their rotors thoroughly well balanced statically and dynamically at the manufacturer's works. Any out of balance that may occur upon erection at site shall be rectified. The Contractor shall confirm in writing that the rotating parts will be tested for balance both statically and dynamically at the manufacturer's works in the presence of the NMMC or his authorized representative.

1.14 PIPING

All pipes and fittings supplied by the Contractors shall conform to the appropriate standards and as per IS-4711.

Each piping system shall be provided with an adequate quantity of valves, drain plugs / cocks, flow indicators, meters, etc. to be approved by the Owner so as to ensure flexibility of operation coupled with reliability, soundness and ease of maintenance of the system.

All piping shall be clean inside and where ending in open connection for other work, the piping shall have the ends capped for protection. Valves shall be easily accessible and gauges and other operating or indicating devices shall be located so that they can be conveniently operated or read from the floor or walkways. Valves shall be suitable for the services intended. Either blind companion flanges or a pipe plug shall be provided, where necessary to protect valves. Where the piping systems must be disconnected for servicing, flanges or unions shall be provided and the piping valves and joints shall be arranged for minimum disturbance or interference with other parts during such operation.

As far as possible the pipes shall not be embedded, but shall be run in trenches or shall be suitably supported by hangers, breakers, pedestals or any other support suited to the requirements. Care should be taken to avoid vibration at the supports. An adequate allowance for the expansion of pipes under service conditions shall be made. Each pipe shall be painted with colours as per standard codes of practice. The material of piping for different services shall be stated in the tender.

Flexible pipe connection to apparatus shall be provided wherever necessary such as in the case of connections from the permanent piping systems to a transformer etc.

For ready identification of different piping systems and their foundations, standard colour code shall be adopted.

1.15 AUXILIARY SUPPLY

The various auxiliaries and controls shall be suitable for 415 / 240V AC 50 Hz and 110V DC respectively , the auxiliary demand shall be inclusive of hydro power plant, Dam Operation and the staff colony Dam.

1.16 PUMPS & MOTORS

Unless otherwise specified all pumps and motors shall be such that their type, capacity and performance shall be best suited to the requirements. The efficiencies shall be as high as practicable and consistent with good design. As far as possible the pumps shall be of a standard size to facilitate replacement of parts. The pumps shall be of the self-priming type. If however, any external mode of priming is employed, these shall be stated in tender and shall be subjected to the approval of the Owner.

All pumps and motors shall be designed and constructed to ensure quiet and satisfactory operation. Suitable gaskets shall be provided for all pipe joints to ensure that the pipe joints are leak proof. If any strainers are required with the pumps, these shall be included in the tender.

The impeller material of all pumps shall be bronze material. All pumps shall be offered complete with the necessary piping, both on the suction and delivery sides, and with all fittings, suited to the size and duty of the pump. Adequate number of valves shall be furnished with each pumping unit to suit its operation and maintenance. Wherever necessary, pumps shall be provided with suitable flow meters or flow indicators and pressure gauges and pressure switches to measure the discharge and the pressure delivered by the pumps. Suitable eyebolts or lifting lugs shall be provided on each pumping set to facilitate handing.

1.17 ELECTRIC MOTORS & MOTOR CONTROL GEARS

The motors shall generally conform to the Indian Standards specification. Indoor motors shall confirm to IP 54 and outdoor to IP 65. The class of insulation shall be suitable for operation in the tropical, high humidity climatic conditions prevailing at site.

1.18 MEASURING INSTRUMENTS

All instruments and motors shall be suitable for operation under the climatic conditions prevailing at site. The instrument cases shall be dust proof and specifically constructed to adequately protect the instruments against damage or deterioration due to high ambient temperatures and humidity. Special care shall be taken in the protection of instruments for outdoor service. The dials, pointers etc. shall be designed to facilitate accurate reading, by minimizing parallax and glare from instrument window, and by providing clear, bold dial markings. The sizes of dial and length of the scales of indicating instruments shall be large enough to suit the requirements, and shall be subject to the approval of the Owner, in each case. The scale

plates of panel mounted indicating instruments shall have a permanent white Matt finish with black graduations. The pointers or the pointer indicating contact setting (in-contact working instruments) shall be distinguished from the main pointer by a distinct colour and / or shape.

Instruments mounted on panels shall be of the semi-flush type, and shall be back connected. All instruments on a switchboard or instrument panel shall be of matching pattern, shape and finish, so as to present a pleasing appearance consistent with the functional requirement. The finish of the instrument case shall be subject to the approval of the Owner. All instruments shall be designed for accurate operations and any errors due to change in ambient temperature, over the entire range of temperatures obtainable at site, shall be kept to a minimum. The instruments shall be provided with all the auxiliary appliances and any special tools required for their maintenance.

The metric units shall be used for marking the instrument dials. The range shall generally be such that the normal operating values are indicated in the middle third of the scale.

All electrical instrument coils shall be designed for continuous operation on at least 115% of the full rated current and for potential of the instruments. The instrument coil ratings shall be coordinated with those of associated instrument transformers.

The VA burden of instrument coils shall be as low as possible, consistent with the best modern design.

Electrical indicating instruments shall comply generally with the requirements of the Indian Standard or any other equivalent Standards and shall be of the accuracy specified in relevant sections, with all digital annunciation.

Recording instruments shall be of the strip chart type with chart scales having suitable width. The charts shall be gear-driven by a self-starting synchronous motor wound spring device having ample torque even at a reduced voltage and with at least 8 hours spring reserve. The device for producing the record on the chart shall be reliable ink recording or printing type. And shall produce clear legible record under all normal conditions of operation. Sufficient number of chart rolls, recording ink and any special tools, required for the maintenance of the instruments shall be furnished with each recorder.

Integrating Watt-hour meters shall comply generally with the requirements of the "Indian Standards" Electricity Meters, and shall be first grade for the purpose of accuracy classification.

Contact making instruments shall have contacts suitable for 240 Volts AC 50 Hz and 110 Volts DC Circuits.

All instruments shall have as high accuracy as possible, consistent with best modern design. The construction of instruments shall be mechanically sound and shall ensure permanence in the accuracy. The limits of error for different instruments shall be stated in the tender and their accuracy classifications, where otherwise not specified shall be subject to the approval of the Owner. All instruments shall be tested in accordance with the requirements of the standards, where specified. In case where no specific standards are mentioned, the Contractor shall submit

the standards in accordance with which the instruments are proposed to be manufactured and tested and these shall be subject to the approval of the Owner, in every case.

1.19 WIRING

All electric wiring of the various equipment panels etc. shall be completed at the manufacturer's works as far as possible. All small wiring shall be arranged neatly into flat or rectangular groups and shall be adequately supported with cleats etc. The small wiring shall be so arranged so as to reduce the number of bonds or crossings to a minimum. There shall be no splices in the wire, and all connections shall be made at the terminal studs, or terminal blocks. Similar circuits shall be arranged to terminate, as far as possible, on adjacent terminals to facilitate grouping and so minimize the number of interconnecting cables. The secondary or control wiring including leads from the current transformer, temperature detectors, alarm contacts, speed and pressure switches etc., shall be enclosed in conduits and shall be carried to dust and water proof and oil tight cabinets located conveniently for connecting the control cables. Pressure circuits shall not cause the progressive failure of adjacent circuits. Alternating current circuits, direct current circuits, and circuits operating at different voltages shall be grouped separately and the wiring of these groups shall preferably be segregated.

For the purpose of easy identification, tracing and reconnection, the writing shall be colour coded and shall be fitted near the terminals with ferrules or such other gaps indelibly marked with the identification number corresponding with that of the associated terminal blocks. When an electrical circuit is extended to several pieces of equipment necessitating sectionalizing of circuit wiring at the terminal blocks of the corresponding equipment, common identification number shall be used for the designation of the circuits at all terminal blocks and connections. The terminal and circuit designation for all wiring shall be subject to the approval of the Owner.

All wiring shall be arranged to terminate on suitable terminal blocks located preferably at the base of the equipment. Terminal blocks shall preferably be made of suitable mould plastic materials with base and integral barriers, and shall be provided with suitable terminal strips.

Terminal block shall have detachable sections in case of removable equipment to separate the conductor and wiring from the equipment wiring for ease of assembly \ disassembly. Adequate number of extra terminals should be provided on each block for terminating spare conductor in the interconnecting cables and of future use. Terminal block compartments shall be separated from the reminder of the equipment by oil and vapour proof barriers where necessary. The seals shall be arranged to facilitate removal or changing of any individual wire without interference with other wires terminating on the blocks.

All wiring shall be stranded have oil and oil vapour proof insulation. All small wiring shall be done with single core cable complying with Indian Standards or with FRLS Poly Vinyl Chloride (FRLS - PVC) insulated cables complying with Indian Standards or with any other type of cables approved by the Owner. Standard conductors shall be tin or alloy coated, and the

conductors sizes used with the different circuits in the switchboard and all other wiring shall have appropriate class insulation and shall withstand all applicable tests specified in their relevant Indian Standards.

1.20 GALVANISING

All galvanizing shall be done after fabrication by the hot dip method. Threads of nuts and bolts shall be so made that, after galvanizing, the nuts will have a neat fit, and can be turned through the length of the threads of the bolts and shall be capable of developing the full strength of the bolts.

All galvanizing materials shall satisfactorily withstand the tests of Indian Standards IS-728 and IS-429 or equivalent. If it is proposed to apply tests in accordance with any other standard, the same shall be clearly described in the Bid, bringing out the difference from the ISI specification.

1.21 SPECIAL TREATMENT

Under the climate conditions prevalent at the site, the equipment furnished under these specifications will be subject to operation under ambient outdoor temperature as high as 43 degrees C and as low as 9 degree C and high relative humidity. All equipment shall, therefore, be suitably designed and treated for normal life and satisfactory operation under the prevailing climatic conditions at the site, and shall be dust and vermin proof.

All parts and surface, which are subject to corrosion, shall be made of such material, and shall be provided with such protective finishes as would protect the equipment installed from any injurious effects of excessive humidity. All electrical auxiliary equipment shall be specially treated for prevailing site conditions and the materials and methods for this treatment shall be submitted by the Contractor and approved in advance by the NMMC.

1.22 MARKING OF PLATES

In order to facilitate identification at destination the several parts of the Facilities shall be suitably marked and the scheme of marking notified to the NMMC.

1.23 DRAWINGS APPENDED

Project Drawings are appended as Annexure 3.3

1.24 DESIGN REQUIREMENTS

1.24.1 General

The equipment shall be designed and manufactured to provide most optimum functional value and neat appearance. All major assemblies or equipment shall be designed to facilitate easy and quick surveillance, maintenance and optimum operation. All control sequences shall be simple and rational.

All live, moving and rotating parts shall be adequately secured in order to avoid danger to the operating staff. All electrical components shall be electrically earthed.

Suitable lifting eyes and forcing off bolts shall be provided where required or where they will be useful for erection and dismantling.

Any change in the design of any part of the equipment which deviates from the technical specifications and becomes necessary after signing the Contract have to be submitted in writing to the Engineer for approval, being sufficiently substantiated and justified.

1.24.2 Design Responsibility

The contractor shall assume full responsibility for a coordinated and adequate design of all equipment specified and shall ensure that such equipment conforms to the best engineering practice for the operating conditions specified. When requested by the NMMC, the Contractor shall furnish complete information as to the maximum stress and other criteria used in the design.

1.24.3 Working Stress

Conservative factors of safety shall be used throughout the design and especially in the designs of all parts subject-alternating stresses of shock. For the rotating parts of the generator and exciters, the maximum units stresses due to runaway speed of turbine shall not exceed two –thirds of the yield point.

Maximum Unit Stresses in Kg/cm^2

Material	**Stress in Tension**	**Stresses in Comprehension**
Cast Iron	140	700
Cast Steel	700	700
Alloy Cast Steel 20 % of the ultimate		20 % of the ultimate
Strength or 33 % of the yield point, whichever is less		Strength or 33 % of the yield point, whichever is less
Plate Steel for		
Principal parts	840	840

For other materials used in the manufacture of the generator and exciter etc. the maximum stresses due to the most serve operating conditions shall not exceed one-third of the yield point nor one-fifth of the ultimate strength of the material. For temporary overloads, unit stresses not exceeding one-half the yield point stress will be permitted.

1.24.4 Standardization of Works

Every effort shall be made to standardize parts, instruments and devices to minimize costs of the Works and facilitate keeping stocks, maintenance, replacement, interchangeability, etc.

1.24.5 Surface Finish

Surfaces to be machine-finished shall be indicated on the shop drawings by symbols. Compliance with the specified surface shall be determined by the sense of feel and by visual inspection of the work compared to applicable "Standard Roughness Specimens", or with roughness feeler gauge instruments.

1.24.6 Fits and Tolerances

Fits and tolerances shall be given in accordance with ISO Standard. Tolerances on matching components shall be suitable for intended service and will ensure interchangeability. Fits shall be selected for the smooth functioning of the components for fairly long life.

1.24.7 Materials

In choosing materials, due regard shall be given to the humid, cold conditions under which equipment is to work. Tropical grade material should be used wherever possible. Material specifications, including grade or class shall be shown on drawings submitted to the Purchaser.

1.25 RESISTANCE TO EARTHQUAKE

The forces being caused by earthquake including hydraulic loads, which may occur additionally, shall be taken into account for the computations. Stresses resulting after including these loads shall not exceed permissible stresses and following provisions shall be made in the generator, Turbine and all switchyard equipment structure.

1.25.1 Mechanical strength

Generator, turbine, switchyard equipment and structure shall be designed to safely withstand earthquake acceleration force 0.2 g both in the vertical and horizontal direction.

1.25.2 Natural frequency

Natural frequency of the machine shall be kept well away (higher) from the magnetic frequency of 100 Hz (twice the generator frequency). The natural frequency must be much away from multiple of runner blades passing frequency.

1.25.3 Generator stator support and bearing blocks / brackets

Generator stator and bearing blocks / brackets of turbine and generator be designed to safely withstand horizontal and vertical forces due to earthquake.

1.26 MANUFACTURING REQUIREMENTS

1.26.1 Materials

All materials used, shall be new and of first class quality free from rust, defects and imperfections. Inspection documents of all materials shall be reviewed and compiled before actual use. The Engineer shall review the inspection records of materials of major components. Materials of limited shelf life shall not be used after their expiry date.

Steel Casting

The Concessioner shall submit to the NMMC, drawings of all important steel castings, showing thereon the location of tension and end test specimens before proceeding with foundry work. The Concessioner shall notify the NMMC in time to have an Inspector present at the foundry when casting have been cleaned and are ready for surface inspection and before any repairs are made and after the castings have been annealed and before they are shipped to machine shop. No repairs shall be made to castings without the knowledge and approval of NMMC. Welding shall be performed only by properly qualified welders and in accordance with the best welding practice. Cracks and other defects disclosed when the casting are cleaned or during machining operations shall be chipped to sound clean metal before any repairs are made. If the removal of metal to uncover the crack or defect reduces the stresses resisting cross section of the casting more than 50 %, the casting may, at the option of the NMMC be rejected. Casting requiring welding repairs impairing the strength of the stress-resisting cross section, at any stage of the manufacture after the first annealing, shall be re-annealed, unless otherwise permitted by the NMMC. All thickness and or other dimensions of the casting shall not be less then called for on the drawings by an amount sufficient, in the opinion of the NMMC, to impair by more than 10 % the strength of casting of the dimensions shown on the drawings and to exceed the stresses allowed under these specifications. Casting shall not be warped or otherwise distorted. The structure of the casting shall be homogeneous and free from excessive non-metallic inclusions. An excessive segregation of impurities or alloys at critical points in a casting will be cause for its rejection.

Steel Plates

Steel plates for all the principal stress-carrying parts shall be Boiler Quality Steel plates as per IS 2002 and steel plates for moderately stressed parts shall be as per IS 2062. The material selected shall be weldable and suitable for the required service.

1.26.2 Workmanship

All works shall be performed and completed in highly professional manner and shall follow the best modern practice in the design and manufacturing of the equipment. All parts shall be made accurately and shall not deviate from drawing and quality requirements. All the

components of the machines shall be interchangeable without any rework or modification in the component.

1.26.3 Welding and Heat Treatment

Welding: All welding (except welding of thin plates or piping of small sizes) shall be performed by electric-arc method and where practical, with process controlled automatic machines. Butt welds welded from one side only, shall be provided with back strips on the whole length of the seam to be welded. Particular care shall be taken in aligning and separating the edges of the members to be joined by butt-welding so that complete penetration and fusion at the bottom of the joint will be ensured. Where fillet welds are used, the members shall fit closely and shall be held together during welding.

Where possible, welding shall be carried out in the workshop. Welding which has to be performed in the field shall be clearly indicated on drawings. After being deposited, welds shall be cleaned of slag and shall show uniform sections, smoothness of weld metal, featheredges without overlap, and no porosity and clinker. Where weld metal is deposited in successive layers, each layer shall be thoroughly peened before the next layer is applied. Visual inspection of the ends of welds shall indicate good fusion with the base metal.

All welds transverse to the direction of flow shall be ground flush with the plates on the inside. Welds shall be ground flush on both the inside and the outside wherever dynamic stress occurs.

The Contractor shall maintain Weld Procedure Specifications (WPS) for the type of welds to be performed in shop. These WPS shall conform to the recommendations of material Contractors, electrode Contractors and approved standards. The WPS shall be got approved from Engineer. However, approval of the welding process shall not relieve the Contractor of his responsibility for correct welding, the use of correct electrodes and for minimizing distortion in the finished structure.

Welding Qualifications: For welding of principal stress carrying parts, the standard of welding procedures, welders and welding operators shall conform to standards equivalent to the requirements of the ASME Boiler and Pressure Vessel Code, Sections VIII and IX, or equivalent standards. For welding of less important parts, the standards and qualifications shall conform either to the AWS Standard Qualification Procedure or equivalent standards.

All welders assigned to the work shall have passed a performance qualification test. If more than one year has elapsed since the welder passed his last test, then he shall again be tested. Welders' test certificates shall be submitted to the Engineer.

Quality and Procedure Control for Welding: Quality control methods, e.g., radiography, ultrasonic crack detection, dye penetration test etc., shall be selected in accordance with the appropriate manufacturing code. However, the Concessioner shall indicate clearly in the Quality Assurance Plan (QAP), the method of control to be used for major fabricated parts.

All welded joints, which have to be tight, shall be inspected or tested by dye penetration tests. All major welds carried out on parts under hydraulic pressure shall be at least ten percent (10%) radio-graphically and hundred percent (100%) ultrasonic examined. All welds on the skin-plates shall be additional dye penetration tested as directed by the Engineer.

The Contractor shall indicate in the corresponding drawings the type of non-destructive testing to be carried out during manufacture and at Site.

Defects and Repairs: Plates with laminations discovered after cutting shall be rejected unless the laminated portion is only local and can easily be repaired; such repairs shall require the consent of the Engineer. Defects in welds, which are to be repaired, shall be chipped out to sound metal and the areas to be DP or ultrasonically tested to ensure that the defective material has been completely removed before repair of welding is carried out. Repairs shall be carried out in accordance with the relevant Standards and to the approval of the Engineer. The Contractor shall be fully responsible for the in-service performance of all welding work. The Work shall be hundred percent (100%) inspected again by the method used first to determine such faulty work.

Heat Treatment: Heat treatment shall be performed on all fabricated parts which are stressed during service and are to be finish machined as per the approved heat treatment / weld procedure. Heat treatment of field erection welding seams shall be performed according to the specifications for the welding procedure for the corresponding parts, which shall be submitted to the Engineer for approval.

1.27 PROTECTION OF MACHINED PARTS AT MANUFACTURING WORKS

1.27.1 Protection of machined surfaces against damages

Finish machined surfaces of large parts shall be applied with anti-corrosive paints and protected with rubber sheet and wooden pads or other suitable means against damages during handling and transportation. Un-assembled pins or bolts shall be oiled or greased and wrapped with moisture-resistant paper or protected by other approved means. Large size bolts and studs shall be wrapped by polythene tapes.

1.27.2 Protection of surfaces against corrosion

All metal parts shall be provided with effective coats of paint, galvanized or hard chrome plated / polished in accordance with the best trade practice to protect from corrosion and give aesthetic look in accordance with relevant I.S.

i) Painting

The Contractor shall submit for Engineer's approval full details of the paints to be used i.e. type, brand of painting materials and method of painting and colour scheme for different type of equipment. While selecting the painting scheme, due attention shall be given to overall aesthetic look of the works in addition to protection of the surfaces. All panels shall be painted

with high decorative finish of uniform shade and shall have peelable protective film to avoid deterioration of paint finish during transportation, storage and handling.

All surfaces to be painted shall be thoroughly cleaned by suitable means before application of paint. For removing rust and mill scale from structural steel, piping and other steel parts, sandblasting shall be preferred. Parts, which cannot be sand blasted shall be cleaned by power tools to the highest degree. After cleaning, the surfaces shall be rinsed and applied one coat of quick drying highly pigmented 2-pack zinc-rich primer, unless otherwise specified. The procedure of painting as recommended by the paint manufacturer/relevant IS e.g. 14177 for Hydraulic Hoists and gates shall be adopted. For all paints the surface temperature of the metal shall not be higher than +50°C during the painting.

Parts, which are embedded in concrete, shall be painted with cement base paints.

ii) Galvanising

Unless otherwise specified, all fasteners and steel structures including ladders, platforms, hand rails etc. and all exterior and interior steel surfaces of outdoor Works shall be hot-dip galvanized or electrolytically galvanized in accordance with relevant IS specifically mentioned in the detailed specifications. For galvanizing, only original blast furnace raw zinc shall be applied, which shall have a purity of 98.5%. The thickness of the zinc coat shall be as under:

- For bolts and nuts of sizes above M36 approx. 36 micrometer and for sizes below M36, 20 micrometer.
- For all other parts, except for hydraulic steel structures or parts intermittently or permanently submerged in water, approx. 30 micrometer
- For hydraulic steel structures or parts intermittently or permanently submerged in water, approx. 80 micrometer.

Bolts, nuts, washers, locknuts and similar hardware shall be galvanized in accordance with the relevant standards.

All plates and shaped components, which have been warped by the galvanizing process, shall be straightened by being re-rolled or pressed without injury to the protective coating. Materials that have been harmfully bent or warped in the process of fabrication or galvanizing shall be rejected.

iii) Chrome Plating and polishing

All hand railings and ladders used in machine hall and instrument holders etc. shall be chrome plated and polished for best aesthetic look as per design requirements and relevant IS specifications.

1.28 MECHANICAL WORKS AND STEEL STRUCTURES

General: All mechanical Works and steel structures of any mechanical or electrical works shall comply these General Technical Specifications.

1.28.1 Bolts, Screws, Nuts etc.: All bolts, studs, screws, nuts, and washers shall be as per ISO metric system. Mild steel bolts and nuts shall be of the precision cold forged or hot forged type with machined faces parallel to one another. All bolts and studs which will be subject to high stress and/or temperature shall be of high tensile material with nuts of appropriate material.

Fitted bolts shall be a driving fit in the reamed holes and shall have the screwed portion of a diameter such that it will not be damaged during driving. They shall be properly marked in a conspicuous position to ensure correct assembly at site.

All parts (other than structural steel work) bolted together, shall be spot faced on the back to ensure that nuts and bolt heads bed down satisfactorily. Mild steel nuts and bolts shall be zinc or cadmium plated. Stainless steel bolts, nuts, washers and screws shall be used for holding renewable parts in water or when exposed to high humidity.

The Contractor shall supply the net quantities plus five percent (5%) of all permanent bolts, screws and other similar items and materials required for installation at the Site. Any such rivets, bolts, screws, etc., which are surplus after the installation of the works, shall be treated as spare parts and shall be wrapped, marked and handed over to the Purchaser.

1.28.2 Seals: Rubber seals shall be made of synthetic rubber suitable for particular application and shall be designed in such a manner that they are adjustable, water tight and readily replaceable. Seals shall be manufactured by molding process and not extruded. All adjusting screws and bolts for securing the seals and seal assembly shall be of non-corrosive stainless steel.

1.28.3 Oils and Lubricants: Different types of oils, lubricants, etc. shall be subject to the written approval of the Engineer. Unless otherwise stated in the Particular Technical Specifications, the oil or grease for bearings, pressure oil systems, transformers, etc., including the necessary quantity for flushing and quantity for first oil change with 20% extra shall be included in the Tender Price.

1.28.4 Mechanical Instruments: All mechanical parts of instruments shall be suitably protected against shocks and vibrations, heat, humidity and splash water, etc. Pressures gauges shall be provided with a damping liquid, e.g., glycerine, to compensate vibrations. Pressure gauges without damping means are not permitted, unless approved by the Engineer.

1.28.5 Pumps: Materials of the main parts of pumps shall be :

- Casing Cast steel
- Impellerstainless steel
- Shaft stainless steel
- Sleevesstainless steel
- Wear rings bronze
- Keys stainless steel

The capacity of the driving electric motor shall be 15 % higher than the maximum power required by the pump at any operation point. The overall pump-motor efficiency for the specified rated head and discharge shall not be less than 60%. The pumps shall withstand corrosion and wear by abrasive matters within reasonable limits. Shafts sealed by packing glands shall be fitted with sleeves. Pump seals shall be replaceable without extensive dismantling of the pump. Leakage water shall be directed to suitable drainage facilities.

1.28.6 Miscellaneous Metalwork

Except where otherwise indicated elsewhere in the Particular Technical Specifications, the Contractor shall supply the following:

- All platforms, ladders, guards, handrails of tubular construction and hatch covers necessary for easy and safe access to Works.
- Safety guards at each point where normal access provision would permit personnel to come within reach of any moving equipment.
- All covers for pipe work, cable trenches and access hatches, required for completing the floors around and over the equipment will be supplied and installed. Unless otherwise approved, floor chequered plates shall be of an angular pattern.

1.29 ELECTRICAL WORKS

1.29.1 General

The electrical items of Works of any electrical or mechanical installation to be provided under this Contract according to the Particular Technical Specifications shall, if not stated otherwise therein, fulfill the requirements of this Section. All components shall be of reliable design.

The power supply and control cables shall be laid up to the common terminal blocks. The Contractor shall ensure that various control/protection devices and instruments supplied against scopes of works under different sections of these Tender Specifications shall be uniform, interchangeable and connected as per system requirement.

Unless otherwise agreed, ratings of main electrical works as selected or proposed by the Contractor, whether originally specified or not, shall generally include a safety margin of 10%. Prior to approval of such basic characteristics, the Contractor shall submit all relevant information such as consumer lists, short circuit calculations, de-rating factors, etc.

Short-circuit calculations shall be evaluated giving full evidence that every electrical component can withstand the maximum stresses under fault conditions, for fault levels and durations obtained under the worst conditions, e.g., upon failure of the corresponding main protection device and time delayed fault clearing by the back-up protection device.

All Works shall be suitable for the prevailing climatic conditions and insensitive to any signals emitted by wireless communication equipment.

1.29.2 Clearances: The layout of the equipment in the powerhouse shall provide ready access for operation and maintenance whilst the remaining sections of equipment are alive. Working clearance provided between isolated equipment and nearest live metal work shall be as per Indian Electricity rules & Standards.

1.29.3 Electrical Supplies For Auxiliary Equipment: The electricity supplies available for various auxiliary equipment will be:

(i) 415 V, 3-phase 50Hz, 4-wire for A.C. power supply,

(ii) 220 V, single phase, 50 Hz for lighting, indication, and anti-condensation heaters,

(iii) 110 V DC for essential indication, controls, protection, alarms and circuit breaker closing and tripping supplies.

1.29.4 Alternating Current Supply Practice: All mains supplies shall be through MCBs/ MCCBs of appropriate rating. Double-pole switches shall be used to break single-phase A.C. mains supplies. For multi-phase supplies, each phase shall be switched simultaneously and the neutral should preferably not be switched.

1.29.5 Direct Current Supply Practice: Power supply bus bars in cubicles shall be carefully routed and each bus bar shall be shrouded. It shall not be possible to inadvertently short bus bars either between themselves or to earth. It shall be possible to remove/replace cards from/to electronic equipment without damage and without interfering with the operation of the rest of the equipment or system.

1.29.6 Terminal Blocks

All terminal blocks shall be mounted in an accessible position with the adequate spacing between adjacent blocks and space between the bottom blocks and the cable gland plate. Sufficient terminals shall be provided to allow for the connection of all incoming and outgoing cables, including spare conductors and drain wires. In addition, twenty percent (20%) spare terminals shall be provided. Not more than two conductors shall be connected under one terminal clamp.

Terminal blocks shall conform to the applicable standards. Circuit terminals for 415/220 VAC and 110 VDC shall be segregated from other terminals and shall be equipped with non-inflammable, transparent covers.

1.29.7 Equipment Wiring

All wiring connections shall be readily accessible and removable for test or other purposes. Wiring between terminals of the various devices shall be point to point. Multi-conductor cables shall be connected to the terminal blocks in such a manner as to minimize crossovers

Each conductor shall be individually identified at both ends through a system providing ready and permanent identification, utilising slip-on ferrules approved by the Engineer. Markers may be typed individually or made up from sets of numbers and letters firmly held in place.

Markers must withstand a tropical environment and high humidity and only fungus proof materials will be accepted. Ferrules of adhesive type shall not be acceptable. All trip circuits shall employ markers having a red background.

1.29.8 Cubicles and Control Panels

Cubicles and control panel enclosures shall be of sheet steel with minimum thickness of 2.0 mm, vermin proof, rigid self-supporting construction and supplied with channel bases. Cubicles shall be fitted with close fitting gasketted and hinged doors capable of being opened through 180 deg. The doors of all cabinets/panels shall be provided with similar integral lock and at least six (6) number of master keys shall be supplied.

The cables and wiring shall enter from bottom or top as necessary for the layout through cable glands. The cubicles and panels shall be adequately ventilated by vents or louvers. Space heating elements with thermostatic control shall be included in each panel.

Unless stated otherwise, all cubicles and panels shall be provided with a ground bus with copper bar extending throughout the length. Each end of this bus shall be drilled and provided with lugs for connecting ground cables.

All instruments, control knobs and indicating lamps shall be flush mounted on the panels. Relays and other devices sensitive to vibration shall not be installed on doors or hinged panels and no equipment shall be installed on rear access doors. The exterior finish of all the panels shall be uniform subject to the approval of the Engineer. The interior of all cubicles and panels shall have a mat white finish unless specified otherwise.

Switched interior light and socket outlets shall be provided for all cubicles and control panels. All cubicles and control panels shall be provided with nameplates, identifying the purpose of the panel and all of its components.

1.29.9 Earthing

Provision shall be made for earthing all equipment intended for connection in an A.C. mains supply. All structural metal work and metal chassis shall be connected to earth. Connection between circuits and metal work shall only be made for reasons of safety and/or reduction of interference. Where such connections are made, they shall not be used as normal current-carrying earth returns. Earthing conductors shall be at least equal in cross-sectional area to the supply conductors and shall be capable of carrying the fault current.

1.29.10 Labels and Plates

Each separate construction unit (cubicle, panel, desk, box, etc.) shall be identified. Cubicles and similar units shall also bear the identification number on the rear side if rear access is possible. The overall designation of each unit shall be given in English language and - if required - also in a selected local language. These labels shall be made of anodized aluminium with black engraved inscriptions, arranged at the top section of the units.

Labels shall be provided for all instruments, control switches, push buttons, indication lights etc. located on the face of the panels. In case of instruments and devices where function is indicated on the device, no separate label is required. All items inside cubicles, panels, boxes, etc., shall be properly labeled with their item number. This number shall be the same as indicated in the pertaining documents (wiring diagrams, Works list, etc.).

1.29.11 Warning Labels

Warning labels shall be made of synthetic resin with letters engraved in English and selected local language, where required in particular cases. For indoor circuit breakers, starters, etc., transparent plastic material with suitably contrasting colours and engraved lettering would be acceptable.

1.29.12 Labels For Cables

Each cable when completely installed shall have permanently attached to each end and at convenient intermediate positions non-corrosive labels detailing identification number of the cable, voltage, and conductor size. The cable identification numbers shall comply with those of the cable list.

1.29.13 Single-Line Diagrams

Each switchgear shall be furnished with a copy of the final as-built single-line diagram detailing all electrical data and denominations, separate for each individual switchgear/distribution board/MCC, placed under glass and frame mounted at an approved location. The same applies to the Station Single-Line Diagram one copy of which shall be arranged in the control room.

1.30 INSTRUMENTATION AND CONTROL EQUIPMENT

Design Criteria

All instruments shall be of an approved and reliable brand. The Works shall be pre-assembled in the Contractor's or Sub-Contractor's workshop, e.g., shop welding of thermometer wells and other connections, wiring of boards, desks, etc., including internal wiring and installation of devices shall be carried out. Fragile instruments shall be removed from the assembly for transportation to site and packed separately.

Shielded cables shall be provided for the control and supervisory equipment where required.

Sizes of Indicators etc.: The meters, instruments etc shall be of standard size, to be selected to guarantee unique appearance of switchgears, control panels, control desks, etc. The front glasses shall be of the anti-glare type.

Measuring Systems: Electric measuring signals of 4-20 mA shall be transmitted to the control room for essential or regulating circuits. Measuring signals for indicating purposes will be 4-20 mA. Measuring ranges of indicators, transducers, etc. shall be selected in such a way that the rated value of the measured magnitude covers approx. 75% of the range.

All local instruments shall, as far as practicable, be mounted vibration free to allow good reading. Wherever required, damping elements shall be used. Corresponding systems shall be grouped together in local panels.

1.30.1 Temperature Measurement

Platinum Resistance thermometers of type PT 100 shall be used. The use of dial-type contact thermometers shall be restricted to bearing metal temperature measuring.

Resistance thermometers shall be equipped with waterproof connection heads. The temperature sensors shall be selected in such a way to minimize the number of different spare inserts.

1.30.2 Pressure Measurements

Pressure gauges shall be shock and vibration-proof (preferably by filling with glycerine) and the movement shall completely be made of stainless steel. The casings shall be dust and watertight and be made of stainless steel. The adjustment of the pointer shall be possible by means of an adjustment device without removing the pointer from its axle.

Each gauge, pressure switch and transmitter for absolute or differential pressure shall be equipped with a pressure gauge isolating valve including a test connection of the screwed type M20 x 1.5 mm so that such device can be removed without any disturbance of the plant operation. If the pressure is pulsating, the devices concerned shall be connected via flexible tubes or other pulse-absorbing means.

The error for pressure transmitters shall be limited to ±0.5%.

1.30.3 Electrical Measurements

All Electrical instruments shall be of flush mounted design, dust and moisture-proof. A.C. ammeters and voltmeters shall have digital type system of not less than 1.5 accuracy class. D.C. measuring instruments shall also be digital type of the same accuracy. Wattmeters shall be suitable for unbalanced systems and accuracy of energy meters should be of 0.2 % accuracy class.

All indicating instruments shall generally withstand without damage a continuous overload of 20% referred to the rated output value of the corresponding instrument transformers.

All instruments mounted on the same panel shall be of same style and appearance.

1.31 PAINTING OF WORKS AT SITE

1.31.1 Painting Materials

Coating materials shall be standard products of a renowned paint manufacturer with proven experience in the field of painting materials. Paint material shall be delivered in unopened original containers bearing the manufacturer's brand name and colour designation, storage directions and handling instructions. The entire paint material for a particular specified paint

system shall be supplied by one manufacturer only, who shall guarantee the compatibility and quality of the paint material. A complete list of the proposed paint material shall be submitted to the Engineer.

The Contractor shall submit to the Engineer for approval an overall colour scheme in accordance with the Particular All final coats shall be in the colours approved by the Engineer. On request of the Engineer, painting samples for the different coats and colours shall be provided. The manufacturer's instructions for preparation and application of all painting and protective coats shall be strictly observed.

1.32 NOISE LEVEL

The equipment 'A' weighted sound pressure level measured at a height of 1.50 m above floor level in elevation and at a distance of one (1) meter horizontally from the nearest surface of any equipment/machine, furnished and installed under these specifications, expressed in decibels to a reference of 0.0002 microbar shall not exceed 90 dBA.

1.33 METEOROLOGICAL DATA

1.34 CODES & STANDARDS

1.34.1 General

All equipment supplied and works execute under these specification shall conform to the latest edition of the applicable standards to gather with any amendment to data.

The codes and/or standards referred to in these specifications shall govern, in all the cases, wherever such references are made. In case of conflict between such codes and/or standards and the specifications, the latter shall govern. Such codes and/or standards are referred to shall mean the latest revisions/amendments/changes adopted and published by the relevant agencies. In case of any further conflict in this matter, the same shall be referred to the Engineer, whose decision shall be final and binding.

Other internationally acceptable standards, which ensure equal or higher performances than those specified shall also be accepted.

Abbreviations have been used for denoting international and National Standardization Organizations.

References Abbreviation	Name & Address
ASA	American Standards Association
ASTM	American Society of Testing and Materials 1916, Race Street, Phildelphia Pennsylvania-19103, USA
BS	British Standards

	British Standards Institution
	101, Pentonvite Road, London N 19 ND, U.K.
CEE	Commission on rules for the approval of Electrical
	Equipment (Netherlands) Netherlands Normilisatie –
	institute Polkwege, Rijswijk (ZH) – 2016, Netherlands.
DIN	Deutsche
IEC	International Electromechanical Commission Bureeque
	Central Delta Commission Electro technique
	International, 1, rue de Varrmbe Geneve, Switzerland.
IS	Indian Standards
	Manak Bhawan, 9 Bahadur Shah Zafar Marg New Delhi-110001
JIS	Japanese National Standards
VDI	German Standards

1.34.2 TURBINES, GENERATORS AND ANCILLARY PLANT

1. International Code for Field Acceptance Test of Hydraulic Turbines Publication no. 41 (IEC - 60041)-1963.
2. International code for testing of speed governing systems for hydraulic turbines. The IEC - 60308 -1970
3. Test code for Hydraulic Prime Movers, ASME Power Test Codes, ASME-New York 1949.
4. International Code for Model Acceptance Tests of Hydraulic Turbines 60193-1965-193A-1972.
5. International Standard for rotating electrical machines (IEC – 1116)
6. Test Procedure for Synchronous Machine; IEE 115

1.34.3 CODES AND OTHER STANDARDS

1.	Bolt calculation	:	VSM 14 332;
2.	Vibrations	:	VDI 2 056;
3.	Shaft coupling	:	ANSI B 49.1;
4.	Shaft alignments	:	NEMA;
5.	IEEE – 1249-1996	:	Std. for computer based control of Hydroelectric power plant automation

1.34.4 INDIAN STANDARDS

Other internationally acceptable standards, which ensure equal or higher performances than those specified shall also be accepted subject to the approval of Engineer-in-charge, provided they ensure equal or better performance:

S. No.	IS:CODE	DESCRIPTION
1.	IS:4722-1968	Rotating electrical machines
2.	IS: 4889	Method for determining Efficiency Rotating Electrical Machines
3.	IS:325-1978	Three phase induction motors
4.	IS:8789-1978	Values of performance for three-phase induction motors
5.	IS:3156	Voltage transformers
6.	IS:L3156 (Pt.I)-1978	General requirements
7.	IS:3156 (Pt.II)-1978	Measuring voltage transformers
8.	IS:3156 (Pt.III)-1978	Protective voltage transformers
9.	IS:3156(Pt.IV)-1978	Capacitor voltage transformers
10.	IS:2705	Current transformers
11.	IS:2705 (Pt.I)-1981	General requirements
12.	IS:2705 (Pt.II)-1981	Measuring current transformers
13.	IS:2705 (Pt.III)-1981	Protective current transformer
14.	IS:2704 (Pt.IV)-1981	Protective current transformers for special purpose applications
15.	IS:2026	Power transformers
16.	IS:2026 (Pt.I)-1977	General
17.	IS:2026 (Pt.II)-1977	Temperature-rise
18.	IS:2026 (Pt.III)-1981	Insulation levels and dielectric tests
19.	IS:2026 (Pt.IV)-1977	Terminal markings, tappings and connection
20.	IS:335-1983	New insulating oils
21.	IS:3231-1965	Electrical relays for power system protections
22.	IS:3043-1966	Code of practice for earthing
23.	IS:13300 - 1992	Nickel Cadmium Aircraft Batteries (aerobatic and Non-Aerobatic) - specification
24.	IS:13118 – 1991	Specification for high voltage alternating current circuit breakers

25.	IS:2147-1980	Degree of protection provided by enclosures for low voltage switchgear and control gear
26.	IS:L1554(Pt.I)-1988	PVC insulated (heavy duty) electric cables for working voltages upto and including 1100 V
27.	IS:13947– 1993 (Part 1 – 5)	Specification for low voltage switchgear and control gear – Part 5 – Control circuit devices and switching elements - section – 1 Electromechanical Control Circuit Devices
28.	IS: 7098 (Part 2) - 1985	Cross-linked polyethylene insulated PVC sheathed cables for working voltages from 3.3 KV up to and including 33 kV.
29.	IS: 3961	Recommended current ratings for cables
30.	IS: 8130	Conductors for insulated electric cables and flexible cords.
31.	IS: 5831	PVC insulation and sheath of electric cables.
32.	IS: 3646 (Part 1 to Part 3)	Code of practice for interior illumination
33.	IS: 732-1989	Code of Practice for wiring installation
34.	IS: 9537	Conduits for Electrical Installation
35.	IS: 2309 – 1989	Code of practice for the protection of buildings and allied structures against lightning (second revision)
36.	IS: 807 – 1976	Code of practice for design, manufacture, erection and testing (structural portion) of cranes and hoist
37.	IS: 3177 - 1999	Code of practice for electric-overhead traveling cranes and gantry cranes other than steel work cranes
38.	IS: 1646 – 1997	Code of practice for fire safety of buildings (general): Electrical Installation
39.	IS: 3034 – 1993	Fire safety of industrial buildings: Electrical generating and distributing stations

1.35 TEST SCHEDULES

The contractor shall prepare and submit for approval the following test schedules at least one month in advance before commencement of the work:

i. Factory tests (3 months advance of delivery)

ii. Pre-commissioning tests on all the equipments/instruments

iii. Commissioning tests on all the equipments/instruments

iv. Acceptance tests on all the equipments/instruments

1.36 COMPLETENESS

The specifications are drawn for the purpose of spelling out the broad requirement. Any item necessary for the proper functioning / performance of the project not mentioned in this specification but is required shall be deemed to be a part of the scope and the contractor shall have to supply, erect and commission this item(s).

SECTION-: TECHNICAL SPECIFICATIONS

SUB-SECTION : 2 TECHNICAL SPECIFICATIONS OF HYDRAULIC TURBINES, GOVERNING EQUIPMENT AND AUXILIARIES

2.1 SCOPE

The Morbe Dam has been constructed by Water Supply and Sanitation Department of the Government of Maharashtra on Dhavri river in the year 1999 and in year 2003, NMMC acquired Morbe Dam for its own independent & operational source of water. Morbe Dam is situated near Khalapur in Raigad district of Maharashtra and is approximately 36 kms. away from Navi Mumbai Head Office

The powerhouse site is on the right Bank of River Vaitarna and the powerhouse area is well connected with an all-weather road.

The scope of contract includes all supplies for turbines and auxiliaries as well as complete mounting ready to operate so that no performance of a third party is needed.

The Contractor must inspect and check all relevant details of the site and is expected to introduce all necessary steps in time. All parts can be delivered directly on site. All workshop-manufactured parts should be coated and be treated as per coating requirements and be equipped with transport lugs for ease of mounting and handling. All lugs shall be retained to allow the future removal for maintenance and re-installation of turbines and auxiliaries.

The relevant codes have to be respected as well as ranked as given below:

Technical details of tender Docs and Specifications

Order form including all relevant supplements

Indian Standards, and with priority, IEC / IEEE Codes

All details requested by governmental bodies within approval documentation

Security codes for onsite manufacturing

Legal and governmental relevant rules

The scope of work under this Section of Technical Specifications includes design, manufacture, shop assembly and testing, transportation & delivery to site, Marine Cum Erection (MCE) insurance, storage at site, installation, commissioning, field acceptance tests, warranty and other services specified or required for the following items of work:

a) Two sets of hydraulic turbines shall be designed to give rated output of 750 kW + 15% continuous overload at rated head with guide vane opening of about 85%. The turbines shall have adequate capacity commensurate with the 15% continuous overload capacity of Generator and each consisting of the following main assemblies:

- Spiral case with stay ring, anchors, tie rods, support plates and embedment.
- Draft tube liner with anchors, tie rods, support pads and embedment etc.,

- Wicket Gate assembly with turning mechanism,
- Turbine Runner,
- Turbine Shaft and shaft seal, if applicable as per manufacturer's design
- Turbine Guide Bearing, if applicable as per manufacturer's design
- Necessary embedded pipe lines,
- Access Shafts, hatch covers, steel walk ways & platforms etc,
- Lubricating Oil System for Bearings,
- Submersible pump motor set for draining turbine inner cone with level sensors,
- Necessary cable junction boxes and cables from electrical items for termination at convenient points,
- Governing system including digital electro-hydraulic governor, speed signal generator, over speed trip device, emergency shut down device, restoring mechanism, oil pressure unit, oil leakage unit and oil pipe lines,
- Turbine Gauge Panel with necessary instruments and safety devices

b) All special tools, tackles and handling devices required for assembly, erection and dismantling during maintenance, templates for repair of runner blades and wicket gates at site, hydraulic testing Pumps with test plugs,

c) All parts and accessories required to make a complete operating unit for controlling and regulating the speed of the turbine in conformity with the performance characteristics.

d) Governor oil, lubricating oil and grease for flushing and first filling with 20% extra quantity, site consumables like welding electrodes, paints and cleaning agents etc. in sufficient quantity

e) Set of Spare Parts for five years trouble free operation as per schedule of spares

f) Turbine Model Testing, if desired by NMMC

g) Marine Cum Erection (MCE) Insurance, transportation, receipt and storage of goods at site

h) Installation, testing, commissioning and acceptance testing of the turbines and associated equipment

i) Preparation and submission of Operation & Maintenance manual and Erection & Commissioning Manual including those for bought out items

j) The Contractor shall be responsible for operation & maintenance of all electro-mechanical equipments for a period of eight (8) weeks.

2.2 TURBINE BASIC DATA & GENERAL INFORMATION ON WATER CONDUCTOR SYSTEM

2.2.1 Turbine Basic Data

Efficiency of the turbines at rated condition (i.e. at rated net head and rated output) shall not be less than 91%.

2.2.2 General Information

Each of the turbines shall be directly coupled to vertical shaft generators.
The direction of rotation shall be clockwise when viewed from top.

General arrangement of the Power House and turbines has been tentatively outlined in tender drawings. The Centre line of the sets shall be fixed suitably corresponding to minimum tail water level. There may be minor change in elevation of turbine Centre line based on the required minimum suction height recommended by the Concessioner, however no significant increase in suction height will be accepted.

The turbine shall have adequate capacity commensurate with the 15% continuous overload (COL) capacity of Generator.

2.3 BASIC PROVISIONS

The turbines shall have adequate capacities commensurate with the 15% continuous overload capacities of Generators. Each turbine would give output higher than the rated output when operating at heads higher than rated head. Each turbine shall comply in all respect of various standards with the requirement of the latest issue of Indian Standard and IEC-41.

Similar machine designed on the basis of model offered against this tender should be under satisfactory operation at least on two different projects for at least last three years.

The turbine manufacturer shall co-ordinate with the generator supplier so that the generator to be coupled with the turbine is matched in respect of speed, runway speed, moment of inertia, overload capacities, couplings and other relevant requirements.

2.4 STANDARDS

Turbines shall meet provision made in the following standards (latest edition) unless otherwise mentioned:

(a) IEC 41: 1991: Field acceptance tests to determine the hydraulic performance of hydraulic turbines, storage pumps and pump-turbines

(b) IEC 193: 1965: International code for model acceptance tests of hydraulic turbines.

Amendment No. 1 (1997)

(c) IEC 193A: 1972: (1965) First supplement to IEC 193

(d) IEC 308: 1970: International code for commissioning, operation and maintenance

of hydraulic turbines

(e) IEC 609: 1978: Cavitations pitting evaluation in hydraulic turbines, storage pumps and pump-turbines

(f) IEC 545: 1976: Guide for commissioning, operation and maintenance of hydraulic turbines

(g) IEC 60994: 1991: Guide for field measurement of vibrations and pulsations in hydraulic machines (turbines, storage pumps and pump turbines)

(h) IEC 61362: Guide to specification of hydro-turbine control systems

(i) ISO 3740: 1980: Acoustics- Determination of sound power levels of noise sources- Guidelines for the use of basic standards and for the preparation of noise test codes

(j) IEC 61366: Hydraulic turbine of giving outputs higher than rated outputs to match

20% overload capability of the generators

(k) VDI 2056 & VDI 2059: Vibration level in rotating machines

Equipment complying with other internationally accepted standards such IEC, BS, USA, VDE etc. will also be considered if they ensure performance and constructional features equivalent or superior to standards listed above. In such a case the Concessioner shall clearly indicate the standards adopted, furnish a copy in English Language of the standards adopted, furnish a copy in English Language of the latest revision of standard along with copies of all official amendments and revisions in force as on date of opening of Bid and shall clearly bring out the salient features for comparison.

2.5 PERFORMANCE GUARANTEES AND LIQUIDATED DAMAGES

2.5.1 Output and Efficiency Guarantees

Maximum Output and efficiency of each turbine at design head shall be stated in Guaranteed Technical Particulars of Turbine and will be guaranteed by equipment suppliers. The turbine shall also be suitable for safe and efficient performance at part loads upto fifty percent (50%) of rated output with minimum head conditions.

Field test (as per IEC-41-1991) shall form the final basis to establish fulfillment of guarantees of the turbine and for purposes of liquidated damages and rejection of plant.

2.5.2 Weighted Average Efficiency

Weighted Average Efficiency of the prototype Turbine - Generator unit shall be determined from the field test values of efficiency at the rated head in accordance with the following formula for rejection limits. The field tests on the turbine shall be carried out by the supplier as specified in IEC or equivalent International Code or mutually agreed method. The field test on the Generator will also be carried out as per appropriate IEC or equivalent International Code or on mutually agreed method.

$\eta E_{av} = K_1 * \eta E_{115\%} + K_2 * \eta E_{100\%} + K_3 * \eta E_{80\%} + K_4 * \eta E_{60\%}$

Where ηE_{av} is the weighted average efficiency of the Turbine-Generator

$\eta E_{115\%} = \eta T_{115\%} * \eta G_{115\%}$ = Efficiency of the Turbine-Generator at 115% of Rated Output at Rated Head

$\eta E_{100\%} = \eta T_{100\%} * \eta G_{100\%}$ = Efficiency of the Turbine-Generator at 100% of Rated Output at Rated Head

$\eta E_{80\%} = \eta T_{80\%} * \eta G_{80\%}$ = Efficiency of the Turbine-Generator at 80% of Rated Output at Rated Head

$\eta E_{60\%} = \eta T_{60\%} * \eta G_{60\%}$ = Efficiency of the Turbine-Generator at 60% of Rated Output at Rated Head

The values of K_1, K_2, K_3 & K_4 are dependent on operating conditions i.e., the percent of time the machine is running in that condition with that efficiency.

Weighted Average Efficiency:

Values of K_1 , K_2 , K_3 & K_4 for Turbines to be provided for Morbe Dam H. E. Project shall be as under:

$K_1 = 0.20$ $K_2 = 0.40$ $K_3 = 0.20$ $K_4 = 0.20$

The weighted average efficiency of the turbine at rated head for one hundred twenty percent (115%), hundred percent (100%), eighty percent (80%) and sixty percent (60%) rated output shall also be guaranteed. These figures shall be applicable for purpose of penalties, rejection limits and bid evaluation. In addition the outputs as per discharge conditions used for calculation of generation shall also be guaranteed. The output of the turbine at full gate and lowest operational wicket gate opening shall be stated in the tender for various runner blade angles. Guarantee is fulfilled only if it is in accordance to the IEC Code 41, at given discharges.

2.5.3 Bid Evaluation- DELETED

2.5.4 Output and Efficiency Tests

Output and Efficiency test as per IEC-41-1991 shall be conducted at different heads and guide vane openings to determine guaranteed efficiency parameters. Any deviation from IEC-41-1991 shall be clearly stated in the DPR. Concessioner shall furnish details of test methods, agency which will conduct the test, provisions to be made for field testing,

calibration of instruments for purposes of test and all other relevant details in the DPR. Contractor shall be under obligation to accept these tests for purposes of liquidated damages. NMMC reserves the right to appoint the contractor or any independent agency or agency recommended by contractor for conducting these tests.

2.5.5 Penalty for Shortfall in Weighted Average Efficiency and Output

DELETE
D

2.5.6 Rejection Limit

Weighted average efficiency or the rated output should be less than the corresponding guaranteed value by two percent (2%) or more after allowing tolerance in computation of efficiency.

2.5.7 Cavitations Guarantees

The Supplier shall guarantee the runner against excessive pitting caused by cavitations for

18 months from the date of commissioning or 8000 hours of operation, whichever is earlier as per clause 3.3.1 of IEC-60609-2 (1997).

Excessive pitting shall be defined as the metal removed from runner by a weight of $W=0.15\ D^2$ per 1000 hours of operation, where, D = Discharge diameter of the runner and W = Weight in kg. If the 18 months of guarantee period expires before completion of 8000 hours of operation, the guarantee shall apply to the actual hours of operation proportionately.

In case of cavitation pitting exceeding the guarantee, the Contractor shall, at his cost, take corrective measures such as repair as per original design, repair as per modifications or replacement etc., and turbine after modification etc., shall be subject to fresh cavitation guarantee as for the original equipment. In determining whether or not excessive pitting has occurred, uniform metal removal by erosion, corrosion or by the presence of injurious elements in water, etc., shall be excluded.

2.5.8 Vibrations and Noise Limit

Turbine design shall ensure smooth and quite operation with low vibrations, pressure pulsation, power fluctuations and noise. The vibration amplitude at the shaft shall not exceed the values specified in ISO-7919 (part-1) and ISO-3945 or VDI 2056 and VDI 2059 or IEC

60034-9 when measured with instruments with1 Hz cut-off frequency.

Maximum noise level resulting from any of the operating conditions shall not exceed 95 db (A)

at any place 1.0 m away from any operating equipment in the machine hall.

2.5.9 Factor of Safety

All parts of turbine shall be designed and constructed to safely withstand the maximum stresses during normal running and runaway and short circuit conditions, out of phase synchronizing and brake application. The maximum unit stresses of the rotating parts shall not exceed two third of the yield point of the material. For other parts, the factor of safety based on yield point shall not be less than 3 at normal conditions. For overload and short circuit conditions, a factor of safety of 1.5 on yield point shall be permitted.

2.5.10 Runaway Speed

The maximum runaway speed shall be stated and guaranteed by the supplier. All rotating parts and bearings shall be capable of withstanding the forces and stresses occurring during runaway speed for at least 15 minutes without any damage to any part. The guide bearing and guide cum thrust bearing shall be capable to withstand runaway speed for 15 minutes without supply of cooling water and continuously with cooling water without abnormal increase of vibrations and temperature.

2.5.11 Speed Rise, Pressure Rise and Inertia

The moment of inertia of the generating unit and closing time of wicket gate shall be so selected that the maximum momentary speed rise of unit shall not exceed 50% of normal speed and pressure rise shall not exceed 40 % of maximum head. The turbine manufacturer shall coordinate with the generator manufacturer for achieving the required flywheel effect.

2.6 MODEL TEST

The Concessioners shall offer the turbine with already tested model and proven performance of prototype machines at least at one project site for a period not less than two years. The Concessioner shall enclose copy of the expected prototype hill chart for the offered Turbines and the efficiency values as guaranteed by the Concessioner. Concessioner shall arrange certificate of trouble free operation of the similar turbines from their owners and enclose the same in the DPR.

The NMMC reserves the right to witness fresh model tests to ensure that the guaranteed parameters will be met by the prototype. For this purpose, the Concessioner shall quote charges for conducting the model test in his laboratory and or in an independent approved laboratory in the presence of NMMC's Engineers and their Consultants.

The tests shall be as per IEC test code publication No.193 and 193A. "International code for Model Acceptance Test of Hydraulic Turbines". Model test results shall be subject to the approval of the NMMC. The contractor shall commence manufacture of the prototype after approval for the model test results. Prototype efficiencies shall be derived from model tests by the Moody's step-up formula as contained in IEC 193 for turbines.

2.6.1 Tests to be conducted on the Model

The final model test series shall include but not be limited to the following

tests:

- Performance (efficiency & output) test under various head conditions and corresponding to 100%, 80%, 60% and 115% rated output.
- Determination of peak efficiency at rated design head at rated speed.
- Measurement of hydraulic thrust and runaway speed test at full (100%) guide vane opening at maximum net head.
- Complete Hill chart
- Cavitation at maximum, rated and minimum head at openings corresponding to guaranteed output.
- Checking of Model dimensions as per IEC.

2.7 RECTIFICATION TO MEET GUARANTEES

The Contractor shall be given three months or mutually agreed time to improve/modify the design of the turbine or to carry out rectification etc., as may be required so that the guarantees are met in case the model tests prove unsuccessful in meeting the guarantees. If the second attempt is also unsuccessful, penalty or rejection of the equipment, as the case may be, shall be applied. However, no delay in the original delivery schedule shall be allowed if the model test results do not meet the guarantees and rectifications are made by the Contractor there after within a period of three months.

2.8 STRESSES AND FACTOR OF SAFETY

All parts of turbine shall be designed and constructed to safely withstand the maximum stresses during the normal running, runaway and short circuit conditions, out of phase synchronizing and brake application. The maximum unit stresses of the rotating parts shall not exceed two thirds of the yield point of the material. For other parts, the factor of safety based on yield point shall not be less than three in normal conditions. For over-load and short circuit conditions, a factor of safety of 1.5 (one and a half) on yield point shall be permitted.

2.9 CRITICAL AND PLANT SIGMA

Values of critical sigma as determined from cavitations model tests as per IEC 193A shall be given in the form of curves of different heads of operation. Plant sigma curves as recommended by the manufacturer shall also be plotted on it clearly to show the safety margin available.

2.10 DEVIATIONS FROM TECHNICAL SPECIFICATIONS

All deviation from General Technical Specifications and Technical Specifications under this section should be clearly brought out at one place in the 'List of Deviations' from Technical Specifications. Any deviation not clearly mentioned in the List of Deviations, but described

elsewhere in the equipment Description shall not be acceptable. After award of contract, the Concessioner has to fulfill all the requirements of technical specifications except the deviations clearly spelt out and accepted by the NMMC.

2.11 Constructional Features of important components

2.11.1 General

The turbine shall be of the spiral casing type so constructed as to allow all the removable parts to be dismantled conveniently. The design shall also permit horizontal movement of runner shaft by an amount sufficient for adjustment of bearings and for clearing the joint at the coupling between the turbine and the generator.

All equipments shall be neatly arranged and shall be readily and easily accessible for operation and maintenance. Necessary walkways, ladders, handrails, chequered plates, platforms, etc., to be provided, wherever required.

Each turbine shall consist of following major parts
:

2.11.2 Spiral Casing with Stay Ring and Generator Side Cover

The Spiral Casing to consist of several steel plate sections, adapted to the side plates of the stay ring and welded in place. On the upstream side, a weld-on flange with a distance piece to provide a connection between the spiral inlet to the turbine inlet valve.

The generator side head over to be either bolted or to form an integrated part of the stay ring.

The assembly will be pressure tested in the works to a mutually agreed test pressure before its shipment to site.

2.11.3 Draft Tubes

Each turbine shall be provided with a Draft tube liner / suction bend of welded construction of structural steel. The draft tube cone shall have machined flange for bolting with the running chamber. Drain box and drain pipes for dewatering of the draft tube (if applicable) shall be included in the scope of supply .The design of the draft tube shall be such as to ensure the best over all efficiency for the turbine and stable and pulsation free operation of the machine

2.11.4 Wicket Gate Mechanism

i. Guide Vanes

Each guide vane and its stem should be an integral casting in 13:4 Stainless Steel. The contacting surface of gates and the gate stems shall be smooth and finish machined. All guide vane bearings (Axial / radial) shall be maintenance free, with appropriate sealing against water flow channel by ‘O’ rings.

ii. Levers / Links

The guide vane links / levers shall be clamped to the guide vane stem and locked in

position during assembly. A suitably designed frictional clutch mechanism shall be provided to prevent possible damage to the wicket gates in case of trapped foreign bodies between the gates.

iii. Servomotors

Double Acting servomotors operated by governor oil pressure shall be mounted on the generator side head-cover. Servomotors shall be of sufficient capacity to operate the gates, when supplied with oil at minimum pressure. Opening / closing timings will be adjusted during workshop tests. The servomotors will be pressure tested at 1.5 times the design pressure.

2.11.5 Runner

The runner to be of 13:4 Stainless Steel as an integrated casting or Cast-weld construction, with labyrinths, separate / integrated at rim & crown. The torque transmission to the turbine shaft shall be via a key, if Turbine shaft is applicable as per the manufacturer's design.

The system adopted by the Concessioner for relieving hydraulic thrust shall be described in details in the DPR.

2.11.6 Turbine Guide and Thrust Bearings, if applicable as per manufacturer's design

The turbine shall be provided with an oil-lubricated guide bearing with suitable Babbitt lining for the shaft. The bearing shall be designed for the turbine radial and axial loads. The bearing shall be split to facilitate dismantling. Bearing shall be provided with suitable instrumentation for monitoring the temperature and oil level. (The turbine manufacturer should co-ordinate with the Generator manufacturer for overall bearing arrangement of generator bearings, flywheel etc). The oil system for both turbine and generator bearings shall preferably be common.

2.11.7 Turbine Shaft, if applicable as per manufacturer's design

The turbine shaft will be 1.5% Mn Steel forging conforming to Bureau of Indian Standards or equivalent International Standards. It will have integrally forged coupling flanges for coupling to generator rotor and turbine runner.

The couplings for connecting to turbine runner and generator rotor shall be friction type with pre-stressed coupling bolts. The tightening torque for coupling bolts will clearly be mentioned on drawing. If necessary, torque transmitting pins will be provided on coupling flanges. Proper size rubber cords shall be used between coupling joints to avoid leakage of oil / water. Torque tightening wrench will be included in scope of supply under special tools.

The shafts and coupling bolts of both the units shall be made interchangeable.

Method to avoid damage due to axial forces of the vertical machine shall be elaborated in the bid document.

Note : *Concessioner can also offer arrangement with turbine runner mounted directly*

on extended generator shaft.

2.12 MAIN INLET VALVE

Each of the turbine inlets shall be provided with individual butterfly type valve of diameter suitable for connecting to penstock. The valves should be so designed as to cause minimum head loss. The valve body should be designed to withstand 150% of the static head on the valve including the pressure rise in the event of sudden gate closure with full rated load throw- off by the turbine.

The valve shall be capable of sealing the water flow through it with full penstock pressure (static head) on the upstream side and atmospheric pressure on the turbine side. The valve shall also be capable of closing automatically under normal & emergency shut down conditions and closing time shall be such that turbine over speed does not exceed 140%. While opening the inlet valve, a bye-pass valve shall be provided to equalize the pressure between the upstream and the downstream sides of this valve.

The valve shall be opened automatically by a single acting hydraulic servomotor and closed by means of counterweight. Manual control of the valve shall also be provided.

2.13 GOVERNING SYSTEM

Being a run-of-river scheme, the selection of the equipments and the control system shall aim at maximizing annual power generation with the available discharge and head conditions with maximum availability, reliability, efficiency based on the available quantity of water. The power generation of the units will be controlled by sensing the water level at intake with appropriate integration of this parameter with turbine governing system, which eventually will dictate the power to be generated. The governor will be electro-hydraulic which can be of manufacturer's own standard, capable of integrating into the unit control system, which have SCADA System (Supervisory Control and Data Acquisition System) with built-in Programmable Logic Control (PLC) for starting and shutting down of individual turbines and generators. The PLC shall be programmable and intelligent to cut-in and cut-out and lower the turbine load depending upon the water level / water availability at the intake.

The programming tool shall be in the Scope of the Concessioner. The Contractor shall have to impart training on the trouble shooting of Governor and its programming to at least two personnel of the NMMC. Operation & Maintenance Manual and Drawings of Control Cards with and other modules shall be made available to the NMMC by the Contractor
/Concessione
r.

Each Turbine would have its dedicated operator console and one master engineering console.

The governor and the control system as a whole shall be operable in manual mode at the discretion of the operator. The manual control shall be robust and shall not need complex maintenance by an expert.

The closing and opening times of guide vans shall be adjustable.

2.14 TURBINE INSTRUMENTATION, CONTROL AND SAFETY DEVICES

Each turbine shall be provided with complete set of instruments, gauges, controls and safety devices at appropriate places for monitoring the conditions of the unit during normal running and emergencies. The instruments and gauges for the turbine include pressure gauges, level indicators, temperature and flow indicators, position indicators etc. These shall be placed on the respective equipment and / or Turbine Gauge Panel. The safety devices shall comprise equipment and devices for sensing abnormal operating conditions and send signal to Unit Control board for indication, annunciation or control action. The Concessioner shall include all the instruments required for the safe and satisfactory operation of the generating units and the auxiliary systems.

A signal flow chart showing various important steps of control, operation and indications etc., during starting, normal stopping, emergency stopping, loading of unit etc., so as to explain the general operating features of turbine; shall be enclosed with the Bid. The safety devices shall include devices to stop the unit automatically in case unit trip command is initiated from any device.

2.15 SPARE PARTS

Spare parts required for five (5) years of trouble free operation as provided in the Schedule of

Spare
s.

2.16 TOOLS

The Concessioner shall include complete set of special tools for the assembly and dismantling of the turbines including special lifting tackles, set of case hardened wrenches and specified tools. The wrenches and tools to be mounted on a neat plate steel wrench board with markings for easy identification.

2.17 SHOP ASSEMBLY AND TESTS

The Concessioners shall submit the Quality Assurance Plan (QAP) indicating the tests to be performed and witnessed by NMMC and their acceptance criteria. The Contractor shall get the quality plan approved from NMMC as per Contract Conditions.

2.18 MATERIAL TESTS

Material tests for important components such as runner levers, wicket gates, turbine shaft, guide & thrust bearing pads / bushes, piston rods and other important components shall be carried out as per agreed quality plan. NMMC shall review the test certificates during inspection.

2.19 ERECTION, TESTING AND COMMISSIONING

2.19.1 Erection / Installation

The Concessioner shall quote equipment wise price for erection, testing and commissioning of turbines, governors, MIV (Butterfly Valve) and associated equipments. All services including storage at site, transportation of equipment from stores to Power House site, handling of equipment in Power House and various consumables required during erection & commissioning etc will be arranged by the Contractor at his expenses. The Contractor will be bound to work in close liaison with Contractors for civil & hydro-mechanical works for marking the locations of equipment and hand over the items of his supply for embedment at agreed schedule. Erection, testing and commissioning of bought out items / equipment shall be arranged by the Contractor at scheduled time at his cost.

The Concessioners shall submit field quality assurance plan indicating the field tests to be conducted by the Contractor and his sub-suppliers and witnessed by the NMMC during pre-commissioning, commissioning and acceptance along with their acceptance criteria. The Contractor shall get the quality plan approved from the NMMC.

2.20 PERFORMANCE TESTING AND MONITORING

2.20.1 The units shall be tested for absolute efficiency as well as for efficiency curve.

2.20.2 Following provisions shall be made as per relevant International standards (IEC and ISO) and Indian Standards (BIS) at the time of executing Civil works and manufacturing the Electro- mechanical works:

(a) Provide permanent benchmarks for reference at the powerhouse building, tailrace channel and intake.

(b) Provide tapping in the penstock and at the exit of draft tube for pressure measurements.

2.20.3 Index Discharge Measurement Provision

Provision shall be made for index discharge measurement for continuous as well as for performance testing as follows:

Tappings shall be provided as per IEC 41 for differential pressure measurement as per IEC

4
1.

The performance tests will be conducted preferably within 2 months of the commissioning of the unit (as per IEC) for the following:

a) Efficiency of generating units

b) Testing for rated discharge and head at the inlet of turbine

2.21 GUARANTEED AND TECHNICAL PARTICULARS

The Concessioner shall furnish Performance Guarantee Particulars and Guaranteed Technical Particulars of Turbine and Governing System given in Schedule A.

2.22 SCHEDULE OF INSTRUMENTS

TABLE
`A'

Schedule Minimum Requirement of Indicating / Recording instruments for Turbine, Governing and Auxiliaries Equipment

S. No.	Parameter indicated / recorded	Type of Instrument	Location	Qty.	Remarks
A	**Temperature of :**				
01	Turbine guide bearing pads	RTD	Turbine Guide Bearing	2	Indication / Alarm at UCB & SCADA
02	Turbine guide bearing	TSD	- do -	1	Alarm / Shutdown
03	Turbine guide bearing oil	RTD	- do -	1	Indication / Alarm at UCB & SCADA
04	Oil in OPU sump	RTD	Local	1	Indication / Alarm at UCB
B	**Pressure of :**				
05	Oil in Pressure Accumulator	PG	Local	1	Local Indication
06	Oil in Governor Actuator	PG	Local	1	
07	Oil in Servomotor	PG	TG Panel	2	
08	Before guide vanes	PG	TG Panel	1	
09	Draft Tube	PVG	TG Panel	1	
10	Water in Shaft Seal	PG	TG Panel	1	If Applicable
11	Air in Shaft Seal	PS	Local	1	If Applicable
12	Air in HP air receiver	PG	Local	1	
13	Air in LP air receiver	PG	Local	1	
14	Cooling Water	PG	Local	1	
15	Low / Very Low / Emergency Low Pressure in OPU	DPS	Local	3	For control of OPU pumps / emergency shut down
16	Low/Very Low air pressure in HP air	DPS	Local	2	For control of compressors
C	**Levels of :**				
17	Oil in Turbine Guide Bearing	SG	Local	1	
18	Oil in Turbine Guide Bearing – Low / High	ELC	Local	2	Alarm in UCB
19	Oil in OPU sump – High / Low	FSW	Local	1	Alarm in UCB

S. No.	Parameter indicated / recorded	Type of Instrument	Location	Qty.	Remarks
20	Oil in Pressure Accumulator – low / very low / high	FSW	Local	3	Alarm/shut down/ control of air qty.
21	Oil in oil leakage unit	FSW	Local	2	Control of pump / alarm
22	Oil in oil leakage unit	SG	Local	1	
23	Leakage water in turbine cover	FSW	Local	2	Alarm in UCB
24	Water in dewatering sump	ELC	Local	3	Control of dewatering pumps / alarm
25	Water in drainage sump	ELC	Local	3	Control of drainage pumps / alarm
D	**Flow of :**				
26	Cooling water in main line	MFR	Local	2	Control of Pumps / alarm
27	Cooling water at TGB outlet	FR	Local	1	Alarm / starting interlock
28	Cooling Water in shaft seal	FR	Local	1	alarm
E	**Other Instruments / Indicators**				
29	Guide Vane Position (%)	Mechanical Indicator	Governor Actuator	1	Duplication at UCB
30	Guide Vane Limiter Position (%)	Elec. / Mech. Indicator	- do -	1	Duplication at UCB
31	Speed of Generating set (0 - 200 %)	Elec. Indicator	- do -	1	Duplication at UCB
32	Control Current in Actuator Solenoid	Elec. Indicator	- do -	1	Duplication at UCB
33	Speed Setting Indicator	Elec. Indicator	- do -	1	Duplication at UCB
34	Gate setting Indicator	Elec. Indicator	- do -	1	Duplication at UCB
35	Servomotor locked / unlocked	LS	Local	2	Starting Interlock
36	Guide Vanes shear Pins fail	LS	Local	24	Alarm

RTD - Resistance Thermometer (these will be wired up to Temperature Indicator& Recorder Instrument mounted on control & Metering Panel)

TSD - Thermo Signaling Device (With two set points for Alarm and Trip commands)

PG - Pressure Gauge

FSW - Float Switch

FR - Flow Relay

MFR - Magnetic Flow Relay

ELC - Electronic Level Controller

TABLE 'B'

SAFETY DEVICES (FOR ALARM / SHUT DOWN)

S. No.	Parameter	Type of Instrumen	Location	Qty.	Remarks
01	Turbine guide bearing pads	RTD	Turbine Guide Bearing	2	Alarm
02	Turbine guide bearing pads	TSD	- do -	1	Alarm/ Shutdown
03	Turbine guide bearing oil	RTD	- do -	1	Alarm
04	Oil in OPU sump	RTD	Local	1	Alarm
05	Very Low / Emergency Low Pressure in OPU	DPS	Local	2	Alarm / Shut down
06	Very Low air pressure in HP air receiver	DPS	Local	2	Alarm
18	Oil in Turbine Guide Bearing – Low / High	ELC	Local	2	Alarm
19	Oil in OPU sump – High / Low	FSW	Local	1	Alarm
20	Oil in Pressure Accumulator – Low/ Very Low	FSW	Local	2	Alarm / Shut down.
21	Oil Level in oil leakage unit - High	FSW	Local	1	Alarm
23	Level of Leakage water in turbine pit - High	FSW	Local	1	Alarm
24	Water Level in dewatering sump - High	ELC	Local	1	Alarm
25	Water Level in drainage sump - High	ELC	Local	1	Alarm
26	Flow of Cooling water in main line - Low	MFR	Local	2	Alarm
27	Flow of Cooling water at TGB outlet- Low	FR	Local	1	Alarm / starting interlock
28	Flow of Cooling Water in shaft seal - Low	FR	Local	1	Alarm
29	Guide Vanes shear Pins fail	LS	Local	24	Alarm

RTD - Resistance Thermometer (these will be wired up to Temperature Indicator & Recorder Instrument mounted on control & Metering Panel)

TSD - Thermo Signaling Device (With two set points for Alarm and Trip commands)

DPS - Differential Pressure Switch

FSW - Float Switch

FR - Flow Relay

MFR - Magnetic Flow Relay

ELC - Electronic Level Controller

SECTION-: TECHNICAL SPECIFICATIONS

SUB-SECTION – 3: TECHNICAL SPECIFICATIONS FOR SYNCHRONOUS GENERATOR AND ITS AUXILLARIES

3.0 SCOPE

The equipment shall include Two (2) Nos. Vertical Shaft Alternating Current, Synchronous Generators, each of capacity 2 x 750 kW with 1`5% continuous overload capacity, 0.85 pf, 11 kV, 50Hz, 428 rpm at site condition of 43°C ambient (maximum) and 9.0°C ambient (minimum) temperatures, with brushless excitation, automatic voltage regulators, neutral grounding cubicles, lightning and surge protection panels, cooling water system, and other accessories, spares and special tools that will be required for satisfactory and efficient operation of the power station. The Concessioner shall be responsible for operation & maintenance of all electro-mechanical equipments including training of NMMC's personnel for a period of eight (8) weeks after successful commissioning of the plant.

Each generator shall be coupled to the turbine matched in respect of speed, runaway speed, moment of inertia, overload capacities, coupling and other relevant requirements.

The generator first critical speed shall be greater than 120% of the runaway speed.

Efficiency of the generator shall not be less than 96% at rated output, rated speed & rated power-factor.

3.1 GENERAL

The generator shall be of air-cooled type with shaft-mounted fans housed in an IP23 enclosure and driven by Hydro turbine directly.

The Contractor shall furnish all technical particulars of the Generator in the data sheet for the generator.

Unit shall be capable of continuous operation at all loads. The excitation system shall be suitable for maintaining the voltage for a grid voltage variation of (-) 25% to + 10 % and / or a frequency variation of $\pm$ 3%. Generation voltage of the unit shall be 11 kV, 3 phase, 50 Hz.

The data like Synchronous speed, short circuit ratio, inertia constant etc., shall be specified by the Supplier.

The generator shall be suitable for operation in all respects and shall deliver rated output under system conditions stated as above. The generator shall remain stable on the sudden application of maximum load or sudden loss of maximum load and during momentary short circuits or sustained ground faults.

The generator shall be star connected and the main and the neutral leads shall be brought out of stator frame for insertion of current transformer for protection, metering and surge

protection apparatus. The generator shall be suitable for grounding through distribution transformer.

The short circuit ratio shall not be less than 0.8 and inertia constant not less than 1. The generator shall be capable of withstanding without damage a 3 second 3 phase short-circuit at its terminals when operating at rated KVA and PF at five percent (5%) over-voltage with fixed excitation in accordance with IEC 34-3.

The maximum line charging capacity at rated voltage that can be obtained without negative excitation and with stable operation of the generator may be indicated, which shall not be less than seventy percent (70%) of rated KVA.

The saturated rated direct axis transient reactance of generator should be guaranteed without any tolerance and shall not exceed thirty percent (30%).

The moment of inertia of the generator shall be so selected that it meets the requirement of turbine runaway speed conditions. The Concessioner shall furnish detailed calculation (in hard and soft copies) for GD^2 of the generator proposed to be supplied.

In the design of generator, each part shall be so proportioned that the maximum unit stresses therein resulting from any continuous operating conditions specified shall not exceed one third of the yield point or one fifth of the ultimate strength of the material whichever is less. In case of specified runaway speeds, unit stresses not exceeding two thirds of the yield point will be permitted.

The machine shall be capable of operating continuous on an unbalanced system such that, with none of the phase current exceeding the rated current, the ratio of the negative sequence component of current to the rated current does not exceed 0.1 and under fault conditions shall be capable of operation.

The design of the generator structure and housing in which resonance might become objectionable shall be so proportioned as to avoid the possibility of resonance with higher rated frequency or multiple.

The synchronous generator shall be designed and constructed so as to facilitate easy repair or replacement of generator stator bars and rotor poles.

3.2 RUNAWAY SPEED

The generator shall be designed so as to be capable of running at the maximum possible runaway speed of the turbine for at least fifteen (15) minutes and this shall be demonstrated by the Supplier to the NMMC or his authorized representative at the time of shop testing of the generator. During the run-away speed test, all parts of the generator and other equipment shall fully and safely withstand stresses resulting from over speed operation.

3.3 INSULATION

The Concessioner shall give full description of the windings offered both as to the conductor and insulation. Detailed drawings shall be submitted showing the arrangement of the conductors and the thickness and nature of all materials used both for insulation and mechanical protection in the slots of the stator.

Insulation of only 'F' class as specified in IEC, specification of the latest issue shall be used. The quality of the insulation must be such that it is non-hygroscopic and no deterioration will take place when subjected to the maximum, specified operating temperatures nor must it be permanently injured when exposed to this feature as the machine is to operate in a most tropical climate.

The end turns and the coil connections shall have not less than full insulation, equivalent to, and of the same construction as the coil insulation in the stator slots. The coil and end turns shall be impregnated with high grade insulating varnish. Provision shall be made for tightly wedging the coils in the slots with the wedges, which shall not shrink or buckle. Care shall be exercised that the blocking of air passages cannot occur.

The insulation and taping of the coils shall be such as to prevent permanent injury from exposure to dampness to provide adequate corona shielding, to withstand high temperatures without injury, to prevent the entering of magnetic particles and to prevent formation of zones.

The insulation should be so chosen to facilitate ungrounded operation without any damage.

3.4 TEMPERATURE RISE

Each Generator shall be capable of delivering rated output continuously at any voltage and frequency in the operating range at rated power factor without exceeding the following values of temperature rise over cooled air temperature not exceeding 40^{o}C and cooling water temperature not exceeding 30^{o}C as per IS : 4722

a. Stator Winding – Class B Temperature Rise

b. Rotor Winding - Class B Temperature Rise

Even though insulation of "Class-F" must be used, when operating continuously at the maximum continuous rating at its rated PF at any working voltages and in any frequency in the range stipulated, the temperature rise shall not exceed the limits specified for "Class-B".

The machine shall further be capable of operating continuously at full load at 0.85 power factor at 11 kV at frequency five percent (5%) below normal satisfactorily and without undue heating.

3.5 EFFICIENCY AND OUTPUT GUARANTEES

3.5.1 Within the limits of temperature rise specified in Clause 3.4 above, the rated continuous and maximum output of each generator shall be guaranteed under penalty with a rejection limit of minus two percent (- 2%) for the rated generator terminal conditions.

3.5.2 The efficiency and output guarantees of the turbo generator unit shall be as per Clause 2.5.1 & 2.5.2 of Sub-section 2 of Section VI - Technical Specification for hydro electric project.

3.5.3 The efficiency of the generator shall also be guaranteed under penalty with a rejection limit of minus two percent (- 2%). The efficiencies shall be determined by the summation of losses method as specified in Indian Standard IS: 4889 for 100 / 80 / 60 and 115% load.

3.5.4 The manufacturer has to provide a calibration protocol giving the rated efficiency at a rated torque for the above given percentage of rated electrical output.

~~3.5.5 The penalty on account of output and efficiency shall be computed separately and the total amount of penalty shall be the sum of the two. No upper ceiling on the total amount of penalty on account of shortfall in the weighted average efficiency and output will be agreed by the NMMC.~~

3.5.6 No tolerance shall be permitted over test figures of output. Tolerance in determination of efficiency shall be as per relevant International Standards.

3.5.7 In addition to the above, the Contractor shall also Guarantee the maximum synchronization time with grid required for evacuation under stable grid conditions.

3.6 BID EVALUATION

DELETED

3.7 CONSTRUCTION

3.7.1 Stator

The stator frame shall be of fabricated steel construction. The frame shall be designed to withstand bending stress and deflections due to its self-weight of the complete core to be supported by it. The stator core shall be built up of segmental punching of low loss, non-oriented steel sheets and end plates, each punching shall be carefully deburred and insulation on both sides with high quality varnish to reduce losses in the core.

The stator winding shall be of multi-Turn or single turn and shall be insulated with Class 'F' insulation. The stator winding shall be star connected with both ends of conductor of each phase brought out of the stator Six (6) Nos. embedded temperature detectors of resistance type shall be provided for stator winding located symmetrically.

3.7.2 Rotor

The design and construction of the rotor shall be in accordance with the best modern practice and shall be fully described in the tender. The factor of safety on yield point of material shall not be less than 1.5.

In case flywheel is required to meet the GD^2 requirements, the same shall be provided by the Contractor at no extra cost to the NMMC.

The insulation between turns of field winding shall consist of special epoxy impregnated asbestos paper and the insulation to ground of glass laminates.

The rotor spider shall be of steel constructions. To facilitate synchronization a shorted damper consisting of several round copper bars in each pole shall be provided.

The field poles shall be provided with adequate damper windings to ensure stability under fault conditions and to meet a minimum of 20.

3.7.3 Earth Terminal

Two (2) Nos. of Earth terminals shall be provided. The earth terminals shall be designed to terminate Galvanized Iron conductors. The size shall be as specified IEC 34-1

3.7.4 Speed Regulation

The moment of inertia of the alternator together with that of the turbine shall be sufficient to ensure stability and the speed regulation specified in the Sub-Section - 2 (covering turbine) for full load rejection. The flywheel effect shall be incorporated in the alternator and turbines as integral part and not added in the shape of separate weights, rings or other means.

3.7.5 Shaft

The generator shaft shall be made of best quality forged alloy steel, properly treated. The shaft shall be of ample size to operate at all speed, including maximum over speed without vibration or distortion and shall be able to withstand short circuit and other stresses without damage.

A complete set of test reports covering metallurgical strength, crystallographic and ultrasonic and baroscopic tests performed in each shaft during various stages of its manufacturing shall be furnished as also the complete specifications of the shaft material forging and its design parameters such as stresses and critical speed.

Suitable precautions shall be taken to prevent harmful flow of shaft current to earth. Any insulation needed shall preferably be arranged.

The coupling between turbine shaft / turbine runner and generator shafts will be flexible coupling with pins and rubber bushes of standard type to take care of any misalignment. Method to avoid damage due to axial forces of the vertical machine shall be elaborated in the bid document.

3.7.6 Noise Level

The noise level shall not exceed 95 dB when measured at a distance of 1 m from any component of the generator.

3.8 LUBRICATION SYSTEM

The bearing offered shall be either grease lubricated or oil lubricated. Concessioner shall indicate the requirement of oil. The oil recommended shall be compatible to the specifications

of indigenous oil, makes turbine oil, which is indigenously available and the contractor shall examine and confirm that these are suitable for lubrication system. First filling oil shall be supplied by the Contractor with ten percent (10%) extra quantity.

3.9 BRUSHLESS EXCITATION SYSTEM

The generator shall be provided with Brushless Excitation System with 'High Initial Response' as described by IEE Std 421 (standard criteria and definitions for excitation system) with a response ratio of 1.5, capable of continuously carrying the required excitation current at 37 ºC ambient temperature when the generator is delivering hundred percent (100%) rated KVA at rated power factor, rated frequency and hundred percent (100%) rated voltage. It shall also be capable of carrying short circuit current for 30 seconds after reaching rated temperature when the generator is delivering hundred percent (100%) rated KVA at rated power factor and 100% rated voltage. AC exciter and generator shall be electrically connected to one another. The exciter shall be of rotating armature and stationary field type to be coupled with a salient pole, rotating field type stationary armature generator. A diode wheel consisting of six diodes and selenium surge suppressor shall be mounted on the shaft. The diodes shall be easily accessible for replacement without dismantling the rotor.

An electronic analogue voltage regulator shall sense the armature voltage and control the DC supply to exciter field, under varying load conditions to maintain the voltage very near to preset value.

3.9.1 Automatic Voltage Regulator

Each automatic voltage regulator (AVR) shall be provided with two channels for working i.e. one in operation and one as standby for automatically coming into operation in case of failure of the first channel in operation. The voltage regulator shall be sensitive to change of ± 0.25% of normal voltage of the generator when operating under steady load conditions for any load or excitation within operating range and shall initiate corrective action without hunting. After full rated load rejection the AVR should limit the maximum-rise of voltage not to exceed 20% of normal rated voltage and shall control the excitation at such a high speed so that the generator voltage settles down within 10 seconds to restore the terminal voltage to a value not more than 5% above or below the voltage being held before load rejection and shall maintain the voltage within these limits throughout the period of generator over-speed. The voltage regulator shall be provided with cross current compensating devices for parallel of generators. The range of the voltage control shall extend from (–) 25% to (+) 10% of rated voltage of the generator.

In addition to two auto channels, manual control shall also be available. The manual control shall be simple and shall not need expert personnel for maintenance and trouble shooting.

Facility for transferring from manual to auto-control and vice-versa without the risk of sudden change of excitation level at the instant of change over shall be provided.

Several Features, but not limited to the following, shall be provided on the AVR:

1. Under frequency limit (V/Hz)
2. Parallel compensation
3. Alarm indications for abnormal conditions
4. Over voltage protection
5. Soft start ability
6. Over excitation limit
7. Under excitation limit
8. Voltage matching

The Contractor shall be responsible for imparting the necessary training to the designated personnel of the NMMC in maintenance and trouble shooting of the excitation system and AVR. Operation and Maintenance Manual and Drawings of Control Cards and other modules of the AVR shall be made available to the NMMC by the Contractor.

3.10 NEUTRAL GROUNDING RESISTOR /TRANSFORMER

The neutral point of generator shall be earthed independently through a neutral grounding transformer with resistor.

Adequately rated neutral grounding resistor shall be supplied and the resistor shall be of stainless steel edge wound type mounted in a shielded safe enclosure. The Ohmic value and kilowatt rating of the resistor shall be such that the transient over voltage on the stator winding during the phase to ground fault on the generator shall be reduced to the minimum value possible and any phenomenon such as Ferro-resonance is avoided.

The Ohmic value of the resistor shall be so selected that it can withstand the earth fault current to a value approximately equal to the leakage capacitive current to ground and to minimize the transient over voltage.

3.11 LAVT PANELS

Necessary surge capacitors and lightning arrestors shall be provided for generator protection. The surge capacitors shall conform to the latest IS: 2834 and shall be rated 0.25 Micro Farad. The capacitors shall be suitable for indoor mounting and shall be provided with built in discharge resistor. The lighting arrestors shall be heavy duty indoor station class gapless metal oxide type suitable for repeated operation to limit voltage surges on alternation current power circuits and to interrupt power follow current. The arrestors shall conform to IEC 99-4. The nominal discharge current of lightning arrestors shall not be less than 10KA. GI earth bus of adequate cross-section will be provided in the cubicle.

3.12 INSTRUMENT TRANSFORMERS

Following points shall be kept in to consideration while designing the instrument transformers:

1. Current transformers for protection shall be of Class PS
2. Current transformers for measurement shall have an accuracy of 0.2
3. Burden on the instrument transformers shall be so selected that the operating point may be at 25% to 70% of the designed burden.
4. Knee point voltage shall be so selected that the operating point may remain at less than 25% of the knee point voltage.
5. Accuracy of VTs for measurement purpose shall be 0.2, for AVR it may be 3.

3.13 WRENCHES, TOOLS AND SPECIAL DEVICES

The supplier shall furnish, for use with the generator(s), a complete set of case hardened end-wrenches one-inch and larger, and all special – 'wrenches, Pipe wrench tools, reamers, slings, spreader bars, lifting devices, crimpling and multi meter, Tong tester, magger and other equipment which may be necessary for assembling, dismantling, erection and maintenance of any part of the generator(s) and auxiliary equipment.

3.14 SPARE PARTS

All spare parts furnished shall be interchangeable with and shall be of the same material and workmanship as the corresponding original parts. Each set of parts shall be furnished complete including the necessary materials required for installation. Spare parts shall be suitably packaged and protected for storage and clearly labeled externally for identification.

3.15 FIELD TESTS

A. After the generator and auxiliary equipment has been installed in the power plant ready for operation each generator shall be tested by the erection supervisor in the presence of the Engineer in charge to determine, whether, the contractor's guarantees and the requirements of these specifications have been fulfilled. The test shall be made in accordance with the latest applicable requirements of I.E.C. standards, British standards, A.S.A. standards, N.E.M.A. and the IEEE-115 test code for synchronous machines, dated June, 1995 and the A.S.M.E. Test code for hydraulic Prime Movers, dated May, 1999 or the latest revisions thereof, except as herein definitely stated. The waving of any test shall not relieve the Contractor of his responsibility to meet fully the requirements of the specifications. All test instruments and instrument transformers etc, shall be furnished by the Contractor. At the time the hydraulic turbine is tested, the Contractor shall furnish necessary calibrated electrical test instrument and instrument transformer for measuring the output of the generator and exciters using indicting watt-meters, ammeters, and voltmeters as recommended for the three wattmeter method in the latest revision of the test code for hydraulic prime movers, published by the American Society of Mechanical Engineers. The Contractor shall cooperate with the Engineer and with the other companies involved

to establish a mutually satisfactory date for testing, so that the generator test may be started immediately after completion of the turbine tests.

B. After the thrust bearing cooling pipeline has been completely assembled, it shall be subjected to a static water pressure of 5.25 kg/cm^2 for a period of not less than one hour, without showing any leaks or any drop in pressure.

C. After complete erection, the generator shall be subjected to the following tests:

1. Alignment of turbine and generator shafts by mechanical rotation of the units

2. Magger test for insulation resistance

3. Dielectric tests of armature and field windings at not less than 80 ºC. The armature winding shall be given a dielectric test in accordance with the latest approved standards, one phase at a time with other windings grounded. The field windings shall be given a dielectric test for one minute

4. Resistance test of armature and field winding.

5. Operation test and adjustment of the entire excitation system to show compliance with all operating requirements of these specifications especially with regard to sensitivity and response.

6. Test for the determination of the time for brakes to stop the machine safely from speed to zero speed with the turbine gates fully closed and with exciter field open.

7. Phase sequence test

D. In addition to the above field tests the following special tests shall be made on one generator:

1. Conventional efficiency test. This test shall include the determination of :

a. Exciting circuit losses

b. Fixed losses

c. Direct load losses

d. Stray load losses

The exciting circuit losses shall be included as a part of the generator losses in determination of the generator overall efficiency by summation of losses method, as laid down in British Standard No. 269.

2. Test to determine the maximum temperature rises of the various parts of the generator, when operating continuously at maximum rated output with the water supply to the surface air coolers regulated so that the temperature of the air leaving the cooler is approximately 40 ºC. Load will be provided by the NMMC. Coolers capacity shall also be tested.

3. Machine parameters tests e.g. Three-phase, short circuit test, to demonstrate that the generator is capable of withstanding short-circuit stresses without injury when the machine is operating under load. This test shall be made by abruptly short-circuiting the generator when operating at no load, rated frequency, and rated voltage, for a period of not more than 10 seconds. One of the current waves, when taken on oscillograph shall be particularly completely offset. If the first short-circuit does not produce this, additional short-circuits shall be applied until such is obtained. The contractor shall be responsible for any and all damage caused by the short-circuit test to the equipment.

4. In addition to the above listed tests, the erection supervisor of the Contractor shall perform other tests, required to establish conformance of the equipment with the guarantees and the specifications, and to obtain data needed in testing the turbine with the generator used as a dynamometer. The waiving of any test by the Engineer shall not constitute relinquishment of the contractor's responsibility to fully meet the requirements, which were to have been demonstrated by that test.

5. The contractor shall furnish a complete list of all testing equipment to perform above field tests and shall also quote unit bid and loan prices. The contractor shall also furnish a complete list of special testing instruments and quote unit prices.

6. Load acceptance and rejection tests- The generator shall be tested at selected loads from no load to full load for load acceptance and rejections. All the parameters of the machine shall be recorded and should be within permissible limits.

7. Subsequent over speed Test:- Within one year after operation has begun, and at such time as directed by the Engineer, the Contractor shall operate each generator at the specified over speed, or at the highest speed obtainable with the available head, whichever is the lower, for a period of not more than 5 minutes after the full speed has been attained. This test is to demonstrate that all parts of the generator will successfully withstand stresses incident to specified runaway speed.

8. Auxiliary equipment- All other auxiliary equipment shall be checked tested and commissioned before the main plant for their satisfactory performance.

9. Synchronization- The generator shall be synchronized with the available system for best performance.

3.16 Tolerances

Tolerance limits for efficiency, total losses and power factor shall be in accordance with the International Electro Technical Commission (IEC) Standards for Electrical Machinery latest edition.

3.17 DRAWING AND DATA TO BE FURNISHING BY THE CONTRACTOR

The Concessioner shall within 100 clear days after acceptance of tender submit for approval by engineering following drawings:

1. Outline drawings of all apparatus shall be furnished by the Contractor for the generator with weights of the equipment and overall dimensions to enable the Engineer to check the final design of the generator foundation and powerhouse structure. These drawings shall cover the overall dimensions of the stator, rotor and shaft with lifting devices, details of shat coupling, size and location of sole plates, location of surface air coolers, generator leads and such other information and data as are needed to complete the civil engineering design. The Contractor shall assist in the finalization of foundation drawings of the generator and other allied powerhouse structures.

2 Following generator drawings shall be subsequently submitted for approval by the Engineer :

   i. Vertical section through the unit.

   ii. Horizontal plan of the top of the units and of bearing brackets.

   iii. Assembly, sub-assembly and detailed drawings as are specifically required to show unit spacing and demonstration that all parts of the apparatus conform to the provision and intent of these specification and shall include generator leads and disconnects, wiring diagrams, location and size of all wires, pipes, terminal blocks etc.

   iv. Applicable parts list, catalogues and operating instructions assembly and detailed drawing to cover all equipment which may be required or useful in erection, operation, maintenance, repair, dismantling or assembling and for the repair and identification of parts for ordering replacement shall be assembled under a suitable common cover and submitted.

3. Built Drawings of all the equipments, control circuits, logical circuits and protection circuits.

3.18 APPLICABLE STANDARDS

Latest edition of the following standards shall be applicable.

IEC-34-1: 1983 – Rotating Electrical Machines Rating and Performance

IEC-34-2A-1972 – Rotating Electrical Machines - Methods for determining losses and efficiency of electrical machinery from tests (excluding machines for traction vehicles

IEC-34-5-1991 –	Classification of degrees of protection provided by enclosures for rotating electrical machines (IP Code)
IEC-85-1987 –	Classification of materials for the insulation of electrical machines
IS-4722 –1992 –	Rotating electrical machines

Equipment complying with other internationally accepted standards such IEC, BS, USA, VDE etc. will also be considered if they ensure performance and constructional features equivalent or superior to standards listed above. In such a case the Concessioner shall clearly indicate the standards adopted, furnish a copy in English of the standards adopted, furnish a copy in English of the latest revision of standard along with copies of all official amendments and revisions in force as on date of opening of bid and shall clearly bring out the salient features for comparison.

SECTION-: TECHNICAL SPECIFICATIONS

SUB SECTION-4: POWER TRANSFORMER & AUXILIARY TRANSFORMER

4.0 CODES

The transformers shall comply with the following Indian Standards:

IS 2026 (Part I, II and III)	Power transformers
IS 325	*Insulating oil*
IS 1271	Classification of insulating materials
IS 3639	Power transformer fittings and accessories
IS 2099	High voltage porcelain bushing screen
IS 6600	Guide for loading of oil immersed transformers

4.1 SCOPE

To serve the two machines of 10.0 MW capacities each, the Supplier shall supply Two (2) Nos. outdoor type step-up transformers of 3 phase, each 15,000 kVA, 11 kV / 132 kV or , 11 kV / 220 kV ONAN, 3 phase, 50 Hz, oil immersed / oil filled, vector symbol Ynd11, natural air cooled (OLTC Type), core type, double wound with copper winding continuously rated and arranged with Vector group of Ynd11 (Delta on LT side and star on HT side with the neutral brought out) shall be supplied. Each transformer shall be contained in a mild steel plate of radiator-cooled tank and shall in general conform to IS 2026. The temperature rise as measured in oil and the temperature of the winding by resistance measurement shall not exceed 50 °C over an ambient temperature of 37 °C. The flux density at rated conditions shall be 1.6 tesla. The transformer bushings shall be high pollution type. Separate neutral CT shall be provided for REF protection.

Tapings shall be provided on HV windings to obtain a variation of (+) 5% to (–) 25% in steps of 1.875%. These tappings shall be controlled by an externally operated ON LOAD Tap Changer. The transformer shall be finished with standard enamel / epoxy paint of a shade approved by the NMMC.

The LV side shall be suitable for cable box, whereas HV size shall be suitable for the chosen conductor size. The conductor size shall be chosen as per the directions of MSEDCL to suit the proposed sub-station coming up near the project site.

The temperature rise on any part of the transformer shall not exceed 40°C by oil thermometer and 60°C in winding by resistance (RTDs) under full load conditions. The covers of the tank of the transformers shall be bolted to the tank for easy maintenance.

Scope of supply also includes one number (1 No.) step down station Auxiliary transformer of 3 phase, approx. 500 kVA capacity, **(Excluding DAM operational requirements)** 11 kV / 433 V Star / Delta, 50 Hz, dry type or oil immersed, naturally self-cooled, core type, double wound with copper winding continuously rated and arranged with Vector group of Dyn11 with the neutral brought out. This auxiliary transformer shall feed 433 V supply to all auxiliaries, control panel etc. kept within the Powerhouse area.

All accessories, fitting and protections needed for the auxiliary transformer shall be indicated by the Concessioner in his DPR.

The transformers shall be provided with Buchholtz relay (gas operated relay) with two sets of contacts, one for alarm and the other for trip. Two dial type temperature indicators, indicating oil temperature and winding temperature for H.V. & L.V. windings shall be provided with 2 sets of contacts, one set for trip and the other set for annunciation. The Buchholtz protection and oil, winding temperature rise protection shall be connected with suitable controls / relays for protecting the transformers. An oil level gauge / switch with two sets of contacts shall be provided in the marshalling box mounted on the transformers.

Transformers shall be supplied with the first fill of transformer oil after flushing the tank with transformer oil and 10% excess quantity of oil in non-returnable drums as per IS – 335. Provision shall be made to connect the HV side of power transformer to 132 kV line with suitable conductors and all the jumpering work within the switchyard shall be in the scope of the Concessioner.

The Auxiliary transformer shall be capable to deliver the power with 750 kVA Transformer, (only for) , for internal consumption of Power plant, Dam infrastructure and staff colony etc., which shall be billed to as per supply regulatory norms.

4.2 SPECIFICATIONS

The transformer shall be in accordance with the following specifications.

4.2.1 POWER TRANSFORMER

Two (2) nos. outdoor type step up transformers each of 3 phase, 50 Hz, 15,000 kVA, 11 kV / 132 kV or 11 kV / 220 kV oil immersed, naturally self cooled core type, double wound with copper winding continuously rated and arranged with vector group of Ynd II with the neutral brought out on the star side shall be supplied to serve two machines, each of 10.0 MW capacities. Each transformer shall be contained in a mild steel plate of radiator cooled tank and shall in general conform to IS: 2026 / 1977. The temperature rise as measured in oil and the winding by resistance measurement shall not exceed 50^{o} C over an ambient temperature of 37^{o} C. The flex density at rated conditions shall be 1.6 Tesla. The transformer bushings shall be of high pollution type.

Tappings shall be provided on HV windings to obtain a variation of (+) 5% to (–) 25% in steps of 1.25% each. These tappings shall be controlled by an externally operated ON LOAD TAP CHANGER (OLTC). The transformer shall be finished with standard enamel / epoxy paint of a shade corresponding to IS: 632.

The transformer shall be provided with Buchholtz relay (gas operated relay) with two sets of contacts, one for alarm and the other for trip. Two dial type temperature indicators, indicating oil temperature and winding temperature shall be provided with two sets of contacts, one set for trip and the other set for annunciation. The Buchholtz protection and oil and winding temperature rise protection shall be connected with suitable controls / relays for protecting the equipment. An oil gauge switch with two sets of contacts shall be provided in the marshaling box mounted on the transformer.

Transformer shall be supplied with the first fill of transformer oil and 10% excess quantity of oil in non-returnable drums as per IS : 335 / 1972. Provision shall be made to connect the HV side of transformer to HG fuse set by conductors. All the jumpering work on 2 pole structure and PTs shall be in the scope of the Concessioner.

4.3 ACCESSORIES / FITTINGS

The following fittings shall be fitted / provided with the transformer:

1	RATING & DIAGRAM PLATE
2	LIFTING LUGS
3	EARTHING TERMINALS - 2 NOS.
4	THERMOMETER POCKET AND THERMOMETERS
5	AIR RELEASE HOLE WITH PLUG
6	OIL FILLING HOLE WITH PLUG ON CONSERVATOR
7	DEHYDRATING BREATHER
8	OIL LEVEL INDICATOR (PLAIN)
9	ON LOAD TAP CHANGEOVER
10	EXTERNALLY OPERATED ON CIRCUIT TAP SWITCH WITH PAD LOCK AND KEYS
11	DRAIN CUM BOTTOM WATER FILTER VALVE WITH PLUG
12	OIL CONSERVATOR WITH DRAIN PLUG
13	FILTER VALVE WITH PLUG - 1 NO. (TOP)
14	UNDERBASE SKIDS WITH FLAT THREAD ROLLERS (UNI-DIRECTIONAL)
15	H.V. TERMINALS – OUTDOOR HIGH POLLUTION TYPE FOR TERMINATION WITH 132 kV CONDUCTOR
16	NEUTRAL TERMINAL ON H.V. SIDE – WITHOUT DOOR, HIGH POLLUTION TYPE BUSHING FOR TERMINATING NEUTRAL TO EARTH
17	L.V. TERMINALS – SUITABLE FOR TERMINATING 11 kV BUS DUCT OR CABLE AS DECIDED DURING DETAILED DESIGN

18	EXPLOSION VENT WITH SINGLE / DOUBLE DIAPHRAGM
19	BUCHHOLTZ RELAY WITH TWO (2) SETS OF CONTACTS
20	OIL TEMPERATURE DETECTOR FOR H.V. & L.V. WINDING WITH DIAL TYPE GAUGE THERMOMETERS WITH TWO (2) SETS OF CONTACTS
21	WINDING TEMPERATURE DETECTOR DIAL TYPE GAUGE WITH TWO (2) SETS OF CONTACTS
22	ONE (1) LOW OIL LEVEL GAUGE / SWITCH WITH TWO (2) SETS OF CONTACTS
23	MARSHALING BOX

4.4 BI-DIRECTIONAL ON LOAD TAP CHANGER (OLTC) WITH AVR

The Power Transformer shall be provided with an On Load Tap Changer (OLTC) on 132 kV side for varying the transformation ratio without producing phase displacement while transformer is in service. The OLTC will be in the steps of 1.25% with a variation of (+) 5% to (-) 25% from rated transformation ratio in 24 equal steps. The OLTC shall be complete with equipment for local / remote electrical and local manual operation. The local remote switch may be housed in a remote control panel. The equipment for local / remote electrical and local manual operation shall be provided and shall comply with the following conditions:

(i) It shall not be possible to operate the electric drive when the manual operating gear is in use

(ii) It shall not be possible for any two electric controls to be in operation at the same time

(iii) The equipment shall be suitable for a supervisory control and indication on a multi way switch, make before break, having one fixed contact for each tap operation from the local or remote

(iv) Control switch shall cause one tap movement only until the control switch is returned to the off position between successive operation

(v) The local control switches shall be mounted in the marshaling box driving gear housing

(vi) The system shall be designed to protect transformer in contingencies when the tap changer would get struck

(vii) The indication for number of tap in use shall be provided at local / remote

(viii) All electrical control switches and local operating gear shall be clearly labeled in a suitable manner to indicate the direction of tap changing.

(ix) The equipment shall be so arranged as to ensure that when a tap change has been commenced it shall be completed independently of the operation of the control relays or switches. If a failure of the auxiliary supply allowing a tap change or any other

contingency would result in that movement not being completed, adequate means shall be provided to safe guard the transformer and its auxiliary equipment.

(x) The system shall be complete with limit switches, motor, relays, connectors, indicators, switches etc.

(xi) If required a separate Buchholtz relay and oil temperature protection may be provided for OLTC with two (2) sets of contacts for trip and annunciation.

OLTC not performing as per the standards, the specifications and the load conditions shall be rejected by the NMMC.

4.5 132 kV or 220kV TRANSFORMER AND FEEDER PROTECTION

132 kV or 220 kV POWER TRANSFORMER SHALL BE PROVIDED WITH FOLLOWING PROTECTIONS:

(i)	TRANSFORMER DIFFERENTIAL RELAY (87 T)
(ii)	OVER CURRENT ON 132 kV or 220 kV(51 T)
(iii)	EARTH FAULT ON 132 kV or 220 kV (64)
(iv)	OVER CURRENT ON 433 V / 11 kV (51 T)
(v)	RESTRICTED E / F (64 REF)
(vi)	UNDER VOLTAGE (27)
(vii)	OVER VOLTAGE (59)
(viii)	TRANSFORMER OVER FLUXING RELAY (99)
(ix)	BUCHHOLTZ (GAS OPERATED RELAYS) PROTECTION FOR MAIN TRANSFORMER & OLTC SEPARATELY
(x)	WINDING TEMPERATURE MAIN TRANSFORMER / OLTC (H.V. & L.V.)
(xi)	LOW OIL LEVEL (ALARM ONLY)
(xii)	TRIP CIRCUIT SUPERVISION RELAY (94) – TWO (2) SETS
(xiii)	UNDER FREQUENCY (81 U)
(xiv)	OVER FREQUENCY (81 O)

NOTE: *The above protective devices are only indicative - any other protective device recommended by the manufacturer / supplier may be given. The manufacturer / Contractor / Supplier shall be responsible and suggest suitable scheme required for the transformer protection keeping modern trends in view. The final scheme will be decided by the NMMC in consultation with the Manufacturer / Contractor / Supplier during detailed / final design*

4.6 STATION / AUXILIARY TRANSFORMER

The loads of station and unit auxiliaries will be fed from a L.T. power and control cubicle and distribution board. The normal incomer feeder for this cubicle will be derived from 500 kVA 11 kV / 433 V auxiliary transformer through 800 A, air circuit breaker on 415 V side.

The emergency incomer feeder to this cubicle will be derived from a D.G. set of 250 kVA, 433 V, 50 Hz rating through an ACB to meet emergency loads in the event of station supply failure. These two ACBs will be electrically interlocked to prevent paralleling of normal and emergency power supplies. The station auxiliary transformer will be of following specification.

CAPACITY	**500 KVA**
VOLTAGE RATIO	11 kV / 433 V
VECTOR GROUP	Dyn 11
TAP CHANGER ON LOAD	± 15% IN THE STEPS OF 2.5%
TYPE	OUTDOOR TYPE
HV / LV	CABLE BOX FOR XLPE ALUMINIUM CABLE
MOUNTINGS	OIL LEVEL INDICATION SILICA GEL BREATHER
COOLING	ONAN TYPE
INSULATION	CLASS B TEMPERATURE RISE
PROTECTION	OVERLOAD / EARTH ON 415 V SIDES
WINDING	COPPER
FLUX DENSITY AT RATED CONDITIONS	1.6 TESLA
BUSHING	HIGH POLLUTION TYPE

4.7 TESTS AND PENALTIES

Power transformer shall be tested for load losses and no-load losses as per the requirements of Indian Standards listed under Para 4.0 above. Contractor shall state the guaranteed values in his Bid.

SECTION-: TECHNICAL SPECIFICATIONS

SUB SECTION-5: TECHNICAL SPECIFICATIONS FOR SWITCHYARD EQUIPMENT

5.0 SCOPE

This specification covers the design, manufacture and shop testing before dispatch and delivery at site of the following Switchyard Equipment of Morbe Dam H.E. Project, Maharashtra, India.

The scope shall cover erection, testing at site, trial run and commissioning of the Switchyard Equipment complete with their fittings and accessories in all respects. The scope shall also cover supply of spare parts including erection and commissioning spares and one set of special tools and tackles as per Contractor's requirements and recommendation.

The Contractor shall adhere to the guidelines / stipulations / rules as per the requirement of MSEDCL or any other Regulatory Authority for interfacing with the main grid for evacuation.

5.1 OUTDOOR SWITCHYARD

5.1.1 Switchyard

The equipment for outdoor switchyard of 132 kV or 220 kV adjoining the powerhouse and those at 132 kV or 220 kV sub-station at the receiving end shall be provided for the evacuation of power generated. These will be provided with the required equipment, which shall be included in the scope of supply. The interconnection between the switchyard adjoining the powerhouse and the 132 kV or 220 kV grid sub-station of MSEDCL is also to be included in Contractor's scope.

Note : *The requirements shown in the SLD are as per NMMC's design. The Concessioner shall submit the requirements as per his design along with his proposed Single Line Diagram.*

SECTION-: TECHNICAL SPECIFICATIONS

SUB-SECTION – 6: INDOOR & OUTDOOR SWITCHGEAR AND ASSOCIATED EQUIPMENT

6.0 SCOPE

This section covers design, manufacture, assembly, shop testing, supply, supervision of erection and commissioning of the following switch gear, control panels and associated equipment for the safe and efficient supervisions, protections, control, metering, annunciation and operation of 2 x 750 kW + 15% continuous overload Turbo Generator units and auxiliary equipment specified in this Bid document. The details of panels / boards described in the Schedule of Requirements (SOR) are only indicative and any other panels required for the turbo generator unit to make it complete shall be included in the scope, even though they are not specifically mentioned in the SOR.

6.1 GENERAL LAYOUT OF THE PANELS

The layout of switchgear and control panels shall be such that the operator will have optimum facility and convenience for operation and maintenance of Turbo generator units including auxiliary and associated equipment.

The panels will be grouped optimally and layout will be finalized in consultation with the NMMC by making suitable modifications as required during detailed design stage.

6.2 MACHINE CONTROL

The machine control shall be Auto & Manual control system.

The Concessioners shall also quote for Auto control system also along with Manual control system.

6.2.1 Manual Control System

The control scheme shall be such that the machine control is through manual sequential operation. The Concessioner shall include all the equipment required for an independent manual control system for manual start / stop and auto shutdown of the Turbo generator units and auxiliary equipment in normal conditions besides all emergencies.

6.2.2 Auto Control System

The Supplier shall also offer the machine auto control system such that the units can be made auto start / shutdown by means of microprocessors. The Supplier shall quote separate price for such auto control system and working features shall be detailed. The NMMC will have the option to choose Auto Control System also.

6.2.3 Option to NMMC on Control System

The NMMC will have option to select either manual control system or auto control system along with Manual control system. In case the NMMC decides not to go in for auto control system, the manual control offered shall be complete for operation of units without any need to add on additional equipment to it.

6.3 GENERAL SPECIFICATION OF THE PANELS AND CONTROL SCHEME

The general specification of panels shall be as follows:

6.3.1 Standards

The equipment covered shall conform to latest edition of IS 4237 or any International Standards. All the panels shall be of uniform height and colour to provide best esthetics and shall give a look of a model station.

6.3.2 Capacity of the Equipment

All the equipment shall be adequately rated to cover the design capacity specified and shall be capable of operating under severest operating conditions without deterioration or damages and capable of withstanding the stresses likely to develop under the severest fault conditions. All the breakers, busbars, cable connections, CT connection etc. shall be suitable for the prescribed symmetrical 3 phase short circuit level and all mechanical stresses resulting from short circuits.

6.3.3 Clearances

All clearances of live parts between phases and earthed metal parts of switchgear, circuit breakers and other equipment shall be adequately rated for 10% over and above the maximum service voltage.

6.3.4 Insulation

The insulation of all high tension and low tension switch gear and other indoor accessories shall be capable of operating continuously at a voltage of 10% over and above maximum rated voltage with frequency variation of +/-3% and under the temperature variation of 37 degrees C (maximum) and (-) 2 degrees C (minimum) and humidity condition of 0 to 85% prevalent at the site.

6.3.5 Operation

All circuit breakers, motors and emergency safety devices shall be suitable for operation from panel and local (near equipment) control system. Similarly, the indication showing the status ON / OFF / TRIP shall be provided on panel and local control station. In case of microprocessor based auto control system to be offered under optional items, all the additional facilities required for such auto control system shall be provided.

6.3.6 Main Switch Gear

The 11 kV and 132 kV or 220 kV Breakers and switch gear shall be of modern design, robust construction and designed to prevent any accidental contact with any live part or spreading of fire or damage due to short circuit etc.

(i) THE 11 kV SWITCHGEAR SHALL CONFORM TO FOLLOWING ELECTRICAL PARAMETERS:

A) Rated voltage 11 kV

B) Maximum voltage 12.1 kV

C) Interrupting and short circuit withstand capacity 25 kA

(ii) THE 132 kVA or 220 kV SWITCHGEAR SHALL CONFORM TO THE FOLLOWING:

A) Rated voltage 132 kV or 220 kV

B) Maximum Voltage 132 kV or 220 kV

C) Interrupting and short circuit withstand capacity 25 kA

(iii) THE AUXILIARY DISTRIBUTION BOARD SHALL CONFORM TO:

A) Rated voltage 433 V

B) Interrupting and short circuit withstand current 25 kA

C) Rated current of Busbars 400 A

(iv) MOTORS 433 V, 3 PHASE

(v) CONTROL CIRCUITS PROTECTION SUPPLY WILL BE 110 V UNDERGROUND DC SUPPLY FOR CONTROL, INDICATION AND ANNUNCIATION

(vi) 110 V, 1 (ONE / SINGLE) PHASE GROUNDED AC CIRCUITS OF STARTER PANEL AT THE OPTION OF NMMC.

(vii) LIGHTNING & SPACE HEATERS 220 V 1 (ONE / SINGLE) PHASE AC

(viii) DC SUPLY 110 V UNGROUNDED, 250 A.H. RATING

6.3.7 Control Power

One control transformer of adequate capacity for 11 kV / 433 V to derive 240 V shall be provided for control supply for AC circuits of starter panel. This control transformer shall be erected in the station auxiliary Board and provided with MCBs on primary and secondary. Separate control supply feeders shall be provided for each equipment / motor control center. Each of these feeders is to be provided with MCB.

6.3.8 General Design of Controls

All the protective and control devices, solenoid valves, closing coils, tripping coils and ON/OFF indications of breakers, annunciation phase and indications of main generating equipment shall be operable on 110 V DC supply. The important devices like speed relays and tachometers shall be on DC system.

The motors of the circuit breakers shall be operable on 110 V AC. The indications of the auxiliaries may be on 110 V AC control supply or 110 V DC as approved by the NMMC during detailed design.

6.3.9 The Spare Parts for the Indoor and Outdoor Switchgear and associated equipment shall be supplied along with main equipment as per Schedule 13.

6.3.10 The Concessioner has to supply One (1) Set of Tools and Plants as per Schedule 14 along with main equipment for maintenance of equipment.

6.3.11 Although Panels with Quantities are shown separately in SOR, different panels may be combined in one as convenient.

SECTION-: TECHNICAL SPECIFICATIONS

SUB-SECTION – 7: TECHNICAL SPECIFICATIONS FOR CONTROL PANELS

7.0 SCOPE

This specification covers the design, manufacture, and shop testing before dispatch and delivery at site of the Control Panels of Morbe Dam H.E. Project, Maharashtra, India.

The scope shall also cover erection, testing at site, trial run and commissioning of the Control Panels complete with their fittings and accessories in all respects. The scope shall also cover supply of spare parts including erection and commissioning spares and one set of special tools and tackles as per Contractor's requirement and recommendation.

7.1 GENERAL SPECIFICATION FOR CONSTRUCTION OF CONTROL PANELS

(i) CONSTRUCTION

The control panels of 1100 V grade covered under this specification shall be of folded construction type of adequate size made out of CRCA sheet of minimum 2 mm thickness. The height and colour of control panels shall be matched.

The panels shall be suitably compartmentalized and provided with double doors at the rear to open the panels for rear access and shall be fitted with lockable handle. The panels shall be free standing floor mounted type, factory assembled and provided with base mounting arrangement for erection at site on foundation plinth laid with channels of size 75 mm height with foundation bolts. The Concessioner shall supply necessary foundation channels, bolts and drawing for erection of panels. The panels shall be provided with dust and vermin proof fittings, cable sealing, ventilating louvers and undrilled cable gland plate for cable entry at the bottom from rear side of the panel. Each panel shall be provided with a lamp operated by door switch for internal illumination.

(ii) SMALL WIRING

The panels shall be complete with small wiring, labels, fuses, links, MCBs, terminal boxes etc.

The terminal block of control wiring shall be of stud type of ELMEX make or equivalent with convenience to disconnect without removing terminals. The control wiring shall be of 2.5 square mm multi strand flexible copper conductor with PVC insulation of 1100 V grade terminating on solder less crimping lugs.

The wiring shall be provided with ferrules, crimping type copper lugs and sleeves. The panels shall be provided with aluminium bus bars of adequate cross section for current rating specified in the Bid document.

(iii) BUS BARS

The bus bars shall be designed with current density of not less than one ampere per sq. mm of cross section for aluminium bus bars. The material of aluminium bus bars shall be of EC Grade E 91 as per IS: 5082. The bus bars may be mounted on suitable insulating supports of adequate voltage rating maintaining adequate clearances between phase to phase and phase to earth as per relevant IS.

The bus bar insulting supports shall be moulded from reinforced thermos setting plastics and shall have greater mechanical strength and higher tracking resistance. The horizontal bus bars shall run in a separate enclosure for total length of the switchgear and control panel and small have provision for inspection of bus bars by removing the front cover or top cover plate. Bus bar shall be suitably sleeved with insulation of adequate voltage rating and provided with adequate heat shrinking devices and expansion joints and shall be suitable to carry full load currents and withstand fault currents. A continuous GI earth strip shall be driven through the panel with two studs brought out side for effective earthing of each panel at two places.

(i) PAINTING

Each panel shall be painted with standard light grey to shade 631 of IS-5 or equivalent with semi-matt finish on the exterior and white enamel of fully glossy finish in the interior. The fabricated panel shall be degreased, photocoated and two coats of lead primer applied before final painting. The panels shall be provided with a space heater and shall be complete with required accessories like CTs, PTs, LAs, etc. All the panels circuit breakers, transformers etc. shall have one uniform colour.

SECTION-: TECHNICAL SPECIFICATIONS

SUB SECTION-8: MISCELLANEOUS ITEMS-LIGHTING, AIRCONDITIONING, VENTILATION SYSTEM AND FIRE FIGHTING EQUIPMENT

8.0 SCOPE

This section covers the design, manufacture, shop testing, supply, erection, testing and commissioning of station lighting, air-conditioning, ventilation system and fire extinguishing equipment for Morbe Dam H.E. Project, Maharashtra, India. The brief details of these equipments are as given below:

8.1 LIGHTING SYSTEM

Lighting system shall be provided for the entire plant, covering all the buildings, switchyard, outdoor areas, roads, yards etc.

8.2 STATION LIGHTING

(i) REQUIRED LIGHTING THAT WORKS ON STATION NORMAL / DG SET EMERGENCY 230 V AC SUPPLY SHALL BE PROVIDED IN AND OUTSIDE THE POWERHOUSE BUILDING, SWITCHYARD AND GATES AREAS TO ILLUMINATE ALL THE AREAS ADEQUATELY. THE FOLLOWING SHALL BE THE MINIMUM LIGHTING.

A) MACHINE HALL & CONTROL ROOM LIGHTING ON AC

(a) 250 Watt Magnetic Induction Lamps for machine hall - 10 Nos.

(b) Decorative type 2 x 40 watt LED light - 13 Sets

B) OUTDOOR YARD & PENSTOCK GATES LIGHTING

(i) 150 watt Magnetic Induction lamps around powerhouse, switchyard, penstock and intake gates - 15 Nos.

(ii) LIGHTNING ON AC SUPPLY

(iii) EMERGENCY LIGHTING ON DC: TO COME INTO SERVICE IN AUTO WHEN AC SUPPLY FAILS.

(iv) 20 WATT 110 V DC LED LIGHTS - 10 Nos.

8.3 CATEGORIES OF LIGHTING

The plant lighting system shall comprise the following (2) categories:

a) Normal 240AC lighting System

b) Emergency 110V DC Lighting System

8.3.1 Normal 240V AC Lighting System

In this system, the lighting circuits shall be fed by the 3 phase, 4 wire normal AC supply available from the normal lighting distribution boards. All the lighting fixtures connected to this system shall be available as long as supply is available from normal source.

8.3.2 Emergency DC Lighting System

a) During station emergency involving total AC failure, incandescent lamp DC lighting fixtures shall be provided for movement of personnel in powerhouse building at strategic locations viz. near entrance, staircase, landings etc. and for lighting the control room and switch yard.

b) These fixtures shall be connected to lighting panels supplied from 110V DC battery in the powerhouse building. These lighting fixtures shall be normally off and shall automatically get switched on the moment AC power supply fails. When power supply is restored, they shall be switched off manually. In fuel oil store, the fixtures shall be "INSTALITE" type, which is permanently connected to normal supply charging a battery and switches on automatically once AC power supply goes off. INSTALITE type fixtures in fuel oil store area shall be of flameproof type.

8.4 LIGHTING SUPPLY DISTRIBUTION SYSTEM

8.4.1 Normal AC Systems

a) For these systems the distribution shall be by 415V, 3 phase, 4wire, 50Hz supply with effectively earthed neutral via AC lighting distribution board (LDB). The LDB will be provided with number of outgoing circuits controlled by MCBs to feed the lighting panels distributed in and around the plant as well as to directly feed three phase street lighting and yard lighting supplies.

b) AC lighting panels shall have 1 phase, 2 wire incomer and number of 1 phase outgoing circuits controlled by MCBs. Lighting panels feeding the lighting fixtures in indoor areas shall be controlled from the respective lighting panels located in various buildings in the plant.

8.4.2 110V DC Lighting System

Emergency DC lighting supply distribution shall be on 110V DC, 2 wire, un-earthed system. This power supply shall be obtained from 110V DC batteries. DC lighting panel shall be provided for distribution of lighting supply. This panel shall have an incoming switch, under voltage relay and number of outgoing circuits controlled by switch fuses. On failure of AC supply connected to this panel, under voltage relay shall drop out and shall switch on the incomer DC contactor and thus provide the DC supply to lighting circuits.

8.5 ILLUMINATION LEVELS AND CHOICE OF LIGHTING FIXTURES

The area wise distribution of average illumination levels and type of luminaries shall be as given below: Lux level design for each area shall be provided for review.

S. No.	Area	Average illumination level in lux	Type of luminaire
1.	Turbine-Generator Hall	250	250W Magnetic Induction Lamp high bay
2.	Battery room	250	2x40 W corrosion proof fitting
3.	Control room	500	2x40 W mirror optic decorative recessed type with adjustable reflector
4.	Switchyard, Intake and Main canal Gates	200	1x 250W Magnetic Induction Lamp flood light, medium beam type
5.	On equipment	250	1x70W Magnetic Induction Lamp substation lantern with prismatic glass reflector
6.	Road	30	1x70W or 1x150W LED street lighting
7.	Stairs, walkways	150	1x40W or 2x40W rail mounted fitting
8.	Toilets, washroom pantry	100	1x40W or 2x40W rail mounted fitting
9.	Passage to control room	150	4x20W decorative with acrylic cover
10.	Office areas	350	2x40 W decorative with louvers
11.	Around the building	Owner's Choice	1x70 W Magnetic Induction Lamp well glass fitting at about 15 to 20m intervals
12.	Entrance	Owner's Choice	1x70W Magnetic Induction Lamp bulk head fitting
13.	Cable vault	150	2x40W industrial type with vitreous enamel reflector
14.	Service bay	200	250W Magnetic Induction Lamp, industrial high bay
15.	Emergency DG room	250	2x40 W industrial type with vitreous enamel reflector

The illumination levels for areas, which are not specifically covered above, shall be decided based on illumination levels indicated for similar areas or in relevant standards.

8.6 LIGHTING SYSTEM DESIGN

The lighting system design shall comply with the acceptable norms and the best engineering practices. The system design shall consider principles of lighting specified in following paragraphs. The lighting layout shall be designed to provide uniform illumination with minimum glare. The layout design shall meet the entire statutory requirement, local rules etc.

8.6.1 Indoor Lighting

The illumination levels for various areas in the plant are indicated in the Table above. Following factors shall be considered while arriving at the utilization factor to determine the number of fixtures for each area/building in the plant.

a) Maintenance Factor

i)	Control room and system cabinet room	0.8
ii)	All other indoor areas	0.7
iii)	Outdoor areas	0.6

b) Reflection factor for wall and ceiling

i)	Control room	0.7 ceiling
		0.1 wall
ii)	Other areas	0.5 ceiling
		0.3 wall

c) The value of the ratio of spacing (S) to mounting height (H) shall be commensurate with the type of fittings selected and uniformity of illumination. The suspension height for suspended fixtures shall not exceed 1m

d) Working plane shall be considered as 0.85 m from floor level

8.6.2 Outdoor Lighting

a) Mounting height, spacing of floodlights shall be based on lamp wattage, uniformity of illumination and vertical angles. Ratio of minimum to average illumination shall not be less than 0.3 and for minimum to maximum shall not be less than 0.05.

b) Maintenance factor of 0.6 shall be considered for average conditions.

c) For switchyard lighting, suitable number of lighting masts shall be provided and switchyard towers shall not be used for lighting purposes. All masts shall be of galvanized steel construction.

8.6.3 Roadway Lighting

a) Lighting design for roadways shall consider a maintenance factor of 0.6 for average conditions.

b) Ratio of minimum to average illumination shall not be less than 0.3. The road lighting layout shall consider the width of the road to decide whether the lighting poles shall be located on one side, on either side or in the central reserve.

c) The mounting height of the luminaries shall be generally 4 m.

8.6.4 Selection of Lighting Fixtures and Accessories

The type of luminaries and accessories like switches, receptacles etc, shall be selected based on the plant area in which they are intended to be used. Outdoor type of fixtures and accessories shall be weatherproof type. Flameproof fixtures shall be used in hazardous areas like fuel oil pump house, fuel oil treatment areas.

8.6.5 Switches and Receptacles

a) In the plant areas, the lighting circuits shall be controlled directly from the MCBs in the lighting panels. Wherever the lighting panel is not in the same area separate switches shall be provided. For cabins, rooms etc. separate switches shall be provided for each point. Similarly, for entrances, building periphery lighting, separate switches shall be provided.

b) 240V, 50Hz, 3 pin power receptacles (5A and 15A) shall be provided in all building/areas of the plant. Also, inside a building, receptacles shall be provided at regular intervals so that any point of the building is not more than 10 m with a minimum of 2 nos. in an enclosed area. Inside each cabin, at least two receptacles shall be provided. The same shall be indoor/outdoor/flame proof as per the location.

8.6.6 Lighting Distribution Board (LDB) and Lighting Panels (LP)

LDB shall be provided with voltmeter and ammeter along with selection switches and "Supply ON" indicating lamps etc. The LDB and LPs shall be sheet steel enclosed and shall be fully dust and vermin proof with a degree of protection of IP 52. Outdoor panels shall be weatherproof types with IP 54 degree of protection. The switch boxes, receptacle boxes etc. shall be made up of 18 SWG sheet steel.

8.6.7 The distribution of lighting fixtures/receptacles shall be such that the loading on each phase of the LDB is approximately equal.

8.6.8 10% spare feeders, with minimum 1 no. feeder, of each type shall be provided in each of the LDB and LPs.

8.6.9 Wiring

a) 1100V grade stranded Copper conductor PVC insulated wires to IS: 694 laid in GI conduits shall be used for lighting in non-hazardous area. In the hazardous area, cable wiring with 1100V grade stranded Copper conductor, PVC insulated, PVC inner sheathed, GI wire armoured and overall PVC sheathed cables to IS: 1554 shall be

adopted. For outdoor areas like transformer yard, switchyard, intake, canal gates and road lighting, cable wiring as above shall be adopted.

b) Minimum size of wires in case of conduit wiring shall be 4 sq.mm. in case of lighting and 6 sq.mm. in case receptacle wiring. Minimum cable size in case of cable wiring shall be 6 sq.mm.

c) Wires of different phases shall be run in separate conduits. However, wires of same phase but having different circuit nos. can be run in same conduit. Wires of lighting and power receptacles will be carried in separate conduits and on separate circuits. Wires of AC and DC lighting systems shall be carried in separate conduits.

d) For outdoor lighting, the cable shall be burried at a minimum depth of 750 mm from ground level. The buried cables shall have suitable bedding, protective covers and markers.

8.6.10 Lighting Circuit Designing

a) In an area, the lighting fixtures shall be arranged in different phases/LPs such that even in case one lighting panel goes faulty, complete lighting is not affected. In case of room, the lighting shall be arranged from two phases.

b) The circuit loading on each circuit shall be restricted to 80% of the MCB rating.

c) The voltage drop from LDB to any fixture shall not exceed 3%

8.6.11 Earthing

a) Lighting fixtures, receptacles, switches, conduits and junction boxes shall be properly earthed using 16 SWG Copper wire run along the entire length of the conduit between the fixture and the corresponding lighting panel where it will be connected to the station earth.

b) For fixtures in hazardous areas, the third core of each single-phase armoured cable circuit shall be used as earthing conductor.

c) For outdoor earthing of lighting poles, junction boxes on the poles, 8 SWG GI wire, shall be run buried in ground at a depth of 600 mm and tapped to each lighting pole. The earth conductor shall be connected to the nearby main earthing grid at the first and last poles of each feeder circuit and at some intermediate poles.

8.6.12 Tests

Routine tests and acceptance tests for the lighting fixtures and accessories covered in this specification shall be carried out as per the relevant Indian Standards. Type test reports for similar fixtures shall be furnished.

8.7 AIRCONDITIONING EQUIPMENT

The control room shall be suitably air-conditioned with 2 Nos. Split type air conditioners. The air conditioners shall be of approved make and provided with separate voltage stabilizers.

8.8 VENTILATION SYSTEM

(i) The powerhouse machine hall and control room shall be provided with exhaust fans for providing ventilation. The machine hall shall be provided with six (6) exhaust fans, the control room shall be provided with two (2) exhaust fans and battery rooms shall be provided with two (2) exhaust fans. The rating of each of the exhaust fan shall be 250 watts minimum. It shall be of industrial and wall mounted type. Total ten (10) Nos. exhaust fans shall be supplied and installed.

(ii) The powerhouse shall be provided with four (4) Nos. pedestal type fans of 250W capacity each for circulation of free air in the powerhouse building and control room area.

8.9 FIRE EXTINGUISHING EQUIPMENT

(i) Suitable fire extinguishing equipment for thermal and electrical fires shall be provided to safeguard the various electrical equipments in and outside the powerhouse to prevent fires.

(ii) 6 (six) sets portable fire extinguishers foam type (pressurized water air type) nine (9) litres capacity, complete with wall hanging bracket and liable for the general purpose protection in the Powerhouse and

(iii) 6 (six) Nos. mobile dry type multipurpose fire extinguishers of minimum 9.2 kgs. Capacity for the purpose of electrical fire protection in the powerhouse shall be provided, complete with wall hanging bracket and liable for the general purpose protection in the power house.

8.10 BATTERY, BATTERY CHARGER AND D.C. DISTRIBUTION BOARD

8.10.1 D.C. Battery

One (1) set of 110 V, 300 AH (Ampere-Hour), Sealed Maintenance Free Valve Regulated Lead DC battery shall be included in the scope to meet 110V DC ungrounded control supply requirements of the power station. The battery shall be capable of catering to DC supply required for on control, indications, annunciation and switch gear, control valves, control relays, emergency lighting and communication system etc. The battery shall be of maintenance free type with sealed cells housed in a rack either mounted beneath the battery charger or separately.

In case the 200 Ah Battery is not sufficient, the equipment supplier shall increase the Battery / Charger capacity to suit the project requirements.

8.10.2 D.C. Battery Charger

A battery charger suitable to maintain boost and float charging for the above battery shall be supplied. The charger shall be provided with separate boost charger and float charger. The circuit shall be designed with I.C. based solid state electronic cards. The battery charger shall be provided with lamp indications and a hooter for alerting the operator for faults like

(i) A.C. mains supply failure

(ii) Rectifier fuse failure

(iii) Capacitor fuse failure

(iv) Charger failure, and

(v) Grounding of battery

The charger shall be equipped with earth fault, over and under voltage supervision. The battery shall be provided with an earth leakage relay to avoid grounding of battery. The construction of the battery charger shall be as per the applicable standards.

8.10.3 110V D.C. Distribution Board - 1 No.

One 110V DC distribution board (DCDB) with incomers from battery and battery chargers provided with adequate number of outgoing feeders will be provided for distribution of DC supply.

The DCDB shall be provided with following:

- MCBs for incoming and outgoing feeders
- Indications for feeders ON/OFF
- Hooter
- Earth leakage protection
- Indoor light
- Heater element

8.11 AC DISTRIBUTION BOARD

Three phase AC distribution board of floor mounted type / wall mounted type shall be provided for meeting the load requirements of the switchyard viz. OLTC motors, auxiliary supply of relay, metering and control panels etc. The control gears shall be of MCCB, compartmentalized type, with IP 52 enclosure or better. The board shall be mounted in the control room.

8.12 DIESEL GENERATOR (DG) SET

(i) One (1) DG set of 250 kVA capacity to develop 3 phase 4 wire 415 volts AC supply shall be supplied with AMF panel for extending emergency AC supply to the required motors of the auxiliaries off the units and station lighting. The DG set shall be mounted on anti vibration pads of adequate rating and supplied in one unit for free mounting on the floor. The length of the manifold of the engine exhaust shall be sufficient to leave the engine outside the engine room. Battery of 300 AH 110 V DC for starting the DG set and a charger for charging the battery shall be included.

(ii) One (1) AMF panel shall be supplied to start the DG set in auto soon after mains supply fails. The DG set shall build the voltage in auto and be able to take direct on line starting of the induction motors provided for the emergency loads and station lighting. The DG set shall also be capable of direct line starting the maximum rated induction motor of the auxiliaries provided for the Powerhouse. The set shall keep on running even if AC supply resumes till it is tripped manually. The alternator of the DG set shall be provided with one power Contractor and one MCCB in series in the AMF panel. The output cable of the alternator after MCCB shall be connected to the ACB of the station auxiliary panel. The power Contractor of the DG alternator shall be able to be closed only when the mains supply ACB on the station board is kept open to ensure non-paralleling of DG set AC supply and mains AC supply from station auxiliary transformer. The DG set shall be switches off in auto after 3 starts on preset intervals in auto. The alternator shall be switched off in auto after 3 starts on present intervals in auto. The alternator shall be provided with (1) under voltage, overload (2) and earth fault protections. The AMF panel shall be of standard make. The AMF panel shall be free standing floor mounting type fabricated in one shipping section with 12 SWG CRCA sheet with MS angle reinforcement. The panel shall be wired with 2.5 sq. mm. copper wire of PVC insulation of 660 / 1100 V grade. All the control wiring shall be brought to a terminal board of ELMEX make stud type or equivalent. All wiring shall be provided with ferrules and copper lugs and sleeves. The bus bar provided for the alternator output shall be of Aluminium and shall be suitably sleeved. Window type bulb indication system with a hooter shall be provided for all major faults of the engine, alternator and control system including Battery Voltage Low. The panel shall be painted outside with grey shade as done in the case of generator unit panels and shall be pained inside with the white glossy paint. The AMF panel shall be provided with all relays, timers and meters etc., for full auto start and manual trip of the DG set as per standard practice. The DG set with AMF panel shall be in full and complete shape as approved by the NMMC during detailed design.

8.13 ELECTRICALLY OPERATED OVER HEAD TRAVELLING CRANE

One (1) electrically operated overhead travelling (EOT) Crane of **75/15** tonne capacity minimum or adequate capacity to handle the equipment like generator which has maximum weight shall be supplied and installed for material handling, service inside Powerhouse. The crane shall be complete with drives for cross travel and long travel motion, runaway rails, bridge girder of adequate size and carriages, gantry rail & hand operated chain pulley hoist conforming to Class II medium duty as per IS: 807 / IS: 3177. The bridge structure shall be double girder construction of steel, adequately braced, reinforced with lateral ties with liberal factor of safety. The deflection of the bridge girder shall be limited to maximum of 1/900 of its span. The bridge girder shall be provided with a 50 sq. mm. gantry rail with fish plates, bolts, nuts and end stops. The end carriages shall be provided with a minimum of two wheels. The wheels shall be in perfect alignment and parallel to each other to ensure no skewing effect. The long travel shall be affected by means of an endless chain operation through chain and chain wheel located at one end. The gears shall be spur / helical type and shall be accurately

machined out from steel billets. The capacity of the crane shall be accurately machined out from steel billets. The capacity of the crane shall be designed to lift the heaviest assembly to be lifted in the Powerhouse. The crane shall be complete in shape conforming to the standards of the Powerhouse service. The make of hoist will be as approved by the NMMC.

8.14 POWER AND CONTROL CABLES

(i) CONTROL CABLES

The control cables shall be multicore, copper, armoured, PVC insulated to 660 / 1100 voltage grade. Each core shall be of multi strand copper conductor of minimum 2.5 square mm. The control cables shall be laid neatly with adequate loop in separate Aluminium trays in cable trench on one side. The cable trays shall be neatly covered with Aluminium tray covers. Each cable should be neatly tagged and binded properly while laying. The cable ends shall be provided with a cable gland of adequate size. The cable shall be neatly dressed and terminated and provided with crimping type copper lugs. Cable cores shall be ferruled and lugs shall be sleeved properly. Control cables shall have adequate spare cores. Wherever necessary, required marshalling or junction boxes shall be provided with terminal blocks. Each terminal block shall be neatly numbered and named.

(ii) POWER CABLE FOR 1100 V GRADE

The power cables shall be of PVC insulated to 1100 volts grade for service voltage of 433 volts with 3½ cores of adequate size. The power cable shall be of multicore Aluminium except for the generator cable.

(iii) POWER CABLE FOR 11 kV

The generator power cable shall be of 11 kV grade armoured XLPE single core Aluminium of adequate size in adequate runs. The same cable will be used from 11 kV bus to the power transformer and station auxiliary transformer. While terminating the 11 kV cables, heat shrinkable cable terminating kits shall be employed as approved by the NMMC.

(iv) LAYING OF CABLES

Each power cable should be laid neatly with adequate looping in separate Aluminium trays fitted in the cable trench and neatly tagged and binded. The cable trays shall be neatly covered with Aluminium covers. The cables ends shall be neatly dressed and terminated and provided with crimping type copper lugs. The cable ends shall be healthy, ferruled and sleeved at the ends of lugs. Cable shall be provided with name / number tags.

(v) DESIGN OF CABLES

The design of the cross-sectional area of the power and control cable shall consider the rating factors liberally as per manufacturer’s standard and Powerhouse practices. The combined rating factor shall be around 0.5 to 0.60 for arriving at cross-sectional area of the conductor.

The cables shall be of reputed marks and the cabling shall be generally conforming to latest edition of I.S. and shall be laid as per Powerhouse practice.

(vi) CIVIL WORKS

All civil works like providing of cable trenches, embodiments in cable trenches shall also be arranged by the Contractor. The angle supports for erection of the cable trenches & channels for erection of chequered plates for covering the cable trenches shall be supplied by the equipment supplier. The chequered plates too shall be supplied by the equipment supplier.

8.15 EARTHING SYSTEM

(i) Necessary earthing system shall be provided for equipment of Powerhouse and switchyard. An earthmat shall be laid beneath the powerhouse raft and raisers shall be brought to machine hall and control room floor level. The earth mat shall be designed considering the earth resistivity, fault level and permissible value of step potential and touch potential following the guide lines of CBIP Manual on layout of substation or equivalent practices the earth resistivity shall be measured by the Concessioner in the Powerhouse area and switchyard area. The earth mat conductor shall be of steel flat of minimum size of 65 x 10 mm and the minimum conductor size of raisers shall be 50 x 65 mm size. A minimum number of about 15 nos. raisers should be brought up at the appropriate places in the powerhouse area. The earth strip where exposed to weather shall be galvanized. All the joints of earth mat conductor shall be welded fully as per I.S. or equivalent standard. The equipment inside the powerhouse shall e effectively earthed using the raisers as per standard practice in vogue. A drawing and design calculations for the earth mat shall be furnished by the supplier and got approved by the NMMC before laying earthmat.

(ii) The earthing of Switchyard equipment shall be done as per powerhouse practice providing adequate number of earth pits designed as per relevant I.S. and provided with cast iron plate and GI strip of adequate size and if necessary earthmat also. Separate earth pits shall be provided for transformer neutral earthing and body earthing. Transformer neutral shall be earthed by GI / Copper strip as approved by the NMMC.

Separate earth pits shall be made for earthing of structures of switchyard. A master earthing has to be laid connecting all the earth pits and nearest earthmat raisers and shall be left in the deepest point of the tailrace pool. The earthing should be completely done for all the equipment providing two body earth and other earthing points as per powerhouse practice.

8.16 DRAWINGS

i) THE FOLLOWING DRAWINGS SHALL BE FURNISHED WITH THE DPR:

A) SINGLE LINE SCHEMATIC DIAGRAM OF POWER AND ELECTRICAL CONTROL AND PROTECTION SYSTEM

B) LAYOUT PLAN OF CONTROL PANELS

C) SCHEDULE OF TESTS

ii) THE FOLLOWING DRAWINGS SHALL BE SUBMITTED AFTER AWARD OF CONTRACT:

A) DETAILED SCHEMATIC DIAGRAM FOR POWER, CONTROL AND PROTECTION SYSTEM, INSTRUMENTAITON, INDICATION AND ANNUNCIATION SYSTEM

B) DETAILED DIMENSIONAL DRAWINGS OF CONTROL PANELS, BREAKERS, SWITCH GEAR

C) DETAILED EQUIPMENT DRAWING FOR POWER AND AUXILIARY TRANSFORMER

D) SWITCHYARD LAYOUT

E) CABLE SCHEDULES AND ROUTE MAPS

F) DESIGN CALCULATION FOR IMPORTANT PARAMETERS OF TRANSFORMER, CABLE SIZES ETC.

8.17 DETAILS OF REQUIREMENT

The Project shall be provided with the equipments with tools and plants as specified in the Schedule of Requirements (SOR).

SECTION-: TECHNICAL SPECIFICATIONS

SUB-SECTION 9: SUPERVISION FOR ERECTION, TESTING AND COMMISSIONING OF EQUIPMENT

9.1 PREAMBLE

This section deals with services required for performing On-site assembly, complete erection, field testing at site, commissioning, Load Testing (trial operation) of 72 hrs, test run of commercial operation and maintenance and training of NMMC's assigned personnel for the equipment supplied for a period of eight (8) weeks.

9.2 SCOPE OF SERVICES

The Concessioner has to send experts and carryout on site supervision of assembly, erection, testing and commissioning of all the equipment of the Project in a complete shape and hand over to the NMMC after carrying out commercial operation and maintenance including Load Testing (trial operation) of 72 hrs, test run of commercial operation and maintenance and training of NMMC's assigned personnel for the equipment supplied for a period of eight (8) weeks.

9.3 ERECTION

(i) The erection of the equipment shall be carried out by the NMMC under the supervision of a qualified expert from the Concessioner. Separate Engineers of the NMMC shall carry out the Electrical and Mechanical (E&M) Works of the Project.

(ii) During operation of units the same expert of Supplier shall carry out the – eight (8) weeks Operation and Maintenance of the units and simultaneously provide training to the assigned personnel of the NMMC.

(iii) The above expert shall be kept posted at the site till the project is completed to make complete coordination between Electrical and Mechanical (E&M) Works of the Project as per the progress of the Civil / Erection works achieved by the NMMC.

(iv) In order to complete the supervision of Erection, Testing & Commissioning of the Project, the Concessioner has to arrange and carry out the following activities, make all the arrangements and bear the costs:

a. Journey, boarding, lodging, transport, amenities, medical, sanitary facilities and any other arrangements of the Concessioner's personnel.

b. Health care, safety and insurance for the Concessioner's personnel, and their dependents during erection, testing and commissioning of the project and the stated period of commercial operation and maintenance of the units.

(v) All compensations to Concessioner / manufacturer's expert at site during supervision of erection, testing, commissioning and load test of 72 hours, 8 weeks of test run operation and maintenance of units and simultaneous training of assigned personnel of the NMMC shall be

borne by the Concessioner. Boarding & lodging of the NMMC's personnel shall be borne by the NMMC.

9.4 COMMISSIONING AND LOAD TESTS

After commissioning is completed, each unit of the project shall be continuously run at rated output for 72 hours and also run at maximum output for further 72 hours continuously and each unit shall be handed over to the NMMC after the stated period of O&M.

Concessioner shall note that the project will be deemed to have been commissioned successfully upon conducting the requisite Field Acceptance Tests as per IEC 41 and the Commissioning Tests as per IEC 545. As specified on Page 79 of Publication No. 175 dated February 1985 of the Central Board of Irrigation and Power titled "Small Hydro Stations Standardization" wherein under Para No. 24.00 Commissioning Tests; it has been clearly mentioned that the turbine, **after continuous operation for 72 hours,** shall be free from problems of leakages, over-heating, excessive vibrations, failures and damage etc. The machine will be handed over to the NMMC thereafter. However, Concessioners shall note that experts of the Concessioner shall remain posted at site to oversee running & maintenance of all three units and shall simultaneously impart training to the assigned personnel of the NMMC for a further period of eight (8) weeks in O&M, trouble shooting, black start and other possible problems.

9.5 COMMERCIAL OPERATION

After handing over, each unit shall be supervised for operation and maintenance of expert Concessioner for eight (8) weeks by keeping engineers / operators of the NMMC in three shift in parallel. The NMMC's operators shall be well-trained to handle the operation of units independently during this eight (8) weeks period by expert(s) of the Concessioner.

9.6 COMMITMENTS

Any commitment made by expert of Concessioner at site relating to their scope of work on the project is binding on the part of the Concessioner. The Concessioner is fully responsible and liable for fulfilling such commitments made during course of contract fulfillment.

SECTION-: TECHNICAL SPECIFICATIONS

SUB-SECTION 10: GATES AND HOISTS

10.1. SCOPE OF WORK

10.1.1. General

The works to be performed under this contract shall be consisting of design, drawing, material selection, fabrication, shop as well as field painting, supply, delivery at site, erection, testing, commissioning, performance guarantee etc. of gates and their hoisting equipment at the sites of Main Inlet Gate and Draft Tube Gates in the powerhouse of Morbe Dam Toe H.E. Project, Maharashtra.

10.1.1.1. MAIN INLET GATE PROVIDED BEYOND THE DEAD FLANGE FITTED AT THE "WYE" POINT FOR THE CONNECTIVITY TO HYDRO POWER PLANT (1 No.)

a) One (1) no. 4000 mm (wide) x 4000 mm (high) fixed wheel type vertical lift Main Inlet Gate for the 3.5 m diameter main penstock provided beyond the dead flange fitted at the "WYE" point including its hoist & hoist structure with skin plate, wheel assemblies, seal assemblies, guides, guide shoes, stiffeners, end vertical girders, horizontal girders, lifting arrangement, 1st stage and 2nd stage embedded parts such as sill beam, side and top seal seats assemblies, track plate and bases and anchorages and dogging arrangement etc. complete in all respects.

b) One (1) set of electrically operated Rope Drum Hoist of adequate capacity for above with ropes, rope drums, central drive unit, end reduction units, floating shafts, manual drive units, sheaves / pulleys, limit switches and hoist supporting structure etc. complete in all respect.

OR

One (1) set of hydraulic hoist of adequate capacity for operation of above gate including hoist suspension and hoist supporting structure, hydraulic unit, control panel etc. complete in all respect.

10.1.1.2. DRAFT TUBE GATES (2 Nos.)

a) Two (2) nos. 6000 mm (wide) x 4000 mm (high) fixed wheel type vertical lift Draft Tube Gates and their hoists & hoist structures with skin plate, wheel assemblies, seal assemblies, guides, guide shoes, stiffeners, end vertical girders, horizontal girders, lifting arrangement, 1st stage and 2nd stage embedded parts such as sill beam, side and top seal seats assemblies, track plate and bases and anchorages and dogging arrangement etc. complete in all respects.

b) Two (2) sets of electrically operated Rope Drum Hoists of adequate capacity for above gates with ropes, rope drums, central drive unit, end reduction units, floating shafts,

manual drive units, sheaves / pulleys, limit switches and hoist supporting structure etc. complete in all respect.

OR

Two (2) sets of hydraulic hoist of adequate capacity for operation of above gate including hoist suspension and hoist supporting structure, hydraulic unit, control panel etc. complete in all respect.

10.1.2. Dry as well as Wet Tests

Dry as well as wet tests are to be carried out for the gates by the Contractor at his own cost. Any defect noticed during the tests and / or during the guarantee period, which shall not be less than Twelve (12) months after final acceptance, shall be rectified by the Contractor at his own cost. Shop as well as field paintings shall be done by the Contractor. The scope of supply includes these requirements. The 1st stage as well as 2nd stage concrete are not in the scope of this work, however, 2nd stage concrete around the 2nd stage embedded parts block-outs shall be done under the supervision of a representative of the gate manufacturer.

The responsibility for correctness and accuracy of alignment of 2nd stage embedded parts would rest with the gate manufacturer and also for other related equipment.

The gate manufacturer, when ordered in writing by the Employer, shall perform extra work in furnishing the material / equipment not covered by these specifications or specification drawings or included in the schedule, but forming an inseparable part of the work contracted for. Extra work / material will be paid for at a lump sum or unit price as may be agreed upon between the Employer and the gate manufacturer and stated in the orders. Whenever, in the judgement of the Employer, it is impracticable to fix the price of work/material ordered in the order, it shall be paid for at actual cost as determined by the Employer plus 16% allowance for superintendence for use of tools and tackles and shop etc.

10.1.3. Wastage of Steel

The wastage of steel for the sections received from the main producers shall not be compensated to the Gate manufacturer. The price will be paid only for the net weight of the Gate based on the sectional unit weight as per table of standard supplied by the SAIL and used in the gates and related equipment. The weights of bolts, nuts, rivets, washers and welding etc. will not be considered in the net weight of gates. All the wastage of steel sections shall be on account of the gate manufacturer. The gate manufacturer, while quoting the rates, should consider this aspect.

10.1.4. Schedule and Progress

Immediately on the Award of Work, the Contractor shall submit the schedule of fabrication and transportation of the equipment to the Employer for approval so as to ensure its delivery within the specified delivery period as given in the Schedule of Milestones. The schedule shall clearly specify all stages of fabrication to enable the Employer to plan his inspection

accordingly as stated in these specifications. The Contractor shall also, during the course of fabrication, submit the monthly progress report along with the photographs of fabrication done during the preceding month to the Employer to apprise him of the progress of equipment.

10.1.5. Delivery Schedule

Time of delivery at the project site is an important factor and the Contractor abide by the time schedule shown under Schedules of Milestones; the time being reckoned from the date of order to proceed with the work.

10.1.6. Warranty

The Contractor shall furnish warranty of the equipment for a minimum period of Twelve (12) months from the date of final acceptance of equipment or commissioning, whichever is later. The Contractor shall guarantee among other things the following items:

a) Quality and strength of the materials used

b) Satisfactory operation of the equipment

c) Safe stresses in all parts under all conditions of operations

d) Protection of equipment against vibrations and corrosion

The Contractor shall rectify, at his own cost, the defect (s) if any, noticed during the warranty period. The Contractor shall assume all responsibility for direct damages causing personal injury or property loss / damage due to any manufacturing defect resulting in failure of equipment being supplied under these specifications.

10.1.7. Atmospheric Conditions

The equipment called for under these specifications shall be suitable for continuous out door operations in the climate at the site of Morbe Dam Toe (2 x 750 kW + 15% COL) H.E. Project, Maharashtra with temperature from minimum of 9^0C to maximum of 43^0C.

10.2. SCHEDULE

Please see Bill of Quantities.

10.3. DRAWINGS AND DATA TO BE FURNISHED ALONG WITH THE TENDER BY THE BIDDER

10.3.1. Each bid shall contain the price bid, quotation and other information asked for vide schedule separately in respect of following:

10.3.2. Gates

10.3.2.1. Preliminary designs & drawings showing the following:

(a) General installation with over all dimensions, weights and materials proposed for use.

(b) Sealing arrangement proposed

(c) Details of any other special features such as lifting arrangement and dogging arrangement etc.

10.3.3. Rope Drum Hoist / Hydraulic Hoist

10.3.3.1. Preliminary design and drawing showing the following:

(a) General arrangement with over all dimensions, weights and materials proposed for use.

(b) Arrangement indicating the end reduction units, gears, pinions, central drive units manual drive operation and proposed tolerances.

(c) Name and specifications of bought our items along with the name of manufacturer's establishment.

10.3.4. Hoist Supporting Structure

10.3.4.1. Preliminary design and drawing showing the following:

(a) General arrangement with over all dimensions, weights and materials proposed for use.

10.3.5. In addition to the above, following information should also be furnished:

(a) Estimated weights and size of major items involved in transportation of the gates and hoisting equipment with sufficient data on chargeable weights and sizes during transportation.

(b) A statement that the Employer's specifications and specification drawings shall become the part of the contract with exception(s), if any, noted.

(c) A statement of the standard specifications, if any, different from those specified in these specifications with (6) six copies in ENGLISH language.

(d) Necessary guarantees as specified in general conditions of contract for proper performance of the equipment and against any defect in accuracy and correctness in designs, fabrication, erection, commissioning, performance, guarantee and delivery etc.

(e) Delivery schedule.

(f) List of projects, where similar equipment have been supplied and installed by the Bidder along with their particulars and performance test reports.

(g) Complete list of spare parts proposed to be supplied along with the equipment.

(h) Contractor's business name and complete details in technical setup.

10.4. Drawings & Data to be furnished by the Contractor after the Award of Work

(a) The Contractor shall submit the following as soon as possible but not later than thirty (30) days from the date of issue of letter of award and before proceeding with the fabrication work for the approval of the Employer.

- Four (4) copies of the detailed design calculations and fabrication drawings of Gates, hoisting equipment, hoist supporting structure and electrical circuit

diagrams showing the specifications for each part and the type of heat treatment, wherever used to demonstrate clearly and fully that the equipment to be furnished under this contract shall conform to the provisions and intent of these specifications & specification drawings.

- Complete list of all equipment showing the dimensions, type, grade and class of material, numbers required and weights etc.
- Complete details such as makes, capacities, ratings and other relevant details such as speed / torque characteristics of electric motors covering starting and running conditions with controls etc. for all standard articles shall be furnished.
- Details of complete coordinated wiring of all electrical equipment along with the detailed drawings supported by catalogues shall be furnished.
- The proposed methods of installations of all anchorages and complete equipment.

(b) Guarantee etc.

(c) Unless otherwise specifically provided for in the schedule and or in the specification and / or in the specification drawings, the Contractor shall furnish all the materials accessories, tools & tackles and appurtenant parts called for in the specification or shown on the specification drawings but not mentioned in the specifications or any thing called for in the specifications but not shown on the drawings as if required or shown in both.

10.5. TECHNICAL REQUIREMENTS

Any fabrication work performed prior to the formal approval of the Employer in respect of the designs and drawings shall be at the risk and cost of the Contractor. The Employer shall have the absolute right to ask the Contractor to carry out any change(s) in the designs and drawings, which may be deemed necessary in the opinion of the Employer to make the equipment conform to the provisions of these specifications and the cost of such changes shall be borne by the Contractor.

However, the approval of Contractor's designs and drawings conveyed by the Employer shall not relieve the Contractor of any of his responsibility under the contract towards the correctness and accuracy of designs, drawings, fabrication, erection, commissioning, and performance.

10.5.1. Design Criteria

Gates shall be designed for "Wet & Accessible" condition in case of operation by Rope Drum Hoist or for "Wet & Inaccessible" condition, in case of operation by hydraulic hoist, in accordance with provisions contained in IS: 4622-1992.

The Rope Drum Hoist / Hydraulic Hoist shall be designed in accordance with provisions contained in IS: 6938-1992, IS: 10210 respectively (Latest editions of IS: codes to be followed).

10.5.2. Operating Criteria

10.5.2.1. Gates

The Main Inlet Gate and Draft tube gates shall be operated under unbalanced hydrostatic head with the help of electrically operated rope drum hoist or hydraulic hoist as may be decided by the Employer. No regulation of discharge has been envisaged with the help of this gate. The normal position of the gate is either fully opened or fully closed.

10.5.3. Standards

i.	Slide type gate (if permitted by Employer)	IS: 9349 – 1992
ii.	Rope drum hoist	IS: 6938 – 1989
iii.	Steel Structures	IS: 800 – 1984
iv.	Hydraulic hoist	IS: 10210 – 1993
v.	Lifting beam	IS: 13591 – 1992
vi.	Fixed wheel gate	IS: 4622 – 1992

10.5.4. Components of Gates & Embedded Parts

10.5.4.1. GATE LEAVES

The gate leaf shall consist of horizontal, end vertical girders, vertical stiffeners and wheel assemblies / slide block assemblies mounted on skin plate in welded construction. The gate leaves shall be designed to close down under its own weight. The rubber seals shall be fixed with the skin plate with the help of C.S.K. screws or bolts & nuts made of stainless steel as indicated on the specification drawings, so as to ensure positive water pressure between the skin plate and seal and to bear tightly on the seal seat to prevent the leakage of water. Sufficient nos. of screws bolts of adequate diameter shall be provided to resist the frictional forces encountered by them during operation of gates under maximum water head. The provisions shall be made for connections of lifting lugs for connecting the hoists with the gates and gate position indicator. The connection of the hoist shall be so made that when the gate is suspended freely, it shall remain in true vertical plane.

10.5.4.2. SKIN PLATES

i) The skin plates and the horizontal / vertical stiffeners shall be designed together as composite members of the following two conditions:

   a) In bending across the stiffeners / horizontal girders or as panel.

   b) In bending, co acting with stiffeners / horizontal girders.

For determining the stresses for "Wet & Accessible" / "Wet & Inaccessible" the procedure as specified in IS: 4622, IS: 153415 and IS: 5620 shall be used, unless otherwise precise methods are available.

ii) For condition in (i) (b) above the width of skin plate co acting with stiffener / horizontal girder for panel shall be assumed as specified in relevant IS codes unless more exact method is available and the actual stresses due to beam action are calculated. Alternatively, the co acting width of skin plate in non-panel fabrication shall be calculated as specified in IS: 4622, IS: 153415 & IS: 5620 respectively.

iii) To take care of corrosion, the actual thickness of skin plate, as calculated shall be increased by at least 1.50 mm. The actual stresses shall not be more than those specified in relevant IS codes. However, the minimum thickness of the skin plate shall not be less than 10.0 mm inclusive of corrosion allowance except for the thickness of web of Rolled Steel sections used.

10.5.4.3. HORIZONTAL AND END VERTICAL GIRDERS AND VERTICAL STIFFENERS

The horizontal girders and vertical stiffeners shall be designed as a simply supported or continuous beams depending upon the framing adopted. The spacing in between the horizontal girders shall be such that the girders shall carry almost equal loads. The end vertical girders shall be designed as continuous beam supported on slide blocks center points with concentrated loads coming from the horizontal girders and shall transfer the same to the adjoining concrete structure through the track plate & track bases. The actual stresses so computed shall not be more than those specified in relevant IS codes.

The connections to the hoisting mechanism at a point other than end vertical girders shall be so made that the stress concentration particularly on the upper fibre of the web of the top girder is avoided. And the hoisting forces shall be dispersed through suitable stiffeners to one or more horizontal girders below the top one. The extra stresses, if any, arising due to this arrangement shall be combined with other stresses to ensure that the permissible limit does not exceed.

10.5.4.4. DEFLECTION OF GATES

The maximum deflection for the gates shall not exceed 1/800 of the span where span is center-to-center distance of wheels / slide blocks, for both types of gates.

10.5.4.5. SEALS

The seals shall be Music Note type Teflon cladded rubber seals for side / top sealing and wedge type rubber seals for bottom sealing conforming to IS: 11855-1986. The seals shall be fixed to the gates by means of either counter sunk screws or bolts & nuts both made of stainless / corrosion resistant steel conforming to IS: 1570 (v) - 1985. Screws / bolts shall designed to withstand the full shear likely to developed during raising or lowering cycle of the gate under maximum hydrostatic head between the seals and seal seat plates due to

frictional forces. In case the screws are used for fixing the seals, these shall be adequately tightened with constant torque and locked by punch mark. Minimum threaded length equivalent to 1.50 times the diameter of screws to ensure against their loosening under vibrations during operations. The seal interference of side / top seals shall be 3.0 mm to 5.0 mm whereas the compression of bottom seal be 5.0 mm. Suitable chamfer at the bottom of skin plate and clamp plates to accommodate the compression of bottom wedge seals.

10.5.4.6. SEAL SEATS, SEAL SEAT BASES & SILL BEAMS

(a) SEAL SEATS

The minimum thickness of seal seats for side / top as well as bottom sealing shall be 16.0 mm after machining, the seal seats shall be of stainless steel conforming to IS: 1570 (v) - 1985. These shall be either welded or screwed to the seal seat bases, in case screwed, the head of screws shall be kept at least 1.0 mm below the surface of the seal seats. The screws shall be made of stainless steel conforming to IS: 1570 (v) - 1985. The surface of seal seats shall be finished to two (2) delta surface finish.

(b) SEAL SEAT BASES AND SILL BEAMS

The seal seat bases and sill beams shall be made of either built up steel plates section or rolled steel sections in welded construction. These shall be aligned and securely fixed with 1st stage embedded parts in block - outs for embedment in 2nd stage concrete. The surface of bottom seal eat already fixed shall be flush with surrounding concrete.

10.5.4.7. FITS & TOLERANCES

The outside diameter of bearings shall be tight fit in the wheel and the wheel pin shall be tight fit in the inside diameter of the bearings.

10.5.4.8. SLIDE BLOCKS

The slide blocks shall be made of Aluminium Bronze Gr. 1 conforming to IS: 305 - 1985. The minimum thickness of slide blocks shall not be less than 16.0 mm after machine finish and shall be fixed to the gate leaf with the help of stainless steel counter sunk head screws of suitable size to withstand the frictional forces being developed due to operation of gates under maximum water head. The head of screws shall be kept at least 1.5 mm below the surface of slide blocks.

10.5.4.9. WHEEL ASSEMBLIES

a) WHEELS

Wheels shall be either of carbon steel or cast steel or forged steel. Wheels shall be so located so that these carry equal load. The wheels shall be designed as per provisions contained in IS: 4622 - 1992.

b) WHEEL AXLES

Wheel axles shall be made of corrosion resistant steel conforming to IS: 1570 (v) - 1985. The axles shall be supported on end vertical plates.

c) BEARINGS

Anti - friction spherical roller bearings SKF or equivalent shall be provided

10.5.4.10. TRACK / BEARING PLATES & BASES

a) TRACK / BEARING PLATES

Track / bearing plates shall be made of Corrosion Resistant steel conforming to IS: 1570 (v) -1985. These plates shall be mounted on the track bases by welding. The minimum thickness of track plate shall not be less than 25.0 mm after machining.

b) TRACK BASES

The track bases shall be made of structural steel rolled or built up sections in welded construction conforming to IS: 2062-1992. These shall be embedded in 2nd stage concrete, which shall not be leaner than M-25 grade conforming to IS: 456 (latest edition). The edge distance of the track base from the groove face shall be determined on the basis of shear strength of concrete. However, the minimum edge distance shall not be less than 150 mm as specified in relevant IS codes.

The track base shall be designed as a beam on elastic foundation. The track base shall be checked for bending stress & shear stress and its flanges for bending. The web of the track base shall be checked for compression and the permissible stress in compression shall not be more than 85% of yield stress of the material. The track base shall also be checked for shear stress in concrete under the base. The bearing and shear stresses for concrete shall not exceed those specified in IS: 456.

The permissible stresses in track base shall not exceed those specified in relevant IS codes.

10.5.4.11. GUIDE PLATES & GUIDE SHOES

Guide plates for gates shall be fixed and embedded in 2nd stage concrete. The minimum thickness shall be 20.0 mm. The guide shall be effective in longitudinal as well as in transverse directions. The clearance between guide plate and guide shoes shall be 4.0 mm to 6.0 mm in each direction.

Guide shoes for gates shall be fixed on the end vertical girders of the gate leaves. The guide shoes shall be made of structural steel. The guide shoes shall be fixed with the help of bolts, which shall be designed to withstand the load, encountered by them during the operation of the gates.

10.5.4.12. BALLAST

The gates shall be self-closing type under their own dead weight. Suitable ballast, if required to make the gate self-closing, may be provided in the form of dead weight. The ballast shall be in the form of cast iron / pig iron billets, concrete or any other suitable material and shall be securely placed in between the webs of horizontal girders ensuring that it does not get dislodged from its position, when the gate is in operation. The effect of dead weight of the ballast on the horizontal girders shall be analyzed. The center of gravity of the gate shall be determined after the ballast has been placed and properly secured in position.

10.5.4.13. ANCHORAGES & ANCHOR BOLTS

The anchorages shall be provided in the 1st stage concrete with suitable block-outs openings to hold and to align the 2nd stage embedded parts in the 2nd stage concrete. The 2nd stage anchor bolts shall have double nuts and washers and the minimum diameter shall be 16.0 mm. For alignments and adjustments purposes enlarged holes shall be provided in the 2nd stage embedded parts. Adequate numbers and suitable size dowel bars shall be provided at suitable spacing in the 1st stage concrete and the surface of 1st stage concrete in block-outs shall be left thoroughly rough to ensure proper bond in between1st stage and 2nd stage concrete.

10.5.4.14. TOLERANCES

The tolerances for embedded parts and for components of the gates shall be as specified in IS: 4622-1992, IS: 5620-1985 and IS: 9349.

10.5.4.15. LIFTING ARRANGEMENT

The lifting arrangement to the gates shall be provided with reference to the true center of gravity of the gates in such a manner that when the gates are hung freely shall remain in true vertical plane. In case the lifting lugs are welded on the web of the top horizontal girder the hoisting forces shall be dispersed through suitable stiffeners to one or more horizontal girders below the top one. The extra stresses, if any, arising due to this arrangement shall be combined with other stresses to ensure that the permissible limit does not exceed.

10.5.4.16. EARTHQUAKE EFFECT

The suitability of gates shall be checked for earthquake effect and the permissible stresses shall be enhanced $33^{1}/_{3}$% subject to an upper limit of 85% of yield point of the material. In case of welded connection the values of permissible stresses shall be the same as permitted for the parent material. And in case of bolts and nuts the increase in stresses shall be maximum of 25% of the permissible stresses.

10.5.4.17. M.W.L. CONDITION

The design of all the gates shall be checked for maximum water level conditions at intake and at draft tube outlet. The permissible stresses in various components of the gates shall be increased by $33^{1}/_{3}$% subject to the upper limit of 85% of yield point stress of the material.

10.6. ROPE DRUM HOIST & THEIR ACCESSORIES

10.6.1. Hoist Capacity

The hoist capacity shall be based on the algebraic sum of the worst combination of following forces developed during either raising or lowering cycle of the gates. The hoist capacity thus calculated shall be increased by 20% as reserved.

(a) All weights of consisting of

i) Gate leaf along with all its components including horizontal girders vertical stiffeners, end vertical girders, diaphragm plates, wheel assemblies or slide blocks etc.

(b) Any hydro - dynamic forces like hydraulic down-pull / uplift.

(c) All frictional forces comprising of:

i) Wheel / sliding friction

ii) Guide friction

iii) Seal friction

iv) Friction of moving parts of hoisting equipment

(d) Silt load, if any.

(e) Seating load.

(f) Any other consideration.

10.6.2. Hoisting Speed

The hoisting speed shall be between 0.3 m to 0.7 m per minute.

10.6.3. Hoist Supporting Structure

The hoist supporting structure shall be made of structural steel conforming to IS: 2062 - 1992 and shall be designed to withstand the hoisting load, wind load, dead weight of hoist and its all components as well as vibrations caused due to operation suitable anchorages for the hoist frame shall be provided to take the worst combination of all loads under which the gates and hoists are under operation.

10.6.4. Components of the Hoists

Each hoist shall comprise of following components:

(a) Central drive unit

Central drive unit shall comprise of an electric motor, single stage reduction gearbox, Electro-magnetic brakes, gate position, indicator and manual drive unit etc.

(b) End gear reduction unit

The end gear reduction unit shall comprise of spur gears, pinions, plummer blocks, shafts, pedestals, rope drums, bearings, couplings and all other such accessories, which may form in-separable components for the satisfactory operations.

(c) Control equipment

The control equipment shall comprise of electric motor, switchgears, limit switches, control panel and various electrical relays required for satisfactory operation of motors and brakes etc.

(d) Miscellaneous parts

Miscellaneous parts like wire ropes rope sockets, turn buckles, pulleys / sheaves, hoist base frames, cover boxes and hoist supporting structure etc.

10.7. MECHANICAL EQUIPMENT

10.7.1. Wire Ropes

10.7.1.1. GENERAL

The wire ropes shall be made of special improved plough steel of 6 x 37 construction Lang's and fibre core and shall conform to IS: 2266-1977.

While selecting the diameter of the wire ropes the efficiency of pulleys, sheaves and drums shall be taken into account.

The wire ropes shall be provided with a device to take care of unequal stretch of rope. Wire ropes shall be guided over as few pulleys as possible. Reverse 'S' shaped bends shall be avoided as far as possible. The ends of rope shall not be subjected to undue twists and turns. Wire rope shall be so fastened on the drum that it may not slip away even at maximum load.

10.7.1.2. BREAKING STRENGTH

The breaking strength of wire ropes, if not specified by the wire rope manufacturer, shall be taken on the basis of IS: 2266-1977.

10.7.1.3. FACTOR OF SAFETY

The minimum factor of safety based on breaking strength and safe working load of the wire ropes shall not be less than six (6) under normal conditions and not less than three (3) under breakdown torque condition of electric motor selected.

10.7.1.4. DRUMS

The drum shall be strong enough to withstand the crushing as well as bending. The crushing strength of the drum shall be calculated as per Para 4.3.3 of IS: 6938 - 1989. The minimum pitch diameter of the drum shall be twenty (20) times the diameter of the wire rope of 6 x 37 construction.

The length of the drum shall be such that each lead off rope has minimum two (2) full turns on the drum, when the gate is at its lowest i.e. closed position and one (1) spare groove for each lead off the drum, when the gate is at its highest position.

The drum may be with flanged ends. The flanges shall projects to a height of not less than two (2) times the rope diameter above the rope. A spur gear secured to the drum may be regarded as forming one of the flanges.

The drum shall be machine grooved and the contour at the bottom of the groove shall circular over an angle of at least 150°. The radius of the groove shall be 0.53 times the diameter of the wire rope duly rounded off to next full mm. The depth of the groove shall not be less than 0.35 times the diameter of the rope. The grooves of the drum shall be so pitched that there is a clearance between adjacent turns of the rope as under:

1.50 mm for ropes upto and including 15 mm diameter

2.50 mm for ropes over 15 mm and including 30 mm diameter

3.00 mm for ropes over 30 mm diameter

The lead angle i.e. fleet angle of the rope shall not be more than 50 or 1 in 15 on either side of helix angle of the groove in the drum

10.7.2. Gears

10.7.2.1. SPUR GEARS

Spur gears of 20° full depth in volute system shall be provided in end reduction units. The correction factor for peripheral speeds and the efficiency shall also be considered. The material of pinions shall be harder than that of gears and shall be free from imperfections such as chatter marks. The gears shall be machine cut and shall be designed as per Para 4.5.0 of IS: 6938 - 1989.

10.7.2.2. SPEED REDUCERS

Standard worm or helical reducers, if used, for the single stage heavy reduction at the central drive unit shall be high-grade reduction unit suitable for the service intended. The proportions of all the parts, therein, shall be in accordance with the best engineering practices. Rating and efficiency of the reducers used in design calculations shall be as per the manufacturer's recommendations. The whole assembly shall be housed in a dust proof casing with suitable lubrication facility. The reducers shall have self-locking characteristics.

10.7.2.3. GATE POSITION INDICATORS

The gate position indicators shall be provided to show the position of the gates, when these are being raised or being lowered. The indicator dial shall be made of non-rusting metal or enameled Plates. The markings on the dial in operating range shall have minimum readability of 1/20th of metre. The metre markings shall be very bold. The words 'CLOSED', 'OPEN' and 'FULLY RAISED' shall also be engraved or permanently marked.

The dial shall be located at a convenient place from where it can be read easily. The indicator points shall be made of non-rusting metal. Electro-plated or digital type indicator may also be provided.

10.7.3. Shafts

10.7.3.1. GENERAL

The shafts shall be solid shafts made of Forged / Rolled steel and shall be designed or appropriate load / torque that is being transmitted by them. The shafts shall have ample strength, rigidity and adequate bearing surfaces. These shall be finished smooth and if shouldered, shall be provided with fillets of large radius.

10.7.3.2. DIMENSIONING OF SHAFTS

In dimensioning of shafts, the ratio of length to diameter > 50, the angle of twist and the rev / min shall be taken into account. In addition to simple bending, pure torsion or the combined effect of bending and torsion. The twist angle, that shall be permitted, is from 1/40 to 1/30 per metre. The linear deflection in the shaft shall not exceed 1.0 (one) mm per metre length of shaft.

10.7.3.3. ALLOWABLE STRESSES

The allowable stresses for solid shafts shall be as per Para 4.7.7 of IS: 6938 - 1989.

10.7.4. Sheaves or Pulleys

All pulleys shall be in true running balance and shall be provided with pressure grease arrangements. The ratio of sheaves pulleys pitch diameter and the rope diameter shall be as per table 3 of IS: 6938 - 1989.

The sheaves or pulleys shall be machine grooved to a depth of not less than 1.5 times the diameter of rope. The grooves shall be finished smooth and shall be free from the surface defects, which may injure the ropes. The rope drum hoist shall be machine grooved and the contour at the bottom of the groove shall be circular over an angle of approximately 130° (minimum angle 120° as per Para 4.3.4.1 of IS: 6938 - 1989. The radius of the groove shall be 0.53 times the diameter of rope. The included angle, which is the angle between the straight slopes at the sides of grooves, shall be approximately 52°. The sheaves pulleys shall be provided with guard plates in order to retain the rope with in the groove.

10.7.4.1. SOCKETS FOR WIRE ROPES

The sockets ends shall be slightly stronger than the wire rope. Molten zinc shall be used to socket the ropes. The material for wire rope sockets shall conform IS: 2485- 1979.

10.7.4.2. TURNBUCKLES & EQUALIZER BARS

Turnbuckles shall be provided to adjust the elongation of wire ropes and equalizer bars shall be provided to ensure equal loading on both sides of the equalizer bars.

10.7.4.3. BEARINGS

All the running shafts shall be provided with ball or roller or bush bearings at their supports. The selection of bearings shall be done on the consideration of duty, load and speed of the

shafts. The life of bearings shall be determined in accordance with the recommendations of their manufacturer. The thickness of bush bearings shall be calculated as per para 4.8.1.3 of IS: 6938-1989 (t = 0.08 d + 3 mm, where d is the diameter of shaft in mm and t is the thickness of bush in mm).

10.7.4.4. COUPLINGS

All couplings shall be of Forged or Cast Steel and shall be designed to transmit the maximum torque that may be developed. Solid couplings shall be aligned in such a way that these meet accurately. Flexible couplings shall be initially aligned with the same accuracy as in case of solid couplings. Flexible couplings shall be fitted between the motor shaft and extension shafts.

10.8. ELECTRICAL EQUIPMENT

10.8.1. Efficiency of System

The usual values of efficiencies adopted for the various elements of hoisting mechanism shall be adopted as given in table 5 of IS: 6938-1989. The overall efficiency of the system, which is the product of individual efficiency of elements, shall than be worked out. The overall efficiency of the system shall be used in calculating the capacity of the electric motor. The ratio of overall running efficiency to the overall starting torque to running torque of motor.

10.8.2. Motors

The motor shall be totally enclosed, fan cooled, high starting torque, squirrel cage, three (3) phase induction electric motor of rated capacity suitable for operation on 400 / 440 volts, 3 phase, 50 cycles / sec., A.C. power supply and outdoor type duty conforming to IS: 325 - 1978 or equivalent. The motor shall be suitable for reversing frequent acceleration and mechanical breaking. The breakdown torque of the motor at rated voltage shall not be less than two (2) times i.e. 200% of the rated torque. During this condition, for checking the components of hoist and the hoist supporting structure, the starting efficiency of the system shall be taken into account. The motors shall be so located that the bush gears and terminals are readily available for inspection and maintenance with no restriction to the ventilation. The motor chosen shall have rated speed not more than 1000 rev. min.

10.8.3. Electro-Magnetic Brakes

The electro-magnetic brakes shall be of spring set, shoe type solenoid operated and continuously rated. These shall be effective in both directions of travel and shall be capable of least 150% of the full load torque exerted by the motor.

10.8.4. Limit Switches

10.8.4.1. GENERAL

The limit switches, after being tripped, shall automatically reset themselves with a reasonable distance traveled in opposite direction. This does not prevent the use of changeover type limit

switches, where resetting is achieved by moving in opposite direction. These may be mechanically driven from the shaft.

10.8.4.2. HOIST LIMIT SWITCH

It is a device provided to cut off the current and to stop the motion of the hoist mechanism and to apply the brake, when the gate has risen to the predetermined level. Limit switches shall be weatherproof type. An inter-locking arrangement shall be provided to isolate the power supply, when the hoist is being operated manually. Adequate adjustment shall also be provided to compensate for rope elongation.

10.9. CONTROL EQUIPMENT

The hoist mechanism shall be complete with one control panel with push buttons, which shall be suitably labeled as 'Raise', 'Stop' and 'Lower' Lamps to indicate the condition of the control circuits and directions of motion may be provided.

The hoist shall be provided with all necessary relays, starters, heaters, if required, fuses, limit switches, indicating lights complete with suitable wiring so that all the functions are carried out smoothly.

All the controls shall be so inter-locked that the proper functioning of individual parts for the purpose is ensured. The wiring shall be as per relevant standards.

10.9.1. Manual Operation

The manual operation shall be provided for emergency operations of the gates in the event of power supply failure. An electric inter-lock shall be provided to prevent the operation due to restoration of power supply, when the manual operation is engaged.

The manual operation should be designed in such a manner that the continuous effort per man does not exceed a crank force of 100 N with 400 mm of crank radius at a continuous rating of 24 rev. min. The maximum number of persons shall not exceed four (4). Manual operation shall be provided with ratchet and pawl arrangement so that gates do not fall of their own weight during manual operation.

10.10. STRUCTURAL DETAILS

10.10.1. General

10.10.1.1. HOIST SUPPORTING STRUCTURE

The hoist supporting structure shall be made of structural steel (weldable) conforming to IS: 2062-1992 and shall be designed to withstand the dead weight of the hoist, hoisting load as well as vibrations coming on the hoist while in operation. Suitable anchorages for the hoist frame shall be provided to take the worst combinations of all loads under which the gates and hoists are under operation. The hoist supporting structure shall be either in riveted or welded construction. The frame shall be of the box type. Field welding will not be accepted. Diaphragms shall be provided to distribute the loads to the sides properly. Shop connection in

the frame shall be either riveted or welded so that the surface of the hoist including the outside of the frame, case and hoist housing and viewed along with the intake structure will be a plane surface except for projections of rivet heads. The structure shall be designed for each of the following combinations.

i) Dead loads plus live load, impact load, wind load @ 50 kg. sq. m. and crowd load @ 500 kg/ q. m on entire area of walkway.

(ii) Dead load with no hoisting load plus effect of storm wind load @ 150 kg/sq. m.

(iii) Breakdown torque @ 200% of rated torque of the motor or actual breakdown torque of the motor as specified by the manufacturer whichever is more.

10.10.2. Interlocking & Earthing

All electrical equipment shall be provided with off position inter-locking and earthing arrangement in Terms of Provisions contained in IS: 3043-1966.

10.11. HYDRAULIC HOISTS & THEIR ACCESSORIES

10.11.1. Mechanical equipment

10.11.1.1. HOIST CAPACITY

The capacity of the hoist shall be based on the algebraic sum of the worst combination of following forces during either lowering or raising cycle. The hoist capacity thus computed shall be increased by at least 20% as reserve.

a) All weights consisting of

   i) Gate leaf along with all its components including ballast, if any.

   ii) Moving parts of hoist like intermediate stems, gate stem, piston etc.

b) Total water load on the gate components including buoyancy.

c) All frictional forces comprising of

   i) Wheel / sliding friction

   ii) Guide friction

   iii) Seal friction

   iv) Friction of moving parts of the hoist

d) Any hydrodynamic loads like hydraulic down pull / uplift.

e) Silt load.

f) Seating load as per clause 5.1 (F) of IS: 10210-1993.

g) Any other consideration

10.11.1.2. DESIGN PRESSURE / OPERATING PRESSURE

The design pressure shall be 20 N/mm^2

10.11.1.3. TEST PRESSURE

The test pressure shall be 150% of the operating pressure for a period not less than 30 minutes.

10.11.1.4. HOIST CYLINDER

The hoist cylinder shall be composed of flanges. The flanges and cylinder of the hoist shall be of either welded construction out of plate steel as per IS: 2002 - 1982 and IS: 2041 - 1982 or carbon steel forging as per IS: 2004 - 1978. If the cylinder is in forged construction, the flanges may be forged as an integral part of cylinder otherwise the flanges of the cylinder shall be butt welded to the cylinder shell. In either case the cylinder shall be annealed and stress relieved before machining. The bore of the cylinder shall be ground, honed and polished where as the outer surface shall be given normal machine finish. After machining, the thickness of the cylinder walls shall not be less than the computed thickness. The fabrication, welding and stress relieving of the hoist cylinder and flanges shall be done in accordance with the provisions in IS: 2825-1969 (code of practice for unfired Pressure vessels) or approved international equivalent standards.

10.11.1.5. CYLINDER HEADS

The cylinder heads shall be designed as a thick plate, held down at the outer perimeter in accordance with IS: 2825 - 1969. In calculations, the extra strength due to the shape of the head may be neglected.

The thickness of the cylinder head shall be determined on the basis of the greater of the two stresses computed as given in IS: 10210-1992. However the actual design stress shall not exceed 25% of yield point.

10.11.1.6. PISTON

The piston shall be designed for operating pressure. The piston shall be made of either cast steel or forged steel or grey iron casting as per IS: 1030 - 1989, IS: 2004 - 1978 and IS: 210 - 1978 respectively. The actual design stress shall not exceed the limit of 25% of yield point. The steel piston shall be provided with suitable precautions so that the finished piston does not scour the smooth finished walls of the cylinder. Piston shall be provided with grooves to accommodate the piston rings, oil rings and provisions for fixing the stuffing box having 'V' - packing rings or other approved equivalents.

10.11.1.7. PISTON RINGS & PACKINGS

The pistons shall be fitted with hydraulic type piston rings and also with a stuffing box having 'V' packing rings or other equivalent to eliminate leakage past the piston and permit holding of the piston in any position for a long period of time when out flow of oil from below the piston is blocked. The piston rings shall serve as a reserve seal in case of packing damage. The piston rings shall be made of either Bronze, or grey iron castings conforming to IS: 318 - 1962

and IS: 210 - 1978 respectively. The actual design stress shall not exceed the limit of 25% of yield point stress.

10.11.1.8. STEMS

10.11.1.8.1. Piston stem

The piston stem shall be of solid corrosion resistant steel or structural steel or forged steel, hard chrome plated to at least 0.05 mm thickness in uniform circular section. The piston stem shall be machined, ground and polished. The design stresses shall not exceed the limit of 40% of yield point at pressure setting of pump relief valve. The stem shall be checked for buckling.

10.11.1.8.2. Other stems may be of solid or hollow construction of any shape.

10.11.1.9. COUPLINGS

The couplings for connecting the stems between the gate and hoist may be Clevis type, split collar type or hook & eye type depending upon suitability.

10.11.1.10. WIPER SCRAPER

A wiper scraper, consisting of corrosion resistant steel scraper and a synthetic rubber-wiping member assembled in tendon position and securely clamped and enclosed in a steel shell, shall be provided to remove foreign matters from stems exposed to water to prevent damage to the packing while the stem enters the cylinder.

10.11.1.11. GATE POSITION INDICATOR

An indicator to show the position of gate in its full travel shall be provided. The indicator shall comprise of an indicator guide and indicator stem. The indicator head fixed at the end of the indicator stem shall move in the guides and shall carry the indicator head which shall indicate the position of the gate on graduated vertical scale.

10.12. HYDRAULIC EQUIPMENT

10.12.1. Oil tanks

Oil tanks made of robust steel construction and suitable for floor mounting shall be installed near power cabinet for serving hoists. The capacity of oil tanks shall be 3 to 4 times the pumping rate per minute plus additional capacity for the volumetric displacement of hoist stem and for temperature produced volume changes. In case of central oil tanks, the capacity of the oil tanks shall be sufficient to meet the following requirements, with each requirement being met independently:

a) Oil fully evacuated from one hoist at a time.

b) Displacement of oil due to piston stem of all the hoists.

c) 200 litres of spare oil or volume of one cylinder whichever is less and

d) Free air space equivalent in volume to 200 litres of oil or volume of one cylinder, whichever is less.

Oil tanks shall be properly painted to ensure cleanliness and to avoid rusting. The tanks shall be provided with breather openings, provision to drain water accumulation from the lower cap, stainer and a transparent gauge to indicate the level of oil in the tank. The filler cap shall be a combination of air vent, dust screen and air filter.

10.12.2. Filters

The tanks shall be provided with screened filters not coarser than 150 microns in the pump suction line of the tank. A pressure filter shall be provided in the return line to remove particles above 10 micron size. The top of filters shall be equipped with pipe plugs or suitable means of venting air from the line. The pressure drop shall not be more than 0.1 kg/sq. mm.

10.12.3. Pumps

Two motor driven oil pumps shall be provided for operating system to ensure operation of gates. In case one motor pump unit fails, single unit shall be able to operate the gate in double the normal piping time. The pumps shall be vane type or gear pump having a speed of not more than 1000 rpm. Pumps shall be suitable to pump hydraulic oil at the design pressure into the system.

One hand pump in addition to the above electrically operated pumps shall be connected in parallel to the system as a standby arrangement.

10.12.3.1. OIL PRESSURE GAUGE

The oil pressure gauge shall be of suitable type to operate rust proof and corrosion resistant moving elements. The pressure range of the gauge shall vary from zero to twice the pressure obtained in the control system with an accuracy of 0.5 % over the entire scale of dial and shall be equipped with screw type device to resist the pointer. The dial shall have a diameter of approximately 150 mm and shall have numerals at 0.20 kg/mm^2 division points and primary division at 0.02 kg/mm^2 intervals. The gauge shall have flanged front suitable for flush mounting having pipe connection at the back.

10.12.3.2. PRESSURE SWITCH

The oil pressure switch shall be of suitable type to operate a mercury switch having a rating of at least 5 amps at 230 volts A.C. The switch shall have independent outside adjustments with locking devices for setting the cut in and cut out pressure and the pressure setting shall be indicated on a calibrated dial. The cage shall have suitable threaded entries at the back for pressure connection and electrical circuit connection and the switch shall have a capacity of at least twice the maximum operating pressure obtaining in the control system.

10.12.3.3. FLOAT SWITCH

A suitable float switch shall be provided to maintain the level of oil in the oil tank. In case the oil level in the tank goes below a predetermined level due to leakage in the hydraulic system thereby causing the entry of air in the hydraulic circuit, a float switch shall have to be provided to give an indication for replenishment of oil in the tank.

10.12.3.4. FOURWAY VALVES

The four way valve for the control system for operating the gates shall be double solenoid controlled, spring centered, 3 (three) position, having sufficient capacity and suitable for a working pressure of at least 2.2 kg/mm^2. The valve shall be equipped with a mounting sub-plate suitably tapped to permit mounting or removal of the valve without disconnecting the piping. Electrical contacts as under shall be provided with each solenoid of each valve, which shall operate during the period, the solenoid remains energized.

Two contacts shall be normally closed and other two contacts open. The above electrical contacts and operating solenoids of the four way valve shall be rated for 5 amps, 240 volts, 50 cycles A.C. supply. The four way valve shall be product of a reputable manufacturer, for the type of service, the valve shall be equipped with push pins for manual operation in case the control supply is not available.

10.12.3.5. THROTTLE VALVE

The throttle valve shall be the cylindrical spool spring-loaded type, the valve shall be rated for a working pressure of at least 2.2 kg / sq. mm. and shall have ample capacity for the work to be performed by it.

10.12.3.6. BACK PRESSURE RELIEF VALVE

The backpressure relief valve shall be of balanced piston type, suitable for a working pressure of 2.2 kg / sq. mm. It shall have an adjustable pressure setting range and shall have sufficient rated capacity. The valve shall be a product of reputed manufacturer, for this type of service.

10.12.3.7. SYSTEM PRESSURE RELIEF VALVE

The system pressure relief valve shall be of balanced piston type with internal drain, having sufficient capacity and shall have an adjustable pressure range of approximately 0.20 to 2.00 kg/sq. mm. The valve shall be a product of a reputed manufacturer.

10.12.3.8. CHECK VALVES

The check valve shall be of spring-closed construction with threaded ends, and shall be rated for a working pressure of at least 2.2 kg /sq. mm.

10.12.3.9. GATE VALVE

The gate valve shall be of the screwed, non-rising stem wedge type and shall be suitable for use with hydraulic oil having characteristics specified in oil pumping unit.

10.12.3.10. HYDRAULIC PIPING AND PIPE FITTINGS

All hydraulic pipings shall be of heavy gauge seamless steel tubing. All pipe fittings shall be of high-class malleable iron or forged steel. All pipes and pipe fittings shall be suitable for work oil pressure of 2.2 kg /sq. mm. and shall be tested to a pressure equal to 150% of above pressure. Fittings shall be proper and leak-proof.

All pipes shall be thoroughly cleaned to remove all dirt and scale from the inner surfaces. All burrs and chips shall be removed before the pipes are assembled and care shall be taken to keep any foreign matter away from entering the system after fabrication is complete. All pipes shall be seamless wrought steel pipes tested for a pressure of 1.5 times the pump capacity.

10.13. ELECTRICAL EQUIPMENT

10.13.1. Motor

The electric motor shall be directly coupled to the oil pump and shall be of sufficient capacity to carry continuously the maximum possible load likely to develop under all conditions specified for operation of gates and shall have nominal speed to match the requirements of the oil pump.

The motor shall be horizontal drip proof, squirrel cage induction type suitable for direct driven non-reversing service, across the full line voltage 400/440 volts, 50 cycles A.C. The motor shall have normal starting torque and low starting current characteristics. The electrical insulation shall be moisture resistant for use with motors, which may be either continuously running or may be idle for long periods under highly humid atmosphere conditions. All the motor bearings shall be self-lubricating and shall be either ball or roller type. The bearings shall be properly sealed against loss of lubricant or entrance of dust.

To prevent condensation the electric motor shall be equipped with 240 volts single-phase heater mounted in or on the frame. The loads of the electric motor and the anti-condensation heater shall be brought out in a terminal box on the motor having suitable cable lugs. The motor characteristics shall conform to IS: 325 - 1978.

10.13.2. Wirings

All wiring of power control cabinets shall be neatly installed, connected and securely anchored in plate in a workmanlike manner. The conductors shall be of standard wire gauge and shall conform to relevant Indian Standard Specifications. Electric connections shall be neat, mechanically tight and secure and shall be made at apparatus terminals and terminal blocks. Terminals for field connection shall be accessible without disturbance to the manufacturer's wiring. The insulation of the control wiring shall be of polyvinyl chloride of similar synthetic insulation of 650 volts grade. To prevent compensation of moisture, all wiring shall be weather proof and suitable for tropical climate and highly humid conditions.

10.13.3. Motor Starter

For each oil pump motor, one magnetic motor starter of suitable capacity rated for 415 volt 3 phase 50 cycles A.C. and direct on line starting service shall be provided. The starter shall be suitable for working in conjunction with the control relay for thermal overload and single phasing protection and shall have a no volt release coil.

10.13.4. Circuit Breaker

There shall be provided one air insulated triple pole breaker for control of each motor. It shall be suitable for use as a break up protection against short circuit currents and conform to IS: 2516 - 1965 or its approved equivalent. It shall be provided with thermal overload release. The breaker interrupting capacity shall not be less than 50 amps. Provision shall exist on the breaker for adjustment of triple setting to suit the requirements of electric motor.

10.13.5. Control Switch

For raising or lowering a gate, spring loaded control switch of self-resetting type shall be provided. The switch shall provide momentary contact when the handle is operated to position R and L for raising and lowering the gate. Control switch shall be of heavy-duty type having silver plated contacts and suitable for flush mounting on a panel. The rating shall be 5 amps, 240 volts and 50 cycles A.C.

10.13.5.1. Push Button

For stopping a gate at intermediate position, spring-loaded push buttons shall be provided. The push button shall be heavy-duty type, having silver plated contacts and suitable for flush mounting on the panel. The push buttons shall have normally close contacts. The rating shall be 5 amps, 240 volts, 50 cycles A.C. supply.

10.13.5.2. Heater Switch

Single pole disconnecting switch rated for amps, 240 volts, 50 cycles A.C. supply shall be provided for the heater in each electric motor in the control cabinets. The switch shall be suitable for flush mounting on a panel.

10.13.5.3. Control Relay

For the overload single-phase protection of the motor, a 3-phase control shall be provided. The overload device shall be set or adjusted to trip the starter between 115% and 120% of the rated normal full load running current of the motor. The relays shall be reset manually.

10.13.5.4. Limit Switches

The limit switch shall be suitable for service under conditions of extreme moisture, shall be drilled and tapped for conduits and shall be designed so that it can be wired and serviced after being mounted in position. It shall have single pole, double break contacts to operate at 240 volts single phase 50 cycle A.C. Limit switches shall function for stopping the gate in fully open position and fully closed position. One limit switch shall be provided to take care of the creep of the piston due to leakage of oil.

10.13.5.5. Indicating Lamps

To indicate the gate at extreme positions and other positions, indicating lamps shall be provided. The indicator lamps shall be water tight, heavy-duty type 20 volts suitable for flush mounting on a panel.

The following indicating lamps shall be provided on the local and remote control cabinets:

a) Gate in fully closed position indicating lamp — Red colour

b) Gate in fully opened position indicating lamp — Green colour

x) Gate in operation indicating lamp — Amber colour

Each of these indicator lamps shall be located on the individual control cabinets as well as remote cabinet with control room in the Power House.

While the gate starts opening or closing, the amber lamp will be lighted and shall remain lighted till the gate is under movement. In addition, provision shall also be made for red lamp or green lamp to flicker to indict the direction of movement of the gates. ONCE THE GATE IS MOVED TO FULLY OPENED OR FULLY CLOSED POSITION the red or green light as the case may be, should become stable and stop flicking and amber light shall switch off automatically.

10.13.5.6. Gaskets

The sheet gaskets used under the seal base plates shall be made of a vegetable fibre compound with glue binder, compressed into a homogeneous structure. The materials shall be treated with glycerol base compound and shall be suitable for use in water.

10.13.5.7. Conduits

All electrical conduits shall be heavy gauge and shall be hot dip galvanized in accordance with IS: 1653 - 1972.

10.13.5.8. Electrical Wirings

All wires for general electrical wiring shall have 660-volt performance grade, rubber or PVC insulation and shall have standard moisture resistant covering. All conductors connected to restore or otherwise subject to abnormal heat shall be 660 volts grade heat resistant installations.

10.14. STRUCTURAL DETAILS

10.14.1. General

10.14.1.1. HOIST SUPPORTING FRAME

The hoist supporting frame shall be either riveted or of welded construction. The material shall be structural steel (weldable) conforming to IS: 2062 - 1992. The frame shall be of the box type. Field welding will not be accepted. Diaphragms shall be provided to distribute the loads properly to the sides. Shop connections in the frame shall be riveted or welded so that the

surface of the hoist including the outside of the frame, case and hoist housing and viewed from the side will be a plane surface except for projections of rivet heads. The structure shall be designed for each of following combinations.

a) Dead loads plus live load plus impact loads plus effect of 50 kg / sq. m. wind load

b) Dead loads with no load on lifting blocks plus effect of 150 kg / sq. m. storm wind load.

c) Breakdown torque 2 times (200 %) of rated torque of the motor or active break down torque of motor as specified by the manufacturer, whichever is more.

10.14.1.2. Inter locking and earthing

Off position interlocking, earthing and other electrical equipment shall be provided in terms of provisions contained in IS: 3043-1966.

10.15. MATERIALS

10.15.1. General

All members and components of the gates, rope drum hoists and monorail crane listed under these specifications and specification drawings shall be fabricated out of unused high grade materials free from any kind of defects and imperfections. All the materials shall conform to the standards specified in these specifications and on the specification drawings, however, if for any, reasons the Contractor desires to deviate from these standards, he shall submit a statement stating the exact nature of deviations or substitutions along with complete and detailed specifications and test reports of the materials which are proposed to be used as substitution or deviation, for the approval of the Employer, prior to the fabrication work is taken up in hands. All such materials or articles or supplies, which are not manufactured by the Contractor, shall be the product of recognized and reputed manufacturer.

The Contractor shall furnish a list of names of the manufacturer(s) of the bought out complete equipment, which are contemplated for incorporation in the work, together with their performance characteristics and other pertinent reports along with the samples of the materials, shall be submitted for approval of the Employer. Any material or equipment used or installed with no prior approval of the Employer shall be at risk and cost of the Contractor.

10.15.2. Recommended Material for Gates & Hoists

S. No	Component articles	Recommended Material	I.S. Specification
A	**Gates**		
1	Skin plate, stiffeners, horizontal / end vertical girders, seal bases, track bases, seal seat bases, clamps, guides & guide shoes, diaphragms, anchor plates and anchorages lifting lugs etc.	Structural steel	IS: 2062 - 1992

S. No	Component articles	Recommended Material	I.S. Specification
2	Seal seats	Stainless steel, 04 cr.18 Ni.10	IS: 1570(V)-1985
3	Track plates	Corrosion resistant steel 30 cr. 13 (hardened to 50 BHN more than that of wheel rim)	-do-
4	Slide block plates	Al. Bronze Gr. AB-I	IS: 305-1985
5	Wheels	Carbon steel Cast steel Forged steel	IS: 570 (II)-1979 IS: 1030 - 1982 IS: 1875 - 1978
6	Side & top seals (Rubber)	Music note type	IS: 11855 - 1986
7	Bottom seals	Wedge type rubber seal	-do-
8	Bearings	Spherical roller bearings	SKF or equivalent
9	Screws / bolts & nuts for seals	Stainless steel	IS: 1570 (v) -1985
10	Wheel axle	Corrosion resistant / stainless steel	- do -
B	**Rope Drum Hoists**		
1.	Wire ropes	6 x 37 construction ungalvanised improved plough steel	IS: 2266 – 1977
2.	Sockets for wire ropes	Forged steel	IS: 2485 – 1979
3.	Rope drums	Cast steel Cast iron Mild steel	IS: 1030 - 1989 IS: 210 - 1978 IS: 2062 - 1992
4.	Gears	Cast steel Carbon steel Forged steel	IS: 1030 - 1989 IS: 1875 - 1978 IS: 2004 - 1978
5.	Pinions	- do -	- do -
6.	Sheaves / pulleys & couplings	Cast steel Cast iron	IS: 1030 - 1989 IS: 210 – 1978
7.	Shafts	Forged steel Mild steel	IS: 2004 - 1978 IS: 2062 - 1992
8.	Bolts & nuts	- do -	IS: 1363 – 1979
9.	Keys & cotters	- do -	IS: 2291 - 1974 IS: 2048 - 1983 IS: 2292 – 1981

S. No	Component articles	Recommended Material	I.S. Specification
10.	Bearings		
a)	Bush bearing	Phosphor bronze Tin Bronze	IS: 28 - 1975 IS: 318 – 1962
b)	Ball / roller bearing	- do -	SKF or equivalent
11.	Equalizer bars, turn buckles, pedestals, covers	Mild steel	IS: 2062 – 1992
12.	Hoist supporting structure	Mild steel	IS: 2062 – 1992
Note: Latest editions / revisions of all IS codes mentioned herein these technical specifications and or on the specification drawings shall be referred.			
C	**Hydraulic Hoist**		
1.	Support	Structural steel Cast steel	IS: 2062 – 1992 IS: 1030 – 1989
2.	Cylinder	Plate steel Carbon steel forging	IS: 2002 – 1982 IS: 2041 - 1982 IS: 2004 – 1978
3.	Cylinder heads	Structural steel Cast steel	IS: 2002 – 1982 IS: 2062 - 1992 IS: 1030 – 1989
4.	Piston stem	C.R. Steel Forged steel	IS: 1570 (v) - 1985 IS: 2004 – 1978
5.	Piston	Cast steel Forged steel Grey Iron casting	IS: 1030 - 1989 IS: 2004 - 1978 IS: 210 – 1978
6.	Piston ring	Bronze Grey iron casting Synthetic PTEE	IS: 318 IS: 210
7.	Clevis pin	C.R. Steel (Min. 141 chromium)	IS: 1570 (V) - 1985
14.	Gland clevis bushing	Cast Manganese Bronze PTEE Synthetic	IS: 6911 – 1972
15.	Stud and bolts	Mild steel	IS: 1363 - 1972
Note: Latest revisions / editions of all IS codes mentioned herein in these technical specification or on the specification drawing and / or otherwise shall be referred.			

10.15.3. Minimum thickness

Steel exposed to water shall have a minimum thickness of 10.0 mm except for the web of rolled steel sections and plates used as stiffeners and girders, for the skin plates the thickness shall not be less than 10.0 mm. A corrosion allowance of 1.5 mm shall be added to

the calculated thickness of skin plate to arrive at the total thickness of the plate to be used as skin plate.

10.15.4. Stresses

The actual stresses in the structural members and components of gates, ropes, drum hoists, monorail crane and the hoist supporting structure, taking into account the worst combination of all loads including impact allowance causing most adverse effect on them, shall not exceed the permissible values of stresses as specified in relevant Indian Standards. The permissible values of stresses in welds shall be same as permitted for the parent material.

10.16. METAL WORK FABRICATION & MACHINE WORKS

10.16.1. General workmanship

All fabrication work under this contract shall be done in accordance with the specifications, which meet with the Employer's approval. All works shall be performed and completed in a thorough workman like manner as per the latest practice in the field of manufacture and fabrication of materials equipment of the type covered by these specifications. The work shall in all cases be of the highest quality and carefully performed to the satisfaction of the authorized representative of the Employer. The Contractor shall warrant all material and workmanship furnished by him to be free of injurious defects. He shall replace, free of cost to the Employer, any material & workmanship notice to be defective during erection or commissioning or performance or guarantee period and bear all the cost of the modification in the field of any defect for which he is responsible. The quality and workmanship shall conform to the latest standards, laid down in Indian Standard Specifications.

All members shall be free of twists, bends or any other deformations. And the surfaces, that will be in contact shall be thoroughly cleaned before assembling, parts shall be adjusted to line and fit and shall be firmly bolted or otherwise held securely together so that surfaces are in close contact before drilling, reaming or welding is commenced. Plates with laminations, discovered during cutting, welding or at any other time, shall be rejected. However, minor surface imperfections can be repaired, wherever possible the prior approval of the Employer. Materials not supplied or workmanship not performed in accordance with approved drawings or specifications shall be rejected and replaced free of cost to the Employer.

If the weight limitations or transport clearance don't permit the gates, anchorages and miscellaneous embedded parts shall be fabricated into sub-assemblies. The Contractor shall submit with this bid a drawing showing the sub-assemblies into which he proposes to fabricate the gates, anchorages, miscellaneous assemblies and embedded parts for transporting them to the site.

All parts of the gates shall be fabricated in accordance with these specifications and drawings. The manufacturer shall take special care in fabrication of parts affecting strength, rigidity and water tightness of the gates. Attention is directed to the fact that rolled edged plates are not suitable for caulking. The seal bases shall be finished after the plates are

welded to the finished surface of the seal bases shall be in the same plane within the tolerances as specified in IS: 4622.

The Contractor may submit for approval of the Employer an alternative procedure for finishing the seal bases or for fastening them to the gates provided that the suggested method produces a water tight sealing arrangement and that final shape & size of plate meet the dimensional & tolerance requirements, shown on the drawing or stated in these specifications. Holes for the wheel pins shall be bored and counter-bored in pairs to common axis after the gate leaf has been completed. The axis of these holes shall be in a common plane, which shall be parallel to the finished surface of the seal bases within the specified tolerances.

The seal rings provided in the wheel assemblies shall be products of well-reputed manufacturer and must be accurately spaced, cylindrical & perpendicular to members. All countersinking shall be true & square with holes.

10.16.2. Tolerances & Fits

The tolerances & fits used for different components shall be according to the best modern shop practice. Due consideration shall be given to special nature of functions of parts & to the corresponding accuracy required to secure proper operation. The fits and tolerances shall generally be in accordance with the provisions contained in IS: 2709 - 1969. These shall be subject to the approval of the Employer.

10.16.3. Field Erection Bolts

The Contractor shall furnish at least 15% in excess of required numbers of field erection bolts and nuts of each size. The bolts in tension shall have a net cross-section at the root of the thread - 15% in excess of the net section required in tension.

10.16.4. Welding

All the surfaces required to be welded shall be prepared and all welding shall be either manually or by the shielded are method or by submerged arc method in accordance with IS: 816 - 1969 andIS: 9575 -1980. Welds shall be made as indicated on the drawings and identified there on by conventional welding symbols as per IS: 813 - 1961. Procedure qualification test shall be required when welding is done by automatic machine. For such tests, the required material, equipment and labour shall be made available by the Contractor at no extra cost to the Employer. However, price bid in the schedule for the Contractor at time of bidding. All welded parts requiring machining shall be completely welded and stress relieved before machining.

10.16.5. Test for Soundness of Welds

All tests for soundness of welds shall be carried out as per IS: 822 (latest edition) and as per other

IS codes listed in appendix 'A' of code. Following procedure should be followed for selection of various tests to be carried out by Contractor.

1) 20% to 30% of fillet welds may be checked by Dye Penetration test or Fluorescent Penetration test.

2) Testing of butt welds shall be checked as under:

a) Butt weld in skin plate

I. 16 butt welds shall be checked by X-ray, radiographic testing. These X-ray films shall be made available to the Employer for his records.

II. 40% of welds shall be checked by Magnetic Particle Impression test.

III. Rest 50% of welds shall be checked by the Soap Bubble Ultrasonic testing.

IV. Butt-welds in the webs and flanges of horizontal girders.

These butt joints shall be checked by Magnetic Particle Impression test for soundness.

10.16.6. Machine Finish

The type of finish, unless otherwise specified shall be that most suitable for the part to which it applies and shall be smooth average or rough as defined in IS: 3073 - 1974. In general, a very smooth surface finish i.e. 3 (three) delta 0.200 to 1.600 microns will be required for all those surfaces which are in sliding or rolling contact, an average or commercial surface finish i.e. 2 (two) delta 1.600 to 6.300 microns for those surfaces in contact where a tight joint is required and a rough finish i.e. Single delta 6.300 microns for all other machine surfaces where selective assembly for matching parts is required. The parts shall be ground, if necessary to obtain the limiting tolerances.

10.16.7. Stress relieving

Stress relieving of parts, wherever required, shall be carried out after all welding are completed but before that part is machines or assembled into structure. The stress relieving of parts shall be done as per provisions contained in IS: 2825 - 1969.

10.16.8. Inter-changeability

All similar items and removable parts of similar equipment, wherever possible, should be interchangeable with each other.

10.16.9. Unit Makings & Match Markings

Each part of the gates embedded parts, the hoists and hoist bridge, which is required to transported as a separate piece shall be marked to show its relative position in the unit to facilitate its assembly in the field. Unit marks and match marks shall be made with heavy steel stamps and painted.

10.17. PAINTING

10.17.1. General

All paints and materials required for the shop as well as field paintings shall be supplied by the Contractor and the cost shall be included in the bid. Paints, which are proposed by the Contractor, must be got approved from the representative of the Employer before its application. The detailed analysis reports in respect of paint properties, chemical composition and performance requirements of the proposed paint shall be submitted by the Contractor for examination and approval of the Employer before the application of the paint. All paints shall be applied by skilled workers in a workman like manner in accordance with the provisions contained in IS: 14177-1994 i.e. "Guide lines for painting system for Hydraulic Gates and Hoists."

10.17.2. Preparation of surfaces for painting

For adherence and durability of the paint system it is extremely important to carry out suitable surface preparation. The surface preparations for painting shall be done in accordance with the following procedure:

All oil, grease and dirt shall be removed from the surface, which is to be painted, by the use of clean mineral spirits, xylol or white gasoline etc. and clean wiping materials prior to sand blasting is done. All surfaces to be painted shall, thereafter be cleaned by sand grit blasting to bare metal without any residual adherents in any form. Small quantities or oil may be removed by the blasting process in which case, however, the abrasive should not be re-used, if it contains sufficient oil or grease to render it unsuitable for blast cleaning purposes. The average surfaces roughness after sand blasting should not exceed 40 microns. Sand blasting should be conducted with sand grit/shot of type approved as per IS: 14177 - 1994 (part-I). After blast cleaning, the surface should be cleaned of loose dust and debris etc. with the help of air blast or blower.

In case rust forms or the surface becomes otherwise contaminated in the interval between cleaning and painting, the re-cleaning process as stated above shall be carried out. Surfaces of stainless steel, corrosion resistant steel, nickel, bronze and machine surfaces adjacent to metal work being cleaned or painted shall be protected by masking tapes or by other suitable means during the cleaning and painting.

10.17.3. Precautions

All paints and coating materials shall be in thoroughly mixed conditions at the time of application.

Air temperature at the time of application of the paint must not be below 16°C and the relative humidity must not be above 90%. All surfaces shall be free of moisture at the time of application. Effective means shall be provided for removing all free oil and moisture from the supply lines of all spraying equipment.

The primer coat shall be applied by brushing or spraying immediately after cleaning the surfaces. Since the primer coat can not be expected to last for an extensive period, it must receive the finishing coat of paint before it deteriorate. The finished surfaces, which are not to be painted, shall be suitably masked during painting.

The surface preparation shall be done as per the requirements of class B as specified in Para 4.2.1.2 of IS: 14177 - 1994. In case the surface preparation is done manually by wire brush, mechanical tools etc. instead of sand blasting all ferrous surfaces exposed to atmosphere or water shall given a coat of rust inhibitive phosphate wash by brush immediately following cleaning operation and surface shall be thoroughly wetted with rust inhibitive wash @ approximately 30 ml / m^2 and allowed to dry for 24 hours rinsing after applications generally not required but un-reacted residue, if any, shall be removed wiping the inhibitive wash has dried thoroughly and after removing un-reacted residue, the application of primer and finishing coats shall be carried out as indicated in the following paras:

10.17.4. Painting Schedule

10.17.4.1. GATES, EMBEDDED PARTS & LIFTING BEAM

10.17.4.1.1. Primer cost

After surface preparation the following coats of primer paints shall be applied.

Exposed embedded parts

Over the prepared surfaces one coat of Inorganic Zinc Silicate primer preferably with the help of airless spraying equipment giving a dry film thickness of 70 ± 5 microns should be applied. Alternatively, two coats of zinc rich primer, which should contain not less than 85% zinc on dry film, should be applied to give a total dry film thickness of 75 ± 5 microns.

10.17.4.1.2. Finishing coats

Exposed embedded parts

Finishing cost shall consist of two coats of solvent-less coal tar epoxy paint. These shall be applied at an interval of about 24 hours. Each coat shall give a dry film thickness of 150 $\pm$ 5 microns. The total dry film thickness of all the coats including primer coating shall not be less than 350 microns.

Gates

Finishing coat shall consist of two coats of solvent-less coat tar epoxy paint. These shall be applied at an interval of about 24 hours. Each coat shall give a dry film thickness of 150 $\pm$ 5 microns. The total dry film thickness of all the coats including primer coating shall not be less than 350 microns.

10.17.4.2. HOISTS AND SUPPORTING STRUCTURE

10.17.4.2.1. Primer coat

a) Structural components

Two coats of zinc phosphate primer shall be applied to give a dry fill thickness of 40 ± 5 microns per coat.

b) Machinery

Except machined surfaces, all surfaces of machinery including gearings, housing, shafting, bearings and pedestal etc. shall be given one coat of zinc phosphate priming paint to give a minimum dry film thickness of 50 microns. Motors and other bought out items shall be painted, if necessary.

c) Un-machined surfaces

All un-machined surfaces shall be given one primer coat of chlorinated rubber based zinc phosphate primer to give a dry film thickness of 50 ± 5 microns.

10.17.4.2.2. Finishing coats

a) Structural components

The finishing coats of paint shall consist of one coat of alkyed based micaceous iron oxide paint to give a dry film thickness of 65 ± 5 microns followed by two coats of synthetic enamel paint conforming to IS: 2932 - 1974 to give a dry film thickness of 25 ± 5 microns per coat. The interval between each coat shall be 24 hours. The total dry thickness of all paints including the priming coat shall not be less than 175 microns.

b) Machinery

The finish paint shall consist of three coats of Aluminium paint conforming to IS: 2932 - 1974 or Synthetic Enamel paint conforming to IS: 2932 - 1974 to give a dry film thickness of 25 ± 5 microns.

c) Un-machined surfaces

The un-machined surfaces of rope drum hoists, monorail crane and supporting structure shall be cleaned and given three coats of vinyl resin / chlorinated rubber to give a dry film thickness of 30 ± 5 microns per coat to obtain a minimum dry film thickness of 125 microns including priming coat.

d) Machined surfaces

All machined surfaces of ferrous metal including screw threads which will be exposed during shipment or installation shall be cleaned by suitable solvent and given a heavy uniform coating of gasoline soluble removable rust preventive compound or equivalent. Machined surfaces shall be protected with the adhesive tapes or other suitable means during the cleaning and painting operation of other components.

10.17.4.3. EMBEDDED PARTS IN CONTACT WITH CONCRETE

All surfaces of embedded parts, which are in contact with concrete shall be cleaned as given in Para 4.2.1.4 of IS: 14177 - 1994 to meet the requirement of Class D and shall be given a coating of cement Latex to prevent rusting. Exposed machined surfaces of ferrous metal, which are to be in rolling and sliding contact shall not be painted but shall be coated with heavy gasoline soluble rust preventive compound in all exposures, where metal will be partially embedded in concrete. In all exposures, where metal will be partially embedded in concrete, it is good practice to extend the protective coating on the non-embedded portion a short distance into the area later to be embedded, thus eliminating problem at the junction point.

10.17.4.4. SURFACES NOT TO PAINTED

The following surfaces are not to be painted unless or otherwise specified:

a) Machine finish or similar surfaces, however, such surfaces should be protected with a corrosion preventive compound.

b) The surfaces, which are in contact with concrete

c) Stainless steel overlay surfaces

d) Surfaces in sliding or rolling contact

e) Galvanized surfaces, brass and bronze surfaces

f) Aluminium alloy surfaces

g) Bare electrical conductors and insulating materials

h) Equipment name plates and instructions etc.

10.17.4.5. HANDLING OF PAINTED METAL WORKS

The metal works to be transported by rail or by road transport shall be loaded so as to prevent shifting and scuffing or gauging of the coating. In loading and unloading and during insulation reasonable care and suitable handling equipment shall be employed to keep abrasion damage at a minimum.

10.17.4.6. INSPECTION AND TESTING

Inspection and testing of paint shall be carried out in accordance with the provisions laid down in IS: 1477 - 1994 (Part - 2)

10.17.4.7. FIELD PAINTING

The painted metal work shall be handled with care so as to preserve the shop coats. The area of the shop paint, which has been damaged during transport shall be cleaned to base metal and re-painted. Paint applied to such areas shall be of the same type as used originally in shop painting.

10.18. TEST & INSPECTION

10.18.1. General

All materials offered under these specifications shall be tested prior to fabrication. After fabrications the parts shall be assembled in the shop and shop testing shall be performed to ensure accuracy in fabrications and workmanship. The Contractor shall carry out such tests as may be required by the Employer in order to determine that the gates embedded parts and rope drum hoists will fulfill the functions for which they have been designed. The Contractor shall be responsible for all modifications and adjustments required for the works as a result of such tests.

10.18.2. Tests of materials

All materials, supplied parts and assemblies thereof being used in the works to be performed under these specifications shall be of tested quality and all works performed shall be subjected to inspections and not parts or supplies or articles or materials shall be dispatched until all tests, analysis and shop inspections have been completed or certified copies of reports of results and analysis have been accepted.

Certified copies in triplicate of the tests made and of the results thereof shall be furnished as soon as possible after the tests are completed. The results of the tests shall be in such forms as to provide means of determining compliance with the applicable specifications for the materials tested. When required tests or trials shall be made in the presence of the inspector duly authorized by Employer, who shall be given sufficient notice to enable him to reach the site of the work in time.

Test specimen and samples for analysis shall be plainly marked to indicate the material to which they represent and if required, they shall be properly packed and prepared for shipment.

All cost of such tests and trials except the pay and allowances including the travelling and other expenses of the Employer's representative shall be borne by the Contractor and shall be including in the bid.

All authorized representative of the Employer shall have free access to the works of the Contractor at all reasonable times and shall be provided with full facilities to inspect the processes of manufacture and the material used. The Employer may reject any work or material that in the opinion of the Employer does not conform the specifications and may order to remove the same and replace or alter to conform to the specifications at the expenses of the Contractor.

10.18.3. Shop Assembly Tests

The equipment after the fabrication and before preparing for dispatch, shall be assembled in the shop for inspection and tested to ensure that all parts and components to be connected are fitted properly and that all the dimensions, clearances and tolerances called for in these specifications and / or shown in the drawings have been obtained.

10.18.4. Operational Tests in Dry

After the completion of erection of the equipment at the site operational tests in dry condition shall be carried out. The tests shall include al least 2 (two) complete traverse from the maximum raised position to the fully seated position on the sill level. All adjustments, clearances etc. shall be checked to ensure proper operation.

10.18.5. Operational tests and Water Level at FRL / MWL / TWL

Operational tests, when the water level is at FRL / MWL / TWL shall be carried out to stimulate the actual operating conditions as closely as possible. At least two complete traverses will be made from the fully raised position to fully closed position as under:

When the gates are in fully closed position, raise the gates to their fully opened position

Lower the gates to the fully closed position

And repeat the same process until these are carried out successfully to the satisfaction of the Employer.

10.18.6. Leakage Tests

Leakage tests shall be carried out with the gates are lowered on to the sill. Before the leakage tests are carried out the gates shall be raised and lowered about 1.0 (one) m several times in order to dislodge any debris that might have lodged in the side and bottom seals. The leakage than shall be measured and it shall not more than 16.0 litres / min. / metre length of seal run.

10.19. ERECTION AND FINAL ACCEPTANCE

10.19.1. General

The equipment covered by these specifications and furnished by the Contractor will be erected completely at the site of work.

10.19.2. Materials and Equipment

The Contractor shall be held responsible for any damage and security of the equipment during transportation. The equipment shall be insured against loss and / or damage during transportation transit at the cost of the Contractor.

10.19.3. Erection Procedure

The Contractor shall prepare a complete erection procedure, which shall describe the sequence of the erection operation to be carried out, the methods to be adopted, the measurements to be taken and tolerances to be met in the erection and alignment of the equipment and shall be submitted to the Employer for his approval prior to the commencement of the erection at site of work and when approved by the Employer, it shall form the part of the specifications furnished by the Contractor.

10.19.4. Warranty

The Contractor shall correct set right / replace at his own expenses any defect in his work within 60 days from the date, the work is finally accepted by the Project Authorities. Final acceptance of the work shall take place only after the completion of erection of gates, hoists and all related components and completion of all tests.

10.20. MISCELLANEOUS

10.20.1. Manufacturer's Name Plate

The Contractor shall be permitted to attach / fix a metal plate describing the name and address etc. of the Contractor's firm and establishment at a suitable location duly approved by the Employer. Case lettering except pattern numbers will not be permitted on any castings.

The following catalogues and manuals shall be included with the equipment at the time of shipment. All catalogues and manuals containing data and literature shall be written in ENGLISH.

a) Technical and design data
b) General description of main components
c) Operating instructions containing General as well as Specific (dealing with any unusual feature of safety precautions)
d) Maintenance and repair instructions in 6 (six) complete sets.
e) Lubrication and lubrication schedule
f) Materials and parts identification list
g) Adjustments
h) Reference drawings
i) A complete list of all special tools is required to follow the servicing procedures correctly.

After the final approval, the Contractor shall complete the submitted documents in order to constitute the 6 (six) complete approved sets of maintenance and operation instructions. All these instructions shall be written in ENGLISH.

10.20.2. Spare parts

The Contractor while bidding the tender, shall submit an item wise list of spare parts indicating their cost of each item or sub-assemblies which may require replacement during normal life expectancy of the equipment. The Employer shall have an option to order the Contractor to supply the spare parts.

All spare parts furnished by the Contractor shall be interchangeable and shall be made of the same material and workmanship as the corresponding part of equipment furnished under these specifications. The Contractor shall furnish list of such additional parts, which he recommends to be purchased by the Employer required for the satisfactory operation of the equipment.

10.20.3. MEASUREMENT AND PAYMENT

The quoted rates shall be deemed to include all items of work listed in these specifications as well as those not specifically listed herein but considered necessary for completion of the work.

Measurement shall be made and paid at the rate per set quoted in the Bill of Quantities.

SCHEDULE-1

TABLE A

SCHEDULE OF INDICATING / RECORDING INSTRUMENTS FOR TURBINE, SYNCHRONOUS GENERATOR & THEIR AUXILIARIES

(To be Filled-in by the Concessioner at the time of detailed Engineering and before Execution)

S. No.	Description of Item to be indicated / measured	Device type	Total quantity per unit	Location
TURBINE				
1	Position of Main Inlet Valve			
2	By Pass Valve Open			
3	Governor Oil Pump Operating			
4	Standby governor oil pump operation			
5	Pressure of shaft seal cooling water			
6	Pressure of regulating oil pressure system			
7	Level of oil in oil pressure tank / vessel			
8	Level of oil in sump tank, if any			
9	Unit speed indication (Speed indicator)			
10	Over speed Indicator			
11	Speed Level setting indicator			
12	Speed Droop setting indicator			
13	Water Level Indicator			
14	Unit Output Meter for Power & Energy			
15	Unit Voltmeter			
16	Unit Ammeter			
17	Pressure of standby governor oil pump			
18	Pressure in governor oil pressure system			
19	Speed Level Setting Indicator of Turbine			
20	Unit Speed Indication (Speed Position Indicator)			
21	Turbine Bearing Temperature (Thrust & Guide Bearing)			
22	Speed Limit Position Indicator			
23	Turbine Water Flow Measurement			
24	Governor Speed Droop Setting			

S. No.	Description of Item to be indicated / measured	Device type	Total quantity per unit	Location
25	Speed of Turbine			
26	Pressure in Main Pipeline (Before Valve)			
27	Pressure in Main Pipeline (After Inlet Valve)			
28	Pressure Gauge for Compressed Air Pressure			
29	Gate limit and gate position indicator			
30	Pressure on inlet side			
31	Pressure of turbine casing			
32	Pressure of draft tube			
33	Runner blade position indicator			
34	Governor Stroke Indicator			
GENERATOR				
1	Dial thermometers for generator, bearings for alarm / trip			
2	6 points indicator for stator winding temperature and bearing temperature			
3	Generator heater ON/OFF indicating lamps			
4	Brakes On / Off indication			
5	Flow meter (water) / Pressure (oil) for bearing cooling (if applicable)			
6	Unit output meter (KW)			
7	Unit KVAR meter with center zero			
8	Unit voltmeter			
9	Unit ammeter			
10	Unit power factor meter (with center zero)			
11	Unit frequency meter			
12	Unit energy meter (kWh)			
13	Main Circuit Breaker Open / Closing Indicating Lamp			
14	Tachometer			
15	Field Voltmeter			
16	Field Ammeter			
17	Balance Indicator of AVR			

S. No.	Description of Item to be indicated / measured	Device type	Total quantity per unit	Location
18	Indicating lamps for field breakers on / off.			
19	AVR Auto / Manual Indicating Lamps			

NOTES:

1. The list is indicative and not limiting. Quantities and items may be increased / decreased by the Contractor to meet the minimum requirement for satisfactory monitoring and control of generating unit etc.

SCHEDULE-1

TABLE B

CONTROLS

(To be Filled-in by the Concessioner at the time of detailed Engineering and before Execution)

S.No.	Description of the item to be indicated / measured	Device Type	Total Quantity per unit	Locations
TURBINE				
1	Governor Speed Droop Setting			
2	Governor Speed Level Setting			
3	Speed Limit Setting			
4	Speed Position Change			
5	Speed Control			
6	Main Inlet Valve Control			
7	Water Level Control			
8	Overspeed Control			
9	Control for Governor Oil Pump Motor			
10	Control for Standby Governor Oil Pump			
11	Control for Compressor			
12	Turbine Shut Down Control (Emergency Stop, Turbine Start & Stop)			
13	Gate Limit Control			
14	Manual Turbine Gate Control			
15	Control for compressor			
16	Speed No Load Device			
GENERATOR				
1	On / Off control for anti condensation heaters			
2	Excitation On / Off Pus Buttons			

S.No.	Description of the item to be indicated / measured	Device Type	Total Quantity per unit	Locations
3	Auto / Manual Selector for AVR			
4	Voltage Rise / Lower Auto Potentio-Meter			
5	Voltage Rise / Lower Manual Protection			
6	Field Breaker On / Off.			

NOTE:

The list is indicative only. Quantities and items may be increased / decreased by the Contractor as to meet the minimum requirements for satisfactory monitoring control of generating unit.

SCHEDULE-1

TABLE C

SAFETY DEVICES (FOR ALARM / SHUT DOWN)

(To be Filled-in by the Concessioner at the time of detailed Engineering and before Execution)

S.No.	Description	Device Type	Qty. per unit	Annunciation at
TURBINE				
1	Turbine Guide & Thrust Bearing Cooling Water Flow or Lube Oil Flow			
2	Governor Oil Pressure			
3	Oil Level in Governor Oil Pressure Receiver			
4	Oil Level in Governor Sump Tank			
5	Governor Standby Running			
6	Unit over speed shut down			
7	Manual emergency shut down			
8	Turbine / Thrust Bearing Temperature			
9	Low Air Pressure			
GENERATOR				
1	Generator Winding temperature	RTD		Alarm & Trip
2	DC control scheme supply failure	Under voltage relay		Alarm & Trip

S.No.	Description	Device Type	Qty. per unit	Annunciation at
3	Generator bearing temperature high	ETD / RTD and dial type thermometer		Alarm & Trip
4	Machine shutdown under various faults	High speed tripping relay		Alarm & Trip
5	Oil level low / high	Level relay		Alarm
6	Flow / No flow of water / oil to bearing of generator	Flow relay		Alarm
7	AVR Over Current			Alarm
8	AVR Control Supply Failure			Alarm & Trip
9	Emergency Shut down	Meter step relay		Alarm & Trip
10	Machine over speed	Speed relay		Alarm & Trip
11	Low or no pressure of water / oil to bearing of generator	Pressure switch		Alarm

NOTES:

i. The list is only indicative. Quantities and items may be increased / decreased by the Contractor to meet the minimum requirements for satisfactory monitoring and control of generating units.

ii. Indicative clearly “alarm” and “alarm with shut down” in each case.

iii. Any other safety devices considered essential by the NMMC shall be supplied as decided at the time of detailed design.

iv. All instruments, controls and safety devices indicated elsewhere under this specification

SCHEDULE-2

GUARANTEED AND TECHNICAL PARTICULARS

(To be Filled-in by the Concessioner at the time of detailed Engineering and before Execution)

TURBINE		
1	**NAME AND ADDRESS OF MANUFACTURER**	
2	**SALIENT DETAILS OF TURBINES**	
(a)	Type of turbine of Turbine	
(b)	Rated Net Head on Turbine	…….. m
(c)	Rated Discharge of Turbine at Rated Head	……..m^3/sec
(d)	Maximum Discharge of Turbine at Rated Head	……. m^3/sec
(e)	Minimum Allowable Safe Discharge at Rated Head	…… m^3/sec
(f)	Center Line of Runner	EL…….. m
(g)	Recommended Turbine Setting with respect to Minimum Tail Water Level of EL 185 m	EL …….m
(h)	Minimum Head under which Turbine can be Operated	……. m
(i)	Maximum Head under which Turbine can be Operated	……..m
(j)	Shaft Orientation	
3	**POWER OUTPUT DETAILS**	
(a)	Guaranteed rated output at rated head and Rated Discharge of 38 m^3/sec	……... MW
(b)	Guaranteed maximum output at rated net head and Maximum Discharge of 42 m^3/sec	……... MW
4	**EFFICIENCY**	
	Guaranteed efficiency at rated head, for the following percentages of outputs	
(a)	115%	
(b)	100%	
(c)	80%	
(d)	60%	
(e)	40% or Minimum allowable discharge whichever is lower	
5	**DISCHARGES**	
	Turbine discharge at rated head, for the following percentages of rated outputs:	
(a)	115%	…… m^3/sec
(b)	100%	…… m^3/sec
(c)	80%	…… m^3/sec
(d)	60%	…… m^3/sec

(e)	40% or Minimum allowable discharge whichever is lower	…… m^3/sec
	Indicate max. & min. discharge in m^3/s	…… m^3/sec
6	**SPEED**	
(a)	Specific speed in M.K.S. units per Turbine	
(b)	Rated speed in r.p.m. (rated speed chosen by NMMC 428 rpm)	
(c)	Designed Maximum Runaway speed in r.p.m. at	
	(i) Rated Head	
	(ii) Maximum Head	
(d)	Duration of Designed Maximum Runaway Speed	……. sec
(e)	Direction of rotation when viewed from driving end	
(f)	Discharge during runaway condition	…… m^3/sec
(g)	Calculated Lowest Critical Speed of Shaft System	
(h)	Maximum Hydraulic Load at Maximum Head of 98 m	
(i)	Maximum Leakage Water through Guide Vane at Maximum Head of 98 m	……. Litres/sec
(j)	Estimated Closing Time	…….. sec
(k)	Total Weight of rotating parts of Turbine	…… MT
(l)	Maximum Pressure Rise at Maximum Rated Load & 50% Load	
7	**SPEED RISE**	
	Momentary Rise in Speed on suddenly reducing load to zero from full rated load / maximum load as percentage of rated speed	
8	**CLOSING TIME**	
	Time of Gate closing for regulation is 15 seconds	…… sec
9	**MOMENTARY DROP IN SPEED**	
	Momentary Drop in speed in increasing load from zero to full rated load / Maximum load as percentage of rated speed	
10	**OPENING TIME**	
	Time of gate opening for regulation in 8 seconds	…… sec
11	**FLYWHEEL EFFECT OF**	
(a)	The generating unit for regulation stated above	……. kg m^2
(b)	Generator	……..kg m^2
(c)	Turbine runner and shaft	……..kg m^2
(d)	Flywheel, if any	……...kg m^2
12	**FACTOR OF SAFETY**	
(a)	Guaranteed minimum factor of safety under worst conditions based on yield point stress of the material	
(b)	Name and location of the part having the factor of safety in 12 (a) above	
13	**EFFECT OF WATER HAMMER**	

	Max. water hammer pressure as percentage of rated head	
14	**RUNNER**	
(a)	Material and composition of Runner	
(b)	Applicable Standards for Material	
(c)	No. of Runner Blades	
(d)	Runner Diameter	
(e)	Weight of runner	
(f)	Source of runner casting	
15	**SHAFT**	
(a)	Material and composition	
(b)	Construction (Forged or Tubular)	
(c)	Applicable Standards for	
	(i) Material	
	(ii) Forging	
(d)	Diameter Inner / Outer	
(e)	Length	
(f)	Weight	
(g)	No. of Pieces	
16	**GUIDE APPARATUS**	
(a)	Material of guide vane	
(b)	No. of guide vanes	
(c)	(i) Leakage through fully closed gate (ii) Torque on runner due to leakage	
(d)	Description of the method of lubrication	
17	**SPIRAL CASING AND SPEED RING**	
(a)	Inlet Diameter of casing	
(b)	Dimensions of casing	
(c)	Maximum/design/working pressure	
(d)	Test pressure	
(e)	Material of casing	
(f)	No. of sections of casing	
(g)	Material and construction of speed/straying	
(h)	No. of vanes in speed/stay ring Material	
18	**DISTRIBUTOR**	
(a)	Elevation of centre line of distributor	……. m
19	**CAVITATION FACTORS**	
(a)	Critical sigma valve	
(b)	Cavitation guarantee in kg / 1000 hrs of operation	

20	**RECOMMENDED PLANT SIGMA**	
21	**DRAFT TUBE**	
(a)	Type	
(b)	Elevation of lowest point in draft tube	…… m
(c)	(i) Total strength of draft tube	……. m
	(ii) Length of steel liner	…….m
(d)	Velocity under full load at:	
	(i) Draft tube exit	……..m/sec
	(ii) Draft tube liner end location	
22	**GUIDE VANE SERVOMOTOR**	
(a)	No. of servomotor	
(b)	Material of servomotor body and piston	
(c)	Rating in kg. m.	
(d)	Range of oil pressure of satisfactory operation Type	
23	**INLET VALVE**	
(a)	Type	
(b)	Operating Method	
(c)	Diameter	
(d)	Materials	
(e)	Seals	
(f)	Operating Pressure	
24	**GOVERNING SYSTEM**	
(a)	Make of Governor	
(b)	Type of Governor	
(c)	Rating	
(d)	Guaranteed Sensitivity (Minimum Speed Change to which governor will respond)	
(e)	Range of adjustment of permanent speed drop	
(f)	Range of adjustment in speed setting	
(g)	Governor Opening & Closing Time	
(h)	Description & Method of Operation	
(i)	Adjustment Range in Governor Opening & Closing Time	
25	**VELOCITIES & SUCTION HEAD**	
(a)	Velocities of water at entry to inlet casing	…….m/sec
(b)	Velocities of water to turbine runner	…….m/sec
(c)	Velocities of water at exit of nozzle	…….m/sec
26	**FLYWHEEL, IF ANY**	
(a)	Location	

(b)	Weight	
(c)	Diameter	
27	**OIL PRESSURE VESSELS**	
(a)	No. of vessels per unit	
(b)	Dimensions of pressure vessels	
(c)	Normal volume of oil in each vessel	
(d)	Normal working pressure	
(e)	Grade of oil recommended	
28	**OIL PUMP AND OPU TANK AND ACCUMULATOR PRE-CHARGED WITH NITROGEN**	
(a)	No. of vessels per unit	
(b)	No. of oil pumps	
(c)	(i) Type	
	(ii) Impeller Material	
	(iii) Body Material	
(d)	Capacity of each pump	
(e)	Pump to be run continuously or intermittently	
(f)	Motor rating	
(g)	Dimensions of Pressure vessels	
(h)	Elevation of sump tank at bottom	…….m
(i)	Grade of Oil	
(j)	Effective volume of sump tank	
(k)	Total volume of oil required for initial filling	…… litres
	(i) Type of Nitrogen bladder	
	(ii) No. of Nitrogen bladder	
(l)	Filling pressure of Nitrogen	
(m)	Pressure of Oil in Accumulator	
(n)	Effective volume of oil in the generating system	…… litres
29	**COMPRESSED AIR EQUIPMENT**	
(a)	No. & capacity of compressors	
(b)	Working pressure	
(c)	Capacity of air receivers	
30	**COOLING WATER SYSTEM**	
(a)	Source of Cooling water (Penstock tapping or tail race pumping)	
(b)	Number of pumps for each unit	
(c)	Rating of each pump (discharge and head)	
(d)	Material of Pump Impeller	
(e)	Material of Pump Body	

(f)	Rating of each motor	
(g)	Material and size of strainer element	
31	**DRAFT TUBE DEWATERING SYSTEM**	
(a)	No. of pumps	
(b)	Capacity of each pump	
(c)	Total dynamic head	
32	**DEWATERING & DRAINAGE SYSTEM**	
(a)	No. of pumps Dewatering/Drainage	
(b)	Type	
(c)	Capacity of each pump	
(d)	Total dynamic head	
33	**HEAVIEST PACKAGE FOR SHIPMENT**	
(a)	Name	
(b)	Weight	……MT
(c)	Dimensions (L x W x H)	… m x .. m x … m
34	**LARGEST PACKAGE FOR SHIPMENT**	
(a)	Name	
(b)	Weight	……MT
(c)	Dimensions (L x W x H)	… m x .. m x … m
35	**HEAVIEST ASSEMBLY TO BE LIFTED BY POWERHOUSE CRANE**	
(a)	Name	
(b)	Weight	……MT
(c)	Dimensions (L x B x H)	… m x .. m x … m
36	**TOTAL WEIGHT OF ROTATING PARTS OF EACH TURBINE**	…… MT
GENERATOR		
1	**Name and address of manufacturer**	
2	**Type and reference**	
3	**Shaft orientation**	
4	**Rated speed and direction of rotation**	
5 (a)	**Normal voltage between phases**	
(b)	Voltage variation	
6 (a)	Frequency	
(b)	Frequency variation	
7 (a)	Guaranteed rated output at specified conditions with generator temperature rise limited to Class – B insulation temperature rise limit	…….kW ….kVA
(b)	Guaranteed maximum output at specified conditions with generator	

	temperature rise limited to Class – B insulation temperature rise limit	
(c)	Rated Voltage, zero leading power factor during line charging with 10% & 20% of Full load	
8	**Rated power factor**	
9	**Guaranteed maximum temp rise for rated and rated maximum outputs guaranteed in item 7 above over cooled air temperature not exceeding 37 deg. C.**	Rated Output Max. Output
(a)	Stator winding by ETD	
(b)	Rotor winding by RTDs / Resistance	
(c)	Bearing by ETD	
(d)	Other parts by thermometer	
10	**Guaranteed maximum output at rated PF and any frequency voltage in the operating range with generator temperature rise limited to Class F insulation temperature rise limit.**	kW kVA
11	**Guaranteed maximum temperature rise for the output guaranteed in item 10 above over cooled air temperature not exceeding 37^0C.**	
(a)	*Stator winding by ETD*	
(b)	Rotor winding by RTDs / Resistance	
(c)	Bearing by ETD	
(d)	Other parts by thermometer	
12	**Guaranteed overall efficiency of generator at rated voltage, power factor (p.f. = 0.85 (lag) – 1.0 (unity) – 0.85 (lead) (adjustable with excitation)), frequency and 75^0 C winding temperature computed by the summation of losses method in accordance with IS: 4889 – 1968 subject to tolerance in IS: 4722 – 1968.**	
(a)	115% rated output	
(b)	100% rated output (Full Load)	
(c)	80% rated output	
(d)	60% rated output	
(e)	40% rated output	
13	**Inherent Regulation, i.e., increase in voltage at constant speed and excitation on taking off**	
(a)	115% full load	
(b)	100 % rated output (Full Load)	
(c)	80% full load	
(d)	60% full load	

(e)	40% full load	
14	**Generator Reactance**	
(a)	Synchronous reactance (saturated)	
	(i) Direct axis	
	(ii) Quadrature axis	
(b)	Direct axis transient reactance	
	(i) Saturated	
	(ii) Quadrature axis	
(c)	Sub transient reactance	
	(i) Direct axis	
	(ii) Quadrature axis	
15	**Momentary speed rise the generator can take**	
16	**Negative phase sequence reactance**	
17	**Zero phase sequence reactance**	
18	**Resistance of armature winding per phase**	
19	**Resistance of field winding**	
20	**Generator time constants**	
(a)	Direct Axis Transient Open circuit	
(b)	Direct Axis Transient Short Circuit	
21	**Generator Characteristic Curves**	
(a)	Open circuit Saturation Curve	
(b)	Short Circuit Saturation Curve	
(c)	Full Load Saturation Curve at Rated Power Factor	
22	**Short Circuit Ratio**	
23	**Synchronizing Power at full load, 50 Hz, power factor (p.f. = 0.85 (lag) – 1.0 (unity) – 0.85 (lead) (adjustable with excitation))**	
24	**Flywheel effect of the**	
(a)	Rotating parts of the generator	
(b)	Flywheel (if any)	
25	**Duration for which all parts are guaranteed to withstand safely maximum runaway speed**	
26	**Guaranteed minimum factor of safety based on yield point stress of material under runaway / short circuit conditions and name and location of part having the minimum factor of safety.**	
27	**Maximum 1 / T value**	
28 A	**Inertia constant**	
28 B	**GD^2 of the Generator**	

29	**Maximum runaway speed of all parts guaranteed to withstand for 15 (fifteen) minutes of duration**	
30	**Embedded temperature detectors**	
(a)	Number	
(b)	Type	
31	**Excitation Equipment**	
(a)	Name of the manufacturer	
(b)	Type	
(c)	Accuracy of voltage regulation	
(d)	Range of voltage level setting	
(e)	Range of compounding / reactance drop compensation	
(f)	Range of control in auto mode	
(g)	Range of control in manual mode	
(h)	Frequency range of operation	
(i)	Excitation power speed	
(j)	Response ratio	
(k)	Max. continuous rating	
(l)	Nominal / ceiling voltage	
32	**Field current for full load on rated P.F. and terminal voltage**	
33	**Stator**	
(a)	Material of stator core	
(b)	Insulation of laminations	
(c)	Insulation of winding	
(d)	Max. temperature rise	
(e)	No. of sections in which stator is divided	
34	**Rotor**	
(a)	Rotor material	
(b)	Rotor construction	
(c)	Air gap	
(d)	Diameter of assembled rotor	
(e)	Factor of safety at maximum runaway speed based on yield point stress of material	
(f)	Construction of field poles	
(g)	Method of attaching field poles	
(h)	Field winding construction	
(i)	Insulation of field winding	
(j)	Construction of Damper winding	
35	**Bearings**	
(a)	Type	

(b)	Number of bearings	
(c)	Bearing oil/grease specification	
(d)	Quantity required for first filling	
36	**Generator Brakes**	
(a)	Speed at which brakes are applied	
(b)	Air pressure for satisfactory operation	
(c)	Brake shoe material	
37	**Main Shaft**	
(a)	Material	
(b)	Details of coupling flange	
38	**Neutral grounding equipment**	
(i)	**Distribution Transformer and Secondary Load resistor**	
(a)	Type	
(b)	Name and address of manufacturer	
(c)	Voltage ratio	
(d)	Continuous rating	
(e)	One minute rating	
(f)	Resistor / secondary load resistor	
(g)	Current rating of resistor	
(h)	Duty cycle of resistor and cooling medium	
(i)	Overall dimensions and weight	
h)	Duty cycle of resistor & cooling medium	
(ii)	**Overall dimensions and weight**	
(iii)	**Neutral Isolating Switch**	
(a)	Type	
(b)	Name and address of manufacturer	
(c)	Voltage rating, frequency	
(d)	Normal current	
(e)	Short time rating	
(f)	Impulse level (1.2/50 micro second wave)	
(g)	Power frequency dry withstand voltage (one minute)	
(h)	Dimensions	
(i)	Weight	
39	**Generator Terminal Equipment Lightning Arrestors**	
(a)	Type	
(b)	Name and address of manufacturer	
(c)	Standards to which it conforms	
(d)	Number of units	

(e)	Rated voltage	
(f)	Nominal discharge current	
(g)	Power frequency withstand voltage (one minute)	
(h)	Max. residual voltage at 10 KA	
(i)	Overall weight	
(j)	Mounting details	
40	**Protective Capacitors**	
(a)	Type	
(b)	Name and address of manufacturer	
(c)	Standard applicable	
(d)	Voltage Rating	
(e)	Capacitance Micro farad	
(f)	Weight	
(g)	Mounting details	
41	**Potential Transformer**	
(a)	Type	
(b)	Name and address of the manufacturer	
(c)	Standard applicable	
(d)	Rated primary voltage	
(e)	Rated secondary voltage	
(f)	Rated burden	
(g)	Accuracy class	
(h)	Temperature rise 1.1 times rated voltage with rated burden & frequency	
(i)	Power frequency withstand voltage (one minute)	
42	**Weight of generator rotating parts**	……. MT
43	**Weight of complete generator**	……. MT
44	**Heaviest package for shipment**	
(a)	Name	
(b)	Weight	……. MT
(c)	Dimensions (L x B x H)	.. m x … m x … m
45	**Largest package for shipment**	
(a)	Name	
(b)	Weight	……. MT
(c)	Dimensions (L x B x H)	.. m x … m x … m
46	**Heaviest assembly to be lifted by power house crane**	
(a)	Name	
(b)	Weight	……. MT
(c)	Dimensions (L x B x H)	.. m x … m x … m

Note	The Concessioner has to offer powerhouse crane capacity based on the maximum weight to be handled inside the powerhouse. NMMC has selected EOT Crane of 25 / 5 Tonne	
CONTROL PANELS		
A	**GENERAL**	
1	Make	
2	Type of sheet steel	
3	Thickness of sheet steel	
(a)	Front	
(b)	Back	
(c)	Sides	
4	Details of Painting	
5	Weight of each panel section	……. MT
6	Overall dimensions of each panel section in mm. (W x D x H)	.. m x … m x … m
7	Total weight of all Panels	……..MT
8	Space required for installation of all Panels	.. m x … m x … m
9	Largest package for transport	
(a)	Gross weight	……..MT
(b)	Overall dimensions	.. m x … m x … m
B	**SEMAPHORE INDICATORS**	
1	Make	
2	Type	
3	Diameter of the disc	
4	Operating voltage	
5	Burden	
C	**CONTROL SWITCHES**	
1	Make	
2	Type	
3	Type of handle	
4	No. of possible positions of the handle with diagrams	
(a)	No. of contacts available in each position	
(b)	Max. No. of contacts which can be accomodated for each position	
5	Rating of contacts	
(a)	Voltage	
(b)	Make & Carry current continuously	
(c)	Make & Carry current for 0.5 second	
(d)	Break resistive load	
1	Whether locking arrangement provided	
2	Mounting details	

3	Dimensions	
4	Other Information, if any	
D	**INDICATING LAMPS**	
1	Make	
2	Type	
3	Rating	
(a)	Current	
(b)	Voltage	
(c)	Wattage	
4	Colour of lamp	
5	Permissible voltage variation	
6	Whether series resistance is provided, if so	
(a)	Ohmic value	
(b)	Power loss	
7	Life of lamp in burning hours	
8	Other information, if any	
E	**PUSH BUTTONS**	
1	Make	
2	Whether integral engraved Inscription plates provided	
3	No.of NO / NC Contacts	
F	**ANNUNCIATORS**	
1	Make & Type	
2	No. of windows	
3	Dimension of each window	
4	No. of lamps per window	
5	Auxiliary supply voltage	
6	Power consumption	
7	Details of auxiliary equipment such as relays etc.	
8	Required instantaneous making capacity of initiating contacts	
9	Type of reset – manual / self	
10	Overall dimensions of anunciators	
11	Technical literature	
12	Brief write up of the scheme furnished	
G	**INDICATING METERS (TO BE FURNISHED)**	
1	Make & Type	
2	Type of movement	
3	Type of mounting	
4	Range	

5	C.T.Ratio	
6	P.T.Ratio	
7	Details of Shunt, if any	
(a)	Rated current	
(b)	Rated voltage drop	
8	Accuracy class	
9	Total deflection angle	
10	Total scale length	
11	Overall dimensions	
12	Burden	
(a)	Current coil	
(b)	Voltage coil	
13	Short time rating	
(a)	Current coil	
(b)	Voltage coil	
(c)	Time	
14	Other details	
15	Details of literature furnished	
H	**ENERGY METERS (TO BE FURNISHED SEPARATELY FOR EACH TYPE OF METER)**	
1	Make	
2	Type of measurement	
3	Measuring range	
4	C.T.Ratio	
5	P.T.Ratio	
6	Current coil rating	
7	Voltage coil rating	
8	Accuracy	
9	Speed of rotor (revolutions / kWh)	
10	VA burden of current coil	
11	VA burden of potential coil	
12	Limits of error at UPF and	
(a)	Rated current	
(b)	25% & 125% of rated current	
(c)	10% rated current	
13	Limits of error at power factor (p.f. = 0.85 (lag) – 1.0 (unity) – 0.85 (lead) (adjustable with excitation))	
(a)	Rated current	
(b)	25% & 125% of rated current	

(c)	10% rated current	
14	Continuous overload rating of current coil	
(a)	For thermal limit	
(b)	For accuracy limit	
15	Short time overload rating of current coil	
(a)	Current	
(b)	Time	
16	Continuous over-voltage rating of potential coil	
17	Reverse running stop provided	
18	Standard to which it conforms	
19	Mounting details	
20	Testing facilities & other details, if any	
I	**DIGITAL FREQUENCY METER**	
1	Class of Accuracy	
2	Type of display	
3	No. of digits	
4	Display size (height in mm)	
5	Range of frequency meter	
6	Rated input voltage	
7	Standard to which it conforms	
8	Mounting details	
9	Testing facilities and other details, if any	
J	**RECORDING INSTRUMENTS (INFORMATION TO BE GIVEN FOR EACH TYPE OF RECORDER SEPARATELY)**	
1	Make & Type	
2	Type of mounting	
3	Range of parameters that can be recorded	
4	Range of basic movement (In case of transducer – operated system)	
5	Accuracy	
6	Chart speed	
7	Paper width	
8	Length of chart	
9	Auxiliary supply	
(a)	Voltage	
(b)	Current	
(c)	Watts	
10	Permissible variation in auxiliary supply	
11	VA Burden	

12	Type of case (Draw-out / Non Draw-out)	
13	Detailed technical literature published	
14	Particulars of drive	
15	Form of reserve drive	
16	Standard to which the recorder conforms	
K	**DIFFERENTIAL RELAYS**	
1	Make	
2	Type	
3	Nominal Voltage	
4	Permissible variation in voltage	
5	Nominal current (In case of current operated relay)	
6	Permissible variation in current	
7	Contacts – Hand reset / Self reset	
8	No. of pair of contact	
(a)	Make contacts	
(b)	Break contacts	
9	Speed of operation of relay	
10	Pick up / Drop off ratio	
M	**RESRICTED EARTH FAULT RELAY**	
1	Make	
2	Type	
3	Reference standards	
4	Rated D.C. voltage	
5	Rated A.C. voltage	
6	Operating principle	
7	Solid state or electro-mechanical	
8	Thermol rating	
9	No. of contacts	
(a)	Normally open	
(a)	Make & carry for 0.5 second	
(b)	Break	
10	Case dimensions (Overall in mm.)	
11	Cut-out dimensions in mm. (H x W)	
12	Contacts – Self Reset / Hand Reset	
13	Burden	
14	Operating Indicator provided	
15	Operating time at 2 x setting current	
16	Tuned to system frequency	

17	Setting range	
N	**SYNCHRONIZING EQUIPMENT**	
1	Make	
2	Type	
3	Reference standards	
4	Double voltmeter provided ?	
5	Double frequency meter provided ?	
6	Synchro scope provided ?	
7	Lamps provided ?	
O	**CTs & PTs**	
1	Make	
2	Type	
3	Ratio	
4	Rated Output VA	
5	Class of frequency	
6	Short time rating	
(a)	Current	
(b)	Voltage	
7	Knee Point voltage for Class ‘PS’	
8	Excitation Current for Class ‘PS’	
(a)	KVP	
(b)	50% KVP	
9	Internal Impedance of	
(a)	Primary	
(b)	Secondary	
10	Temparature rise	
11	Mounting details	
12	Overall dimensions	
13	Any other details	
POWER TRANSFORMER		
1	Name and address of manufacturer	
2	Type	
3	Full load rating (HV)	
4	Rated no load voltage (HV)	
5	Rated current	
6	Type of cooling	
7	Rated % impedance	
8	Rated frequency	

9	Winding connections	
(i)	HV	
(ii)	LV	
10	Vector group	
11	Tapping on windings	
12	Winding insulation and category as per IS:2020	
13	Impulse withstand voltage	
14	Power frequency withstand voltage	
15	Guaranteed maximum temperature rise	
	a) Winding	
	b) Oil	
16	Losses	
	a) No load at rated voltage and frequency	
	b) Load loss at rated current at 75 deg. C	
17	Maximum flux density at rated voltage	
18	Current density	
	a) HV	
	b) LV	
19	Dial size of meters	
20	Weights	
	a) Core and winding (kg)	
	b) Oil (kg)	
	c) Tank and fittings (kg)	
	d) Total	
21	Overall dimensions	
22	Winding material	ALARM TRIP
23	Type of winding:	
(a)	HT	
(b)	LT	
24	(i) Buchholtz relay	
	(ii) Oil temperature	
	(iii) Winding temperature	
	(iv) Minimum oil gauge provided	
25	Tappings for HV / LV variation	
(a)	Range	
(b)	No. of steps	
(c)	Value of the step	

26	Efficiency at 75 deg. C (Power factor (p.f. = 0.8 (lag) – 1.0 (unity) – 0.8 (lead) (adjustable with excitation))	
	i) At full load	%
	ii) at 3/4 full load	%
	iii) at 1/2 full load	%
	iv) at 1/4 full load	%
27	a) Regulation at full load at 75 deg. C and unity (1.0) P.F.	
	b) Regulation at full load at 75 deg. C and 0.8 PF (lagging)	
	c) Regulation at full load at 75 deg. C and 0.8 PF (leading)	
28	No. of radiator / coolers	
29	Rating of each radiator / cooler (percentage of load)	
30	Insulation level	
(a)	Separate source power frequency withstand voltage LV / HV	
(b)	Induced over voltage withstand voltage LV / HV	
(c)	Full wave lightning impulse withstand voltage LA / HV	
(d)	Switching impulse withstand voltage LA / HV	
31	Terminal arrangements	
(a)	HV	
(b)	LV	
(c)	Neutral	
32	Reference standards	
OLTC		
1	Make	
2	Type	
3	Rating	
(a)	Rated voltage	
(b)	Rated current	
(c)	Step voltage	
(d)	No. of steps	
4	Control	
5	Auxiliary Supply Details	
6	Voltage for Control	
7	Local switch	
8	Indications provided	
9	Protections employed	
	(a) Buchholtz relay	
	(b) Oil temperature	

10	Details of electric drive	
	(a) kW	
	(b) Voltage	
11	Annunciation's provided	
12	Approximate overall weight	
13	Approximate overall dimensions	
14	Approximate quantity of oil	
STATION AUXILIARY TRANSFORMER		
1	Name and address of manufacturer	
2	Full load rating	
3	Rated no load voltage (HV)	
4	Rated current (HV)	
5	Type of cooling	
6	Rated % impedance	
7	Rated frequency	
8	Winding connections	
(i)	HV	
(ii)	LV	
9	Vector group	
10	Tappings on windings	
11	Winding insulation and category as per IS: 2026	
12	Impulse withstand voltage	
13	Power frequency withstand voltage	
14	Guaranteed maximum temperature rise	
	a) Winding	
	b) Oil	
15	Losses	
	a) No load	
	b) Load loss at 75 deg. C	
16	Maximum flux density at rated voltage	
17	Current density	
	a) HV	
	b) LV	
18	Dial size of meters	
19	Weight	
	a) Core and winding	…….kg
	b) Oil	…….kg
	c) Tank and fittings	……..kg

	Total	
20	Overall dimensions	… m x ... m x .. m
21	Winding material	
22	Minimum oil gauge provided	
23	On load tap details	
	a) Number of taps	
	b) Steps in each tap	
24	Noise Level dB(A)	
BATTERY & BATTERY CHARGER		
(A)	**BATTERY**	
1	Name and address of manufacturer	
2	Applicable Standard	
3	Type, designation as per IS (maintenance free)	
4	Manufacturer's type designation	
5	Capacity in Amperes of the battery	
6	Rated voltage & current of battery	Voltage Current
(i)	Normal	
(ii)	Maximum	
(iii)	Minimum	
7	Nominal Cell voltage (volts)	
8	No. of cells in each bank	
9	No. of spare cells in each bank	
10	Material of containers	
11	Thickness & type of material separators	
12	Construction details & dimensions	
(i)	a) Positive Plate	
	b) Negative Plate	
(ii)	Method of supporting elements	
13	Provision to provide earth leakage relay	
(B)	**BATTERY CHARGER**	
1	Type of rectifier	
2	No. of units	
3	Manufacturer's type & designation & standards applicable	
4	AC Supply unit kVA & Voltage	
5	Percentage taps provided on transformer	
6	Rated DC output for	
(i)	Boost Charger (Amp.)	
(ii)	Float Charger (Amp.)	

7	Rated DC output voltage for	
(i)	Boost Charger (Amp.)	
(ii)	Float Charger (Amp.)	
8	Rated DC voltage controls for	
(i)	Boost Charger (Amp.)	
(ii)	Float Charger (Amp.)	
9	DC output voltage regulation from no load to full load	
10	Maximum ripple current	
11	Overall efficiency	
12	Unit dimensions	
13	List of major accessories or spares	
14	Constructional details	
15	Protective features specified are given under specification	
DIESEL GENERATOR (DG) SET		
(i)	**ENGINE**	
1	Name and address of manufacturer	
2	Type & Model	
3	Method of starting	
4	Rated Horse Power	
5	Guaranteed Fuel Consumption	
(a)	At Full Load	
(b)	At 1/2 Load	
6	Lubricating Oil Consumption	
7	Safety Protection Provided	
8	Method of Cooling	
9	Tachometer	
(ii)	**ALTERNATOR**	
1	Name and address of manufacturer	
2	Manufacturer's Type	
3	Rated kW capacity	
4	Rated kVA capacity	
5	Rated terminal voltage	
6	Rated power factor	
7	Rated stator current	
8	Rated speed	
9	Inherent voltage regulation	
10	Efficiency at rated power factor at	
(a)	Full Load	

(b)	3/4 Load	
(c)	1/2 Load	
11	Excitation current at rated power factor output & power factor	
12	Peripheral speed of the rotor	
13	Critical speed of the rotor	
14	Class of Insulation of	
(a)	Stator	
(b)	Rotor	
15	Method of cooling	
16	Max. temperature rise of the stator	
(iii)	**DIESEL GENERATOR SET**	
1	Starting time	
2	Interval between starting impulses	
3	No. of starting impulses (Maximum)	
4	Time for picking up full load	
(iv)	**DIESEL GENERATOR CONTROL PANELS**	
1	Name and address of manufacturer	
2	Outline dimension (L x W x H)	
3	Type of mounting	
(v)	**BATTERY**	
1	Type	
2	Name and address of manufacturer	
3	Capacity in 10 hours rating	
4	Voltage	
(vi)	**CHARGER**	
1	Type	
2	Voltage	
3	Current	
(vii)	**WEIGHT SCHEDULE**	
1	Weight of engine less flywheel	
2	Weight of flywheel	
3	Weight of generator	
4	Total Equipment Weight	
(viii)	**FOUNDATION FRAME**	
1	Size	
2	Anti vibration pad capacity	
3	Name and address of manufacturer	
4	Quantity of pads	

(ix)	**FUEL TANK CAP**	
E.O.T. CRANE		
1	Rated Capacity	
2	Make	
3	Class of duty	
4	Bridge Girder	
(a)	Type	
(b)	Span	
5	Gantry Rail Size	
6	Hoist Type	
7	Make of Hoist	
8 (a)	Size of chain	
(b)	Type	
9 (a)	Type of Hook	
(b)	Material	
10	Gears / Pinions	
(a)	Type	
(b)	Material	
11	Bearing	
(a)	Type	
(b)	Make	
12	Gantry Rail Material	
13	Maximum hook approach	
(a)	Pendent end	
(b)	Other end	
14	Wheel load	
15	Length of travel	
16	Clearance from bottom of roof	
17	Maximum lift	
18	Total weight of crane	

In addition to the above, it is further guaranteed that the generator shall be capable of evacuating power under adverse voltage conditions (+10% & -25%) in the grid without any loss in efficiency and damage to the equipment.

SCHEDULE - 3

SCHEDULE OF CAPITAL INVESTEMNT FOR TURBINE, GENERATOR & ASSOCIATED EQUIPMENT

(To be Filled-in by the Concessioner)

S. NO.	ITEM	QUANTITY	(PRICE IN RUPEES)			
			F.O.R. WORK		F.O.R. SITE	
			UNIT PRICE	TOTAL PRICE	UNIT PRICE	TOTAL PRICE
TURBINE						
1	Turbine Complete	2 NOS.				
2	Governor with Oil pressure system	2 NOS.				
3	Main Inlet Valve	2 NOS.				
4	Common Auxiliaries					
(a)	Cooling water system	2 SETS				
(b)	Compressed air system	2 SETS				
(c)	For nitrogen filling of pressure vessels	2 SETS				
(d)	Dewatering system	1 SET				
(e)	Drainage system	1 SET				
5	Spares as per Schedule No. 3 and in addition recommended spares	ITEMWISE PRICES				
6	Supervision charges (Indicate number & daily rates)					
GENERATOR						
1	Generator complete with accessories as per schedule of requirements	2 NOS.				
2	Fire Protection Equipment	1 SET				
3	Testing Devices and instruments required during assembly / erection and commissioning and for field tests	RENTAL OR PRICE AS THE CASE MAY BE				
4	Charges for Supervisor / Engineers for Assembly, Erection, Commissioning and Field Acceptance Tests (Indicating Terms & Conditions)					

SCHEDULE-4

SCHEDULE OF CAPITAL INVESTMENT FOR MATERIALS, DIMENSIONS & WEIGHTS OF MAJOR COMPONENTS OF EQUIPMENTS

(To be Filled-in by the Concessioner)

COMPONENT	MATERIAL	THICKNESS	STANDARD
TURBINE			
Runner			
Runner Body			
Shaft			
Anchor Frame			
Transient piece			
Inlet pipe			
Stay ring			
Outer casing			
Bearings			
G.V. Servomotor			
GENERATOR			
Stampings			
Rotor Stampings			
Insulation			

SCHEDULE-5

SCHEDULE OF TECHNICAL PARTICULARS OF MICROPROCESSOR BASED AUTO CONTROL SYSTEM

(To be Filled-in by the Concessioner)

S.NO.	NAME OF EQUIPMENT	TECHNICAL PARTICULARS
1	MICROPROCESSOR	
2	CRT	
3	PRINTER	
4	UPS	

SCHEDULE-6

SCHEDULE OF MANDATORY SPARES

(To be Filled-in by the Concessioner)

S.NO.	ITEM OF SPARE	QTY.	REMARKS
SPARES FOR TURBINE			
I	**FOR TURBINE**		
1.	Wearing rings (stationery) if any	1 SET	
2.	Shaft seal packings	2 SETS	
3.	Guide vane stem packings	1 SET	
4.	Shear pins/friction clutch components	1/2 SETS	
5.	Guide vanes	4 NOS.	
6.	Piston rings for servomotor cylinders	2 SETS	
7.	Packing and sealings, all types and sizes	2 SETS	
8.	Guide vane bearing bushes	1 SET	
9.	Bushes/bearings for regulating mechanism	1 SET	
II	**OIL PRESSURE VESSEL & OIL PUMPING UNIT FOR TURBINE**		
1.	Oil Pump bearings of OPU	1 SET	
2.	Seals / Packings (All types)	1 SET	
3.	Filter elements for oil	1 SET	
4.	Solenoids / coils	1 SET	
5.	Spring (all types)	1 SET	
6.	Level relay	1 SET	
7.	Pressure switches	1 SET	
8.	Ball bearings (all types)	1 SET	
9.	Pump unloader valve	1 SET	
10.	Safety relief valve	1 SET	
11.	Flexible hose pipes	1 SET	
12.	Non – return valves for OPU	1 SET	
13.	Pressure gauges	1 SET	
14.	Level gauge	1 SET	
III	**INSTRUMENTS AND SAFETY DEVICES FOR TURBINE**		
1.	Filter element for cooling water system	2 SETS	
2.	Pressure gauge for cooling water	2 NOS.	
3.	Hose pipe of cooling water inlet to turbine guide bearing	2 NOS.	

S.NO.	ITEM OF SPARE	QTY.	REMARKS
4.	Bearings of C.W. Pump & Motor	1 SET (4 NOS.)	
5.	Resistance type temperature detectors (RTDs)	2 NOS.	
6.	Level switches	1 SET	
7.	Dial type thermometers	1 SET	
8.	Coils / Contacts / Springs for auxiliary relays, Solenoids and Switches etc.	1 SET	
IV	**GOVERNOR SPARES FOR TURBINE**		
1.	I / O Cards	1 NO.	
2.	Speed pick up transducers	1 NO.	
3.	Runner feedback transducers	1 NO.	
4.	Guide vane servomotor feedback transducers	1 NO.	
V	**GREASE LUBRICATING SYSTEM FOR TURBINE**		
1.	Grease Feeders	1 SET	
2.	Primer equipment	2 SETS	
GENERATOR SPARES FOR GENERATOR			
1.	Bearing bushes NDE, DE	1 Set	
2.	RTDs	2 Nos.	
3.	Dial thermometers	1 No.	
4.	Excitation Spares – AVR module	1 Set	
5.	Speed Sensing Probe	1 No.	
INDOOR SWITCHGEAR & OUTDOOR YARD SPARES			
1.	11 kV Generator breaker closing coil & trip coil	As per recommendations of the Supplier	
2.	11 kV Generator breaker spring charge motor		
3.	11 kV breaker contacts (fixed / movable)		
4.	132 kV or 220kV Transformer breaker closing coil & trip		
5.	132 kV or 220kV Transformer breaker spring charge motor		
6.	132 kV or 220kV Transformer breaker (fixed / movable)	1 SET (FOR 1 BREAKER)	
7.	Fuses	10% OF EACH TYPE	
8.	Bulbs & Holder	10% OF EACH TYPE	
TRANSFORMER SPARES			
1.	H.T. bushes for 11 / 132 kV or 220kV, 15,000 kVA Transformer	1 No.	

S.NO.	ITEM OF SPARE	QTY.	REMARKS
2.	L.T. bushes for 11 / 132 kV or 220kV, 15,000 kVA Transformer	1 No.	
3.	H.T. bushes for 11 kV / 433 V, Transformer	1 No.	
4.	L.T. bushes for 11 kV / 433 V, Transformer	1 No.	

NOTES:

1. The above is minimum mandatory requirement. The Concessioner may quote for any additional spares that he considers are necessary.

2. Where the “UNIT” is shown as a “SET”, the Concessioner should clearly state what constitutes a set.

3. All spares as recommended by manufacturers for trouble-free maintenance for at least 5 (five) years should be incorporated in the list of spares given above.

SCHEDULE-7

SCHEDULE OF DEVIATIONS FROM TECHNICAL SPECIFICATIONS

DELETED

SCHEDULE-8

SCHEDULE OF TESTS PROPOSED TO BE PERFORMED ON THE "EQUIPMENT"

SL. NO.	NAME OF EQUIPMENT	NAME OF TESTS PROPOSED AT MANUFACTURER'S WORKS BEFORE DISPATCH	NAME OF TEST PROPOSED AT SITE DURING ERECTION, TESTING & COMMISSIONING	NAME OF SPECIAL TOOLS TACKLES, INSTRUMENTS METERS, GAUGES NEEDED TO BE PROVIDED BY THE NMMC TO CONCESSIONER'S SUPERVISORS
1.	TURBINE			
2.	GENERATOR			
3.	OPU			
4.	AUXILIARIES			

Signature:

Name:

Company:

Seal of Company

Date:

SCHEDULE - 9A

SCHEDULE OF MANDATORY MAINTENANCE TOOLS & PLANTS

FOR THE FACILITIES

SL. NO.	DESCRIPTION (NAME OF THE SPARE PART)	QTY.
1	500 V, 500 Mega Ohms range hand driven & Electric, generator type megger with leather case	1 NO. each type
2	1000 V, 1000 Mega Ohm range hand driven & Electric, generator type megger with leather case	1 NO. each type
3	Tong tester 0-600V, 0-1000A clip on voltmeter and ammeter with leather case	1 NO.
4	160 lph stream line oil filtration plant	1 NO.
5	Oil testing kit	1 SET
6	Analog meter	1 NO.
7	Hand held phase type sequence meter 50 to 500V	1 NO.
8	Earth megger	1 NO.
9	Blower	1 NO.
10	Soldering iron	1 SET
11	Handle held speedometer	1 NO.
12	Generator air gap gauge	1 NO.
13	Pole screw tightening wrench for generator	1 NO.
14	Torque wrench for rectifier assembly of generator	1 SET
15	Vernier calipers 300m	1 NO.
16	Dial gauge with magnetic base – 0.01 mm accuracy	3 SETS
17	Screw gauge	1 NO.
18	Inside & outside calipers	1 NO. EACH
19	Master level 0.02 mm/m accuracy	1 NO.
20	Ring spanners & double end open jaw spanners 5m to 36m set; 36 x 41; 46 x 51 and 50 x 55 mm Size	1 SET EACH
21	Single end open jaw spanner & Single end ring spanners -46, 50, 51 & 55 mm Size	2 NOS. EACH
22	Box spanner – 10 to 32 mm with accessories	1 SET
23	Circlip opener (Inside & Outside) 6”	1 NO. EACH
24	Hammers – Ball pen 1kg. & straight – 5 kg & 10 kg	1 NO. EACH
25	Hydraulic jack 5 & 10 tonne	1 NO. EACH

SL. NO.	DESCRIPTION (NAME OF THE SPARE PART)	QTY.
26	Flexible shaft grinder	1 NO.
27	Pistol drilling machine	1 NO.
28	Shim cutter 12” size	1 NO.
29	Die set with wrench for no. 25, 40 & 50 mm	1 NO. EACH
30	Pipe wrench 18”, 24”	1 NO. EACH
31	Screw wrench 18”, 24”	1 NO. EACH
32	Allen keys 5mm to 24mm	1 SET
33	Cutting pliers 6” & 8” size	1 NO. EACH
34	Nose pliers 6” & 8” size	1 NO. EACH
35	Hacksaw frame 12”	1 NO.
36	Rough & Smooth Flat, round, half round & triangular file 12” size	1 NO. EACH
37	Center punch & Letter punch	1 NO. EACH
38	Chisels 12 mm 7 20 mm width	1 NO. EACH
39	Bench vice 12” size	1 NO. EACH
40	Screw drivers 6”, 9”, 12”, 16”	1 NO. EACH
41	Grease gun 12”	1 NO.
42	Wire slings 10 tonne & 5 tonne capacity	4 NOS. EACH
43	“D” shackles 10 tonne & 5 tonne capacity	4 NOS. EACH
44	Tap set with wrench m 10, 12, 16, 18, 20, 24	1 SET
45	Feeler gauge 0.05 mm to 1 mm size 6”, 18”	1 SET EACH

NOTE: *These lists of tools & plants are to be quoted & delivered by the Contractor. These items remain the property of the NMMC for the purpose of Maintenance of Units / Facilities.*

SCHEDULE – 9B

SCHEDULE OF DIMENSIONS & WEIGHTS

SL. NO.	DESCRIPTION	NO. OF PACKAGES	SHIPPING DIMENSION OF EACH PACKAGE (meters)	SHIPPING WEIGHTS OF EACH PACKAGE (kgs.)
1	Inlet pipe		DIA. x LONG	
2	Transient piece			
3	Inlet casing			
4	Runner assembly			
5	Turbine main shaft assembly			
6	Stub shaft assembly			
7	Oil header assembly			
8	Guide bearing			
9	Shelf seals assembly			
10	GV servomotor			
11	Embedded pipes			
12	Drainage & Dewatering			
(a)	Pumps			
(b)	Valves			
(c)	Strainers			
(d)	Piping			
13	Cooling water			
(a)	Pumps			
(b)	Valves			
(c)	Strainers			
(d)	Piping			
14	OPU			
15	Valves & fittings			
16	Generator			

SECTION-

SCHEDULE OF REQUIREMENTS

SECTION-VI B

SCHEDULE OF REQUIREMENTS

A. General

The Concessioner shall quote for Facilities including Design, Material selection, manufacture, assembly, intermediate storage, tests at Concessioner's works including type tests, packing & forwarding for shipment, delivery at site (final destination), receipt & storage at site, and services for performing On-site assembly, complete erection, field testing at site, commissioning, Load Testing (trial operation) of 72 hrs, test run of 8 weeks inclusive of commercial operation and maintenance & training of NMMC's assigned personnel in accordance with Clause 25 of GCC and Clause 10 of SCC of 3 units in respect of "Facilities" comprising of Electro-Mechanical Equipment of 1.5 MW Morbe Dam (2 x 750 kW + 15% COL) Hydroelectric Project with its dam site located across Dhavari River, Raigad District Mahrashtra, India.

B. Facilities

The Concessioner has to include in the scope all the Facilities required for the project in full and complete shape even though some of the equipment may not be specifically mentioned as detailed out below:

S.No	Description	Quantity
A	**Turbine and its Auxiliaries**	
1	Turbine having rated output 0.75 MW capacity with 15% COL at Rated Head, 428 rpm, Synchronized speed, complete with all accessories, auxiliary equipment.	2 Sets
2	Digital Electronic Governor	2 Sets
3	Oil Pressure Unit with tank including pumps, oil, distribution valves, directional control valves, regulation valves, Bladder accumulators etc. (Common for Turbine & MIV) for regulation of guide vanes of each turbine with two numbers of oil pumps driven by electrical motors (main and standby) mounted on the oil tank and provided with adequate pressure oil accumulators with nitrogen charged bladders including safety and indicating device, valves, strainers, relays, instruments, piping etc., in a complete shape.	2 Sets
4	Cooling water system (Open Loop Type) for generator air coolers, thrust bearing oil coolers, guide bearings oil coolers complete with pumps, filters, valves, fittings and other accessories with penstock tapping.	1 Lot
5	Drainage and dewatering system with two electrical motor pump set of Submersible type pumps (main and standby) two non-return valves, required isolating valves, fitting, mountings and connected piping etc., in a complete	1 Lot

S.No	Description	Quantity
	shape and all accessories as required.	
6	Portable Compressed Air System	1 No.
B	**Main Inlet Valve (MIV)**	
1	Main Inlet Valve (Butterfly Valve) of 2000 mm diameter, Hydraulically operated along with By-Pass Arrangement, Dismantling Joint, necessary piping, PN 14 is provided with single seal arrangement complete with upstream piping along with bypass arrangement. etc.	2 Sets
C	**Generator and its Auxiliaries**	
1	Vertical Synchronous Generator, Three Phase, 11 kV, 11765 kVA+15% COL, 428 rpm, 50 Hz (±3%), 0.85 p.f. (lag), direct driven, complete with thrust and guide bearings, upper and lower bracket with instrumentation, Auxiliaries & Lubrication Arrangements etc., in a complete shape.	2 Sets
2	Digital Brushless Excitation system equipment complete with Digital AVR (1 Auto +1 Manual) along with excitation transformer and other accessories.	2 Sets
3	Neutral Grounding Transformer (NGT) Panel	2 Nos.
4	Lightning Arrestor-Voltage Transformer (part of 11kV Switchgear)	2 Nos.
D	**Control, Metering and Protection Panels**	
1	Electrical Protection System with numeric type integrated protection relays for generating units, generator step-up transformer, Synchronization relay and outgoing transmission lines complete with all accessories, wiring and cubicles etc.	1 Lot
2	SCADA Control and Monitoring System comprising of distributed digital controls, monitoring & information system for entire Power system	1 Lot
E	**Power House Switchgears**	
1	11 kV Generating Voltage Switchgear Panel	1 Lot
2	Low Voltage Switchgear Panel (LTAC)	1 Lot
F	**Other Electrical and Mechanical Equipment**	
1	11 kV/132kV or 11 kV/220kV, 15MVA ONAN, 3 phase, Step-up Transformer complete with bushings, under-carriage, off load tap changer and all accessories/ fittings, Cooling medium as mineral oil and earthing HV Neutral solidly Earthed.	2 Sets
2	Auxiliary Transformer 500 kVA, 11 / 0.433 kV 3 phase ONAN type complete with all accessories and first Oil filling.	1 No.
3	110 Volt, 300 AH capacity DC System consisting of battery banks, battery chargers, UPS, distribution boards of appropriate ratings, racks.	1 Lot
4	100 KVA, DG Set including control panel with protection system, switches, indicating instruments etc.	1 Lot

S.No	Description	Quantity
5	Above Ground Earthing / Grounding System for powerhouse equipment including Switch Yard Equipment complete with all accessories.	1 Lot
6	75/15 T Electric Overhead Travelling (EOT) crane for Powerhouse	1 Lot
7	132 kV or 220kV OUTDOOR SWITCHYARD EQUIPMENTS having single bus system with fault level of 31.5kA for 1 sec. along with Support Structures and Accessories	1 Lot
8	Power (Aluminum conductor), Control (Copper Conductor) and instrumentation cable, along with GI cables trays, hardware and accessories for powerhouse and switchyard.	1 Lot
9	Ventilation System for Power house (min.12 nos. Exhaust Fans) or as per site requirement.	1 Lot
10	Control room Air conditioning System (min. 2 Nos., 2 ton window AC) or as per site requirement.	1 Lot
11	Fire Extinguishing system for power house and switchyard (or as per site requirement, portable fire extinguishers)	1 Lot
12	Earthing system and lightning protection system for powerhouse and switchyard equipment.	1 Lot
13	Normal and emergency lighting system for powerhouse & switchyard.	1 Lot
14	Schedule of Mandatory spares as per list enclosed at Annexure-I	1 Lot
15	Mandatory maintenance tools and plants as per list enclosed at Annexure-II	1 Lot

TECHNICAL PARTICULARS OF E&M EQUIPMENT TO BE INSTALLED AT MORBE DAM TOE H.E. PROJECT

Project Name: Morbe Dam Foot H.E. Project			
Description	**Unit**	**Project Requirement**	**Designed Offer**
A. TURBINE			
Turbine Type	-		
Capacity	MW	(2 x 10 MW +15% COL)	
Rated Head	m	80	
Maximum Head	m	93	
Minimum Head	m	68	
Rated discharge for 1 machine	m^3/s	14.11	
Rated discharge for 2 machines	m^3/s	28.22	
Overload discharge for 1 machine	m^3/s	16.29	
Overload discharge for 2 machines	m^3/s	32.58	
Turbine Speed	rpm	500	
Runner Diameter (D_2)	mm	1380	
Runner Weight	Kgs	1900	
Efficiency at Overload (115%)	%	93.58	
Efficiency at Rated load (100%)	%	93.92	
Average Part Load Percentage (90-40%)	%	85.9	
Runaway Speed < 2 times rated speed	rpm	1010	
Runaway Speed Duration	minutes	15	
Turbine setting with respect to Tail Water Level of EL 185 m	m	-(ve) 1.5	
Runner Centre Line Elevation			
Speed Rise	%	Max. Permissible = 50%	
Pressure Rise	%	Max. Permissible = 50%	
Butterfly Valve Diameter (2 nos.)	mm	2000	
Governor		Electronic	
Oil Pressure System			
Cooling Water System		Penstock tapping	
Runner Material		4/13 Stainless Steel, Material composition of Blade = ZG0Cr13Ni4MO	
TURBINE EFFICIENCIES			
Efficiency at 115%			
Efficiency at 100%			
Efficiency at 80%			
Efficiency at 60%			
Efficiency at 40%			
Weighted average efficiency of Turbine			
Turbine discharge at rated head, for the following percentages of rated outputs:			

Project Name: Morbe Dam Foot H.E. Project			
Description	**Unit**	**Project Requirement**	**Designed Offer**
115%			
100%			
80%			
60%			
40% or Minimum allowable discharge whichever is lower			
Indicate max. & min. discharge in m^3/s			
B. GENERATOR			
Type		Horizontal Synchronous	
Rating		2 Nos. 10 MW rated output, 11 kV, 0.85 pf, 500 rpm, 50 Hz, with 15 % overload	
Rated Power Factor		0.85	
Frequency Variation		.+/- 3%	
Voltage Variation		.+/- 10%	
Insulation Class		F/B	
Generator Brakes		pressure oil operated spring brakes (manual/automatic)	
Inertia Constant		1.0	
Short Circuit Ratio		1.1	
Efficiency at 115%			
Efficiency at 100%			
Efficiency at 80%			
Efficiency at 60%			
Efficiency at 40%			
Weighted average efficiency of Generator			
Weighted average efficiency of Turbine-Generator Set		Min 85%	
Generator Reactance			
Synchronous reactance (saturated)			
Direct axis transient reactance			
Sub transient reactance			
GD^2 of the Generator			
C. TRANSFORMER			
Type & Rating		Two (2) nos. 11 / 132 kV or 11 / 220 kV, 15000 kVA, ONAN, 3 phase, 50 Hz outdoor step-up transformers	
Full load loss, kW			
No Load Loss, kW			
Auxiliary Transformer		1 No. 500 kVA, 11 / 0.433 kV	
Efficiencies at 75 deg C			

Project Name: Morbe Dam Foot H.E. Project			
Description	**Unit**	**Project Requirement**	**Designed Offer**
i) At full load	%		
ii) at 3/4 full load	%		
iii) at 1/2 full load	%		
iv) at 1/4 full load	%		
OLTC			
D. CONTROL PANELS			
Neutral Grounding Transformer (NGT) Panel (2 Nos.)			
Lightning Arrestor-Voltage Transformer (part of 11kV Switchgear) (2 Nos.)			
Control, Metering and Protection Panels			
11 kV Generating Voltage Switchgear Panel			
Low Voltage Switchgear Panel (LTAC)			
E. EOT CRANE			
Electric Overhead Travelling (EOT) crane for Powerhouse		75/15 T	
F. DC SYSTEM			
DC System consisting of battery banks, battery chargers, UPS, distribution boards of appropriate ratings, racks.		110 Volt, 300 AH capacity	
DG Set including control panel with protection system, switches, indicating instruments etc.		250 KVA	
G. SWITCHYARD EQUIPMENTS			
Above Ground Earthing / Grounding System for powerhouse equipment including Switch Yard Equipment complete with all accessories.			
132 kV or 220 kV OUTDOOR SWITCHYARD EQUIPMENTS having single bus system with fault level of 31.5kA for 1 sec. along with Support Structures and Accessories			
Power (Aluminum conductor), Control (Copper Conductor) and instrumentation cable, along with GI cables trays, hardware and accessories for powerhouse and switchyard.			
Ventilation System for Power house (min 12 nos. Exhaust Fans) or as per site requirement.			
Control room Air conditioning System (min 2 Nos., 2 ton window AC) or as per site requirement.			
Fire Extinguishing system for power house and switchyard (or as per site requirement portable fire extinguishers)			
Earthing system and lightning protection system for powerhouse and switchyard equipment.			
Normal and emergency lighting system for powerhouse & switchyard.			
Mandatory spares			
Mandatory maintenance tools and plants			

Annexure-I

SCHEDULE OF MANDATORY SPARES

S. No.	Description	Qty.	Unit
A	**MECHANICAL EQUIPMENTS**		
1	**Turbines**		
a)	Runner seals	Set	1
b)	Guide vane O-ring	Nos.	10
c)	DU bushes for one guide vane	Nos.	5
d)	Labyrinth seal rings pre-machined	Set	1
e)	Guide vane lever	Nos.	5
f)	Runner seals	Set	1
g)	Feedback Transducer, connector, magnetic ring	No	1
2	**Hydraulic oil pressure unit**		
a)	Filter servo-valve	Set	1
b)	Filter elements	Set	1
c)	Bearing for motor	Nos.	1
d)	Oil tank level switch	Nos.	1
e)	Pressure switch	Nos.	1
f)	Return line filter element	Nos.	1
g)	Safety relief valve for accumulator	Nos.	1
3	**Turbine inlet valve (BUTTERFLY TYPE)**		
a)	Flap Seal	No.	1
b)	Seals for MIV servomotor	Set	1
c)	Proximity sensor for bypass needle valve	No	1
B	**ELECTRICAL EQUIPMENTS**		
1	**GENERATOR and EXCITATION**		
1.1	**Generators**		
a)	Duples Type RTD	Nos.	2
b)	Braking Liner	Set	1
c)	Dial thermometer	Set	1
1.2	**Generator lube oil pumping unit**		
a)	Filter Element	No.	1
b)	Pressure Gauge	No.	1
2	Control & Protection panel		
2.1	**Control Panel**		
a)	LED/Fuses/Push button (10% of total used)	Set	1
b)	Meter (Digital Multifunction type)	Nos.	2
2.2	**Protection Panel**		

S. No.	Description	Qty.	Unit
a)	Trip Circuit Supervision Relay	Nos.	2
b)	Tripping relay	Nos.	2
3	**11 kV MV Switchgear**		
a)	Circuit breaker operating mechanism	Set	2
b)	Fixed and moving contacts	Set	2
c)	CT's of each type	Set	1
d)	PT's of each type	Set	1
e)	Meters of each type	Set	1
f)	Indicating lamps	Set	1
4	**132 kV or 220 kV Switchyard**		
a)	Circuit breaker operating mechanism	No.	1
b)	Fixed and moving contacts of breaker	Set	1
c)	Fixed and moving blades of isolator	No.	1
d)	Operating mechanism of isolator	No.	1
e)	Supporting Insulator of isolator	No.	1
f)	Connectors of each type	Set	1
g)	Insulator strings	Nos.	5
5	**0.433 kV LTAC Panel**		
a)	MCCB's of each type	Nos.	2
b)	CT's of each type	Nos.	2
c)	Relays of each type	Nos.	2
d)	Ammeters, voltmeters and watt-meters	Nos.	2
e)	Indication lamps	Nos.	6
6	**Power Transformer**		
a)	H.V bushing complete with gaskets etc.	No.	1
b)	L.V terminal bushing	Set	1
c)	Gaskets for all openings with tank requiring gaskets	Set	1
d)	Oil and winding temperature indicators	Nos.	2

Annexure-II

MANDATORY MAINTENANCE TOOLS & PLANTS

S. No.	Description	Qty.	Unit
A	**Electrical Tools**		
1.	5000 V, 1000 Mega Ohms range hand driven & electric generator type Megger	1	No.
2.	Tong tester 0-600V, 0-1000A clip on voltmeter and ammeter	1	No.
3.	Analog meter (Multi meter) "MOTOWANE" model 8X Mark III	1	No.
4.	Hand held phase type sequence meter 50 to 500V	1	No.
5.	Earth Megger	1	No
6.	Soldering iron	1	No
7.	Handle held speedometer	1	No
B.	**Mechanical Tools**		
1.	Vernier calipers 300 mm	1	No.
2.	Dial gauge with magnetic base – 0.01 mm accuracy	2	Sets
3.	Screw gauge	1	No.
4.	Inside & outside calipers (150 mm)	1	No.
5.	Master level 0.02 mm/m accuracy	1	No.
6.	Ring spanners & double end open jaw spanners 5 mm to 36 mm set; 36 x 41; 46 x 51 and 50 x 55 mm Size	1	Set each
7.	Single end open jaw spanner & Single end ring spanners 46, 50 & 55 mm size	1	No. each
8.	Box spanner – 10 to 32 mm with accessories	1	Set
9.	Circlip opener (Inside & Outside) 6"	1	No. Each
10.	Hammers – Ball Pin - 1kg.	1	No. each
	Straight - 5 kg & 10 kg		
11.	Pistol drilling machine	1	No.
12.	Shim cutter 12" size	1	No.
13.	Die set with wrench for no. 25, 40 & 50 mm	1	No. Each
14.	Pipe wrench 18", 24"	1	No. Each
15.	Screw wrench 18", 24"	1	No. Each
16.	Allen keys 1.5mm to 10mm	1	No. Each
	12mm to 24mm		
17.	Cutting pliers 6" & 8" size	1	No. each
18.	Nose pliers 6" & 8" size	1	No. each
19.	Hacksaw frame 12"	1	No.
20.	Rough & Smooth Flat, round, half round & triangular file 12" size	1	No. each

S. No.	Description	Qty.	Unit
21.	Center punch & Letter punch	1	No. each
22.	Screw drivers 6", 9", 12", 16"	1	No. each
23.	Tap set with wrench M10, 12, 16, 18, 20, 24	1	Set
24.	Feeler gauge 0.05 mm to 1 mm size 6", 18"	1	Set each
25.	Measuring Tape 5 & 15 m	1	No. each
C.	**Maintenance Slings & Lifting Devices**		
1.	Wire slings + "D" Shackles	1	Set
2.	Runner removal equipment	1	Set

NOTES:

1. The Maintenance Tools & Plants shall remain the property of the NMMC after delivery by the Contractor.

2. While quoting the price for the Facilities, the Concessioners shall take into account the terms of the contract. The attention of the Concessioners is invited to the following:

A. The above is only illustrative and not exhaustive list. Concessioner shall ensure inclusion of all necessary E&M equipment, tools and testing instruments for on site erection, testing, commissioning and maintenance including trial operations, test runs etc. Such additional E & M items, tools / instruments, if any, are to be listed separately for information only.

BILL OF QUANTITIES

Designs, Drawings, Material Selection, Supply, Fabrication / Manufacture, Assembly, Testing at manufacturer's works, applying shop coat of paint, packing and forwarding for shipment, insurance, delivery to project site (final destination), receipt at site, storage at site and services for performing on-site assembly, erection, final painting, commissioning & testing at site as well as first 8 weeks Operation & Maintenance (O&M) and training of employers' personnel for hydro-mechanical equipment complete as per technical specifications and as directed by the Engineer for the proposed Morbe (2 x 750 kW + 15 % COL) Dam Toe hydropower project, Distt. Raigad, Maharashtra for the following Hydro-Mechanical equipment :

PACKAGE 1-1 : GATES & HOISTS

1-1 (a) Schedule for One (1) no. 4000 mm (wide) x 4000 mm (high) fixed wheel type vertical lift Main Inlet Gate for the 3.5 m diameter main penstock provided beyond the dead flange fitted at the "WYE" point including its hoist & hoist structure of Morbe (2 x 750 kW + 15 % COL) Dam Toe hydropower project, Distt. Raigad, Maharashtra

S. No.	Items of Work	Unit	Quantity	Estimated Weight / Set (MT)	Total Weight (MT)	Unit Rate / MT (Rs.)	Total Amount (Rs.)
		1	2	3	4 = (2x3)	5	6 = (4x5)
1	**MAIN INLET GATE for the 3.5 m DIAMETER FOR THE MAIN PENSTOCK PROVIDED BEYOND THE DEAD FLANGE FITTED AT THE "WYE" POINT FOR VENT OF 4.0 m (wide) x 4.0 m (high) SIZE (1 NO.)**						
a.	Design, Fabrication and Supply at site FIRST STAGE EMBEDDED PARTS including shop painting etc., complete, as per Technical Specifications and/or as directed by the Engineer	SET	ONE (1)				
b.	Erection of the First Stage Embedded Parts including field painting, etc complete as per Technical Specifications and/or as directed by the Engineer	SET	ONE (1)				

S. No.	Items of Work	Unit	Quantity	Estimated Weight / Set (MT)	Total Weight (MT)	Unit Rate / MT (Rs.)	Total Amount (Rs.)
		1	2	3	4 = (2x3)	5	6 = (4x5)
c.	Design, Fabrication and Supply at site SECOND STAGE EMBEDDED PARTS of gate including shop painting etc., complete as per Technical Specifications and/or as directed by the Engineer	SET	ONE (1)				
d.	Erection of the Second Stage Embedded Parts including field painting etc., complete as per Technical Specifications and/or as directed by the Engineer.	SET	ONE (1)				
e.	Design, Fabrication and Supply at site fixed wheel vertical lift **MAIN INLET GATE PROVIDED BEYOND THE DEAD FLANGE FITTED AT THE "WYE" POINT** of size **4000 mm x 4000 mm** with all accessories such as wheel assemblies, seals, guides, skin plate, stiffeners, horizontal and end vertical girders, lifting arrangements etc, including shop painting, as per IS: 4622 and technical specifications and/or as directed by the Engineer.	SET	ONE (1)				
f.	Erection of the above gate including field painting, testing, commissioning etc., complete as per Technical Specifications and/or as directed by the Engineer	SET	ONE (1)				
g.	Design, Fabrication including shop painting and Supply at site HOIST BRIDGE and deck over gate groove in the main inlet gate	SET	ONE (1)				

S. No.	Items of Work	Unit	Quantity	Estimated Weight / Set (MT)	Total Weight (MT)	Unit Rate / MT (Rs.)	Total Amount (Rs.)
		1	2	3	4 = (2x3)	5	6 = (4x5)
	including hand railing, approach ladder / stairways etc., complete as per Technical Specifications and/or as directed by the Engineer						
h.	Erection of the above structures including field painting, testing and commissioning complete as per Technical Specifications and/or as directed by the Engineer	SET	ONE (1)				
i.	Design, fabrication and supply including shop painting of DOGGING BEAM arrangement with its embedded parts complete as per Technical Specifications and/or as directed by the Engineer	SET	ONE (1)				
j.	Erection of the Dogging Beam and Embedded Parts complete as per Technical Specifications and/or as directed by the Engineer	SET	ONE (1)				
k.	Design, Fabrication including shop painting and Supply at site with all accessories ROPE DRUM HOIST of adequate capacity with mechanical items such as ropes, rope drum, spur gears, gear box, pinions, plummer blocks, bearings, sheaves / pulleys, gate position indicator, shaft manual drive arrangement, dogging arrangement etc. and electrical items such as motor, limit switches, control panels. etc.	SET	ONE (1)				

S. No.	Items of Work	Unit	Quantity	Estimated Weight / Set (MT)	Total Weight (MT)	Unit Rate / MT (Rs.)	Total Amount (Rs.)
		1	2	3	4 = (2x3)	5	6 = (4x5)
	complete as per Technical Specifications and/or as directed by the Engineer						
l.	Erection of the above hoist, Testing and Commissioning etc., complete as per Technical Specifications and/or as directed by the Engineer	SET	ONE (1)				
m.	Design, Fabrication, Testing and Supply at site with all accessories HYDRAULIC HOIST of adequate capacity including control panel, hydraulic circuit, pumps, motors, gate position indicator etc. for Main Intake service gate complete as per Technical Specifications and / or as directed by the Engineer	SET	ONE (1)				
n.	Erection of the above hoist, Testing and Commissioning etc., complete as per Technical Specifications and/or as directed by the Engineer	SET	ONE (1)				
	TOTAL ESTIMATED COST OF ALL ABOVE ITEMS						
					Say Rs.		
Note:	Bidders should quote for both Rope Drum Type Hoist as well as Hydraulic Hoist. Final selection of type of hoist shall be made by the Employer before placing the orders.						

1-1 (b) Schedule for Two (2) nos. 6000 mm (wide) x 4000 mm (high) fixed wheel type vertical lift Draft Tube Gates and their hoists & hoist structures for Morbe (2 x 750 kW + 15 % COL) Dam Toe hydropower project, Distt. Raigad, Maharashtra

S. No.	Items of Work	Unit	Quantity	Estimated Weight / Set (MT)	Total Weight (MT)	Unit Rate / MT (Rs.)	Total Amount (Rs.)
		1	2	3	4 = (2x3)	5	6 = (4x5)
1	**DRAFT TUBE GATES (2 NOS.) FOR VENT SIZE 6.0 m (wide) x 4.0 m (high)**						
a.	Design, Fabrication and Supply at site FIRST STAGE EMBEDDED PARTS including shop painting etc., complete as per Technical Specifications and/or as directed by the Engineer	SETS	TWO (2)				
b.	Erection of the First Stage Embedded Parts including field painting, etc complete as per Technical Specifications and/or as directed by the Engineer	SETS	TWO (2)				
c.	Design, Fabrication and Supply at site SECOND STAGE EMBEDDED PARTS of gate including shop painting etc., complete as per Technical Specifications and/or as directed by the Engineer	SETS	TWO (2)				
d.	Erection of the Second Stage Embedded Parts including field painting etc., complete as per Technical Specifications and/or as directed by the Engineer.	SETS	TWO (2)				
e.	Design, Fabrication and Supply at site fixed wheel vertical lift DRAFT TUBE GATES with all accessories such as wheel assemblies, seals, guides, skin plate, stiffeners, horizontal and end vertical girders, lifting arrangements etc, including shop painting, as per IS: 4622 and technical specifications and/or as directed by the Engineer.	SETSS	TWO (2)				

S. No.	Items of Work	Unit	Quantity	Estimated Weight / Set (MT)	Total Weight (MT)	Unit Rate / MT (Rs.)	Total Amount (Rs.)
		1	2	3	4 = (2x3)	5	6 = (4x5)
f.	Erection of the above gate including field painting, testing, commissioning etc., complete as per Technical Specifications and/or as directed by the Engineer	SETS	TWO (2)				
g.	Design, Fabrication including shop painting and Supply at site HOIST BRIDGE and deck over gate groove on the Draft Tube deck slab including hand railing, approach ladder/ stairways etc., complete as per Technical Specifications and/or as directed by the Engineer	SETS	TWO (2)				
h.	Erection of the above structures including field painting, testing and commissioning complete as per Technical Specifications and/or as directed by the Engineer	SETS	TWO (2)				
i.	Design, fabrication and supply including shop painting of DOGGING BEAM arrangement with its embedded parts complete as per Technical Specifications and/or as directed by the Engineer	SETS	TWO (2)				
j.	Erection of the Dogging Beam and Embedded Parts complete as per Technical Specifications and/or as directed by the Engineer	SET	TWO (2)				
k.	Design, Fabrication including shop painting and Supply at site with all accessories ROPE DRUM HOIST of adequate capacity with mechanical items such as ropes, rope drum, spur gears, gear box, pinions, plummer blocks, bearings, sheaves / pulleys, gate position	SETS	TWO (2)				

S. No.	Items of Work	Unit	Quantity	Estimated Weight / Set (MT)	Total Weight (MT)	Unit Rate / MT (Rs.)	Total Amount (Rs.)
		1	2	3	4 = (2x3)	5	6 = (4x5)
	indicator, shaft manual drive arrangement, dogging arrangement etc. and electrical items such as motor, limit switches, control panels. etc. complete as per Technical Specifications and/or as directed by the Engineer						
l.	Erection of the above hoist, Testing and Commissioning etc., complete as per Technical Specifications and / or as directed by the Engineer	SETS	TWO (2)				
m.	Design, Fabrication, Testing and Supply at site with all accessories HYDRAULIC HOIST of adequate capacity including control panel, hydraulic circuit, pumps, motors, gate position indicator etc. for Draft Tube gates complete as per Technical Specifications and / or as directed by the Engineer	SETS	TWO (2)				
n.	Erection of the above hoist, Testing and Commissioning etc., complete as per Technical Specifications and / or as directed by the Engineer	SETS	TWO (2)				
	TOTAL ESTIMATED COST OF ALL ABOVE ITEMS		TWO (2)				
					Say Rs.		
Note:	Bidders should quote for both Rope Drum Type Hoist as well as Hydraulic Hoist. Final selection of type of hoist shall be made by the Employer before placing the orders.						

GUARANTEE

It is hereby certified that the specifications, specification drawings, design data and design/operating criteria have been carefully studied and the equipment offered under this schedule shall be designed, fabricated, supplied, erected and commissioned in accordance with the design and operating criteria and specifications and is guaranteed to give satisfactory performance for a period **Twelve (12) months** from the date of final acceptance of equipment after erection, commissioning and testing.

Place……. Signature of the Bidder

Dated…….. (Seal)

SECTION – B – TECHNICAL SPECIFICATIONS OF FLOATING SOLAR PV POWER PLANT

Contents

A Design Philosophy 195

B Electrical System 198

1 Photovoltaic Modules 198

2 String Combiner Box 202

3 Power Conditioning Unit 203

4 Solar and DC Cables 207

5 Inverter Transformer and Auxiliary Transformer 209

6 LT Switchgear 213

7 HT Switchgear 220

8 AC Cables 229

9 Auxiliary Supply System 230

10 Uninterrupted Power Supply 231

11 Battery and Battery Charger 233

12 Earthing 235

13 Lightning Protection System 237

14 Communication Cables 237

15 SCADA 238

16 Control and Relay Panel 244

17 Illumination 248

18 Weather Monitoring System 251

19 CCTV Camera 253

20 Fire Alarm System 254

21 Testing Instruments 255

22 Power evacuation system 258

C Civil Works 259

1 General 259

2 Survey Works 260

3 Topographical Survey 260

4 Hydrographic Survey 261

5 Geotechnical Investigations 262

6 Other Investigations 264

7 Roads & Access Pathways: 264

8 Area Grading and Land Development 266

9 Peripheral boundary Wall/Fence 267
10 Plant Layout: 268
11 Design Loads 268
12 Foundations (General) 271
13 Concrete Works 271
14 Miscellaneous Steel Works 271
15 Plinth protection and drain 272
16 Plinth filling for buildings 272
17 Fire Extinguishers 272
18 Sand buckets 272
19 Sign Boards and Danger Boards 273
20 Masonry Work 273
21 Plastering, Pointing & Coping Works 273
22 Building Water Supply & Plumbing Works 274
23 Sewage Treatment facility 274
24 Pipe & Cable Trenches 274
25 Water Supply and Cleaning of Modules 275
26 Miscellaneous Structures: 276
27 Floating System 276
28 Buildings (the common Control centre shall be used for Hydro & Solar plant) 278
D. Performance Measurement Procedure 279
1 Performance Ratio (PR) 279
2 Capacity Utilization Factor (CUF) 279
E. SPECIAL TECHNICAL CONDITIONS 280
Annexure - A 284
Pre-dispatch inspection procedure 285
1 Objective: 285
2 Standard: 285
3 Definitions: 285
4 Inspection Schedule: 285
5 Scope of Inspection: 285
6 Sampling Process: 286
7 Decision Rules for Acceptance/Rejection 287
8 Inspection Process 287

9 Re-inspection and review 288
10 Inspection Summary: 288
11 Disclaimer: 288
Annexure - B 291
1 INTRODUCTION 292
2 FUNCTIONAL GUARANTEE TESTS FOR SOLAR PV PLANT 292
2.1. PERFORMANCE RATIO GUARANTEE TEST 292
2.2. CAPACITY UTILIZATION FACTOR (CUF) 298

DISCLAMIER:

The specifications mentioned for all the equipment which include Solar modules, PCU, combiner boxes, DC cables, module mounting structures, transformer, CT, PT, LT/ HT cables, interfacing panels, switch gears & other associated equipment etc., to complete the power generation and evacuation to the designated substation, in the present bidding documents are for the reference only. It is subject to revise/ alter as per the design/ planning/ good engineering practices etc., to be carried out by the selected Concessioner, to the satisfaction of the Employer or its authorized representatives. It is advised that the Concessioners must satisfy himself with the prevailing site conditions before design/ plan. The design must be optimized as per the site conditions and directions to achieve the maximum output from the installed capacity at all times. Moreover, the components not separately mentioned, but are required to complete the plant for operation are deemed to be also included in the scope of Concessioner and shall be vetted by the Employer or its authorized representatives.

A Design Philosophy

1. The main objective of the design philosophy is to construct the plant with in-built Quality and appropriate redundancy to achieve high availability and reliability with minimum maintenance efforts. In order to achieve this, the following principles shall be adopted while designing the system.

1.1. Adequate capacity of SPV modules, PCUs, Junction boxes etc. to ensure generation of power as per design estimates. This will be done by applying liberal de-rating factors for the array and recognizing the efficiency parameters of PCUs, transformers, conductor losses, system losses, site conditions etc.

1.2. Use of equipment and systems with proven design and performance that have high availability track records under similar service conditions.

1.3. Selection of the equipment and adoption of a plant layout to ensure ease of maintenance.

1.4. Strict compliance with approved and proven quality assurance (QA) systems and procedures during different stages of the project, starting from sizing, selection of make, shipment, storage (at site), during erection, testing and commissioning.

1.5. Proper monitoring of synchronization and recording, to ensure availability of power to the grid.

1.6. The plant Data Acquisition and control system should be designed to ensure high availability and reliability of the plant to assist the operators in the safe and efficient operation of the plant with minimum effort.

1.7. It should also provide the analysis of the historical data and help in the plant maintenance people to take up the plant and equipment on predictive maintenance.

1.8. System design shall have intelligent protection mechanism which may include very fast responsive microprocessor-based relays etc., so that any disturbance from the grid will not cause any damage to the equipment of the Solar Power Plant.

1.9. The system shall be designed for the water surface area shall not be more than About 10,000 - 11,000 square meters/ MW of installed capacity.

2. The basic and detailed engineering of the plant shall aim at achieving high standards of operational performance especially considering following:

2.1. SPV power plant should be designed to operate satisfactorily in synchronization with the grid within permissible limits of high voltage and frequency fluctuation conditions. It is also extremely important to safeguard the system during major disturbances, internal and external surge conditions while ensuring safe operation of the plant.

2.2. Module Mounting Structures shall be designed for stability under design wind load conditions specified in this document while optimizing energy generation and level changes due to release of water or filling of dam.

2.3. Shadow free plant layout to ensure minimum losses in generation during the day time.

2.4. Higher system voltage and lower current options to be followed to minimise ohmic losses.

2.5. Selection of PCUs with proven reliability and minimum downtime. Ready availability of

requisite spares.

2.6. Careful logging of operational data / historical information from the Data Monitoring Systems, and periodical analysis of the same to identify any abnormal or slowly deteriorating conditions.

2.7. The designed array capacity at STC shall be suitably determined to meet the proposed guaranteed generation output at the point of interconnection by the contractor in his bid. The contractor shall take care of first year degradation also by installing additional DC capacity as the CUF calculations will not factor the first-year degradation of the modules.

2.8. Each component offered by the Concessioner shall be of established reliability. The minimum target reliability of each equipment shall be established by the Concessioner considering its mean time between failures and mean time to restore, such that the availability of complete system is assured. Concessioner's recommendation of the spares shall be on the basis of established reliability.

2.9. Concessioner shall design the plant and equipment in order to have sustained life of 25 years with minimum maintenance efforts.

2.10. The work execution planning for supply, erection, commissioning and all other allied works for SPV Power Plant shall be such that it is completed within stipulated time from the date of order/ LOI/ NTP.

3. The specifications provided with this bid document are functional ones; any design provided in this document is only meant as an example. The Contractor must submit a detailed design philosophy document for the project to meet the functional requirements based upon their own design in-line with the above. The Concessioners are advised to visit the site and satisfy themselves before bidding.

4. Approval of drawings and documents prepared by the Contractor:

All documents and drawings shall be submitted to the Employer both in soft as well as hard copies (3 nos.) for review and approval. Every drawing shall also be submitted in'*.dwg' format. In case of design calculations done in spread sheet, editable (working) soft copy of the spread sheet shall also be submitted along with 'pdf' copies during every submission. The Employer shall return, as suitable, either soft or hard copies to the Contractor with category of approval marked thereon. The drawings/documents shall be approved in any one of the following categories based on nature of the comments/ type of drawing or document.

Category-I:	Approved
Category-II	Approved subject to incorporation of comments. Re-submit for approval after incorporation of comments
Category-III	Not approved. Re-submit for approval after incorporation of comments
Category-IV	Kept for record/ reference
Category-IVR	Re-submit for record/ reference after incorporation of comments

Note: Approval of document neither relieves the Vendor/ Contractor of his contractual obligations and responsibilities for correctness of design, drawings, dimensions, quality & specifications of materials, weights, quantities, assembly fits, systems/ performance requirement and conformity of supplies with Technical Specifications, Indian statutory laws as may be applicable, nor does it limit the Employer/ Purchaser's rights under the contract)

The Contractor shall submit complete Master Document & Drawing list (MDL) to the Employer within 2 weeks after issue of LOA,. The MDL shall list all the Drawings & Documents envisaged for submission/ approval from the Employer and shall also have all the required information like drawing no (both vendor and Employer's drawing no), title, scheduled date of submission, actual date of submission and approval. The category of approval shall be decided mutually between Contractor and the Employer at the time of finalization of the MDL which shall be the basis for drawing & document approval process during project execution.

The construction shall be done only as per drawings approved under Category - I, II & IV.

B Electrical System

1 Photovoltaic Modules

1.1. Standards and Codes

Photovoltaic Modules shall comply with the specified edition of the following standards and codes or equivalent Indian Standards, wherever applicable.

Standard	Description
IEC 61215-1 Ed.1	Terrestrial photovoltaic (PV) modules - Design qualification and type approval - Part 1: Test requirements
IEC 61215-1-1 Ed.1	Terrestrial photovoltaic (PV) modules - Design qualification and type approval - Part 1-1: Special requirements for testing of crystalline silicon photovoltaic (PV) modules (with 4000 hours Damp Heat Test and 400 Thermal cycles)
IEC 61730-1 Ed.2	Photovoltaic (PV) module safety qualification - Part 1: Requirements for construction
IEC 61730-2 Ed.2	Photovoltaic (PV) module safety qualification - Part 2: Requirements for testing
IEC 61701 Ed.2	Salt mist corrosion testing of photovoltaic (PV) modules - Severity 1
IEC 62716 Ed.1	Photovoltaic (PV) modules - Ammonia corrosion testing
IEC TS 62804-1 Ed.1	Photovoltaic (PV) modules - Test methods for the detection of potential-induced degradation - Part 1: Crystalline silicon under conditions of 85^{o}C/85% RH for minimum 192 hours.
As per the Solar Photovoltaics, Systems, Devices and Components Goods (Requirements for Compulsory Registration) Order, 2017, PV Modules used in the grid connected solar power projects shall be registered with BIS and bear the Standard Mark as notified by the Bureau of Indian Standards. Further, PV Modules should have been included in the ALMM list as per MNRE Approved Models and Manufacturers of Solar Photovoltaic Modules (Requirements for Compulsory Registration) Order, 2019.	

1.2. Technical Requirements

Parameter	Specification
Cell type	Mono-crystalline or Multi-crystalline or Thin Film
Module Efficiency	≥ 17% for Mono-crystalline ≥ 16.5% for Multi-crystalline ≥ 16.5% for Thin film
Rated power at STC	No negative tolerance is allowed
Temperature co-efficient of power	Not less than -0.43%/°C for crystalline Si Not less than -0.32%/°C for thin film
Lamination (in case of Thin Film Modules)	Glass-Glass with Anodized aluminium frame
Application Class as per IEC 61730	Class A
Origin	Cells and Modules shall be domestically manufactured

1.3. Component Specifications

1.3.1. The PV Modules glass panel shall be:

i. For PV Modules with backsheet, toughened low iron glass with minimum thickness of 3.2 mm for multi or mono-crystalline modules.

ii. In case of glass-glass Modules, glass thickness on each side shall be minimum of 2 mm. It shall be laminated using a laminator with symmetrical structure, i.e. heating plates on both sides.

iii. The glass used shall have transmittance of above 90%.

1.3.2. The back sheet used in the PV modules shall be of three-layered structure durable for humid - hot conditions with properties of moisture barrier, elongation retention and UV resistance. The back sheet shall have the following properties.

Parameter	Value
Material thickness	≥ 300 micron
Water vapour transmission rate	< 2 g/m^2/day
Partial discharge test voltage	≥ 1000 V / 1500 V
Elongation at break	> 100%
Adhesion strength with encapsulant	> 40 N/cm
Interlayer adhesion strength	> 4 N/cm

The Employer reserves the right to conduct Pressure Cooker (PC) test/ Highly Accelerated Stress Test (HAST) to confirm the durability of the back sheet in accelerated conditions.

1.3.3. The encapsulant used for the PV modules should be UV stable and PID resistant in nature. No yellowing of the encapsulant with prolonged exposure shall occur. The encapsulant shall have the following properties.

Parameter	Value
Gel content	> 75%
Volume resistivity	> 1×10^{14} Ω.cm
Peeling strength with glass	> 60 N/cm

1.3.4. The sealant used for edge sealing of PV modules shall have excellent moisture ingress protection with good electrical insulation (Break down voltage >15 kV/mm) and with good adhesion strength. Edge tapes for sealing are not allowed.

1.3.5. The material used for junction box shall be UV resistant to avoid degradation during module life. The degree of protection of the junction box shall be at least IP 67. Minimum three number of bypass diodes and two number of IEC 62852/EN 50521 certified MC4 compatible connectors with appropriate length of IEC 62930/EN 50618 certified 4 sq.mm copper cable shall be provided. The cable length shall be in accordance with the PV Module wiring strategy and adequate to ensure that the cable bending radius standard is not exceeded.

1.3.6. Each PV Module shall be provided a bar code which is embedded inside the module lamination and must be able to withstand harsh environmental conditions. The bar code data base shall contain the following information. Bar code scanner and database of all the modules containing the following information shall also be provided.

i. Name of the manufacturer of PV Module
ii. Name of the Manufacturer of Solar cells
iii. Type of cell: Mono crystalline /Half Cut Mono PERC MBB / Polycrystalline / Bihybrid /Cadmium Telluride / Concentrated / Half cut MBB Heterojunction / N Type IBC
iv. Month and year of the manufacture (separately for solar cells and module)
v. Country of origin (separately for solar cells and module)
vi. I-V curve for the module
vii. Peak Wattage, Im, Vm and FF for the module
viii. Unique Serial No. and Model No. of the module.
ix. Date and year of obtaining IEC PV module qualification certificate
x. Name of the test lab issuing IEC certificate
xi. Other relevant information on traceability of solar cells and modules as per ISO 9000 series.
xii. The selection of Solar PV modules shall be as follows:
xiii. CUF for the SPV Plant shall not be less than 19%

xiv. SPV models shall be of minimum efficiency of 19% and system losses shall be limited to 10%, the PV Technology of CdTe (Cadmium telluride Photovoltaics) or higher shall be considered.

1.4. Warranty

1.4.1. PV modules must be warranted with linear degradation rate of power output except for first year (up to 3% including LID) and shall guarantee minimum 80% of the initial rated power output at the end of 25 years.

1.4.2. The modules shall be warranted for minimum of 10 years against all material/ manufacturing defects and workmanship.

1.4.3. The above warranties shall be backed by third party insurance.

1.5. Approval

1.5.1. The Contractor shall provide Guaranteed Technical Particular (GTP) datasheet and Bill of Materials (BOM) of the module that is submitted for approval along with the datasheets of each component. The component datasheet shall contain all the information to substantiate the compliance for component specifications mentioned above.

1.5.2. The Contractor shall also provide test certificates corresponding to the standards mentioned above along with complete test reports for the proposed module. The tests should have been conducted at a test laboratory compliant with ISO 17025 for testing and calibration and accredited by an ILAC/IECEE member signatory. Laboratory accreditation certificate or weblink along with scope of accreditation shall also be submitted.

1.5.3. The BOM proposed shall be the subset of Constructional Data Form (CDF)'s of all the test reports.

1.5.4. The Contractor shall submit a detailed Manufacturing Quality Plan (MQP) for the PV Module with list of checks/tests performed during incoming material inspection, production, pre-dispatch and package.

1.5.5. The Contractor shall obtain the approval of the proposed module make & model prior to manufacturing/ inspection call.

1.6. Manufacturing and Inspection

1.6.1. The Employer shall perform material inspection at the Manufacturer's factory before the start of proposed manufacturing schedule. Proof of procurement of components as per the approved BOM mentioning manufacturer name, manufacturing date and relevant test certificate shall be submitted during material inspection for verification.

1.6.2. The Manufacturing shall start only after the clearance by the Employer after the material inspection.

1.6.3. The cells used for module making shall be free from all defects like edge chipping, breakages, printing defects, discoloration of top surface etc. Only Class A solar cell shall be used.

1.6.4. The modules shall be uniformly laminated without any lamination defects.

1.6.5. Current binning of modules shall be employed to limit current mismatch of modules.

Different colour codes shall be provided on the modules as well as pallet for identification of different bins. Maximum three nos. of bins will be allowed for each Module rating.

1.6.6. Pre-dispatch inspection of modules shall be performed as per the inspection protocol attached in Annexure - A.

1.7. Transportation, Handling, Storage and Installation

1.7.1. Transportation, handling, storage and installation of modules shall be in accordance with the manufacturer manual so as not to breach warranty conditions. The Standard Operating Procedure (SOP) for the same shall be shared by the Contractor prior to dispatch for approval.

1.7.2. It is required to construct a temporary platform (graded) while keeping the modules at least above the highest flood level. If the contractor scheduled/ planned to mount the modules immediately after the receipt at site, then the module shall be kept in common storage area with proper arrangement.

1.7.3. The stacked modules, in any case, shall be stacked as per the manufacturer's recommendation only and shall be covered with tarpaulin sheet.

2 String Combiner Box

2.1. Standards and Codes

Standard/Code	Description
IEC 60529	Enclosure Ingress Protection
IEC 62262	Enclosure Impact Protection
IEC 60269	Fuse
IEC 61643-11	Surge Protection Device
IEC 62852 or EN 50521	Solar cable connector
IEC 60695-2-11	Fire hazard testing

2.2. Construction

2.2.1. SCB enclosure shall be made of UV resistant, fire retardant, thermoplastic material. Enclosure degree of protection shall be at least IP 68 and mechanical impact resistance shall be at least IK 08.

2.2.2. Not more than two strings can be connected in parallel to a single input of SCB. One spare input terminal along with connector shall be provided for each SCB.

2.2.3. Every SCB input shall be provided with fuses on both positive and negative side. In case of negative grounded system, fuse at positive side only is acceptable. The rating of the fuses shall be selected such that it protects the modules from reverse current overload. The fuses shall be 'gPV' type conforming to IEC 60269-6.

2.2.4. DC switch disconnector of suitable rating shall be provided at SCB output to disconnect both positive and negative side simultaneously.

2.2.5. Type-II surge protective device (SPD) conforming to IEC 61643-11 shall be connected between positive/negative bus and earth.

2.2.6. Resistance Temperature Detector (RTD) type or semiconductor type temperature sensor shall be provided to monitor the cabinet temperature.

2.2.7. MC4 connector conforming to IEC 62852 or EN 50521 shall be provided at each SCB input. Cable gland of suitable size for DC cables shall be provided at the SCB output.

2.2.8. UV resistant printed cable ferrules for solar cables & communication cables and punched/ embossed aluminium tags for DC cables shall be provided at cable termination points for identification.

2.2.9. Wireless communication interface shall be provided to communicate the data to SCADA. The following parameters shall be measured/ monitored and made available at SCADA.

(i) String current

(ii) Bus voltage

(iii) Output current

(iv) Cabinet temperature

(v) DC disconnector switch ON/OFF status

(vi) SPD operating status

2.3. Warranty

The SCB unit shall be warranted for minimum of 5 (five) years against all material/ manufacturing defects and workmanship.

2.4. Tests

Routine tests and acceptance tests for the assembled unit shall be as per the Quality Assurance Plan (QAP) approved by the Employer.

3 Power Conditioning Unit

3.1. Standards and Codes

Power Conditioning Unit (PCU) shall comply with the specified edition of the following standards and codes.

Standard	Description
IEC 61683 Ed.1	Photovoltaic systems - Power conditioners - Procedure for measuring efficiency
IEC 62109-1 Ed.1	Safety of power converters for use in photovoltaic power systems - Part 1: General requirements

IEC 62109-2 Ed.1	Safety of power converters for use in photovoltaic power systems - Part 2: Particular requirements for inverters
IEC 61000-6-2 Ed.2	Electromagnetic compatibility (EMC) - Part 6-2: Generic standards - Immunity standard for industrial environments
IEC 61000-6-4 Ed.2.1	Electromagnetic compatibility (EMC) - Part 6-4: Generic standards - Emission standard for industrial environments
IEC 62116 Ed.2	Utility-interconnected photovoltaic inverters - Test procedure of islanding prevention measures
IEC 60068-2-1:2007	Environmental testing - Part 2-1: Tests - Test A: Cold
IEC 60068-2-2:2007	Environmental testing - Part 2-2: Tests - Test B: Dry heat
IEC 60068-2-14:2009	Environmental testing - Part 2-14: Tests - Test N: Change of temperature
IEC 60068-2-30:2005	Environmental testing - Part 2-30: Tests - Test Db: Damp heat, cyclic (12 h + 12 h cycle)
IEC 60068-2-52:2017	Environmental testing - Part 2-52: Tests - Test Kb: Salt mist, cyclic (sodium chloride solution) Severity level 1
CEA Technical Standards for Connectivity to the Grid Regulations 2007 with 2013 Amendment	
As per the Solar Photovoltaics, Systems, Devices and Components Goods (Requirements for Compulsory Registration) Order, 2017, Inverters used in the grid connected solar power projects shall be registered with BIS and bear the Standard Mark as notified by the Bureau of Indian Standards.	

3.2. Technical Requirements

Parameter	Specification
Rated AC power	As per design
Maximum input voltage	1000 V / 1500 V
Rated AC output voltage	As per design
Tolerance on rated AC output voltage	+/-10%
Rated frequency	50 Hz
Operating frequency range	47.5 Hz to 52 Hz
Power factor control range	0.9 lag to 0.9 lead
European efficiency	Minimum 98%
Maximum loss in Sleep Mode	0.05% of rated AC power
Total Harmonic Distortion	Less than 3% at 100% load
Degree of protection	IP 55 (Indoor)/IP 68 (Outdoor)

3.2.1. The rated/ name plate AC capacity of the PCU shall be AC power output of the PCU at 50°C.

3.2.2. Maximum power point tracker (MPPT) shall be integrated in the PCU to maximize energy drawn from the Solar PV array. The MPPT voltage window shall be sufficient enough to accommodate the output voltage of the PV array at extreme temperatures prevailing at site.

3.2.3. The PCU output shall always follow the grid in terms of voltage and frequency. The operating voltage and frequency range of the PCU shall be sufficient enough to accommodate the allowable grid voltage and frequency variations.

3.3. Construction

3.3.1. Power Conditioning Unit (PCU) shall consist of an electronic three phase inverter along with associated control, protection, filtering, measurement and data logging devices.

3.3.2. Every DC input terminal of PCU shall be provided with fuse of appropriate rating. The combined DC feeder shall have suitably rated isolators for safe start up and shut down of the system. One spare DC input terminal shall be provided for each PCU.

3.3.3. Type-II surge protective device (SPD) conforming to IEC 61643-11 shall be provided on both DC and AC side of PCU.

3.3.4. AC relay shall be provided at the output of PCU for protection and isolation.

3.3.5. The PCU shall be tropicalized and the design shall be compatible with conditions prevailing at site. Suitable number of exhaust fan shall be provided for cooling keeping in mind the extreme climatic condition of the site as per the recommendations of OEM to achieve desired performance and life expectancy.

3.3.6. All the conducting parts of the PCU that are not intended to carry current shall be bonded together and connected to dedicated earth pits through protective conductor of appropriate size. DC negative terminal shall be grounded. In case DC negative grounding is not possible, appropriate anti-PID device shall be provided.

3.3.7. Dedicated communication interface shall be provided to monitor the PCU from SCADA.

3.3.8. PCU front panel shall be provided with LCD/ LED to display all the relevant parameters related to PCU operation and fault conditions. It shall include, but not limited to, the following parameters.

i. DC input power
ii. DC input voltage
iii. DC input voltage
iv. DC input current
v. AC output power
vi. AC output voltage (all the 3 phases and line)
vii. AC output current (all the 3 phases and line)
viii. Frequency
ix. Power Factor

3.4. Operating Modes

Operating modes of PCU shall include, but not limited to, the following modes. These operating modes and conditions for transition are indicative only. The Contractor shall provide the detailed flow chart indicating the various operating modes and conditions for

transition during detailed engineering.

3.4.1. Standby Mode

The PCU shall continuously monitor the input DC voltage and remain on Standby Mode until it reaches the pre-set value.

3.4.2. MPPT Mode

When the input DC voltage is above the pre-set value and AC grid connection conditions are fulfilled, the PCU shall enter into MPPT mode.

3.4.3. Sleep Mode

When the AC output power/DC input voltage decreases below the pre-set value for pre-set time delay, the PCU shall switch into Sleep Mode.

3.5. Protection Features

The PCU shall include appropriate self-protective and self-diagnostic feature to protect itself and the PV array from damage in the event of PCU component failure or from parameters beyond the PCU's safe operating range due to internal or external causes. The self-protective features shall not allow signals from the PCU front panel to cause the PCU to be operated in a manner which may be unsafe or damaging. Faults due to malfunctioning within the PCU, including commutation failure, shall be cleared by the PCU protective devices.

The PCU shall provide protection against the following type of faults, among others.

i. DC/AC over current
ii. DC/AC over voltage
iii. DC reverse polarity
iv. DC earth fault
v. AC under voltage
vi. AC under frequency/over frequency
vii. Islanding
viii. Over temperature
ix. Lightning surges

3.6. Grid Support Functions

3.6.1. Active power regulation

The PCU shall be able to limit the active power exported to the grid based on the set point provided through PCU front control panel. The PCU shall also be able to automatically the limit the active power after an increase in grid frequency above a pre-set value. The ramp rate shall be adjustable during operation and start-up after fault. The applicability of the requirement shall be as per CEA regulation and compliance.

3.6.2. Reactive power control

The PCU shall be able to inject /absorb reactive power to/ from the grid based on the set point provided through PCU front control panel. The same shall be performed automatically with adjustable ramp rate based on dynamic changes in grid voltage or reactive power reference.

3.6.3. Voltage Ride Through

The PCU shall remain connected to the grid during temporary dip or rise in grid voltage as per the LVRT and HVRT requirements of CEA Technical Standards for Connectivity to the Grid Regulations. The PCU shall also be able to inject reactive power during the period of voltage dip.

3.6.4. Warranty

The complete Power Conditioning Unit shall be warranted for minimum of 5 (five) years against all material/ manufacturing defects and workmanship.

3.7. Tests

3.7.1. Type Tests

The type test certificates as per the standards mentioned above should be from any of the ILAC/IECEE member signatory accredited Test Centres. Laboratory accreditation certificate or weblink along with scope of accreditation shall also be submitted. It is the responsibility of the Contractor to substantiate the compliance for CEA Regulations using test reports.

3.7.2. Routine Tests

Routine tests and acceptance tests shall be as per the Quality Assurance Plan (QAP) approved by the Employer.

4 Solar and DC Cables

4.1. Standards and Codes

Cable	From	To	Conductor/ Insulation	Voltage Rating	Applicable Standard
Solar Cable*	Module	SCB	Copper/ XLPO	1.1 kV DC/ 1.5 kV DC	IEC 62930/ EN 50618
DC Cable	SCB	PCU	Copper / XLPE	1.1 kV DC/ 1.5 kV DC	IS 7098
* Cable used for module interconnection shall also be referred as solar cable.					

4.2. Both solar and DC cables shall be marine grade cables complying with relevant standards.

4.3. Solar cable outer sheath shall be flame retardant, UV resistant and black in colour. Solar cable with positive polarity should have marking of red line on black outer sheath.

4.4. DC cables shall be single core, armoured, Flame Retardant Low smoke (FRLS), PVC outer sheath conforming to IS 7098.

4.5. In addition to manufacturer's identification on cables as per relevant standard, following marking shall also be provided over outer sheath.

(i) Cable size and voltage grade

(ii) Word 'FRNC/ FRLS' (as applicable) at every meter

(iii) Sequential marking of length of the cable in meters at every meter

4.6. Cables shall be sized based on the following considerations:

(i) Rated current of module

(ii) The average voltage drop in the cables (Modules to Inverter) shall be limited to 1.5 % of the rated voltage. The Contractor shall provide voltage drop calculations in excel sheet.

(iii) Short circuit withstand capability.

(iv) De-rating factors according to laying pattern

(v) De-rating factors according to laying pattern

4.7. Warranty

The cables (Solar and DC) shall be warranted for minimum of 5 (five) year against all material/ manufacturing defects and workmanship.

4.8. Tests

Type tests, Routine test and acceptance tests requirements shall be as per IEC 62930/EN 50618 for solar cables and IS 7098 for DC cables.

4.9. Installation

4.9.1. Cable installation shall be as per IS 1255.

4.9.2. Only terminal cable joints shall be accepted. No cable joint to join two cable ends shall be accepted.

4.9.3. Solar cables shall be provided with UV resistant printed ferrules and DC cables shall be provided with punched/ embossed aluminium tags. The marking shall be done with good quality letter and numbers of proper size so that the cables can be identified easily.

4.9.4. Cable terminations shall be made with properly crimped lugs and passed through cable glands at the entry & exit point of the cubicles. Bimetallic lugs shall be used for connecting Cu bus bar and Al cables or vice-versa.

4.9.5. Solar/DC cables shall be laid on the waterbed from PV Modules/SCB to inverter, if placed on shore. There shall be one spare run of cable per inverter.

4.9.6. Solar cables shall be aesthetically tied to Module Mounting Structure using UV resistant cable-ties suitable for water-based applications.

4.10. Cable Sealing System

4.10.1. Cable sealing system: Modular multi-diameter cable sealing system consisting of frames, blocks and accessories shall be installed where the underground and over ground cables enter or leave LCR/MCR enclosures/Buildings. Cable sealing system shall consist of multi-diameter type peel-able blocks of different sizes to suit the various cables. It should be simple, easy and quick to assemble & re-assemble the cable sealing system. Solid blocks shall not be used on frame. Frames & stay-plate material shall be of galvanized steel and for compression, single piece wedge with galvanized steel bolts shall be used. 30% spare blocks on the frame shall be provided for expansion in future. Cable sealing system should have been tested for fire/ water /smoke tightness

5 Inverter Transformer and Auxiliary Transformer

5.1. Standards and Codes

Inverter transformer shall comply with the latest edition of the following standards and codes including amendments.

Standard	Description
IS 2026, IEC 60076	Specification of Power Transformers
IS 11171, IEC 60076-11	Dry-Type Power Transformers
IS 2099, IEC 60137	Bushings for alternate voltage above 1000 V
IS 3639	Fittings and Accessories for Power Transformers
IS 12063	Degree of protection provided by enclosures
IEC:62770:2013 & IS:16659	Unused natural esters for transformers and similar electrical equipment
IEC 62975:2020	Natural Ester: Guideline for maintenance and use in Electrical Equipment
IEC 60076-14 & IS 2026-14	Liquid immersed power Transformers using High Temperature insulation material
IS 1180 Part 3	Outdoor type , insulated liquid immersed distribution transformer Up to and Including 2500 KVA, 33 kV–specification
CBIP publication no. 295	
CEA 2010 regulations and other statutory regulations with any latest amendments	

5.2. Technical Requirements

Parameters	Inverter Transformer requirement	Auxiliary Transformer
VA Rating	As per system design requirement	
Voltage Ratio	11 kV / Inverter output voltage	As per system design
Duty, Service & Application	Continuous Solar Inverter application and converter Duty (Outdoor)	Continuous application (Outdoor/Indoor)
Winding	As per system design requirement	2
Frequency	50 Hz	50Hz
Nos. of Phase	3	3

Vector Group & Neutral earthing	As per system/inverter manufacturer requirement	Dyn11
Cooling	ONAN / KNAN	ONAN/ AN
Tap Changer	OCTC, No. of steps shall be as per system requirement	
Impedance at 75°C	As per Inverter Manufacturer requirement	As per system requirement
Permissible Temperature rise over an ambient of 50°C (irrespective of tap)		
Top Oil	50°C	As per IS/IEC
Winding	55°C	As per IS/IEC
SC withstand time (thermal)	2 second	2 second
Short Circuit Apparent power	As per system requirement	
Termination	As per system requirement	
Bushing rating, Insulation class (Winding & bushing)	36 kV - porcelain bushings 1.1 kV - epoxy bushings	As per the system requirement
Noise level	As per NEMA TR-1	
Loading Capability	Continuous operation at rated MVA on any tap with voltage variation of +/-3%, also transformer shall be capable of being loaded in accordance with IEC 60076-7	
Flux density	Not to exceed 1.9 Wb/sq.m. at any tap position with combined frequency and voltage variation from rated V/f ratio by 10% corresponding to the tap. Transformer shall also withstand following over fluxing conditions due to combined voltage and frequency fluctuations: a) 110% for continuous rating b) 125% for at least one minute c) 140% for at least five seconds. Concessioner shall furnish over fluxing characteristic up to 150%	
Air Clearance	As per CBIP	

5.3. Construction

5.3.1. The transformer shall be provided with conventional single compartment conservator with prismatic toughened glass oil gauge. The top of the conservator shall be connected to the atmosphere through indicating type cobalt free silica gel breather with transparent enclosure. Silica gel shall be isolated from atmosphere by an oil seal. Inverter transformers shall be provided with Magnetic Oil Gauge (MOG) with low oil level alarm contact.

5.3.2. It is the responsibility of the Contractor to ensure that the inverter transformer comply with all the requirements of inverter provided by the inverter manufacturer.

5.3.3. Inverter Transformer shall be designed for at least 5% total harmonic distortion (THD) to withstand distortion generated by the inverter as well as possible outside harmonics

from the network and to follow the guide lines of MSETCL/ STU.

5.3.4. The transformer shall be suitable for continuous operation with a frequency variation of ± 2.5% from nominal frequency of 50 Hz without exceeding the specified temperature rise.

5.3.5. Inverter Transformer shall have shield winding between LV & HV windings. Each LV winding must be capable of handling non-sinusoidal voltage with voltage gradient as specified by the inverter manufacturer. Also, shield winding shall be taken out from tank through shield bushing and the same shall be brought down to the bottom of the tank using copper flat and support insulator for independent grounding.

5.3.6. Neutral bushing of Inverter duty transformer shall be brought outside the tank for the testing purpose. It shall be covered with MS sheet and a sticker "For testing purpose only. Do not earth". Neutral bushing of auxiliary transformer shall be brought outside the tank for earthing.

5.3.7. Transformer shall have 150 mm dial type Oil Temperature Indicator (OTI) and Winding Temperature Indicator (WTI) with alarm and trip contacts. All indicators shall have accuracy of 1.5%. For inverter transformers, WTI shall be provided for all the windings.

5.3.8. The radiators shall be detachable type, mounted on the tank with shut off valve at each point of connection to the tank, lifts, along with drain plug/ valve at the bottom and air release plug at the top.

5.3.9. Marshalling Box shall be of sheet steel, dust and vermin proof provided with proper lighting and thermostatically controlled space heaters. The degree of protection shall be IP 55. Marshalling Box of all transformers shall be preferably Tank Mounted. One dummy terminal block in between each trip wire terminal shall be provided. At least 10% spare terminals shall be provided on each panel. The gasket used shall be of neoprene rubber. Wiring scheme (TB details) shall be engraved in a stainless-steel plate with viewable font size and the same shall be fixed inside the Marshalling Box door.

5.3.10. Buchholz relay, double float type with alarm and trip contacts, along with suitable gas collecting arrangement shall be provided.

5.3.11. Inverter transformer shall be provided with spring operated Pressure Relief Device (with trip contacts) with suitable discharge arrangement for oil. For Auxiliary transformers, diaphragm type explosion vent shall be provided.

5.3.12. Filter valve at top the tank and drain cum sampling valve at bottom of the tank shall be provided.

5.3.13. All external surface of the transformer shall be painted with two coats of epoxy-based paint of colour shade RAL 7032. Internal surface of cable boxes and marshalling box shall be painted with epoxy enamel white paint. The minimum dry film thickness (DFT) shall be 100 microns.

5.3.14. LV and HV cable box shall be provided with disconnecting chamber to facilitate the movement of transformer without disturbing cable box and termination.

5.3.15. Air release plug, bi-directional wheel/skids, cover lifting eyes, transformer lifting lugs, jacking pads, towing holes, core and winding lifting lugs, inspection cover, rating plate, valve schedule plate, accessories and terminal marking plates, two nos. of earthing terminals shall be provided.

5.3.16. Rain hoods to be provided on Buchholz, MOG & PRD. Entry points of wires shall be suitably sealed.

5.3.17. The accessories listed above are indicative only. Accessories which are not mentioned above but required for satisfactory operation of the transformers are deemed to be included in the contract without extra charges.

5.3.18. Fire-protection for inverter transformer shall be provided in accordance with relevant CEA regulations as amended time to time.

5.4. Dry Type Auxiliary Transformer

5.4.1. Transformer shall be cast resin encapsulated dry type transformer, made of cold rolled grain-oriented silicon steel laminations of M4 grade or better. Winding conductor shall be electrolytic grade Copper/Aluminium and insulation shall be Class F or better.

5.4.2. The transformers shall be housed in a metal protective housing, having a degree of protection of IP-55 suitable for indoor installation. The enclosure shall be provided with suitable hardware and accessories required for satisfactory operation of the transformer per the relevant standard.

5.5. Warranty

The transformer shall be warranted for minimum of 5 (five) years against all material/manufacturing defects and workmanship.

5.6. Testing and Inspection

5.6.1. Type Tests and Special Tests

The following type test and special test reports shall be submitted during detailed engineering. The tests should have been conducted on the similar transformer by NABL accredited laboratory.

5.6.1.1. Type Tests

i. Lightning impulse (Full & Chopped Wave) test on windings as per IEC 60076-3
ii. Temperature Rise test at a tap corresponding to maximum losses as per IEC 60076-2

5.6.1.2. Special Tests

i. Measurement of acoustic noise level as per NEMA TR-1
ii. Short-circuit withstand test as per IEC 60076-5

In case the contractor is not able to submit the test reports during detailed engineering, the contractor shall submit the reports of type/special tests either conducted by NABL accredited laboratory or witnessed by Employer.

5.6.2. Routine Tests

Each completed transformer shall be subjected to following routine tests as per the latest edition of IEC 60076 unless specified otherwise.

i. Measurement of winding resistance at each tap
ii. Measurement of voltage ratio between HV and LV windings at each tap
iii. Check of vector group
iv. Measurement of no-load loss and no-load current
v. Measurement of short-circuit impedance and load loss
vi. Magnetic balance test as per CBIP manual publication no. 295
vii. Applied voltage test
viii. Induced voltage withstand test
ix. Measurement of insulation resistance
x. Partial discharge measurement
xi. Marshalling box functional test
xii. IR Measurement on wiring of marshalling box

5.6.3. Tests at Site

After erection at site all transformer(s) shall be subjected to the following tests.

(i) Measurement of voltage ratio

(ii) Check of vector group

(iii) Magnetic balance test

(iv) Measurement of insulation resistance

In case the equipment is not found as per the requirements of the Technical Specifications of NIT, all expenses incurred during site testing will be to the Contractor's account and the equipment shall be replaced by him at free of cost.

6 LT Switchgear

The LT switchgear specifications mentioned in this section are applicable for auxiliary supply distribution panel, AC combiner box and LT switchgear panels in case of string inverter configuration.

6.1. Standards and Codes

All equipment provided under LT switchgear shall comply with latest revisions and amendments of the relevant IEC standards and IS codes. In particular, the switch gear shall comply with the following standards and codes.

Standard/Code	Description
IEC 61439-1	Low-voltage switchgear and control gear assemblies - Part 1: General rules
IEC 61439-2	Low-voltage switchgear and control gear assemblies - Part 2: Power switchgear and control gear assemblies

IEC 60947-1	Low-voltage switchgear and control gear - Part 1: General rules
IEC 60947-2	Low-Voltage Switchgear and Control gear: Circuit Breakers
IEC 60947-3	Low voltage switchgear and control gear: Part 3 Switches, disconnectors, switch-disconnectors and fuse combination units
IEC 60947-4-1	Low-voltage switchgear and control gear - Part 4-1: Contactors and motor-starters - Electromechanical contactors and motor-starters
IEC 60947-5-1	Low-voltage switchgear and control gear - Part 5-1: Control circuit devices and switching elements - Electromechanical control circuit devices
IEC 62052-11	Electricity metering equipment (a.c.) - General requirements, tests and test conditions - Part 11: Metering equipment
IS 694	Polyvinyl chloride insulated unsheathed-and sheathed cables/ cords with rigid and flexible conductor for rated voltages - up to and including 450/750V
IEC 61869	Instrument Transformers
IS 3043	Code of practice for earthing
IEC 60255	Measuring relays and protection equipment - Part 1: Common requirements

6.2. Technical Parameters

System Details	
Rated system voltage	415 V ± 10%, 3 Phase, 4 wire, Neutral Solidly Earthed
Rated frequency	50 Hz ± 5%
System fault current	As per system requirement
Air Circuit Breaker (ACB)	
Type	Air break
Rated Current	As per system requirement
Operating Duty	O - 0.3sec - CO - 3min - CO
Rated Ultimate Short-Circuit	
Rated Short-Circuit Making	As per rated ultimate short-circuit breaking
Moulded case circuit breaker (MCCB)	
Release	Microprocessor based
Rated current	As per system requirement
Poles	4 poles
Rated insulation level	690 /1000 V

Rated Ultimate Short-Circuit Breaking Capacity & Rated Service Short-Circuit Breaking Capacity	As per system fault current
Rated Short-Circuit Making Capacity	As per rated ultimate short-circuit breaking capacity
Utilization category	A
Current transformer (CT)	
Type	Cast Resin Bar Primary
Voltage class and frequency	650 /1000 V, 50 Hz
CT Secondary Current	1 A
Class of insulation	Class F
Accuracy class & burden	
a) For Protection	5P20, 5 VA PS Class for REF and core balance CT (CBCT)
b) For Metering	Class 0.5, 5 VA (min)
Minimum primary earth fault current to be detected by CBCT	1 A
Instrument Security Factor for metering CT	5
Digital Multifunctional Meter (MFM)	
Accuracy class	0.5 class
Communication with SCADA	RS485 communication with Modbus RTU

6.3. Constructional Details

6.3.1. The panel shall be metal enclosed, free standing, floor mounted, modular type with compartmentalized construction having degree of protection of IP 4X (Indoor) and IP66 (outdoor) as per IS/IEC 60529. All doors and covers shall be provided with neoprene gaskets to prevent entry of vermin and dust.

6.3.2. All switches, push buttons etc. shall be operated front and shall be flush/semi-flush mounted.

6.3.3. The panel shall be fabricated from 2 mm CRCA sheet steel for frame & load bearing surfaces. Partitions may be fabricated from 1.6 mm CRCA if no components are mounted on them.

6.3.4. Cable entries shall be from bottom. The opening of cable entry shall be covered by 3mm thick gland plates with proper sealing to avoid water and rodent entry.

6.3.5. Earthing bus bar of suitable cross section shall be provided throughout the length of panel.

6.3.6. The panel shall be duly wired with suitable size of 1.1kV, PVC insulated cable and terminals shall be brought out for cable connections. 10% spare terminals subjected to minimum one of each rating shall be provided on each distribution switchgear. All wire shall have ferrules as per wiring diagram.

6.3.7. The panel shall be painted with 2 coats of primer after pre-treatment and 2 coats of Polyurethane / epoxy paint with shade as decided by the Owner.

6.3.8. The panel shall be of dead front construction suitable for front operated and back maintained functioning.

6.3.9. 240 V, 5 A, 3 pin industrial socket-outlet with ON/OFF switch shall be provided in each panel.

6.3.10. Each panel shall be provided with LED lamp rated for 240 V, 50 Hz, single phase AC supply for interior illumination controlled by door switch.

6.3.11. Suitable lifting hooks shall be provided for each panel.

6.3.12. Each switchgear panel shall be provided with thermostatically controlled space heaters to prevent condensation within the enclosure. The space heater shall be connected to 240 V, 50 Hz, single phase AC supply through suitable switch and fuse.

6.3.13. Earth leakage relay with Core balance CTs (CBCT) shall be provided on main incoming feeders having phase CT ratio more than 50/1A. CBCT's shall be circular window type with window size based on the overall diameter of the cables, to be finalized during detailed engineering.

6.4. Air Circuit Breaker

6.4.1. The circuit breaker shall be three pole, air break, horizontal draw-out type.

6.4.2. The circuit breaker shall have three positions, i.e. SERVICE, TEST and ISOLATED.

6.4.3. The circuit breaker operating mechanism shall be based on motor operated spring charging and it shall be re-strike free, trip free both electrically and mechanically, with anti-pumping feature.

6.4.4. The rated control voltage of the spring charging motor shall be 110 VDC/230 VAC. Closing coil shall operate at all values of voltages between 85% and 110% of rated voltage. Opening coil shall operate correctly under all operating conditions of the circuit breaker up to the rated breaking capacity and at all values of supply voltage between 70% and 110% of rated voltage.

6.4.5. The spring charging motor shall have adequate thermal rating such that continuous sequence of the closing and opening operations is possible as long as power supply is available to the motor. It shall also be possible to charge the spring manually and close the breaker in the event of failure of motor / control supply to motor. Operating handle shall be provided for charging the operating mechanism. After failure of control supply to the motor, one open-close-open operation shall be possible with the energy contained in the operating mechanism.

6.4.6. The motor rating shall be such that it requires not more than 30 seconds for full charging of the closing spring. Closing action of the circuit breaker shall compress the opening spring ready for tripping. When closing springs are discharged after closing the breaker, they shall be automatically charged for the next operation.

6.4.7. Mechanical indicators shall be provided to indicate OPEN/CLOSE,

SERVICE/TEST positions of the circuit breaker and CHARGED/ DISCHARGED positions of the closing spring. An operation counter shall also be provided.

6.4.8. The circuit breaker shall be provided with microprocessor based front adjustable protection release for overload, short circuit and earth fault.

6.4.9. Mechanical/Electrical interlocks shall be provided to prevent mal-operation and in particular to ensure the following.

i. It shall be possible to close the circuit breaker only if it is in SERVICE or TEST position.

ii. It shall be possible to open the door only when the breaker is in TEST position.

iii. Movement of the circuit breaker between SERVICE and TEST positions shall be possible only if the breaker is OFF.

iv. Racking in the circuit breaker from TEST to SERVICE position shall be possible only if door is closed.

6.4.10. Telescopic trolley or suitable arrangement shall be provided for maintenance of circuit breaker. The trolley shall be such that the top most breaker module can be withdrawn on the trolley and can be lowered for maintenance purpose. The telescopic trolley shall be such that all type, size and rating of breaker can be withdrawn/inserted.

6.4.11. The circuit breaker shall have suitable provision for integration with SCADA.

6.5. Instrument Transformers

6.5.1. Instrument transformers shall be completely encapsulated cast resin type, suitable for continuous operation at the ambient temperature prevailing inside the switchgear enclosure, when the switchgear is operating at its rated load and the outside ambient temperature is 50°C.

6.5.2. Polarity marks shall indelibly be marked on each instrument transformer and at the lead terminals at the associated terminal block.

6.5.3. HRC fuses of suitable rating shall be provided on primary side of voltage transformers. For secondary side, four pole Miniature Circuit Breakers (MCB) shall be provided.

6.5.4. For auxiliary supply switchgear, earth leakage relay with Core balance CTs (CBCT) shall be provided on main incoming feeders having phase CT ratio more than 50/1A. CBCT's shall be circular window type with window size based on the overall diameter of the cables, to be finalized during detailed engineering.

6.6. Bus bar

6.6.1. Bus bar shall be made of copper or aluminium with uniform cross section throughout their length. They shall be adequately supported on insulators to withstand electrical and mechanical stresses due to specified short circuit current.

6.6.2. All bus bars joints shall be thoroughly cleaned and anti-oxide grease shall be applied. Plain and spring washers shall be provided to ensure good contacts at the joints and taps. Wherever aluminium to copper connections are required, suitable bimetallic connectors or clamps shall be used.

6.6.3. Bus bars shall be provided with heat shrinkable sleeves of suitable insulation class throughout their length with proper colour coding. All bus bar joints and taps shall be shrouded.

6.6.4. Bus bar support insulators shall be made of non-hygroscopic, arc and track resistant, high strength material suitable to withstand stresses due to over voltage and short circuit current.

6.6.5. The Contractor shall submit busbar sizing calculation for specified continuous and short time current ratings during detailed engineering.

6.7. Earthing

6.7.1. An earth bus made of copper or aluminium shall be provided throughout the length of the panel. It shall be bolted to the framework of each panel and brazed to each breaker earthing contact bar, earthing shall be designed as per IS: 3043 (1987).

6.7.2. The earth bus shall have sufficient cross section to carry maximum fault current without exceeding the allowable temperature rise.

6.7.3. All non-current carrying conductors of the panel shall be connected to the earth bus. All joints to the earth bus shall be made through at least two bolts. Hinged doors shall be earthed through flexible earthing braid of adequate cross section. Suitable provision shall be provided at each end of the earth bus for connection with Owner's Earth conductor.

6.7.4. Positive earthing of the carriage and breaker frame shall be maintained when it is in the connected position and in all other positions whilst the auxiliary circuits are not totally disconnected.

6.7.5. All metallic cases of relays, instruments and other panel mounted equipment shall be connected to earth bus by independent copper wires of size not less than 2.5 sq. mm with green colour insulation.

6.7.6. Instrument transformer secondary neutral point shall be earthed at one place only on the terminal block. Such earthing shall be made through links so that earthing of one circuit may be removed without disturbing the earthing of other circuits.

6.8. Multi-Function Meter

6.8.1. Digital, flush mounting type Multi-Function Meter (MFM) of 0.5 accuracy class shall be provided. It shall have provision for integration with SCADA.

6.8.2. MFM shall have provision to display the following parameters.

(i) Line and phase voltages

(ii) Line and phase currents

(iii) Active power, Reactive power, Apparent power

(iv) Frequency

(v) Power factor

(vi) Total Harmonic Distortion (THD)

6.9. Wiring and Terminal blocks

6.9.1. All internal wiring shall be done with 650 V grade, 1.5 sq.mm. PVC insulated stranded flexible copper wire. For CT secondary circuits, 2.5 sq.mm copper wire shall be used.

6.9.2. Wire terminations shall be made with solderless crimping type tinned copper lugs, which shall firmly grip the conductor. Insulation sleeves shall be provided at all the wire terminations.

6.9.3. Printed identification ferrules, marked to correspond with panel wiring diagram shall be provided at both ends of each wire. The ferrules shall be firmly located on each wire so that they cannot move or turn freely on the wire. Wire identification shall be done in accordance with IS 11353.

6.9.4. The Contractor shall be solely responsible for the completeness and correctness of the internal wiring and for the proper functioning of the connected equipment.

6.9.5. All internal wiring to be connected to the external equipment shall terminate on terminal blocks. Terminal blocks shall be rated for 650 V, 10 A and made of noninflammable material.

6.9.6. CT and VT secondary circuits shall be terminated on stud type, disconnecting terminal blocks.

6.9.7. At least 10% spare terminals shall be provided on each panel and these spare terminals shall be distributed on all terminal blocks.

6.10. Warranty

LT switchgear panels shall be warranted for minimum of 5 (five) year against all material/ manufacturing defects and workmanship.

6.11. Testing and Inspection

6.11.1. Type Tests

The switchgear panel shall be of type tested design. Type test reports as per the following standards shall be submitted during detailed engineering. The tests should have been conducted on the similar equipment by NABL accredited laboratory.

Equipment	Standard
Switchgear Panel	Relevant parts of IEC 61439
Air Circuit Breaker	IEC 60947-2
Moulded Case Circuit Breaker	IEC 60947-2
Current Transformer	Relevant parts of IEC 61869
Voltage Transformer	Relevant parts of IEC 61869

In case the contractor is not able to submit the test reports during detailed engineering, the contractor shall submit the reports of type/special tests either conducted by NABL accredited laboratory or witnessed by Employer.

6.11.2. Routine Tests

Routine tests and acceptance tests shall be as per the Quality Assurance Plan (QAP) approved by the Employer.

7 HT Switchgear

7.1. Standards and Codes

All equipment provided under HT switchgear shall comply with latest editions and amendments of the relevant IEC standards and IS codes. In particular, the switchgear shall comply with the following standards and codes.

Standard/Code	Description
IS/IEC 62271-1	High Voltage Switchgear and Control gear - Part 1: Common Specifications
IS/IEC 62271-100	High Voltage Switchgear and Control gear - Part 100: AC Circuit Breakers
IS/IEC 62271-102	High Voltage Switchgear and Control gear - Part 102: AC Disconnectors and Earthing Switches
IS/IEC 62271-200	High Voltage Switchgear and Control gear - Part 200: AC Metal Enclosed Switchgear and Control gear for Rated Voltages Above 1 kV and Up to and Including 52 kV
IEC 61869	Instrument Transformers
IS 3231	Electrical relays for power systems protection
IEC 60255	Measuring relays and protection equipment
IEC 61850	Communication networks and systems for power utility automation
IEC 61131-3	Programmable controllers - Part 3: Programming languages
IS 9385	High voltage fuses
IS 9431	Indoor post insulators of organic material for systems with nominal voltages greater than 1000 V up to and including 300 kV
IEC 60099-4	Surge arresters - Part 4: Metal-oxide surge arresters without gaps for A.C. systems
IS 3070-3	Lightning Arresters for Alternating Current Systems - Part 3: Metal Oxide Lightning Arresters Without Gaps
IEC 62052-11	Electricity metering equipment (A.C.) - General requirements, tests and test conditions - Part 11: Metering equipment
IEC 62053	Electricity metering equipment (A.C.) - Particular requirements
IS 14697	AC Static Transformer Operated Watthour and Var-hour Meters, Class 0.2S and 0.5S

7.2. Technical Parameters

Parameter	Specification
System Parameters	
Highest system voltage	11 kV
Rated system voltage	12.5 kV
Rated frequency	50 Hz
Number of phases	3
Power frequency withstand voltage	kV (r.m.s.)
Lightning impulse withstand voltage	kV (peak)
System fault current	As per system requirement
Circuit Breaker	
Type	Vacuum type
Operating duty cycle	O - 0.3sec - CO - 3min - CO
Short circuit breaking current	As per system requirement
Short circuit making current	2.5 times S.C. breaking current
Re-strike performance class	C2
Mechanical endurance class	M1
Current Transformer	
Accuracy class	0.2 for metering (0.2s for metering at outgoing feeder), 5P20 for protection
Rated VA burden	As per requirement
Insulation class	Class F
Voltage Transformer	
Accuracy class	0.2 for metering, 3P for protection
Rated VA burden	As per requirement
Insulation class	Class F

7.3. Switchgear Panel

7.3.1. The switchgear panel shall be free standing, floor mounted, single front, single tier fully compartmentalized, metal enclosed construction. Each panel shall have separate compartments for circuit breaker, bus bars, cable termination and auxiliary circuit.

7.3.2. The circuit breakers shall be mounted on horizontally withdrawable trucks with locking facility in SERVICE and TEST positions.

7.3.3. The panel enclosure shall be constructed with CRCA steel/Aluzinc sheet. The thickness of load bearing members shall be minimum 3 mm and that of non-load bearing members shall be minimum 2 mm.

7.3.4. All surfaces shall be painted with two coats of machine powder coated paint of colour shade RAL 7032. The minimum dry film thickness (DFT) shall be 100 micron.

7.3.5. The circuit breaker and auxiliary circuit compartments provided on the front side shall have separate concealed hinged doors. Cable and bus bar compartments provided on the rear side shall have separate bolted covers. All doors and covers shall be provided with neoprene/synthetic rubber gaskets to prevent entry of vermin and dust.

7.3.6. Pressure relief device shall be provided in each high voltage compartment of a panel to safely vent the gases in the event of internal arc. Seal-off bushing arrangement shall be provided between the breaker compartment and bus bar/cable compartments to prevent transfer of arc from one compartment to other.

7.3.7. Automatic safety shutters shall be provided to cover up the fixed high voltage contacts on bus bar and cable sides when the truck is moved to TEST position.

7.3.8. Degree of protection shall not be less than IP 5X for auxiliary circuit compartment. However, for remaining compartments it shall not be less than IP 4X.

7.3.9. Mechanical /Electrical interlocks shall be provided to prevent mal-operation and in particular to ensure the following.

i. The breaker shall be operated only if it is in SERVICE or TEST position.

ii. Movement of the breaker truck between SERVICE and TEST positions shall be possible only if the breaker is OFF.

iii. It shall be possible to open the door only when the breaker is in TEST position.

7.3.10. Panel shall be provided with local bus-bar protection

7.3.11. Each switchgear panel shall be provided with thermostatically controlled space heaters, separately for breaker, cable and bus bar compartments, to prevent condensation within the compartment. The space heater shall be connected to 240 V, 50 Hz, single phase AC supply through suitable switch and fuse.

7.3.12. 240 V, 5 A, SPN industrial socket-outlet with ON/OFF switch shall be provided in each panel.

7.3.13. Each panel shall be provided with LED lamp rated for 240 V, 50 Hz, single phase AC supply for interior illumination controlled by door switch.

7.3.14. Gapless, metal-oxide surge arrestors shall be provided between line and earth in cable compartment of the switchgear panel.

7.3.15. Suitable lifting hooks shall be provided for each panel.

7.4. Circuit Breakers

7.4.1. Circuit breakers shall be of vacuum type. It shall comprise of three separate identical single pole units operated through the common shaft and shall be fully interchangeable both electrically and mechanically.

7.4.2. The circuit breaker operating mechanism shall be based on motor operated spring charging and it shall be re-strike free, trip free both electrically and mechanically, with anti-pumping feature.

7.4.3. The rated control voltage of the spring charging motor shall be 110 VDC/230 VAC. Closing coil shall operate at all values of voltages between 85% and 110% of rated voltage. Opening coil shall operate correctly under all operating conditions of the circuit breaker up to the rated breaking capacity and at all values of supply voltage between 70% and 110% of rated voltage.

7.4.4. The spring charging motor shall have adequate thermal rating such that continuous sequence of the closing and opening operations is possible as long as power supply is available to the motor. It shall also be possible to charge the spring manually and close the breaker in the event of failure of motor / control supply to motor. Operating handle shall be provided for charging the operating mechanism. After failure of control supply to the motor, one open-close-open operation shall be possible with the energy contained in the operating mechanism.

7.4.5. The motor rating shall be such that it requires not more than 30 seconds for full charging of t he closing spring. Closing action of the circuit breaker shall compress the opening spring ready for tripping. When closing springs are discharged after closing the breaker, they shall be automatically charged for the next operation.

7.4.6. Mechanical indicators shall be provided to indicate OPEN/CLOSED positions of the circuit breaker and CHARGED/ DISCHARGED positions of the closing spring. An operation counter shall also be provided. These indicators and counter shall be visible from the panel front door without opening it.

7.5. Relays

7.5.1. All relays shall be microprocessor based numerical type. However, auxiliary relays can be static or electromechanical type. The relays shall be flush mounted on panel front with connections from the inside.

7.5.2. Auxiliary voltage of the relays shall be 110 VDC and the relays shall be capable of operating continuously between 80 - 120% of auxiliary voltage.

7.5.3. All numerical relays shall have adequate number of freely configurable, optically isolated, Binary Inputs (BI) and potential free Binary Outputs (BO).

7.5.4. All numerical relays shall have minimum four no. of current inputs, three for phase current and one for earth current, suitable for CT secondary current of 1A. The current inputs shall be compatible with both residual connected CT and Core Balance CT (CBCT). In addition, numerical relay in main outgoing feeder shall have three no. of voltage inputs for Under Voltage/Over Voltage protection.

7.5.5. All I/O's shall have galvanic isolation. Analog inputs shall be protected against switching surges and harmonics.

7.5.6. Making, breaking and continuous capacity of the relay contacts shall be adequate enough for the circuits in which they are used.

7.5.7. The numerical relay shall have the following protection functions with at least two independent protection setting groups. The protection functions shall be selectable from any of the IEC characteristic curves.

(i) Definite time (DT) phase over current protection

(ii) Inverse Definite Minimum Time (IDMT) phase over current protection

(iii) Definite time (DT) earth fault current protection

(iv) Inverse Definite Minimum Time (IDMT) earth fault current protection

(v) Under Voltage protection

(vi) Over Voltage protection

7.5.8. Transformer feeder protection relay shall have provision for the following protection functions.

(i) Buchholz alarm & trip

(ii) Oil Temperature Indicator (OTI) alarm & trip

(iii) Winding Temperature Indicator (WTI) alarm & trip

(iv) Pressure Relief Valve (PRV) trip

(v) Magnetic Oil Gauge (MOG) alarm

7.5.9. All numerical relays shall have provision for measurement and storage of electrical parameters such as voltage, current, frequency, active power, reactive power etc.

7.5.10. The numerical relay shall be able to record faults and events in non-volatile memory.

(i) Fault record - At least 5 recent faults including the protection function operated, operating phase(s), voltages and currents along with date and time stamp.

(ii) Event record - At least 200 events with date and time stamp.

7.5.11. The numerical relay shall have trip circuit supervision facility to monitor the circuit breaker trip circuit both in pre-trip and post-trip conditions. The relay shall also be able to provide circuit breaker monitoring, CT and VT supervision.

7.5.12. The numerical relay shall have self-diagnostic feature with separate output contact for indication of any internal relay failure.

7.5.13. The numerical relay shall have RS-232/RS-485/RJ-45/USB ports on front side for local communication with PC and on rear side for remote communication to SCADA system.

7.5.14. The numerical relay shall have feature for time synchronization through the SCADA System / networking.

7.5.15. The numerical relay shall be provided with backlit alphanumeric LCD to access protection settings, measurement parameters, fault and event records. Read and write access to protection settings shall be password protected.

7.6. Instrument Transformers

7.6.1. Instrument transformers shall be completely encapsulated cast resin type, suitable for continuous operation at the ambient temperature prevailing inside the switchgear enclosure, when the switchgear is operating at its rated load and the outside ambient temperature is 50°C.

7.6.2. Polarity marks shall indelibly be marked on each instrument transformer and at the lead terminals at the associated terminal block

7.6.3. Voltage transformers shall be single phase units. Bus voltage transformers shall be housed in a separate panel on withdrawable truck.

7.6.4. HRC fuses of suitable rating shall be provided on primary side of voltage transformers. For secondary side, four pole Miniature Circuit Breakers (MCB) shall be provided.

7.7. Earthing

7.7.1. An earth bus made of copper shall be provided throughout the length of the panel. It shall be bolted to the framework of each panel and brazed to each breaker earthing contact bar. earthing shall be designed as per IS: 3043 (1987).

7.7.2. The earth bus shall have sufficient cross section to carry maximum fault current without exceeding the allowable temperature rise.

7.7.3. All non-current carrying conductors of the panel shall be connected to the earth bus. All joints to the earth bus shall be made through at least two bolts. Hinged doors shall be earthed through flexible earthing braid of adequate cross section. Suitable provision shall be provided at each end of the earth bus for connection with Owner's Earth conductor.

7.7.4. Positive earthing of the breaker truck and frame shall be maintained when it is in the connected position and in all other positions whilst the auxiliary circuits are not totally disconnected.

7.7.5. All metallic cases of relays, instruments and other panel mounted equipment shall be connected to earth bus by independent copper wires of size not less than 2.5 sq. mm with green colour insulation.

7.7.6. Instrument transformer secondary neutral point shall be earthed at one place only on the terminal block. Such earthing shall be made through links so that earthing of one circuit may be removed without disturbing the earthing of other circuits.

7.7.7. Separate earthing trucks shall be provided for earthing of busbars and incoming/outgoing feeders. The trucks shall have voltage transformer to indicate presence of voltage prior to earthing. An audible alarm shall also be provided in case of voltage on the earthing terminal. Integral earth switches may also be considered instead of earthing trucks. The earthing truck/switch shall have short circuit withstand capability equal to that of the associated switchgear panel.

7.7.8. The interlocks shall be provided to ensure the following.

i. It is not possible to rack-in the earthing truck/close the earthing switch when the breaker truck is in SERVICE position.

ii. It is not possible to rack-in the breaker truck into SERVICE position when earthing truck is connected/earthing switch is in closed position.

7.8. Bus bar

7.8.1. Bus bar shall be made of copper or aluminium with uniform cross section throughout their length. They shall be adequately supported on insulators to withstand electrical and

mechanical stresses due to specified short circuit current.

7.8.2. All bus bars joints shall be thoroughly cleaned and anti-oxide grease shall be applied. Plain and spring washers shall be provided to ensure good contacts at the joints and taps. Wherever aluminium to copper connections are required, suitable bimetallic connectors or clamps shall be used.

7.8.3. Bus bars shall be provided with heat shrinkable sleeves of suitable insulation class throughout their length with proper colour coding. All bus bar joints and taps shall be shrouded.

7.8.4. Bus bar support insulators shall be made of non-hygroscopic, arc and track resistant, high strength material suitable to withstand stresses due to over voltage and short circuit current.

7.8.5. The Contractor shall submit busbar sizing calculation for specified continuous and short time current ratings during detailed engineering.

7.9. Measuring Instruments

7.9.1. All the measuring instruments shall be digital, flush mounting type with communication facility.

7.9.2. All feeders except main outgoing feeder shall be provided with digital Multi-Function Meter (MFM). Tri Vector Meter (TVM) shall be provided for the main outgoing feeder (in the HT Panel). Accuracy class of MFM shall be 0.2 and that of TVM shall be 0.2S.

7.9.3. Measuring instruments shall have provision to display the following parameters.

(i) Line and phase voltages

(ii) Line and phase currents

(iii) Active power, Reactive power, Apparent power

(iv) Frequency

(v) Power factor

(vi) Total Harmonic Distortion (THD)

7.10. Wiring and Terminal blocks

7.10.1. All internal wiring shall be done with 650 V grade, 1.5 sq.mm. PVC insulated stranded flexible copper wire. For CT secondary circuits, 2.5 sq.mm copper wire shall be used.

7.10.2. Wire terminations shall be made with solderless crimping type tinned copper lugs, which shall firmly grip the conductor. Insulation sleeves shall be provided at all the wire terminations.

7.10.3. Printed identification ferrules, marked to correspond with panel wiring diagram shall be provided at both ends of each wire. The ferrules shall be firmly located on each wire so that they cannot move or turn freely on the wire. Wire identification shall be done in accordance with IS 11353.

7.10.4. The Contractor shall be solely responsible for the completeness and correctness of the internal wiring and for the proper functioning of the connected equipment.

7.10.5. All internal wiring to be connected to the external equipment shall terminate on terminal blocks. Terminal blocks shall be rated for 650 V, 10 A and made of noninflammable material.

7.10.6. CT and VT secondary circuits shall be terminated on stud type, disconn ecting terminal blocks.

7.10.7. At least 10% spare terminals shall be provided on each panel and these spare terminals shall be distributed on all terminal blocks.

7.11. Warranty

The HT panel unit shall be warranted for minimum of 5 (five) years against all material/ manufacturing defects and workmanship.

7.12. Testing and Inspection

7.12.1. Type Tests

The switchgear panel shall be of type tested design. The following type test reports shall be submitted during detailed engineering. The tests should have been conducted on the similar equipment by NABL accredited laboratory.

Test	**Standard**	**Relevant IEC Clause**
Switchgear Panel		
Dielectric tests		
Power frequency voltage test	IEC 62271-200	6.2.6.1
Lightning impulse voltage test	IEC 62271-200	6.2.6.2
Dielectric tests on auxiliary and control circuits	IEC 62271-200	6.2.10
Measurement of the resistance of the main circuit	IEC 62271-200	6.4.1
Temperature-rise tests	IEC 62271-200	6.5
Short-time withstand current and peak withstand current tests	IEC 62271-200	6.6
Verification of the IP coding	IEC 62271-200	6.7.1
Verification of making and breaking capacities	IEC 62271-200	6.101

Mechanical operation test	IEC 62271-200	6.102
Internal arc test	IEC 62271-200	6.106
Circuit Breaker		
Mechanical operation test at ambient air temperature (M2 Class)	IEC 62271-100	6.101.2
Basic short-circuit test-duties	IEC 62271-100	6.106
Relays		
Vibration tests	IEC 60255-21-1	
Shock and bump tests	IEC 60255-21-2	
Seismic tests	IEC 60255-21-3	
Electromagnetic compatibility requirements	IEC 60255-26	
Product safety requirements	IEC 60255-27	
Common requirements	IEC 60255-1	
Functional requirements	Relevant parts of IEC 60255-100 Series	
Communication requirements	IEC 61850	
Current Transformers		
Temperature-rise test	IEC 61869-2	7.2.2
Impulse voltage withstand test on primary terminals	IEC 61869-2	7.2.3
Tests for accuracy	IEC 61869-2	7.2.6
Short-time current tests	IEC 61869-2	IEC 61869-2

Voltage Transformer

Temperature-rise test	IEC 61869-3	7.2.2
Impulse voltage withstand test on primary terminals	IEC 61869-3	7.2.3
Test for accuracy	IEC 61869-3	7.2.6
Short-circuit withstand capability test	IEC 61869-3	7.2.301

In case the contractor is not able to submit the test reports during detailed engineering, the contractor shall submit the reports of type/special tests either conducted by NABL accredited laboratory or witnessed by Employer.

7.12.2. Routine Tests

Routine tests and acceptance tests shall be as per the Quality Assurance Plan (QAP) approved by the Employer.

8 AC Cables

8.1. Standards and Codes

All AC Cables shall conform to the following standards and codes

IS 7098 Crosslinked polyethylene insulated PVC sheathed cables, Part 1: For working voltage up to and including 1100 V

IS 7098 Crosslinked Polyethylene Insulated Thermoplastics Sheathed Cables Part 2: for Working Voltages from 3.3 kV up to and Including 33 kV

8.2. All AC cables shall be flame retardant, low smoke (FRLS) type designed to withstand all mechanical, electrical and thermal stresses develop under steady state and transient operating conditions.

8.3. Only terminal cable joints shall be accepted. No cable joint to join two cable ends shall be accepted. However, cable joints may be allowed if the route length is more than maximum available drum length subject to Employer's approval.

8.4. In addition to manufacturer's identification on cables as per relevant standard, following marking shall also be provided over outer sheath.

(i) Cable size and voltage grade

(ii) Word 'FRLS' at every meter

(iii) Sequential marking of length of the cable in meters at every meter

8.5. Cables shall be sized based on the following considerations:

(i) Rated current the equipment

(ii) Maximum voltage drop in LT cable (from PCU to Transformer) shall be limited to 0.5% of the rated voltage. For HT cables, maximum voltage drop shall be limited to 0.5 % of the rated voltage. The Contactor shall provide voltage drop calculations in excel sheet.

(iii) Short circuit withstand capability as per design for 1s.

(iv) De-rating factors according to laying pattern

8.6. Warranty

All cables shall be warranted for minimum of 5 (five) year against all material/ manufacturing defects and workmanship.

8.7. Testing

Routine test and acceptance tests requirements shall be as per relevant standards for all cable sizes.

8.8. Installation

8.8.1. Cable installation shall be as per IS 1255.

8.8.2. Cable terminations shall be made with properly crimped lugs and passed through cable glands at the entry & exit point of the cubicles. Bimetallic lugs shall be used for connecting Cu bus bar and Al cables or vice-versa.

8.8.3. All AC cables shall be provided with punched/embossed aluminium tags. The marking shall be done with good quality letter and numbers of proper size so that the cables can be identified easily.

9 Auxiliary Supply System

9.1. Scheme for auxiliary supply system shall be submitted by the Contractor during detailed engineering for the approval by Employer.

9.2. It shall mainly comprise of auxiliary transformer (if required), AC distribution board(s) (ACDB), Battery & battery charger system, emergency lighting network, Uninterrupted power supply (UPS), distribution cables and metering & protective devices.

9.3. Auxiliary system shall be provided with two independent sources for reliable auxiliary power supply.

9.4. Following consideration shall be taken into account while sizing the auxiliary transformer:

(i) 20% future load margin

(ii) 20% design margin

(iii) Total connected load at 0.8 power factor

10 Uninterrupted Power Supply

10.1. Standards and Codes

Standard/Code	Description
IEC 62040-1	Uninterruptible power systems (UPS) - Part 1: General and safety requirements for UPS
IEC 62040-2	Uninterruptible power systems (UPS) - Part 2: Electromagnetic compatibility (EMC) requirements
IEC 62040-3	Uninterruptible power systems (UPS) - Part 3: Method of specifying the performance and test requirements

10.2. General Requirements

10.2.1. The Uninterrupted Power Supply (UPS) system shall be designed to supply power to following loads (but not limited to).

(i) Data logger / SCADA / EMS

(ii) Fire Detection/ Alarm Panel (iii) HMI of SCADA

(iv) Emergency Lighting

(v) Inverter's Auxiliary supply (if applicable)

(vi) HT panel auxiliary

(vii) CCTV

10.2.2. Sizing of UPS shall be done considering the above-mentioned load at power factor of 0.8 lagging inclusive of 10% design margin at 50 ˚C.

10.3. System Description

10.3.1. The UPS shall automatically provide continuous, regulated AC power to critical loads under normal and abnormal conditions, including loss of input AC power. The UPS system shall consist of the following major equipment.

(i) UPS Module

(a) Insulated Gate Bipolar Transistor (IGBT) Converter

(b) Insulated Gate Bipolar Transistor (IGBT) Inverter

(c) Digital Signal Processor (DSP) using Pulse Width Modulation (PWM) for Direct Digital Control (DDC) of all UPS control and monitoring functions

(d) Static bypass switch

(ii) Battery system for 2 hours

(iii) Battery protective and disconnect device

iv) Maintenance bypass switch

(v) LCD display panel and LED indications

(vi) Integrated UPS Communications Protocols capable of communicating with SCADA system

10.3.2. The UPS shall meet the following minimum specifications.

Parameter	Specification
Topology	Online double conversion UPS
Input	
Voltage	415 V ± 10% AC
Frequency	50 ± 5 Hz
Power factor	0.95
Output	
Voltage	230V ± 1% AC
Frequency	50 Hz
Power factor	0.8
Battery	
Type	Sealed, Maintenance-Free (AGM) battery
Capacity	100% UPS load for 2 hours
Monitoring and communication	
LED Indicators	Load on Inverter, Battery operation, Load on Bypass, Overload, LCD Fault, UPS Fault
Electrical contacts	Closing contacts for each of the following conditions: 1. Unit on Battery 2. Low Battery 3. Summary Alarm 4. UPS On
Local Display	LCD/ LED
SCADA communications	RS-232 & RS-485 Interface Port
Overall efficiency	>90%
Electrical Protection	Input/ output under voltage, over temperature, overload, Short circuit, battery low trip

10.3.3. The UPS shall be forced air cooled by internally mounted fans. The fans shall be redundant in nature to ensure maximum reliability. The fans shall be easily replaceable without the use of special tools.

10.3.4. Contractor shall provide the Operation & Maintenance Manual and mandatory spare parts list along with the equipment

10.4. Warranty

UPS shall be warranted for minimum of 5 (five) years and batteries shall be warranted for a minimum of 2 (two) years against all material/ manufacturing defects and workmanship

10.5. Tests

10.5.1. Routine tests and acceptance tests on final product shall be done as per QAP approved by the Employer.

10.5.2. On completion of installation and commissioning of the equipment on site tests shall be carried out with the max. available load, which does not exceed the rated continuous load. An on-site test procedure shall be submitted by contractor include a check of controls and indicators after installation of the equipment.

11 Battery and Battery Charger

11.1. Standards and Codes

Standard/Code	Description
IEC 60896-22:2004	Stationary lead-acid batteries - Part 22: Valve regulated types - Requirements
IEC 60896-21:2004	Stationary lead-acid batteries - Part 21: Valve regulated types - Methods of test
IS 1652	Specification for stationary cells and batteries, lead acid type (with plante positive plates)
IS 8320	General requirements and methods of tests for lead acid storage batteries.
IS 15549	Stationary Regulated Lead Acid Batteries

11.2. General

110 V DC system (Battery, Battery Charger & DCDB) in accordance with this specification and standards stated herein, shall comprise of the following.

(i) Sealed Maintenance Free (VRLA) Battery complete with racks & accessories.

(ii) One No. Float charger.

(iii) One No. Float cum Boost charger.

(iv) DC Distribution Board (DCDB)

11.3. Battery

11.3.1. Battery shall be used to supply the following loads with back up of two hours in case of complete power failure:

(i) Trip and closing coil of HT circuit breaker

(ii) Spring charging motors for HT circuit breaker

(iii) Annunciator and Indication circuit of HT panel

(iv) Auxiliary supply to protection relays

11.3.2. The battery sizing shall account for suitable temperature correction factors, ageing factors of 1.25, design margin of 1.25 & depth of discharge of 80%.

11.3.3. The design of the battery bank and sizing calculation along with the data sheet for the battery and battery charger shall be submitted for approval.

11.3.4. Battery voltage - 220V dc or 110V dc

11.4. Battery Charger

11.4.1. The Float Charger shall be used to supply normal DC loads and float charging current of charged battery. The Float cum Boost charger shall be designed to supply boost charging current requirement of the associated battery as well as to supply normal DC load. After full discharge of battery bank, the Float Cum boost charger shall be capable of charging the battery to its full capacity in 8 hours duration while supplying normal DC load.

11.4.2. The float charger shall have both auto and manual voltage regulation arrangements with provision of selector switch.

11.4.3. Suitable filter circuits shall be provided in all the chargers to limit the ripple content (peak to peak) in the output voltage and current to 2% and 5% respectively.

11.4.4. Digital Outputs shall be configured for connection to the SCADA to monitor the outputs like charger output current, output voltage, float/boost mode, etc.

11.4.5. The charging equipment shall be housed in a free standing, floor mounted compartmentalized panels. Panel shall have provision for bottom cable entry with removable undrilled cable gland plate of 3.0 mm thickness.

11.4.6. The panel shall be of CRCA sheet steel construction having thickness of at least 2.0 mm. Degree of protection provided by the enclosure to the internals of charger shall be IP-42.

11.4.7. The instruments, switches and indicating lamps shall be flush mounted on the front panel.

11.5. DC distribution board (DCDB)

11.5.1. DCDB shall be a separate panel but shall form an integral part of a battery charger panel board.

11.5.2. Doors and covers shall be provided with neoprene gaskets to prevent entry of vermin and dust. Also, door shall be provided with lock and key arrangement to prevent unauthorized access to the board.

11.5.3. DCDB shall have adequate number of outgoing feeders with double pole, DC MCBs. At least 20% feeders shall be provided as spare.

11.6. Warranty

Batteries and battery charger shall be warranted for minimum of 2 (two) years against all material/ manufacturing defects and workmanship.

11.7. Tests

Routine tests and acceptance tests shall be as per the Quality Assurance Plan (QAP) approved by the Employer.

12 Earthing

12.1. Standards and Codes

Earthing system shall comply with latest revisions and amendments of the relevant IEC standards and IS codes. In particular, earthing system shall comply with the following standards and codes.

Standard/Code	Description
IS 3043	Code of Practice for Earthing
IEEE 80	IEEE Guide for Safety in AC Substation Grounding
IEC 62561-2	Requirements for conductors and earth electrodes
IEC 62561-7	Requirements for earthing enhancing compounds
IEEE 142	IEEE Recommended Practice for Grounding of Industrial and Commercial Power Systems
Indian Electricity Rules	

12.2. General Requirements

12.2.1. Earthing system shall be designed based on system fault current and soil/water resistivity value obtained from geo-technical investigation/ hydrography report. Earth grid shall be formed consisting of number of earth electrodes sufficient enough to dissipate the system fault current interconnected by earthing conductors.

12.2.2. The earth electrode shall be made of high tensile low carbon steel rod, molecularly bonded by high conductivity copper on outer surface with coating thickness not less than 250 micron as per relevant standards. Suitable earth enhancing material shall be filled around the electrode to lower the resistance to earth. Inspection chamber and lid shall be provided as per IS 3043.

12.2.3. Earth conductors shall be made of copper bonded steel or galvanized steel of sufficient cross section to carry the fault current and withstand corrosion.

12.2.4. Earth conductors buried in ground shall be laid minimum 600 mm below ground level unless otherwise indicated in the drawing. Back filling material to be placed over buried conductors shall be free from stones and harmful mixtures.

12.2.5. Earth electrodes shall not be situated within 1.5 m from any building whose installation system is being earthed. Minimum distance between earth electrodes shall be two times the driven depth of the electrode.

12.2.6. All welded connections shall be made by electric arc welding. For rust protection the welds should be treated with red lead compound and afterwards thickly coated with bitumen compound.

12.3. Earthing of Floating Platform

12.3.1. All the conducting parts of floating platform that are not intended to carry current shall be bonded to the earthing system by two distinct connections.

12.3.2. Earth grid may be floating on the reservoir or constructed on the shore connected with the floating platform depending on design, safety and statutory requirements.

12.3.3. Earth electrodes of the DC earth grid shall be uniformly distributed so that optimum earth resistance is offered to leakage current flowing from floating platform.

12.3.4. SCB equipment/SPD earthing point shall be connected to the DC earth grid using flexible copper cable of sufficient cross section as recommended by the manufacturer. The connection with the DC earth grid shall be done using suitable bimetallic lugs and stainless-steel fasteners.

12.4. PCU Earthing

12.4.1. DC negative bus bar of the PCU shall be earthed to avoid Potential Induced Degradation (PID). DC negative bus bar and PCU equipment earth shall be bonded to the PCU earth bus and connected to earth electrodes through flexible copper cable of sufficient cross section as mentioned by the manufacturer.

12.4.2. In case earthing of DC negative bus bar of PCU is not allowed by the manufacturer, suitable anti-PID device shall be provided with the consent of PV Module and PCU manufacturer. However, PCU equipment earth shall be connected to earth electrodes through flexible copper cable of sufficient cross section as mentioned by the manufacturer.

12.5. Transformer Earthing

12.5.1. Inverter transformer neutral shall be floating, not to be earthed. However, recommendation of inverter manufacturer shall also be taken into account.

12.5.2. Transformer tank, cable box, marshalling box and all other body earth points shall be earthed.

12.5.3. Inverter transformer shield shall be earthed separately using minimum two no. of earth electrodes. Earthing conductor between shield bushing and earth electrodes shall be copper flat of suitable size not less than 25 x 6 mm.

12.5.4. Neutral and body of the auxiliary transformer shall be earthed.

12.6. Main Control Room Earthing

12.6.1. Metallic enclosure of all electrical equipment inside the main control room shall be connected to the earth grid by two separate and distinct connections.

12.6.2. Cable racks and trays shall be connected to the earth grid at minimum two places using galvanized steel flat.

12.6.3. SCADA and other related electronic devices shall be earthed separately using minimum two no. of earth electrodes.

12.7. Switchyard Earthing

The metallic frame work of all switchyard equipment and support structures shall be connected to the earth grid by means of two separate and distinct connections.

Switch yard shall be shielded against direct lightning stroke by provision of overhead shield wire or earth wire or spikes (masts) or combination thereof as per CEA 2010(Technical standards)- 42(2)(c)

12.8. Tests

Type test reports for earthing electrode, earth enhancing compound and its associated accessories shall be submitted during detailed engineering for approval.

On completion of installation, continuity of earth conductors and efficiency of all bonds and joints shall be checked. Earth resistance at earth terminations shall be measured and recorded.

The earth plate shall be provided to facilitate its identification and for carrying out periodical inspection.

13 Lightning Protection System

13.1. Lightning Protection System (LPS) for entire plant (off-shore and on-shore) against direct and indirect lighting strokes shall be provided as per IS/IEC 62305:2010.

13.2. Protection level for the entire plant shall be Level - I.

13.3. Air terminals, down conductors and earth termination system shall be designed as per relevant parts of IS/IEC 62305:2010.

13.4. Necessary foundation/anchoring for holding the air terminals in position to be made after giving due consideration to shadow on PV array, maximum wind speed and maintenance requirement at site in future.

13.5. The product shall be warranted for minimum of 2 (two) years against all material/ manufacturing defects and workmanship.

13.6. Type test reports as per IS/IEC 62305:2010 shall be submitted during detailed engineering for approval.

14 Communication Cables

14.1. Optical Fibre Cables

14.1.1. Optic Fibre cable shall be 4/8/12 core, galvanized corrugated steel taped armoured, fully water blocked with dielectric central member for outdoor/ indoor application so as to prevent any physical damage.

14.1.2. The cable shall have multiple single-mode or multimode fibres on as required basis so as to avoid the usage of any repeaters.

14.1.3. The outer sheath shall have Flame Retardant, UV resistant properties and are to be identified with the manufacturer's name, year of manufacturing, progressive automatic sequential on-line marking of length in meters at every meter on outer sheath.

14.1.4. The cable core shall have suitable characteristics and strengthening for prevention of damage during pulling.

14.1.5. All testing of the optic fibre cable being supplied shall be as per the relevant IEC, EIA and other international standards.

14.1.6. The Contractor shall ensure that minimum 100% cores are kept as spare in all types of optical fibre cables.

14.1.7. Cables shall be suitable for laying in conduits, ducts, trenches, racks and underground buried installation.

14.1.8. Spliced/ Repaired cables are not acceptable. Penetration of water resistance and impact resistance shall be as per IEC standard.

14.2. Communication Cable (Modbus)

14.2.1. Data (Modbus) Cable to be used shall be shielded type with stranded copper conductor. Cable shall have minimum 2 pair each with conductor size of 0.5 Sq.mm. Cable shall be flame retardant according to IEC 60332-1-2.

14.2.2. Cable shall be tested for Peak working voltage of not less than 300 V and shall be suitable for serial interfaces (RS 422 and RS 485).

14.2.3. Communication cable shall be laid through underground with suitable HDPE ducts.

15 SCADA

15.1. General Requirements

15.1.1. The Contractor shall provide complete SCADA system with all accessories, auxiliaries and associated equipment and cables for the safe, efficient and reliable operation and monitoring of entire solar plant and its auxiliary systems.

15.1.2. The Contractor shall provide all the components including, but not limited to, Hardware, Software, Panels, Power Supply, HMI, Laser Printer, Gateway, Networking equipment and associated Cables, firewall etc. needed for the completeness.

15.1.3. SCADA System shall have the provision to perform the following features and/or functions:

(i) Web enabled Operator Dashboards: Showing key information on Generation, Performance and Current Status of various equipment in Single Line Diagram (SLD) format with capability to monitor PV array string level parameters.

(ii) Real time Data Logging with Integrated Analytics & Reporting: Logging of all parameters - AC, DC, Weather, System Run Hours, Equipment Status and Alarms as well as derived/ calculated/ integrated values. The SCADA User interface shall be customizable and enable Report Generation and Graphical Analysis.

(iii) Fault and System Diagnostics with time stamped event logging.

(iv) Support for O&M Activities: The interface shall allow integration with Surveillance System(s), Module Cleaning System and various other O&M support systems to provide a Data Analysis and Decision Support System for smooth and efficient Plant Operations.

(v) AI based Distributed Analytics for Predictive Maintenance, trend analysis and Alerts.

(vi) Generate, store and retrieve user configurable Sequence of Event (SOE) Reports.

(vii) Interface with different field equipment in the plant and work seamlessly with field equipment supplied by different companies.

(viii) Transfer of plant data reliably, to an Owner designated server or Cloud (Option: check with client) on any kind of remote network including low bandwidth and wireless links such as 2G/3G/VSAT

(Note: Telecom Lease line connection, if required for transferring data from Plant over internet shall be taken by Contractor in the name of Employer for O&M period)

15.1.4. The Control system shall be designed to operate in non-air-conditioned area. However, the Contractor shall provide a Package/ Split AC of suitable capacity decided by heat load requirement in SCADA room at Main Control Room.

15.2. Architecture

15.2.1. The SCADA System shall be built over Industrial IoT architecture with integrated Analytics, secure web access, enterprise software and Database.

15.2.2. Data acquisition shall be distributed across MCR and LCRs while plant level data aggregation shall be done in both local and remote server (as specified by Owner).

15.2.3. Analog and Digital IO modules shall have integrated processor for distributed IO processing and control.

15.2.4. Data communication system shall be built over fibre optic cables/ wireless network with high bandwidth TCP/IP communication (Fast Ethernet or 802.11a/b/g/n) across all Inverter and Control Rooms with Internet/Intranet access at Main Control Room. Firewall shall be provided for network security.

15.2.5. Plant SCADA Server shall have Industrial Grade server hardware running SCADA & Monitoring Software with data storage (complete plant data) space for 2 years.

15.2.6. Plant data for monitoring and control operations should be accessible without dependence on external network.

15.2.7. A server running SCADA & Monitoring Software shall be configured at the Owner's office in Hyderabad (HQ Server/Remote Server) having the same specifications as the Plant Server, in parallel with Plant Server to enable easy access to plant data from outside the plant without having to login to plant server. Effectively, the plant data shall be replicated in both places i.e. between systems at the Plant Server and Remote Server to provide data redundancy for critical plant data.

15.2.8. Operator Workstation/PC shall be of Industrial Grade for browser-based access to plant data from Plant or remote server. Plant control & SLDC/Utility related operations shall only be initiated through browser-based interface requiring no client software or database to be installed on the Workstation. All critical software and Plant Data shall be installed/stored on local and remote servers only with user access control for protecting the software and data assets from accidental deletion or corruption.

15.2.9. Internet/Intranet at Plant: Public or private network access shall be provided at the plant through any broadband/VSAT connectivity of 2Mbps or higher bandwidth. In case no broadband/VSAT connectivity can be provided at the plant, a 3G/4G data card from any Internet Service Provider (ISP) may be provided. SCADA system shall be capable of sending all plant data in real time to the Remote Server.

15.2.10. GPS based Time Synchronization System: The SCADA system shall have a Master/Slave Clock system along with antenna, receiver, cabinet and internal interconnection cables. All SCADA controllers, servers, OWS and communicating equipment shall be synchronized to the GPS clock.

15.3. Industrial IoT Controllers & Data Acquisition

The Plant SCADA and Monitoring System may use one or more IIoT Controllers at each Inverter Control Room and MCR for the purpose of data acquisition and data forwarding to the Local and Remote SCADA Servers. The IIoT Controllers shall meet the following minimum requirements:

15.3.1. The IIoT Controllers shall be distributed in nature and work independently of other IIoT Controllers or any central controller in the system.

15.3.2. Shall be capable of supporting wide range of field protocols to communicate with different field equipment (Modbus over RS485/Ethernet, etc.)

15.3.3. Shall have local storage for a minimum of 2 weeks (in case of network failure).

15.3.4. Provide web-based interface to configure the controller for various equipment in the field.

15.3.5. IO Functionality: Shall support status monitoring of VCBs & Trip relays on RMU/HT & Transformer panels through distributed DI/AI modules.

15.3.6. Controls: Shall be capable of Controlling breakers (ON/OFF). Both ON/OFF and Parameter control of inverters shall be supported.

15.3.7. Data Communication with Servers: Shall send the data collected, from all the equipment at Inverter Control Room and/or Main Control Room, to the Monitoring & Control Server.

15.3.8. Controllers shall be capable of sending data over Internet connections USB data cards.

15.3.9. Shall not require a static public IP address, at the plant for the purpose of remote access.

15.4. Functionalities

15.4.1. The SCADA system shall monitor instantaneous and cumulative electrical parameters from all DC& AC Equipment including inverters, string combiner boxes, weather station, MFM, Transformer and Switchgear (LT & HT Panels) at regular intervals not greater than one minute.

15.4.2. The SCADA system shall monitor Instantaneous and cumulative environment parameters from weather sensors or data loggers at same interval as electrical parameters and provide PR, CUF on the fly.

15.4.3. The SCADA system shall provide Alarms and Alerts on equipment faults and failure in less than 5 seconds. Alarms on status change of hardwired DI shall also be provided.

15.4.4. The SCADA system shall provide configurable alerts on any parameter crossing settable thresholds. The list of such parameters shall be finalised in consultation with the Owner.

15.4.5. The SCADA system shall enable integration with other sub-systems at the plant for supporting O&M activities. The list shall include but not limited to:

(i) Surveillance Cameras,

(ii) Module Cleaning System - For monitoring of water usage and efficacy of cleaning process.

15.4.6. The SCADA system shall have user-friendly browser-based User Interface for secure access from anywhere, for minimum ten concurrent connections from the Operator PC or other securely connected laptop/mobile, for plant monitoring, O&M, daily reporting, and analysis. A dashboard providing summary details of total plant generation, day's export, irradiance, Inverter Control Room level generation and performance indicators like PR and CUF.

15.4.7. Reporting: The SCADA system shall provide downloadable reports in Excel/PDF, configurable for equipment parameters across the plant.

15.4.8. The system shall have Configurable Analysis page for self-configured as well as on demand Analytics charts.

15.4.9. The SCADA system shall be extensible to include maintenance of O&M schedules and related activities for plant equipment as per the O&M Manual.

15.4.10. Connectivity shall be provided to Owner's Data Monitoring Centre. Data collected by Plant SCADA shall be replicated in real-time, using industry standard interfaces such as Web Services, OPC-UA, data files, as required - with Owner's Central Monitoring System in Hyderabad. The data recording intervals for different parameters from different devices in the solar plant shall be considered when creating schedules to "push" the data from Plant SCADA to data receivers stationed at Hyderabad.

15.4.11. Mobile User Interface: summary of plant performance and issues should be accessible in a mobile Native UI or browser UI.

15.4.12. Data Communication to SLDC: SCADA system shall provide required interface to integrate with TRANSCO-SLDC, in compliance with grid code, to send any parameters specified by SLDC.

Note: The methodology and specification of SLDC interface will be provided separately by SLDC/TRANSCO and it shall be the responsibility of the Contractor to determine the same.

15.4.13. Power Plant Control: SCADA system shall provide required interface to the local SCADA operator to set various power control modes (active/ reactive power/ frequency/ PF) through the inverters over industry standard communication protocols like Modbus over TCP/IP.

15.4.14. Forecasting and Scheduling: SCADA shall provide day ahead and week ahead forecasting and scheduling for power generation at the plant as per SLDC/Utility stipulations.

15.4.15. Predictive Maintenance: SCADA system shall have in-built or pluggable frameworks to support AI based Predictive Maintenance for all key equipment including inverters, transformers and switchgear at the plant.

15.4.16. All programming functionalities shall be password protected to avoid unauthorized modification.

15.4.17. The Contractor shall provide software locks and passwords to Employer for all operating & application software. Also, the Contractor shall provide sufficient documentation and program listing so that it is possible for the Employer to carry out modification at a later date.

15.5. Earthing

15.5.1. Two isolated electronic earth pits near to SCADA panel at every Inverter and Control Room with < 1 Ohm resistance shall be provided. One earth pit shall be used for protective/body earth and the other to be used for Signal Earth.

15.5.2. Apart from providing separate earth pits, manufacturer specified earthing recommendations shall be followed for all communicating equipment connected to SCADA. This includes but is not limited to SMBs, Inverters, WMS and Switchgear panels.

15.6. Communication Cable Laying

15.6.1. All RS485, IO and CAT6 cables shall be laid in separate conduits with a minimum separation of 1.5ft from AC/DC power cables all along.

15.6.2. Power cables shall be laid deep in the trenches first. Data cables shall be laid in separate conduits after partially filling the trenches to ensure minimum 1.5 ft separation between power and communication cables all along the trench.

15.6.3. IO Cables between switch gear panels and SCADA panel shall be laid on separate cable trays, with a minimum of 1.5ft separation from trays carrying AC Power cables.

15.6.4. RS485 & CAT6 cables between switch gear panels or Inverters and SCADA panel shall be laid on separate cable trays, with a minimum of 1.5ft separation from trays carrying AC Power cables.

15.7. Control Cabinets / Panels / Desks at Main Control Room

15.7.1. The cabinets shall be IP-55 protection class. The Contractor shall ensure that the temperature rise is well within the safe limits for system components even under the worst condition and specification requirements for remote I/O cabinets.

15.7.2. The cabinets shall be totally enclosed, free standing type and shall be constructed with minimum 2 mm thick steel plate frame and 1.6 mm thick CRCA steel sheet or as per supplier's standard practice for similar applications.

15.8. Software Licenses

The Contractor shall provide software license for all software being used in Contractor’s System. The software licenses shall be provided for the project and shall not be hardware/ machine-specific.

15.9. Hardware at Main Control Room

15.9.1. The Hardware as specified shall be based on latest state of the art Workstations and Servers and technology suitable for industrial application & power plant environment.

15.9.2. The Local Monitoring & Control Server and the Operating Work station, to be deployed in the Plant Control Room, shall have the following server hardware and operating system along with accessories:

Plant Server	
Server Hardware	Hex/Octal Core Xeon, 32GB RAM (expandable to 64 GB RAM), 4 X 2TB SATA hard discs in RAID 5 configuration, 2TB external USB hard disc (for backup), dual power supplies, 2 LAN ports, LCD console, keyboard & mouse. The Server hardware shall be housed in a rugged fan-cooled, and rodent-proof Server Rack.
Operating System	Operating System and Database shall be of enterprise scale (RedHat Linux or equivalent Linux OS, Oracle/MySQL or equivalent DB), with required AMC for 5 years.
Accessories	1. Monitor: Min 22" LED Flat Monitor with non-interfaced refresh rate min. 75 Hz. 2. Keyboard: ASCII type 3. Pointing Device: Mouse 4. Intelligent UPS (on line): Minimum 2 hour battery backup.
Operator Workstation	
Hardware	i7 CPU running at 3.0 GHz or faster with 8GB RAM, 500GB hard disk, 25" LED monitor, keyboard and mouse, 4 USB ports, LAN port
Operating System	Windows operating system necessary tools and anti-viruses software.
Accessories	1 Screen Display unit Min 50" LED Flat monitor with wall monted arrangement for the display of SCADA. 2. A3 /A4 Size monochrome laser printer 3 UPS of required capacity with 2 hour battery backup

15.9.3. All network components of LAN and Workstations shall be compatible to the LAN, without degrading its performance.

15.10. Factory Acceptance Test (FAT)

FAT procedure shall be submitted by Concessioner for approval. SCADA shall communicate with all third devices which are part of solar plant and same shall be demonstrated during the FAT.

16 Control and Relay Panel

16.1. Standards and Codes

All equipment provided under Control and Relay Panel shall comply with latest editions and amendments of the relevant IEC standards and IS codes. In particular, the C&R Panel shall comply with the following standards and codes.

Standard/Code	Description
IS 3231	Electrical relays for power systems protection
IEC 60255	Measuring relays and protection equipment
IEC 61850	Communication networks and systems for power utility automation
IEC 61131-3	Programmable controllers - Part 3: Programming languages
IS 9385	High voltage fuses
IS 9431	Indoor post insulators of organic material for systems with nominal voltages greater than 1000 V up to and including 300 kV
IEC 60099-4	Surge arresters - Part 4: Metal-oxide surge arresters without gaps for A.C. systems
IS 3070-3	Lightning Arresters for Alternating Current Systems - Part 3: Metal Oxide Lightning Arresters Without Gaps
IEC 62052-11	Electricity metering equipment (A.C.) - General requirements, tests and test conditions - Part 11: Metering equipment
IEC 62053	Electricity metering equipment (A.C.) - Particular requirements
IS 14697	AC Static Transformer Operated Watthour and Var-hour Meters, Class 0.2S and 0.5S

16.2. Construction

16.2.1. The control and relay panel shall be free standing, floor mounted, simplex type, metal enclosed construction. The panel enclosure shall be made of CRCA steel sheet. The thickness of load bearing members shall be minimum 3 mm and that of non-load bearing members shall be minimum 2 mm.

16.2.2. All external surface shall be painted with two coats of epoxy-based paint of colour shade RAL 7032. Internal surface shall be painted with epoxy enamel white paint. The minimum dry film thickness (DFT) shall be 100 micron.

16.2.3. Controls, indications, relays, meters and other instruments shall be flush mounted on the front of the panel. Door shall be provided at the rear of the panel. All doors and removable covers shall be provided with neoprene or synthetic rubber gasket.

16.2.4. The panel shall be dust, moisture and vermin proof with degree of protection not less than IP 4X as per IEC 60529.

16.2.5. Cable entry shall be through the bottom of the panel. Gland plate of thickness not less than 3 mm shall be provided.

16.3. Relays

16.3.1. All relays shall be microprocessor based numerical type. However, auxiliary relays can be static or electromechanical type. The relays shall be flush mounted on panel front with connections from the inside.

16.3.2. Auxiliary voltage of the relays shall be 110 VDC and the relays shall be capable of operating continuously between 80 - 120% of auxiliary voltage.

16.3.3. All numerical relays shall have adequate number of freely configurable, optically isolated, Binary Inputs (BI) and potential free Binary Outputs (BO).

All I/O's shall have galvanic isolation. Analog inputs shall be protected against switching surges and harmonics.

16.3.4. All numerical relays shall have sufficient number of current and voltage inputs required for all the required protection functions.

16.3.5. The numerical relay shall provide choice of ANSI/IEC/IEEE relay characteristic curves with wide protection setting ranges through a minimum of two protection setting groups.

16.3.6. Making, breaking and continuous capacity of the relay contacts shall be adequate enough for the circuits in which they are used.

16.3.7. All numerical relays shall have provision for measurement and storage of electrical parameters such as voltage, current, frequency, active power, reactive power etc.

16.3.8. The numerical relay shall be able to record faults and events in non-volatile memory.

(i) Fault record - At least 5 recent faults including the protection function operated, operating phase(s), voltages and currents along with date and time stamp.

(ii) Event record - At least 200 events with date and time stamp.

16.3.9. The numerical relay shall have trip circuit supervision facility to monitor the circuit breaker trip circuit both in pre-trip and post-trip conditions. The relay shall also be able to provide circuit breaker monitoring, CT and VT supervision.

16.3.10. The numerical relay shall have self-diagnostic feature with separate output contact for indication of any internal relay failure.

16.3.11. The numerical relay shall have two serial communication ports, one on front side for local communication with PC and another on rear side for remote communication with SCADA system as per IEC 61850.

16.3.12. The numerical relay shall have feature for time synchronization through the SCADA System / networking.

16.3.13. The numerical relay shall be provided with backlit alphanumeric LCD or LED to access protection settings, measurement parameters, fault and event records. Read and write access to protection settings shall be password protected.

16.3.14. Necessary software and hardware to up/down load the data to/from the relay from/to the PC shall also be provided.

16.4. Protection Scheme

The following protection schemes shall be implemented for the protection of power transformer and its feeder.

(i) Biased Differential Protection with Second Harmonic Restraint
(ii) Non-directional Over Current and Earth Fault Protection
(iii) Restricted Earth Fault Protection
(iv) Under Voltage and Over Voltage Protection (xii) Buchholz Alarm and Trip
(v) OTI Alarm and Trip
(vi) WTI Alarm and Trip
(vii) PRV Trip
(viii) MOG Alarm
(ix) OSR Trip

The above-mentioned protection schemes are indicative only. All the protection schemes required for safe and reliable operation of power transformer and the feeder shall be provided.

16.5. Measuring Instruments

16.5.1. All measuring instruments shall be enclosed in dust proof, moisture resistant cases and flush mounted on the panel.

16.5.2. Analog Ammeter and Voltmeter with selector switch shall be provided. Accuracy class shall be 0.5 or better. Instrument dial shall be with white scale, black pointer and black numerals.

16.5.3. Digital Multi Function Meter (MFM) of accuracy class 0.2 or better shall be provided. It shall have communication capability for integration with SCADA. MFM shall be able to measure line & phase voltages, line & phase currents, active power, reactive power, apparent power, power factor and frequency.

16.6. Control Switches

All control switches shall be rotary operated type with adequate making, carrying and breaking current ratings. The control switches shall be pistol grip type, lockable with spring return to normal position. They shall be flush mounted on the panel with shrouded terminals.

16.7. Indications

All indicating lamps shall be flush mounted LED type with supply voltage of 110 VDC. Lamp covers shall preferably be screwed type and moulded from heat resisting material. Indicating lamps shall be provided for R, Y, B PT supply, Breaker ON & OFF, Auto trip, Spring charged, Trip circuit healthy, etc.

16.8. Annunciation

Flush mounted static type annunciator with sufficient number of windows to accommodate all trip and alarm signals shall be provided. Separate audible annunciation for alarm and trip shall be provided by means of buzzer and hooter. Visual annunciation shall be by flickering of facia. Push buttons for test, accept and reset shall also be provided.

16.9. Earthing

16.9.1. An earth bus made of copper or aluminium shall be provided throughout the length of the panel and bolted to the framework of the panel. The earth bus shall have sufficient cross section to carry maximum fault current without exceeding the allowable temperature rise.

16.9.2. All non-current carrying conductors of the panel shall be connected to the earth bus. All joints to the earth bus shall be made through at least two bolts. Hinged doors shall be earthed through flexible earthing braid of adequate cross section. Suitable provision shall be provided at each end of the earth bus for connection with earth grid.

16.9.3. All metallic cases of relays, instruments and other panel mounted equipment shall be connected to earth bus by independent copper wires of size not less than 2.5 sq. mm with green colour insulation.

16.9.4. Instrument transformer secondary neutral point shall be earthed at one place only on the terminal block. Such earthing shall be made through links so that earthing of one circuit may be removed without disturbing the earthing of other circuits.

16.10. Mimic Diagram

Coloured mimic diagram made of metal or plastic with symbols to facilitate exact representation of the system shall be fixed on the front of control panel. Semaphore indicators shall be incorporated in the mimic diagram for indicating position of circuit breakers, isolators and earthing switches. The rated control voltage of semaphore indicator shall be 110 / 220 VDC.

16.11. Wiring and Terminal Blocks

16.11.1. All internal wiring shall be done with 1100 V grade, 2.5 sq.mm. PVC insulated stranded flexible copper wire. For CT secondary circuits, 4 sq.mm copper wire shall be used.

16.11.2. Wire terminations shall be made with solderless crimping type tinned copper lugs, which shall firmly grip the conductor. Insulation sleeves shall be provided at all the wire terminations.

16.11.3. Printed identification ferrules, marked to correspond with panel wiring diagram shall be provided at both ends of each wire. The ferrules shall be firmly located on each wire so that

they cannot move or turn freely on the wire. Wire identification shall be done in accordance with IS 11353.

16.11.4. The Contractor shall be solely responsible for the completeness and correctness of the internal wiring and for the proper functioning of the connected equipment.

16.11.5. All internal wiring to be connected to the external equipment shall terminate on terminal blocks. Terminal blocks shall be rated for 1100 V, 10 A and made of non-inflammable material.

16.11.6. CT and VT secondary circuits shall be terminated on stud type, non-disconnecting terminal blocks.

16.11.7. At least 10% spare terminals shall be provided on each panel and these spare terminals shall be distributed on all terminal blocks.

16.11.8. Screw driver operated stud type test terminal block shall be provided.

16.12. Accessories

(i) Thermostatically controlled space heater with switch for isolation

(ii) 240 V, 15 A industrial socket with ON/OFF switch

(iii) LED lamp controlled by door switch

16.13. Warranty

The control and relay panel unit shall be warranted for minimum of 5 (five) years against all material/ manufacturing defects and workmanship.

16.14. Testing and Inspection

16.14.1. Type Tests

The Contractor shall submit type test report of the panel for degree of protection as required by the Technical Specifications as per IEC 60529. The test should have been conducted by NABL accredited laboratory.

16.14.2. Routine Tests

Routine tests and acceptance tests shall be as per the Quality Assurance Plan (QAP) approved by the Employer.

17 Illumination

17.1. Standards and Codes

LED luminaires shall be tested at independent laboratory as per the following test standards.

Standard/Code	Description
LM79-08	Electrical and Photometric Measurements of Solid-State Lighting Products
LM 80-15	Measuring Luminous Flux and Color Maintenance of LED Packages, Arrays and Modules

17.2. General specification

17.2.1. This specification covers design, supply and installation of White-LED Hight Mast Lighting for illumination of Plant on-shore facilities including installation sites for inverters, Main Control Room and entry points in the plant installation area.

17.2.2. The Contractor shall furnish Guaranteed Technical Particulars of the LED luminaires, from renowned brands available in the market for approval of Employer.

17.2.3. Lighting system shall work on the auxiliary supply and same shall be incorporated in auxiliary loads. The Contractor shall provide minimum 20% of total lighting points as emergency lighting points, fed from UPS DB or DCDB as per scheme adopted by the Contractor. Indoor and outdoor emergency lights shall be provided at each inverter room, main control room, security room and main gate.

17.3. Lighting Levels

17.3.1. The average LUX level of 200 lm is to be maintained in switchyard. However, a lux level of 300 lm ((10+10) additional switchable on requirement only) is to be maintained in switchyard on transformer.

17.3.2. The lighting system for outdoor and indoor areas of solar power plant shall be designed in such a way that uniform illumination is achieved. Average LUX level to be maintained in different areas shall be as under:

Area	LUX
Control Room and equipment rooms	300
Office	300
Battery & other rooms	150
Internal/Periphery Roads	30
Transformer yard/Switchyard	200
H - pole and metering point	100

17.3.3. The lighting level shall take into account appropriate light output ratio of luminaires, coefficient of utilization maintenance factor (of 0.7 or less) to take into account deterioration with time and dust deposition.

17.4. LED Luminaire for Outdoor Applications

17.4.1. LED luminaires shall meet the following parameters.

Parameter	Specified Value
Input voltage	170 - 260 V
Input Frequency	50 Hz +/-1 Hz
Power Factor	0.90 (Minimum)
Luminaire efficacy	> 130 lumens per watt
Beam Angle	Minimum 120°
Total Harmonic Distortion	< 10 %

Working Humidity	10% - 90% RH (Preferably Hermetically sealed unit)
Degree of Protection	Minimum IP 65 (for Outdoor fixtures)
Luminaire Casing	die cast Aluminum.
Colour Temperature	5700 K (cool day light)
Colour Rendering Index	> 65
Moisture protection in case of casing damage	IP 68 (driver unit shall preferably be totally encapsulated)

17.4.2. The LED luminaire (outdoor) housing, heat sink, pole mounting bracket, individual LED reflectors and front heat resistant tempered glass should be provided.

17.4.3. The LED luminaire (outdoor) housing should be made of non-corrosive, high- pressure, die-cast aluminium and the housing should be power coated grey, so as to ensure good weathe rability. Each individual LED source should be provided with an asymmetrical distribution high reflectance aluminized reflector, which should ensure that the light distribution of the luminaire is suitable for road lighting applications (wide beam distribution) and should ensure high pole to pole spacing.

17.4.4. The luminaire should be provided with in-built power unit and electronic driver.

17.4.5. The luminaire should be suitable for standard street light poles and should be suitable for side entry and bottom entry (post top).

17.4.6. GI Lighting pole of suitable diameter capable of withstanding system and wind load, shall be provided with average Zn coating thickness of 80micron. The street light poles shall have loop in loop out arrangement for cable entry and light fixture / wiring protected with suitably rated MCB.

17.4.7. All outdoor lighting system shall be automatically controlled by synchronous timer or photocell. Provision to bypass the timer or photocell shall be provided in the panel.

17.4.8. Lighting panels shall be earthed by two separate and distinct connections with earthing system. Switch boxes, junction boxes, lighting fixtures, etc. shall be earthed by means of separate earth continuity conductor. Cable armour shall be connected to earthing system at both the ends. Proper earthing of street light poles shall be ensured.

17.4.9. Junction box for lighting shall be made of fire retardant material. The degree of protection shall be IP66 for outdoor JB.

17.4.10. Lighting cables, wherever exposed to direct sunlight, shall be laid through Double Wall Corrugated (DWC) HDPE conduits.

17.5. <u>LED Luminaire/Lamps for Indoor Applications</u>

17.5.1. LED luminaire/lamps shall have minimum 3-star BEE rating.

17.5.2. All indoor LED luminaire/lamps shall be supplied with proper diffuser to avoid direct visibility of LED and suitable heat sink for longer life.

17.6. <u>Warranty</u>

All luminaires shall be warranted for minimum of 2 (two) years against all material/ manufacturing defects and workmanship.

18 Weather Monitoring System

As a part of weather monitoring system, the Contractor shall provide the following measuring instruments with all necessary software and hardware required to integrate with SCADA.

18.1. Pyranometer

18.1.1. The Contractor shall provide secondary standard pyranometers (ISO 9060 classification) along with necessary accessories for measuring the incidental solar radiation at horizontal and inclined plane of array.

18.1.2. Specification of the pyranometer shall be as follows.

Parameter	Specification
Spectral Response	0.31 to 2.8 micron
Time response (95%)	Maximum 15s
Nonlinearity	± 0.5%
Temperature Response	± 2%
Tilt error	< ± 0.5%
Zero offset thermal radiation	±7 W/m^2
Zero offset temperature change	±2 W/m^2
Operating temperature range	0°C to +80°C
Non-stability	Maximum ± 0.8%
Resolution	Minimum +/- 1 W/m^2

18.1.3. Each instrument shall be supplied with necessary cables. Calibration certificate with calibration traceability to World Radiation Reference (WRR) or World Radiation Centre (WRC) shall be furnished along with the equipment. The Contractor shall provide instrument manual in hard and soft form.

18.2. Temperature Sensor

18.2.1. The Contractor shall provide minimum no. of temperature sensors for ambient temperature measurement with shielding case and module temperature measurement) as per Scope of supply specified in this document. The temperature sensor shall be Resistance Temperature Detector (RTD)/ Semiconductor type with measurement range of 0°C to 80°C. The instrument shall have valid calibration certificate.

18.2.2. Contractor shall provide Built-in wireless modem placed on the Floating Platform for wireless transmission of Module temperature data to the SCADA

18.3. Anemometer

Contractor shall provide minimum one no. ultrasonic wind sensor (no moving parts) for wind speed and direction monitoring.

Parameter	Specification
Velocity range with accuracy limit	0 - 60 m/s with +/-2% accuracy @12 m/s; Resolution: 0.01 m/s
Wind direction range with accuracy limit	0 to 360° (No dead band) with +/-2° accuracy @12 m/s; Resolution: 1°
Mounting Bracket	Anodized Aluminium bracket to reduce corrosion, all mounting bolts of SS
Protection Class	IP68
Output	RS232 and RS485

18.4. Data logger and Data Acquisition System

Data logger for the weather monitoring station should have the following features:

18.4.1. Provision for analog, digital and counter type inputs for interfacing with various type of sensors

(i) Analog Input

- Adequate nos. for all analog sensors with redundancy
- Provision for operation in different current and voltage ranges as per connected sensors
- Accuracy of +/-0.1% of FS

(ii) Digital Inputs

- Adequate no. of Digital inputs and outputs for the application

(iii) Provision for RS232 and RS485 serial outputs

(iv) Built-in battery backup

(v) Connectivity and Data transmission:

- Built-in GSM/ GPRS modem for wireless data transmission to SCADA/ cloud server (procurement of GPRS enabled SIM Card and connection subscription to be the responsibility of Contractor). It should be possible to remotely communicate with the device for configuration settings.
- RS485 MODBUS interface for data collection and storage on SCADA

- Web interface with provision for user login to enable viewing and downloading of weather data in XLS/ CSV format
- Communication protocol should support fast data transmission rates, enable operation in different Frequency bands and have an encryption-based data security layer for secure data transmission

(vi) Display Settings: Graphic LCD screen which should be easily accessible and should display relevant details like all sensor values, battery strength, network strength etc.

(vii) Provision of Time synchronization from telecom time or server time

(viii) Data Storage: Provision for at least 2 MB internal Flash Memory and at least 8 GB Micro SD card (expandable)

(ix) Protection level: IP68

19 CCTV Camera

19.1. CCTV Cameras along with monitoring station and all other accessories required for its proper operation must be installed to have complete coverage of following areas for 24 hours.

(i) PCU Installations

(ii) Main Control Room

(iii) Store Room

(iv) substation area

(v) PV cell access area

19.2. Monitoring station of the CCTV Network shall be installed in Main Control Room.

19.3. The CCTV system shall be designed as a standalone IP based network architecture. System shall use video signals from different cameras at defined locations, process the video signals for viewing on monitors at control room and simultaneously record all video streams using latest compression techniques.

19.4. Camera shall be colour, suitable for day and night surveillance (even under complete darkness) and network compatible.

19.5. It shall be possible to control all cameras i.e., PTZ auto/ manual focus, selection of pre-sets, video tour selection etc. The software shall support flexible 1/2/4 windows split screen display mode or scroll mode on the display monitor for live video.

19.6. The system shall support video analytics in respect of the following:

(i) Video motion detection

(ii) Object tracking

(iii) Object classification

(iv) Camera server shall be provided with sufficient storage space to storage recordings of all cameras at HD mode for a period of 15 days. All recordings shall have camera ID, location, date and time of recording.

20 Fire Alarm System

20.1. Standards and Codes

Standard/Code	Description
IS 2189	Selection, Installation and Maintenance of Automatic Fire Detection and Alarm System Code of Practice
IS 2171	Portable Fire Extinguishers, Dry Powder (Cartridge Type)
IS 8149	Functional requirements for twin CO2 fire extinguishers (trolley mounted)
IS 2546	Galvanized mild steel fire bucket
National Building code 2005	

20.2. The Contractor shall ensure the compliance of fire detection and alarm system as per relevant standards and regulations. The installation shall meet all applicable statutory requirements and safety regulations of state/central fire department/body or any other competent authority in terms of fire protection.

20.3. Firefighting system for the proposed power plant for fire protection shall be consisting of but not limited to:

(i) Sand buckets

(ii) Portable fire extinguishers (CO2 and dry powder type)

(iii) Microprocessor based fire alarm panel

(iv) Multi sensor smoke detectors

(v) Hooter cum strobe

(vi) Manual call points

(vii) Cables from sensor to fire Panel.

20.4. Minimum two numbers of fire extinguishers (CO2 and Foam type each, of capacity 10 kg having BIS certification marking as per IS: 2171) shall be provided at every building/ enclosure, transformer yard and switchyard. However, the Contractor must comply with existing building code for fire protection and relevant IS codes.

20.5. Four numbers of stand with four sand buckets on each stand shall be provided in the Transformer Yard. Sand buckets inside the building shall be provided at strategic locations as decided during detailed engineering.

20.6. Digital output from the fire detection system shall be integrated with SCADA.

20.7. The Contractor shall submit the plan for fire and smoke detection system for the Employer's approval.

21 Testing Instruments

The Contractor shall provide the following set of instruments for on-site testing.

21.1. Earth resistance tester

Parameter	Specification
Display	Backlit LCD or LED display
Range	Earth Resistance: up to 2000 Ω Earth Voltage: 200 V
Accuracy	± (2% + 5)
Safety Ratings	IP 56
Programmable Limits setting	Enabled
Accessories	
Earth Ground Stakes (4 Nos)	
Three cable reels with cable length up to 20 m	
Carry Case-1 (capable of handling tester along with accessories)	
1 set of spare battery	

21.2. Array tester

Parameter	Specification
Display	Backlit LCD or LED display
Functionality	All electrical tests required by IEC 62446-1:2016
Memory	Up to 200 records & USB downloadable to Computer
Accessories	
A set of two, 4mm fused leads for extra protection during installation tests.	
Leads which enable the array tester to connect directly to PV arrays	
1 set of spare battery	

21.3. Insulation tester

Parameter	Specification
Display	Backlit LCD or LED display

Insulation Test Range	0.1 MΩ to 10 GΩ
Test Voltage	250V, 500V, 1000V, 5000V
Test Voltage accuracy	+20% on positive side only no negative variation is allowed
Insulation Test Current	1 mA nominal
Auto Discharge	Discharge time< 0.5 Second for C = 1
Open Circuit test Voltage	>4 V, <8 V
Accessories	
Heavy duty Test Lead Set - 4 Nos.	
Carry Case with sufficient space for accommodating accessories.	

21.4. Digital Multimeter

Parameter	Specification
Display	Backlit LCD or LED display; Minimum resolution: 5 ¾ places for DC, 4 ¾ places for AC
Measuring Category	1000V CAT III as per IEC Standard 61010-1; wave shape independent RMS measurement (True RMS) suitable for operation in the site conditions.
Additional Functions	Resistance (Ω), Temperature (^{o}C), Continuity, Diode, Capacitance, Frequency, Duty cycle measurement
Accessories	
Temperature Probe	
Silicon Test Lead	
Alligator Clip	
Carry Case with sufficient space for accommodating accessories.	

21.5. Clamp meter

Parameter	Specification
Display	Backlit LCD or LED display
Measuring Category	1000V CAT III as per IEC Standard 61010-1; wave shape independent RMS measurement (True RMS) suitable for operation in the site conditions.

Current Range	AC & DC Current up to 1000A/400 A
Voltage range	AC & DC Voltage up to 1000V
Additional Functions	Resistance, continuity, diode and non-contact voltage detection, Active, Reactive and Apparent Power, THD, PF
Accessories	
Test leads	
Electrical test leads	
Probe light & extender	
Carry Case with sufficient space for accommodating accessories.	

21.6. Infra-red thermal imaging camera

Parameter	Specification
Spectral response	8 µm to 14 µm (LW)
Temperature-sensitivity and calibration range	-20 °C to +120 °C
Atmospheric air temperature	-10 °C to +40 °C
Thermal sensitivity	NETD ≤ 0.1 K at 30 °C
Geometric resolution	640 x 480 pixels
Photo camera resolution	Approx. 30 times of IR camera resolution
Absolute error of measurement	< ± 2 K
Adjustable parameters	Emissivity, ambient temperature
Adjustable functions	Focus, temperature level and span
Measurement functions	Measuring spot, measuring area with average and maximum temperature
Calibration	The measuring system (Camera, lens, aperture and filter): The camera has to be traceably calibrated at least every two years. The calibration has to be documented. If the camera is not compliant, it has to be readjusted by the manufacturer.
Documentation	Storing of the infrared picture with the radiometric data

21.7. Digital lux meter

Parameter	Specification

Range	0 - 1000 lux
Accuracy	± (2% + 5)
Resolution	1 lux
Display	3½ digits, Backlit LCD/LED

21.8. All testing equipment shall possess valid calibration certificate issued from approved NABL labs.

21.9. Instruments of superior rating is allowed after seeking consent of the Employer.

21.10. Maintenance, calibration, up keeping, repair & replacement of these tools will be in the scope of the Contractor during 5 years of O&M.

21.11. It is Contractor's responsibility to arrange for tools, tackles, logistics, test kits, manpower, experts etc. required for trouble free operation of Plant.

22 Power evacuation system

22.1. The contractor has to do the power evacuation and integration to and with the designated substation via either overhead transmission line or underground cables at specified grid voltage with all necessary infrastructure such as protection switchgears and metering systems as per the requirement of the STU/Employer.

22.2. The power evacuation system for the plant shall be as per the local DISCOM requirement and appropriate approval. The contractor shall get the route approval from the Employer and TSTRANSCO/TSNPDCL as the case may be prior to start of the construction. Any changes in the route or scheme introduced by DISCOM at any point of the time prior to commissioning shall be complied without any additional cost to the Employer.

22.3. The ROW for the TL/UG cable shall be obtained prior to the construction of the line from the concerned authorities.

22.4. Overhead Transmission Line

In case the power evacuation is planned with overhead transmission line for plant internal and external evacuation, the design of tower and its accessories shall be as per the DISCOM's requirement and the design shall be submitted to Employer for approval/ accord.

22.5. Underground cable

In case the power evacuation is planned with underground cable for plant internal evacuation, the cable shall be approved by the Employer. However, in case of external power evacuation, the evacuation plan shall be as per DISCOM's requirement and the same shall be submitted to Employer for approval/ accord.

C Civil Works

1 General

1.1. This section of Technical Specifications describes detailed technical and functional requirements of all civil and structural works included in the scope.

1.2. This excludes design, supply and installation of Galvanised 220 kV and 132 kV Transmission Line towers, Tower extensions & accessories and 11 kV, 22 kV, 22kV & 33 kV transmission poles & accessories which shall be designed following latest guidelines of respective SEB (State electricity board) and got approved before execution. In absence of SEB/ STU guidelines REC (Rural electrification corporation) standards may be followed. Poles at corner with angle > 10^0 shall be provided with 4-pole structure or lattice tower. Use of PCC spun poles is not acceptable. Approved copies of these designs & drawings shall be submitted to the Employer for reference and record.

1.3. Standards & Codes

1.3.1. All design and construction of civil works shall conform to relevant Indian standards such as BIS, IRC, MORTH, NBC etc.

1.3.2. Design of steel structures shall conform to IS: 800, 801 or 802 as applicable. Design of concrete structures shall conform to IS: 456. For design of liquid retaining structure IS: 3370 shall be followed. Only in case of non-availability of Indian standard, equivalent American or British standard may be used for design with prior approval of the Engineer and the contractor shall submit proper justification for the same along with his request to the Engineer for review and approval, and the decision of the Engineer shall be final and binding.

1.3.3. All the design/ drawings shall be prepared/ approved either by in-house Engineering Team of the contractor (or by his Engineering Consultant) with qualified engineering staff with relevant experience in successful design of solar SPV plants.

1.3.4. The design calculations for MMS, RCC structure, Steel structure, Foundation system including piling, Road work, Drainage work, etc. shall be submitted for prior approval of Engineer before commencement of construction.

1.3.5. As per project requirements, the Employer may ask for approval of all civil designs and drawings by a Chartered Civil/ Structural Engineer.

1.4. The design calculations shall be supplemented with a neat sketch showing the structure geometry, node and member nos., lengths of various typical members, support points and type of supports, types of materials & type of sections with properties considered in analysis & design. The report shall also include back-up calculations for various loads adopted in design, brief write-up on primary load cases and design load combinations considered and conclusions on design results (with supporting sketches) for easy reference and clarity. Where a computer program (other than STAAD) is used for analysis and design, the contractor shall include a write-up on the computer program used along with examples

for validation check. Design Input (format suitable to the programme used and also in STAAD format) and output file shall also be given in the design report and in soft copy to facilitate its review and approval by the Engineer.

1.5. The methodology for construction of MMS and its foundations, Road & drainage works and Procedure for pile load test shall also be submitted for prior approval of Engineer before start of these works.

2 Survey Works

2.1. The contractor shall carry out detailed Topographical (on-shore) and Hydrographic survey of the proposed water body for floating solar project site. The work shall be carried out through an agency with relevant experience and qualified survey team. The Contractor shall submit the credentials of the proposed agency along with relevant certificates and in support thereof and the names of the key personnel with details of their qualification, designation and relevant work experience for verification/ approval of the Agency by the Employer.

2.2. All survey equipment shall be tested for their accuracy before use. Only calibrated instruments with valid certification shall be used for conducting the survey.

3 Topographical Survey

3.1. The Contractor shall be responsible for detailed Topographical Survey of the proposed project site (on-shore).

3.2. The Topographical survey shall be conducted at 20m x 20m grid, or as directed by the Engineer, with the help of digital surveying instruments like Total Station.

3.3. The Contractor shall carry the Bench Mark from nearest Greatest Trigonometric Survey (GTS) Bench mark or any other established source like Railway station, Permanent PWD/ WRD structure etc. as approved by the Engineer by fly-levelling and establish 4 Permanent Bench Marks (PBM) (2 on each bank) at site with an accuracy of 0.005m. All subsequent transfer of levels shall be carried out with respect to these PBMs. The work shall also include constructing permanent reference pillars (RP) at suitable locations as directed by the Engineer. These reference pillars shall be labelled permanently with their respective coordinates and reduced levels for future use. The PBMs and RPs shall be shown on the survey drawings.

3.4. While carrying bench mark to the project site, levels shall also be established on the permanent objects like culverts etc. at least on one object in every 1 (one) km if available along with route with adequate description about the objects. These levels shall be maintained at site & also mentioned in the survey report to facilitate locating these objects later on.

3.5. The survey work shall be carried out based on WGS 84 reference ellipsoid and UTM grid system. The contractor shall also establish the latitudes and longitudes of all the

corners of the project site. At least 50m width of the adjoining plots and surrounding areas shall also be covered in the survey for correlation with adjoining plots and facilities. The grids for the survey work shall be established in N-S & E-W direction (corresponding to Geographical North or Plant North) as directed by the Engineer.

3.6. Positions, both in plan and elevation, of all natural and artificial features in the area like waterways, railway tracks, trees, cultivation, houses, fences, pucca and kutcha roads including culverts and crossings, foot tracks, other permanent objects like telephone posts and transmission towers etc. are to be established and subsequently shown on survey maps by means of conventional symbols (preferably symbols of survey of India Maps). All hills and valleys within the area/areas are to be surveyed and plotted on maps by contours. Any unusual condition or formation on the ground, locations of rock outcrops (if visible on the surface) and springs/falls, sand heap/dune, possible aggregate deposits, water bodies etc. shall also be noted and plotted on contour maps.

3.7. The record of measurement of all Reduced Levels (RL) shall be submitted in digital format, (in x, y z coordinate system) along with preliminary contour plan of the site, for Engineer's review before submission of final contour map. The contour interval shall be as required for proper representation of the topography however it shall not be more than 0.5m. The Contractor shall submit survey maps of the site in 1:10,000 scale indicating grid lines and contour lines, demarcating all permanent features like roads, railways, waterways, buildings, power lines, natural streams, trees, sand dunes etc. Present use of the site i.e. mining, quarrying, agriculture etc., existing drainage pattern of the site, possibility of water logging and high flood level of the area shall also be captured in the document. The project plot boundary with coordinates of all corner points along with coordinate grid of 50m x 50m interval shall be marked on the contour map.

4 Hydrographic Survey

4.1. The Contractor shall be responsible for detailed hydrographic survey of the proposed project site. He shall mobilize all required number of survey equipment and survey vessel with all necessary equipment including equipment for collecting water samples etc.

4.2. The contractor shall visit the site to collect all required information like depth of water in the reservoir, access to survey vessel etc. to decide the requirement of manpower and equipment to be mobilised for hydrographic survey work

4.3. The Contractor shall be responsible for establishing horizontal control (accuracy ± 1m) and vertical control (accuracy ± 0.1m) & establishing peg marks at survey grid interval along the shore.

4.4. The hydrographic survey shall be conducted at 20 m x 20 m grid (compatible with on shore topographic survey) or as directed by the Engineer using Automated Hydrographic Survey System (AHSS) (using digital single beam echo sounder for depth measurement, GPS/DGPS for position fixing and Hypack (or) equivalent hydrographic survey software

for data logging).

4.5. The soundings shall be reduced to Chart Datum (CD) / Sounding Datum (SD) to assess the bed profile. All co-ordinates to be shown in the report shall be based on WGS, 1984 reference ellipsoid and UTM, relevant zone with WGS 84 co-ordinates and MSL.

4.6. The Contractor shall be responsible for collecting and testing water sample at surface (at min. 9 strategic locations to be decided during the survey as per project needs) at 0.5 d & at 0.2 d from sea bed (d = Depth of Water).

4.7. The Contractor shall install water level gauges at critical locations (to be established during the survey) for recording daily & seasonal water level variations, low water level (LWL), high water level (HWL). The Contractor shall also collect data for daily water levels for preceding 10-15 years, LWL, HWL, High and Low tide etc. from Central water commission (CWC), state and local authorities. The contractor shall evaluate mean yearly values of MWL & LWL for 25 years return period using proven statistical data analysis software.

4.8. The Contractor shall measure water flow/ current velocity at designated depths from the water surface for 30 days at the time of survey work. The Contractor shall also collect data for daily flow/ current velocity over preceding 10-15 years from CWC, State and local authorities.

4.9. Submission of Hydrographic survey Report

4.9.1. The survey charts shall be prepared on scale of 1:10000 (for width more than 500m) and 1:5000 (for width less than 500m) with contours at interval not more than 0.5m shall be indicated on the charts. The charts/ drawings shall also include cross sectional and longitudinal profiles of the bed surface surveyed showing LWL (Chart Datum) and HWL with respect to MSL

4.9.2. Records (values) of measurement of Current Velocity and their positions shall be plotted on the chart and details shall be mentioned in the report. The report shall also include reports of water sample tests and the positions of sampling points shall be shown on the charts.

4.9.3. Information regarding any prominent under water obstructions, large coral formations etc. which may affect the design of maroon/ anchor supports shall be recorded and included in the report.

4.9.4. The existing conditions of the banks, whether protected or unprotected are to be collected and indicated in the report including recommendations (as required to ensure stable slopes) for proposed protection works etc. shall be included in the report.

4.9.5. The survey data shall also be submitted in digital format for record and future reference

5 Geotechnical Investigations

5.1. The Contractor shall be responsible for detailed Geotechnical investigations at the proposed project site (on-shore) for the purpose of foundation design for various structures and other design/ planning requirements. The investigation work shall be

carried out through any Govt. approved/ NABL accredited agency. The Contractor shall submit the credentials of the proposed agency along with relevant certificates in support thereof for verification/ approval of the Investigation Agency by the Engineer.

5.2. The scope of work includes execution of complete soil exploration including boring and drilling, standard penetration test (SPT), collecting disturbed (DS) and undisturbed samples (UDS), collecting ground water samples, electrical resistivity tests (ERT), conducting laboratory tests on collected samples of soil/ rock & ground water and preparation and submission of report. SPT shall be carried out in all types of soil deposits and in all rock formations with core recovery up to 20% met within a borehole. SPT test shall be conducted at every 1.5 m interval or at change of strata. The starting depth of SPT shall be 0.5 m from ground level. UDS shall be collected at every 1.5 m interval or at change of strata.

5.3. The field investigations shall mainly include drilling of min. 7m deep borehole, conducting SPT and collecting Disturbed (DS) and Undisturbed samples (UDS) and Electrical Resistivity Test. Number and location of bore holes and Trial pits shall be decided as per the project layout, site topography and soil conditions in consultation with the Employer. There shall be minimum 2 nos. of Boreholes per patch of land (however, total number of boreholes shall not be less than 5 at each location) 1 no. of Trial pit, 2 nos. of ERT per patch of land and 1 no. of Ground water sample for laboratory investigations. The soil/ rock samples for laboratory investigations shall be collected from each borehole and trial pit in sufficient nos. pits, Boreholes & ERT shall be submitted to the Employer for review and approval before start of work. Laboratory tests shall be conducted on DS & UDS samples and ground water samples in sufficient no. & shall include, Soil classification, Grain size analysis including Hydrometer analysis, determination of Bulk and dry density, Specific gravity, Natural moisture content, Atterberg limits, Tri-axial shear tests (UU), Undrained shear test, Consolidation tests, Unconfined compression tests, Free swell index, chemical analysis of soil and water samples to determine the carbonates, sulphates, chlorides, nitrates, pH, Organic matter and any other chemicals harmful to concrete and reinforcement/ steel. Laboratory tests on rock samples shall be carried out for Hardness, Specific Gravity, Unit Weight, Uniaxial Compressive Strength (in-situ & saturated), Slake Durability etc

5.4. After completion of field and laboratory work, the contractor shall submit a Geotechnical Investigation Report for Employer's approval. All bore log details and lab test results shall be presented in the report as per provisions of relevant BIS standards indicating BH coordinates, Existing GL, Depth of water table, Method of drilling etc. The report shall include a Map showing the locations of various field tests including coordinates, calculations and recommendations for foundation type, min. depth and safe bearing capacity (SBC) for various Plant buildings (MCR etc.) and Open installations, Switchyard structures & Sub-Station, Transformer foundation, HT lines etc. corresponding to settlement of 25mm & 40mm.

5.5. The report shall include the study for “Liquefaction potential assessment of the ground and suggestions for any ground improvement measures” as required.

5.6. The report shall also include ground water analysis (water sample collected from bore well) to ascertain its suitability for construction purposes, recommendations for type of cement, grade of concrete & minimum cement content as per prevalent soil characteristics with respect to presence of aggressive chemicals and environment exposure conditions as per relevant BIS specifications. However, minimum grade of concrete shall be M25 (M30 in coastal areas/ marshy soil) for all RCC works except liquid retaining structures like underground water tank etc. where minimum grade of concrete shall be M30 (M35 in coastal areas/ marshy soil). Cement higher than 43 Grade, shall not be used in construction.

5.7. All buildings/ Open installations, Switchyard and Sub-station area shall have levelled ground. No foundation for Buildings, Switch yard equipment & structures, Sub-stations, HT Line Towers, Transformer etc. shall rest on filled up ground. However, minor structures like cable trench, cable rack, pipe pedestal etc. may rest in filled up soil with max. safe bearing capacity for design consideration not more than 3 T/m^2.

6 Other Investigations

6.1. The contractor shall also obtain and study other input data at proposed project site for design of the project from metrological department/ local govt. authorities. This shall include data related to Rainfall (max. 24hour rainfall for 25 years return period), Maximum & Minimum ambient temperature, Humidity, HFL etc.

6.2. The Contractor shall also identify potential quarry areas for coarse and fine aggregates to be used for concrete and shall carry out the concrete mix design for different grades of concrete to be used before start of work. The concrete mix shall be designed for each source of cement and aggregates as per provisions of relevant BIS Standard. The concrete mix design shall be carried out through NABL accredited Laboratory or any Govt. agency approved by the Engineer. In case the contractor proposes to use RMC, he shall submit the Concrete mix design report from the RMC supplier for review and approval by the Engineer. (In case of RMC, reports for periodic cube tests from the supply batch shall also be submitted for review and record).

7 Roads & Access Pathways:

7.1. Approach Road:

7.1.1. Suitable approach road (as applicable) from nearest public road up to plant Main gate (on-shore), and access pathways from Main gate to MCR, Store Room and other facilities shall be provided for safe and easy transportation of men, material and equipment. The Approach road connecting nearest public road and the Main gate shall be of 2.5m wide carriage way. The access pathways connecting Main gate and MCR, Store Room & other

facilities shall be 1.5m wide. The top elevation of approach road (TOR) and access pathways shall be minimum 200 mm above FGL to avoid flooding during rains. The roads shall be provided with alongside drains as per design requirements of drainage system to avoid flow of storm water over the road.

7.1.2. Following minimum road section details shall be followed for approach road:

1. Topping: wearing course of 100 mm thick PCC (1:2:4) laid in alternate concrete blocks of size not more than 3.5m x 5m
2. WBM (CBR>100%): compacted 75 mm thick, Grade III
3. WBM (CBR>100%): compacted 100 mm thick, Grade II
4. Granular sub-base (CBR>15%): compacted 350 mm thick,

   Note - A drainage layer of 100 mm over the entire formation width shall be provided conforming to the gradation given in Chapter 6 of IRC SP-20. This layer will form a part of the designed thickness of sub-base.

7.1.3. The construction of road shall conform to relevant IRC/ MORST standards.

7.1.4. Drain, cable or any other crossing shall be provided with RCC box or precast concrete pipe culvert. The culvert design shall conform to relevant IRC standard. Except for module cleaning system the pipes for road culverts shall be of minimum class NP3 conforming to IS 458 with min. soil cover of 750mm above the pipe. In case of soil cushion less than 750mm suitable concrete (M20) bedding/ encasement shall be provided. Water supply pipe for module cleaning and service/ drinking water (over ground) shall be taken through Medium class GI steel pipe conforming to IS: 1161. Minimum dia. of casing pipe to be used for crossing any facility like electric cable, water pipe line etc. shall be 150mm.

7.2. Access Pathway:

7.2.1. All access pathway shall be of concrete block paving constructed by providing and laying 60mm thick factory made cement concrete interlocking paver block of M -30 grade made by block making machine with strong vibratory compaction, of approved size, design & shape, laid in required colour and pattern over and including 50mm thick compacted bed of coarse sand and filling the joints with fine sand; over well compacted granular sub-base of 250mm thickness

7.2.2. Factory made precast kerb stones of M-25 grade cement concrete shall be provided along both sides of the pathway to the required line, level and curvature, jointed with cement mortar 1:3 (1 cement: 3 coarse sand), including making joints with grooves (thickness of joints except at sharp curve shall not to more than 5mm), including making drainage opening wherever required.

7.2.3. Pre-cast RCC Drainage pipes, 100 dia. & of Class NP-2 shall be provided for smooth flow of rain water as per design requirements

7.3. The design and drawings for approach road, access pathways shall be submitted to the Employer for approval before execution.

8 Area Grading and Land Development

8.1. The Finished Grade Level (FGL- minimum 350mm average above NGL/EGL) of theentire area of both patches of land at each location of project site shall be fixed with reference to the highest flood level (HFL) and surrounding ground profile at proposed site to avoid flooding of plant site. The data regarding HFL at proposed site shall be obtained from the metrological department by the Contractor. In case of absence of this data, the Contractor shall assess the required information through local site reconnaissance. The minimum plinth level of all buildings/ open installations shall be 450 mm above FGL.

8.2. A detailed drawing for site levelling and grading (if necessary) shall be submitted by the Contractor before commencement of grading and area development works. The estimated volume of cutting and filling shall also be marked on the grading drawings for reference. The final grade levels to be adopted for different blocks shall be clearly marked on the on-shore Plant Layout

8.3. The Contractor is responsible for making the site ready and easily approachable by clearing bushes, felling of trees (mandatory permissions/ licenses/ statutory clearances from competent authorities if required for cutting of trees, blasting or mining operations, disposal of waste material etc. shall be obtained by the Contractor), cutting, filling with selected excavated earth or borrowed earth including identifying borrow areas. Except in exceptional cases (with approval of the Employer), filling shall be made up of cohesive non-swelling material. The filling for levelling/ reclaiming the ground/ area shall be done in layers not more than 150mm of compacted thickness in case of cohesive (clayey) soils and 250mm compacted thickness in case of granular (sandy) soils with compaction up to 95% (of modified proctor density) and 80% (of relative density) respectively. The slope at edge of graded areas shall not be steeper than 1:1.5 (1 Vertical: 1.5 Horizontal) in cutting and 1:2 (1 Vertical: 2 Horizontal) in filling. In case of filling with rock material, the edges shall be provided in line with provisions of relevant BIS standard.

8.4. It shall be ensured that the land is graded or levelled properly for free flow of surface run-off. All existing drains passing through the patch of project land shall be re-routed along the periphery outside boundary fence for smooth flow of diverted surface run-off to natural drainage channel. It is advisable to follow the natural flow of water at the ground as far as possible for drainage design.

8.5. In case the filled up earth is brought from outside the plant or borrow areas (when the material inside plant area is not found suitable for grading work or if directed by the Employer), the Contractor shall carry out all required soil investigations to ascertain the suitability of the borrowed soil for land development and filling purposes. Contractor's scope shall also include arranging land lease, getting all necessary statutory approvals for mining, payment of necessary challan etc. Excess earth, if any, shall be disposed of properly at location as directed by the Employer.

9 Peripheral boundary Wall/Fence

9.1. The plant peripheral boundary of each patch of land (on shore equipment area) shall be provided with Chain link wire fencing.

9.2. The fence/ wall shall be provided with Main entry gate. The fencing/ wall shall be with 2.5m height above grade level including 400mm dia. GI concertina wire along with 3 no. of barbed wires on either arm to be fixed on Y shape GI angle brackets. The main gate shall be min. 3.5m wide (clear), double leaf with one leaf of width 1.5m for pedestrian movement

9.3. Chain link fencing

9.3.1. The fencing shall be of Chain link of poly coat GI mesh fabric with internal, corner and stay posts of RCC (min 200mm x 200mm size, M30 grade) along with 150mm height 230 thick brick/ 300 thick RR masonry toe wall, with 100mm thick PCC (1:3:6) foundation.

9.3.2. The brick masonry toe wall shall be plastered with 15thick CM (1:4) plaster on both faces. In case of RR masonry, the joints shall be properly raked and pointed with CM (1:3). The toe wall shall have min. 50 thick PCC (1:2:4) coping finished smooth and projecting 25mm on either side of the wall with top sloping inwards. The depth (below NGL) and width of toe wall foundation shall not be less than 450mm and 500mm respectively.

9.3.3. Spacing of intermediate posts shall not be more than 2.5m. Every 10^{th} intermediate post shall be provided with a stay post while every corner post shall be provided with two stay posts on either side.

9.3.4. At pond or drain area suitable grid of MS solid SQ bar of min. Size 25 mm x 25 mm (spacing of vertical bars not more than 125mm) shall be provided in place of toe wall for smooth flow of water.

9.3.5. Poly coat GI chain link mesh (50x50mm) shall conform to ASTM 668 and fencing shall conform to ASTM 567.

9.3.6. Each fence panel, in lieu of tie wire, shall be provided with 35x35x3mm GI edge angle at top and bottom with mesh fabric firmly secured to them and to intermediate and corner posts

9.3.7. All MS sections shall be painted with 2 coats of epoxy paint of approved make and shade over 2 coats of suitable primer. GI edge angles shall be hot dip galvanised with min. average zinc coating of 80 microns on each face

9.4. Main Gate

9.4.1. The Main entry gate (2.5m height) shall of rugged design with solid MS steel sections(20x20mm). The spacing of vertical members shall not be more than 125 mm.

9.4.2. The gate shall be complete with MS flat guide track, castor wheel(s), GI fittings &fixtures like hinges, aldrop, locking arrangement, posts etc.

9.4.3. The main gate shall be of 2.5m height.

9.4.4. The gate shall be provided with the Project name plate (2.5mx 1m, 3mm thick MSplate). The gate shall be painted with 2 coats of epoxy paint over 2 coats of suitable primer.

9.4.5. The gate shall be painted with 2 coats of epoxy paint of approved make and shade over 2 coats of suitable primer.

9.4.6. All design and drawings for peripheral boundary fence/ Wall and Main gate shall be submitted for Engineer's approval before execution.

9.5. Floating fence

9.5.1. Floating fence with floating buoys (with durable UV resistant material suitable to withstand the aqueous environment and be eco-friendly to bio diversity) shall be formed around every floating platform

9.5.2. Concept design and drawings shall be submitted for approval prior to execution

10 Plant Layout:

10.1. The contractor shall submit drawing showing proposed layout of On-shore plant facilities and floating SPV modules. The layout drawing shall show various requirements of the project like, Reference coordinate grid, Geographical and Plant North, Layout of boundary fence including coordinates of all corner points, Location of main entrance gate, Layout of main approach road to main gate, Internal pathways, Security cabin (s), MCR and Open installations with coordinates, Lightening arrester, UG/Over ground water Tank(s), Storm water drains, Corridor for buried cables etc. All the facilities and buildings shall be presented with suitable Legend. The drawing shall be in suitable scale to have proper representation of the information.

10.2. The On-shore plant facilities & floating SPV module layout drawing shall be submitted by the contractor for review/ approval by the Employer.

11 Design Loads

11.1. Unless otherwise specified elsewhere, Dead load, Live load, Wind load and Seismic load for buildings and structures shall be considered as per provisions of relevant BIS standards.

11.2. The following minimum imposed load as indicated for some of the important areas shall, however be considered for the design. If actual expected load is more than the specified minimum load, then actual load is to be considered.

S. No.	Area	Minimum Imposed (Live) Load
1	Roof	1.50 kN/ Sqm
2	Building floors (GF) & Grade Slab	10.00 kN/ Sqm
3	RCC Floors (General)	5.00 kN/ Sqm

4	Outdoor platforms, Stairs, Landing and Balconies, Walkway, Chequred plate & Grating (except cable trench cover)	5.00 kN/ Sqm
5	Road culverts & allied structures over drain & pipe crossings subjected to vehicular traffic	Design for Class - 'A' loading (Wheeled & Tracked both) as per IRC Standard
6	Underground structures such as Sump, Pit, Trench, Drain, UG tank etc.	In addition to Earth pressure and Ground water table at FGL, a surcharge of 10kN /Sqm shall also be considered. The structure shall be designed for following criteria - (a) Inside empty with outside fill+ surcharge and water table at GL & (b) Inside water with no fill & water table outs side
7	Pre-cast and chequred plate cover over cable trench	4.00 kN/ Sqm
8	a) Main access & Internal Roads b) Peripheral Road	a) As per IRC SP 20 corresponding to vehicular traffic of 150 commercial vehicles per day and critical in-field CBR b) As per IRC SP 20 corresponding to vehicular traffic of 45 commercial vehicles per day and critical in-field CBR (however, if peripheral road also serves as access to plant buildings/ facilities, the criteria under 'a' shall be followed for design)

11.3. Primary Loads

(i) Dead Load (DL)

(ii) Live Load (LL)

(iii) Snow Load (SnL), if applicable

(iv) Wind Load (WL) - Both along X & Z horizontal direction

(v) Seismic Load (EL) - Both along X & Z horizontal direction

11.4. Basic wind speed (Vb) at project site shall be taken as per IS 875 (part-3) unless otherwise specified elsewhere.

11.5. To calculate the design wind speed (Vz), the factors K1 (probability factor or risk coefficient), K2 (terrain roughness and height factor) and K3 (topography factor) shall be considered as per IS 875 (Part-3). (However, minimum values for K1, K2 and K3 shall be 1.0, 1.05 and 1.0 respectively)

11.6. The importance factor for cyclonic region, 'k4' shall be taken as 1.15. Provisions of IS: 15498 shall also be followed to ensure general safety of the structure.

11.7. For MMS placed on Floating structures, the influence of wind speed off the coast shall be taken as 1.15 times the basic wind speed (Vb) in the absence of any definite wind data. This factor 1.15 shall be used in addition to k4.

11.8. To calculate the design wind pressure 'pd', factors 'ka' (area averaging factor) and 'kc' (combination factor) shall be taken as 1.0. (The factor 'kd' shall be taken as 1.0 in case of plant site within 60km of sea coast).

11.9. The Seismic Load shall be considered corresponding to Earth quake zone at site as per IS: 1893 (Part- 4) with Importance factor 1.5.

11.10. Notes for WL on MMS

WL shall be considered as detailed below for estimation of WL (±X, ±Z direction) under primary loads.

Load due to wind on side (exposed) face of respective MMS members (Drag force) for wind acting in (±) X & Z direction shall also be considered along with (i) & (ii) below.

(i) Load due to fair (positive pressure) wind direction on design tilt angles of MMS members for wind acting in (±) X, Z direction

(ii) Load due to adverse (negative pressure) wind direction on design tilt angles of MMS members for wind acting in (±) X, Z direction

(iii) Load due to wind on side (exposed) face of respective MMS members (Drag force) for wind acting in X & Z direction to be considered along with (i) & (ii) above.

11.11. Design Load combinations

11.11.1. Appropriate Load factors in LSM design for concrete structures and appropriate Factor of safety in WSM design (ASD) for all steel structures including MMS shall be considered as per relevant BIS standard. No increase in permissible stress is permitted in design of MMS

11.11.2. Following load combinations shall be considered in design:

(i) DL + LL

(ii) DL+LL ±WLx

(iii) DL + LL ± WLz

(iv) DL + LL ± ELx

(v) DL + LL ± ELz

11.11.3. All buildings, structures and foundations shall be designed to withstand loads corresponding to worst design load combination.

12 Foundations (General)

12.1. Contractor shall design all foundations for buildings, equipment, HT line Towers, Switch yard structures, Transformer and all other structures as per relevant BIS standards and recommendations of Geotechnical investigation report. The depth of foundation (below NGL) shall not be less than 1m except in case of chain link fencing post (for boundary & transformer yard fencing) where it shall not be less than 800mm (below NGL).

12.2. Min. thickness of PCC below brick wall shall be 150mm.

12.3. All foundations of one building shall be founded at same RL (Reduced level) with respect to foundation depth below lowest NGL (Natural ground level) in the building area. The Levels shall be obtained with reference to the already established TBM using digital survey instrument such as Total Station.

12.4. All design & drawings shall be submitted to the Engineer for approval before execution.

13 Concrete Works

The project site is along the sea shore with environment exposure conditions classified as 'severe' as per IS:456 and the ground water may have high level of dissolved salts containing sulphates and chlorides. Considering this, Ordinary Portland cement - 43 grade with C3A contents<5% conforming to IS: 8112 or Portland slag cement with slag>50% conforming to IS:455 shall be used in all concrete works.

13.1. Construction of all RCC works shall be done with approved design mix as per IS 456 and the materials used viz. Cement, coarse & fine aggregate, Reinforcement steel etc. shall conform to relevant BIS standards.

13.2. The minimum grade of RCC shall be as specified under Cl. No. 5.7 above. Unless otherwise specified elsewhere, PCC shall be of min. grade M10 (nominal mix 1:3:6) except for mud mat, back filling of ground pockets or leveling course which shall be of grade M7.5 (nominal mix 1:4:8).

13.3. Reinforcement steel shall be of high strength TMT bars of grade Fe500 D conforming to IS: 1786 with anti-corrosive coating to withstand aqueous environment. Ductile detailing in accordance with IS: 13920 shall be adopted for superstructure and substructure of all RCC buildings and structures.

13.4. Unless specified otherwise for grouting works anti shrink ready mix grout of approved make or cement mortar (CM) grout with non-shrink compound shall be used. The grout shall be high strength grout having min. characteristic strength of 35 N/mm^2 at 28 days.

14 Miscellaneous Steel Works

14.1. Unless otherwise specified elsewhere, all structural steel work shall be designed as per provisions of IS: 800 with working stress method of design (WSD).

14.2. Structural steel hot rolled sections, flats and plates shall conform IS: 2062, structural Pipes shall be medium (M)/ high (H) grade conforming to IS: 1161, chequered plate shall conform to IS: 3502 and Hollow steel sections for structural purposes shall conform to IS: 4923.

15 Plinth protection and drain

15.1. 750mm wide plinth protection with min. 75mm thickness of PCC (1:3:6) over 75 mm thick bed of dry brick ballast, 40mm nominal size well rammed and consolidated and grouted with fine sand, shall be provided around all the buildings.

15.2. A peripheral drain (except for Security room/ cabin) of min. internal size 250mm x 250mm with brick walls in CM 1:6 over 75mm thick PCC (1:3:6) bedding with 12mm thick plaster in CM 1:5 and 25thk PCC (1:3:6) coping at top shall be provided along the periphery of the plinth protection for collection and disposal of rain water from building roof. The drain shall be provided with 12mm thick plaster in CM 1:5 on inside face and 25mm thick PCC (1:3:6) coping at top

16 Plinth filling for buildings

Plinth beam, when provided, shall be taken minimum 200mm below FGL. The plinth filling below Ground floor (GF) for all buildings shall be provided with following specifications.

(i) Well compacted sub-grade

(ii) Well compacted bounder soling with interstices filled with sand over compacted sub-grade

(iii) 75mm thick PCC 1:3:6 over (ii)

(iv) 100mm thick PCC 1:2:4 over (iii)

17 Fire Extinguishers

17.1. All buildings shall be installed with required no. of fire extinguishers as per relevant BIS standard and NBC. Liquefied CO2/ foam/ ABC type fire extinguisher shall be upright type of capacity 10kg conforming to IS: 2171, IS: 10658.

17.2. The fire extinguisher shall be suitable for fighting fire of Oils, Solvents, Gases, Paints, Varnishes, Electrical Wiring, Live Machinery Fires, and all Flammable Liquid & Gas.

18 Sand buckets

18.1. Sand buckets shall be wall mounted made from at least 24 SWG sheet with bracket fixing on wall conforming to IS 2546.

18.2. All buildings shall be provided with required number of sand buckets as per relevant BIS standard and NBC. 4 (four) number of bucket stands with four buckets on each stand shall be provided in the transformer yard.

19 Sign Boards and Danger Boards

19.1. The sign board containing brief description of major components of the power plant as well as the complete power plant in general shall be installed at appropriate locations of the power plant as approved by Engineer.

19.2. The Signboard shall be made of steel plate of not less than 3 mm. Letters on the board shall be with appropriate illumination arrangements.

19.3. Safety signs, building evacuation plan and direction signs, assembly points shall also be placed at strategic locations.

19.4. The Contractor shall provide to the Engineer, detailed specifications of the sign boards.

20 Masonry Work

20.1. The masonry work shall be of bricks, laterite blocks (as per site conditions) or concrete blocks.

20.2. All external walls of buildings shall be 230mm and internal walls shall be 230mm or 115mm as per requirements.

20.3. All concrete block masonry walls shall be min. 200mm thick.

20.4. Brick work shall be in cement mortar (CM) 1:6 & 1:4 for 230 mm and 115 mm thick brick wall respectively unless specified.

20.5. Unless otherwise specified elsewhere, Bricks shall be of class designation 5 conforming to IS: 1077, IS: 2212 & IS: 3495.

20.6. All concrete blocks shall be of min. compressive strength of 7.5 N/mm2 and shall be of Grade-A conforming to IS: 2185.

20.7. The laterite blocks shall conform to IS: 3620.

20.8. All buildings shall be provided with suitable damp-proof course (DPC). The DPC shall be with PCC (1:2:4) using 6 down coarse aggregate and water proofing admixture. The min. thickness of DPC shall be 40mm.

20.9. The construction of brick masonry shall conform to IS: 2212. Construction of Concrete block masonry shall conform to IS: 2572.

21 Plastering, Pointing & Coping Works

21.1. All brick masonry work shall be provided with plaster.

21.2. Wall and ceiling plaster shall be in cement mortar (CM) 1:6 and 1:3 respectively

21.3. Thickness of plaster shall be 18mm and 12mm respectively for rough and smooth surface of the masonry wall. The ceiling plaster shall be 6mm thick.

21.4. All joints in stone masonry shall be raked and pointed in cement mortar (CM) 1:3 except specified otherwise.

21.5. Exposed top surface of brick or stone masonry shall be provided with 25 mm thick plain cement concrete (PCC) coping (1:2:4) with trawl finish. All exposed coping shall be provided with suitable slope and projection for easy drainage of water.

21.6. All door and window chajja shall be provided with 10mm wide drip course.

22 Building Water Supply & Plumbing Works

22.1. C-PVC pipes shall be used for all internal building water supply works while all external water supply pipes shall be uPVC conforming to relevant BIS standard.

22.2. Rain water pipe shall be of PVC conforming to relevant BIS standard.

22.3. All sewerage, waste water and ventilation pipes shall be of HDPE conforming to relevant BIS standard.

22.4. MCR building and Security room shall be connected to Sewage treatment facility including all associated works like Manholes etc.

23 Sewage Treatment facility

23.1. The Contractor shall design & provide soak pit and RCC Septic tank for treatment of sewage and waste water from MCR. The septic shall be designed as liquid retaining structure conforming to IS:3370 for design loads as specified under Clause No. 6. However, in case of ground water within 1.5 m of finished grade level or the soil strata being of low permeability (permeability ≤ 10^{-6} m/s) where septic tank and soak pit arrangement is not effective, suitable packaged sewage treatment plant of reputed make/manufacture shall be provided. The sewage treatment facility shall be of required capacity and of proven design suitable for total of 15 people.

23.2. The design and drawings shall be submitted for approval prior to execution.

24 Pipe & Cable Trenches

24.1. All trenches inside the building and transformer area shall be of RCC. The min. wall and base slab thickness shall be 100mm for depth ≤ 850mm and 150mm for depths > 850mm.

24.2. The trench shall be designed for lateral load due to external soil fill, ground water table at FGL and 10.0 KN/ Sqm surcharge. External trenches shall be kept min. 100mm above FGL to avoid entry of rain water. In case of straight length of the trench being more than 40m, suitable expansion joints with PVC water stop shall be provided.

24.3. Internal trenches (inside buildings) shall be provided with chequred plate (min. 8mm thick with angle stiffeners as required) covers while external trench shall have precast concrete covers.

24.4. Min. thickness of precast cover shall be 50mm. Both bearing edges of the cable trench and all edges of pre-cast concrete covers shall be provided with min. 50x50x6 mm edge protection angle with lugs.

24.5. The trench cover (chequered or pre - cast both) shall be provided with suitable lifting hooks.

24.6. As required suitable MS insert plates shall be provided on trench wall to support the cable rack/ pipe.

24.7. The trench bed shall have a slope of approx. 1(V):250(H) along and 1(V):50(H) across the length of the trench. The cable trench shall have a dewatering sump (s) of size 450x450x450 mm depth at suitable location to facilitate collection & pumping out of rain water from the trench.

24.8. The external buried cables shall be laid in excavated trench as specified under specifications for Electrical works. The sand for filling shall be of Grade - IV conforming to IS: 383.

25 Water Supply and Cleaning of Modules

25.1. The Contractor shall design and install the effective module cleaning system.

25.2. A regular supply of suitable quantity of water shall be ensured by the Contractor to cater day-to-day requirement of drinking water and for cleaning of PV modules during entire O&M period.

25.3. The Contractor shall estimate the water requirements for cleaning the photovoltaic modules at regular frequency in order to operate the plant at its guaranteed plant performance. However, minimum consumption of 2 litre / sq.m of surface area of SPV module shall be considered in estimation of required quantity of water storage.

25.4. As the ground water at site may contain high concentration of chlorides and may not be suitable for construction and module cleaning purposes. Suitable water for construction and module cleaning purposes (during plant operation) by providing RO plant of requisite capacity including storage facilities shall be arranged by the Concessioner.

25.5. Water used for drinking & PV module cleaning purpose shall be of potable quality and fit for cleaning the modules with TDS generally not more than 75 PPM. In case of higher salt contents, the water shall be thoroughly squeezed off to prevent salt deposition over module surface. However, water with TDS more than 200 PPM shall not be used directly for module cleaning without suitable treatment to control the TDS within acceptable limits. The water must be free from any grit and any physical contaminants that could damage the panel surface.

25.6. If required, for settlement of any grit/ unacceptable suspended particles in the water a settling tank shall be installed before the inlet of the storage tank. Suitable arrangement for discharge/ disposal of sediment/ slush shall be provided in silting chamber by gravity disposal in surface drain or with provision of sludge sump and pump of adequate capacity.

25.7. The Contractor shall propose a suitable module cleaning system which shall include installation of ground mounted polyethylene tank (s) of required storage capacity, pumps (including 1 No. standby pump), boats for delivery of water to floating platforms, flexible hose pipes, taps, valves (NRV, Butterfly valve, Ball valve, Gate valve, PRV, scour valve etc.), Water hammer arrester(s), pressure gauge, flow meter etc. as per the planning & design.

25.8. The Polyethylene storage tank shall conform to IS 12701. The valves shall conform to IS 778. A suitable metal sheet canopy for protection from direct sunlight shall be provided over the tank area.

25.9. Module cleaning procedure and pressure requirement at discharge point shall be as per the recommendation of PV module manufacturer. However, discharge pressure at outlet shall not be less than 50 kg/cm^2 (5 MPa).

26 Miscellaneous Structures:

26.1. Structure for weather monitoring device & Lightening Arrestor:

Weather monitoring device shall be mounted on tubular steel pole of required height.. The pole shall be secured to an independent RCC foundation structure through Base plate and Anchor bolt assembly. 200 long 20 dia. rods shall be welded to the pole at 300 mm C/c for access to the device for maintenance purpose. The support structure shall be hot dip galvanized.

27 Floating System

27.1. Standards and Codes

Float materials shall comply with the latest edition of the following standards and codes including amendments.

Codes	Description	Property Values
ASTM D1693	Standard Test Method for Environmental Stress-Cracking of Ethylene Plastics	Resistance, F50 (hrs.) > 500
ASTM D790	Standard Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials	Secant Flexural Modulus at 2% Strain > 1000 MPa
ASTM D 638	Standard Test Method for Tensile Properties of Plastics	Tensile Strength at Yield > 27 MPa`
ASTM D695	Standard Test Method for Compressive Properties of Rigid Plastics	Compressive Stress at Yield > 10 MPa
ASTM D 2565	Standard Practice for Xenon-Arc Exposure of Plastics Intended for Outdoor Applications	More than 50% of its original break elongation after 10,000 hours exposure
ASTM G7/G7M	Standard Practice for Atmospheric Environmental Exposure Testing of Non-metallic Materials	

UL 94 or Equivalent IEC/ISO standards	Standard for Safety of Flammability of Plastic Materials for Parts in Devices and Appliances testing	Classification HB or better

27.2. The floating system shall consist of multiple modular floating units/platforms and connected to the ground using anchoring and mooring system. However, the float unit shall have minimum material thickness of 3 mm, with moisture retention of less than 5%. Floating system/platform shall be fenced with vacant floats to demarcate boundary.

27.3. The Contractor shall consider following factors while designing the floating systems:

(i) Buoyancy of the floats shall maintain the minimum clearance and stability of the floating system in the reservoir.

(ii) Weight of algae growth: There is a chance of development of algae on the structures including floats. Therefore, while designing the system, sufficient factor of safety shall be considered.

27.4. Floats shall be designed to prevent/mitigate stagnation of water.

27.5. The floating unit shall be manufactured from thermoplastic material with UV stabilizer (not less than UV24 additive package) and corrosion-resistant additives so that the floating unit shall sustain for 25 years in the aqueous environment.

27.6. The floats may be filled with virgin expanded polystyrene foam to increase the strength of the float and to serve as backup floatation system.

27.7. All the materials used in the floating system shall comply with national and international environment laws and regulations.

27.8. The materials used for manufacturing the floating unit shall be tested at ILAC accredited testing laboratory for ensuring the suitability of the material for use in aqueous applications.

27.9. All the modules shall be accessible for maintenance once multiple floating units are connected together.

27.10. All fasteners used in the floating system shall be made of SS 316.

27.11. Aluminium alloy, if used in the floating system, should be of 5052 grade or higher, suitable for aqueous applications.

27.12. The Floating system shall be able to support the load of O&M Personnel (at least 2 personnel 80 kg each) and equipment like String Combiner Box etc.

27.13. The floating units shall be re-processable and recyclable at the end of its useful life.

27.14. The Contractor shall get the design of the modular floating platform vetted and the prototype validated by IITs, Navi Mumbai, having Multi Element Wave Maker or other methodology as per the recommendation of the Institute and submit it for Employer's approval during detailed engineering.

27.15. The floating system, or sections thereof, shall be anchored using concrete blocks. Sea floor drilling is not permitted for anchoring/tethering.

27.16. Tethering hawser for mooring/anchoring system shall be stranded steel (with protective Zinc coating)/steel reinforced polyester/ rubber type to withstand abrasion, UV radiation and chemical weathering for the plant design life.

27.17. The mooring system shall be designed to keep the floating platform in position during fluctuation in water level.

27.18. The complete system (floating, anchoring & mooring system) shall be designed to withstand maximum wind speed of the location as per IS 875 - Part 3, worst-case waves, tides (regular and random) and water currents prevailing at the proposed reservoirs.

27.19. The Contractor shall propose an Erection and Construction methodology with a minimum of following details:

i. Float Assembly Plan

ii. Equipment required for Assembly

iii. Mooring and Anchoring methodology

iv. Safety Plan for Installation

27.20. Warranty: The Floating System including floats, mooring and anchoring mechanism shall be warranted for 10 years.

28 Buildings (the common Control centre shall be used for Hydro & Solar plant)

The specifications provided below apply to MCR, ICR and Store Room.

28.1. General Requirement

28.1.1. Plant buildings/ open installations are required to be constructed for housing the electrical equipment/ panel (Local Control Room Building - LCR) and Control room cum office cum store (Main Control Room Building - MCR).

28.1.2. All buildings shall be Pre Engineered Building type or Portable Cabin as per specifications laid down in this document. The equipment area shall be designed with OEM requirements to ensure all satisfactory operations.

28.1.3. The contractor shall submit the proposed based on manufacturer recommendation, easy passage of O&M persons and cable trench layout required, equipment layout drawings to the Employer for approval before development of Architectural drawings.

D. Performance Measurement Procedure

1 Performance Ratio (PR)

Performance Ratio (PR) test for Operational Acceptance shall be performed as per the procedure attached in Annexure-C. PR shall be measured separately for each land plot.

2 Capacity Utilization Factor (CUF)

Capacity Utilization Factor of the plant shall be calculated as per the procedure attached in Annexure-C.

E. SPECIAL TECHNICAL CONDITIONS

1.1. The Contractor is advised to inspect the site and study the nature of soil, topography, hydrography and other conditions to decide the extent of scope of area grading, ground compaction, and foundation system to be provided before submission of the Bid. The Employer shall not be responsible for any variations in soil characteristics and other conditions, between those observed during preliminary site visit and detailed investigations to be carried out by the Contractor during contract execution and there shall be no compensation what so ever in the contract price on this account.

1.2. The Contractor is advised to ascertain the availability of good quality ground water at site for construction, drinking and module cleaning purpose. In case of non-availability of ground water source, the contractor shall explore the option of supply of water through water tankers. In case the water quality is not suitable for drinking or module cleaning purpose, the Contractor shall install suitable water treatment facilities.

1.3. PV Modules (TS Clause 1.3)

1.3.1. Only Glass-glass PV Modules with or without frame shall be allowed.

1.4. Power Conditioning Units (Clause 3)

1.4.1. Power Conditioning Unit shall be outdoor type.

1.5. HT Switchgear (Clause 7)

1.5.1. HT Switchgear shall be GIS Type .

1.6. Module Mounting Structures (MMS)

1.6.1. The MMS shall be made from aluminum alloy grade 54300 (N8) conforming to IS 8147: 1976 with minimum member thickness of 2 mm. The Contractor can also propose other material. However, structural steel shall not be used, in any case, as a material for the MMS. Note: The details of the MMS design along with project details where it has been deployed shall be submitted along with the bid.

1.6.2. PV Modules shall be fastened to the MMS with adequate no. of fasteners as per the recommendation of PV Module manufacturer for the design wind speed. All fasteners and washers - both for MMS connections and fixing of PV Module shall be adequately protected from atmosphere and weather prevailing in the area.

1.6.3. The module mounting structure design shall allow transverse movement of Float blocks to allow for waves to pass through.

1.6.4. The structure shall be designed to allow easy replacement of any module and shall be in linewith site requirements.

1.6.5. Welding of structure at site shall not be allowed and only bolted connections shall be used.

1.7. Boundary Wall (TS Clauses 9.1-9.3)

1.7.1. The specifications for construction of boundary wall / fence are as below (Please refer to the drawing for details.)

a) Pre-stressed concrete post with M 25 grade concrete

b) Concrete mix : M 25 grade design mix finished smooth

c) Reinforcement : 7 Nos 4 mm dia high tensile carbonized steel

d) Size of post : 150 mm x 150 mm with suitable groove on both sides to accommodate 50 mm thick RCC panel.

e) Length of post 2.70 m, of which 0.90 m shall be below GL and 1.80 m shall be above GL

f) Spacing of posts 2.15 m c/c, one extra post for every corner and one extra post at every 15th post and at change of level.

1.7.2. Pre-stressed concrete panels with M 25 grade concrete

a) Concrete mix : M 25 grade design mix finished smooth

b) Reinforcement : 4 Nos 3 mm dia high tensile carbonized stee

c) Size of each panel : 2.13 m X 0.30 m X 0.05 m

1.7.3. Concertina wire fencing:

50 x 50 x 6mm 86 micron HDG MS angle U post above top of compound wall fixing of the same to the posts with 50x6 mm MS flat 300mm long both sides and fixed in the groove of the post.(as shown in the drawing)

1.7.4. SPECIFICATIONS FOR 450mm DIA. CONCERTINA COIL

Diameter of the coil	:	450mm
Number of rounds	:	50 no. rounds per 5meter length
Galvanization	:	Up to 20 microns
Spring core	:	2.5mm thick; tensile strength @ 165 Kg/Sqmm
Tape	:	0.52mm thick and weight 43.478 gm/Meter
Blade profile	:	Minimum length of 11mm and width before crimping 18mm
Blade pitch	:	25mm c/c
Clips	:	5 nos per 2 spirals

1.7.5. SPECIFICATIONS FOR GALVANISED STEEL BARBED WIRE

No. of strands	:	12 nos
Type	:	Type-A (IOWA type)
IS code	:	IS 278-1978 (Sl.No.5)
Details		

line wire	:	2.25mm
point wire	:	2.00mm
Spacing of barbs	:	75mm
Mass	:	106 to 97 gr/Meter

1.7.6. Erection:

a) Earth work 0.60x0.60x0.90m for columns and 2.10x0.30x0.30m for panels in all types of soils and ordinary rock not requiring blasting.

b) Posts shall be erected in the pits of 0.60x0.60x0.90m with 0.60x0.60x0.60m CC 1:2:4 concrete.

c) 1 panel shall be inserted below ground level.

d) 6 panel shall be inserted between the columns above ground level

e) The panels shall be suitably grouted at column joints in CM (1:4) to prevent removal.

1.7.7. Finishing:

a) The gaps in earth work shall be filled back properly and surrounding shall be leveled to bring back to original condition.

b) Acrylic exterior emulsion Grade-II 2 coats over one coat primer shall be provided to entire wall

Design Considerations

1.1. The basic wind speed ‘Vb’ = 44 m/sec

1.2. Seismic zone - III as per IS: 1893

1.3. Design rainfall intensity for storm water drainage - 65 mm/hr

1.4. Security cabin(s) required at strategic locations shall be decided in consultation with Employer.

Note - For detailed technical specifications of various works under the Scope, please refer Section -VII B, “Technical Specifications”

Annexure - A

Pre-dispatch Inspection Protocol for Crystalline PV Modules by Employer or Employer Deputed Agency

Pre-dispatch inspection procedure

1 Objective:

The objective of this document is to establish General inspection protocol with objectivity for verification of Quality Parameters of Solar Modules by the customer (or its authorised inspection agency) prior to dispatch. The decision rules and procedure specified herein seek to uphold quality standards based on industry best practices and technical specifications laid out in tender documents as well as to control risks associated with item procurement.

2 Standard:

Sampling for determining Acceptance Quality Level (AQL) shall follow ISO 2859-1: 1999.

3 Definitions:

1. Lot: All products/items manufactured in one batch. Notwithstanding the aforementioned definition, the customer or authorized inspection agency can lay down alternate/additional criteria for determining a lot.
2. Major Defect: A defect that reduces the usability or causes the product to fail to fulfil its nominal characteristic function.
3. Minor Defect: A defect that does not reduce the usability of the product, but does not meet the quality standard.

4 Inspection Schedule:

Customer representative shall propose the schedule for Pre-despatch Inspection of Finished Goods to the Customer well in advance, and in no case less than 3 working days prior to commencement of Inspection at a location within India and 7 days in case of a foreign country.

5 Scope of Inspection:

Supplier representative will accompany the Inspector while doing the inspection which shall typically consist of 2 steps for clearance of each Lot:

BOM verification: To be conducted prior to the commencement of production.

The details of materials used will be verified from the ERP/Manufacturing data and corroborated with the Construction Data Form (CDF). This shall include verification of following:

Item	Method of Verification
Shelf life of the following BOM items: □ EVA □ PV Module Back sheet □ Sealant and potting material (Silicone)	Verify the expiry date/shelf life and storage conditions The PV Module manufacturer shall submit all required information to prove that materials being used are within their shelf life

Note: Supplier shall provide the necessary documents for approval of BOM as per IEC standards and tender Technical Specifications.

Witness Tests:

Manufacturer shall assist the Inspecting agency to witness following checks, the details of which are provided elsewhere in this document:

I. Flash test- As per sampling Plan

II. Visual Inspection- As per sampling Plan

III. EL Inspection-As per Sampling Plan

IV. Electrical Characteristics (Other than Flash Test)- As per Sampling Plan

Note: The Supplier shall furnish soft and hard copy of the Production Quality Plan prior to commencement of the Inspection.

6 Sampling Process:

a. Supplier shall provide the list of modules in a lot ready for despatch, along with flash test data (Measured Electrical Data, Pmax) prior to commencement of Inspection tests.
Note: Smallest lot size for Inspection: 20% of the capacity as per the PO.

b. Supplier will arrange to move the PV Modules from FG to Inspection area.

c. Same samples shall be used for all Witness Tests stated at 5.2 above.

d. Inspector shall commence Inspection process by randomly selecting samples from the list of serial nos. (pallet-wise) provided by Supplier as per ISO 2859: Single Sampling Plan for Normal Inspection, General Inspection plan level-II. However, the Inspector shall reserve the right to switch to tightened or reduced level of Inspection as per the lot quality.

7 Decision Rules for Acceptance/Rejection

Following is a summary of Decision Rules for Acceptance/Rejection of a given Sample in a lot offered for Inspection:

Table 1: AQL Levels

Defect Type	AQL (%)
Major (Ma)	2.5
Minor (Mi)	4

Table 2: Inspection Levels

Inspection steps	Inspection item	Inspection level
1	Flash Test	General inspection level I
2	Visual	General inspection level I
3	EL	General inspection level I
4	EC (Other than Flash Test)	10 Nos. per lot

8 Inspection Process

a. Electrical Inspection - Flash Tests

For Electrical inspection following preparation will be done:

- Module Temp Stabilisation: Modules will be kept in controlled environmental condition till it reaches 25 $\pm 2^0$C
- Calibration of Sun-simulator: Sun-simulator will be calibrated as per Calibration Reference. Reference should calibrated against Calibration Reference tested from reputed testing lab TUV / Fraunhofer etc. Testing of modules will be done at STC condition, AM=1.5

Note:

(i) All modules selected for sampling inspection will be re-tested in the sun-simulator. A Pmax retest (repeatability test) variation of ± 2 % on actual flash Pmax value will be acceptable.

(ii) The Supplier shall provide a valid calibration certificate of the apparatus used.

b. Visual Inspection:

- Customer representative will verify the module visual characteristics as per the Visual Acceptance norms.
- The Visual Inspection shall be carried out in a well-lit room. It shall be the responsibility of the Supplier to ensure adequate brightness in the room.

c. Electroluminescence (EL) Inspection:

- The EL image shall have sufficient resolution for analysis of defects.
- Hi-pot test shall be done as per IEC procedure. The Supplier shall provide a validcalibration certificate of the apparatus used.

9 Re-inspection and review

In case of minor non-conformities like cleaning issues, label mismatch, etc. which can be easily reworked, Supplier shall rework/replace the modules and offer them for reinspection to Inspector.

10 Inspection Summary:

Once the inspection is completed Customer Representative will compile his Inspection Summary Report and share with Supplier and give necessary recommendation on despatch depending upon the audit findings based on the observations made. This report shall be provided within same day of inspection (Format Attached).

11 Disclaimer:

Inspection by NMMC/ Employer does not absolve the responsibility of the Supplier/vendor to ensure quality during production of the material and its transport to site. Any damages during transport/ handling shall be replaced before erection at site as directed by Engineer-in-charge without any extra cost to the purchaser.

Sampling Plan

(Sampling Plan as Per ISO 2859) -1

(Sampling Plan as Per ISO 2859) - 2 - Normal, Tightened and Reduced)

Customer inspection Report

CUSTOMER INSPECTION REPORT			
Ref. No. & Date:			
Client:	PMC: NMMC	EPC Contractor: PO Ref. No :	
Place of Inspection:	Date of inspection:	Lot Size	Sample Quantity
Problem Quantity: Detail: Inspection Result (OK/Not OK):			
Visual Inspection Problem Quantity: Detail:			
Flash Test Problem Quantity: Detail:			
EL Inspection: Problem Quantity: Detail:			
EC Inspection (Hipot,DC Continuity,IR): Problem Quantity: Detail:			
Any Other Criteria/Remarks:			
Is the shipment qualified to be released?		Yes No	
From Client	From EPC Contractor	NMMC	

Enclosed: Test Details, Flash Test Report, EL test (images- soft copy), EC Test Report

Disclaimer: This Inspection by NMMC/ Employer does not absolve the responsibility of the vendor to ensure quality during production of the material and its transport to site. Any damages during transport/ handling shall be replaced before erection at site as directed by Engineer-in-charge without any extra cost to the purchaser.

Details:

Lot :				Date
S.No.	Defect	Module Id	Type (Ma/Mi)	Details
1				
2				
….				

Annexure - B

PG Test Procedure

1 INTRODUCTION

This document lays down the procedures and requirements for conducting Functional Guarantee tests including scope of the tests, procedures for the tests, reporting formats and process for determining test results in accordance with the Tender Specifications, applicable standards and industry best practices.

2 FUNCTIONAL GUARANTEE TESTS FOR SOLAR PV PLANT

Functional Guarantee for Solar PV Plant shall comprise of following Guarantees:

a) Performance Ratio Guarantee test for operational acceptance.

b) Annual Generation Guarantee up to a period of 25 years (O&M Period), starting from the date of Operational Acceptance.

2.1. PERFORMANCE RATIO GUARANTEE TEST

A Performance Ratio Guarantee test shall be commenced within 60 days of the commissioning of Plant Facilities to demonstrate that the plant has achieved the Guaranteed Performance Ratio in line with requirements under section VII of the bidding document. This will be one of the pre-conditions for the Plant Operational Acceptance. Performance Ratio (PR) test period would be continuous measurement of 30 consecutive days. The test shall be conducted in accordance with the IEC-61724 as per the methodology described in Technical Specifications under section VII of the bidding document. The procedure of PR test is described further in Section 2.4. The report shall contain all the measured energy and Met data values, calculations, results and conclusions.

2.1.1. Performance Ratio

The Performance Ratio (PR) of the PV Plant is calculated as follows (according to IEC 61724 Ed.2).

$$PR = \frac{E_{out}}{\sum_k \left(\frac{(C_k \times P_o) \times (G_{i,k} \times \tau_k)}{G_{i,ref}} \right)}$$

where

PR Temperature Corrected Performance Ratio

Eout Cumulative AC energy measured at the injection point (ABT meter) over the duration of reporting period (kWh)

τ_k Duration of the k^{th} recording interval, i.e. (1/60) hour

∑ Summation over all recording intervals in the reporting period, (1/4) hour

Ck Power rating temperature adjustment factor and can be calculated as below

Ck = 1 + γ x (Tavg_mod,k - Tref)

γ Temperature coefficient of power with negative sign ($°C^{-1}$)

$T_{avg\_mod,k}$ Average PV Module temperature measured at the commencement of time interval 'T_k' (°C)

Tref PV Module temperature at which Po is determined, i.e. 25°C

Po Installed nominal peak power of PV modules, i.e. Nameplate rating at STC (kWp)

$G_{i,}$ Average irradiance measured at the Plane of Array (POA) at the commencement of time interval τ_k (kW/m^2)

Gi,ref Irradiance value at which Po is determined, i.e. 1 kW/m^2

2.1.2. General Requirement

- The Functional Guarantee shall comprise of a set of visual/mechanical/Electrical checks followed by a Performance Ratio (PR) test of the Plant Facilities.
- The PR test shall be carried out for a period of 30 consecutive days at site by the Contractor in presence of the Employer/ Employer's Representative/ Owner's Engineer.
- These tests shall be binding on both the parties to the contract to determine compliance of the equipment with the guaranteed performance parameters.
- The test will consist of guaranteeing the correct operation of the Plant Facilities, by way of the performance ratio based on the reading of the energy produced and delivered to the grid (ABT meter) and the Plane of Array incident solar radiation.
- PR is calculated as per the formula given in Clause no. 2.1 and recorded as per the format provided at Annexure 1.
- The filled-in format shall be signed by both the parties (EPC Contractor and NMMC) and each party will keep one copy for record. The same will be recorded for 30 consecutive days.
- The Functional Guarantee condition for the purpose of Provisional Acceptance of the Plant Facilities shall be considered to have been met if the guaranteed Performance Ratio (PR) is achieved on a daily basis for 30 consecutive days* as per Clause 2.1.5 of this document.
- During this PR test, equipment failure/interruption of any kind, except for SCADA communication failures, will not be accountable. In case of a breakdown, the test may be resumed once the complete system is rectified and working properly.

  * Interruptions due to communication breakdown only may be exempted based on specific approval to the effect that generation is not affected and equipment failure (Refer Clause 2.1.5) is not attributable. In such case, the test shall be extended for affected no. of days (up to 5 days)

2.1.3. Pre-PR Test

2.1.3.1. The EPC Contractor shall perform start-up tests after successful completion of visual inspection and functional testing. Such testing shall be conducted under the NMMC's / Owner's Engineers supervision and recorded.

2.1.3.2. Preliminary Test Check

The preliminary checks include all the warranty certificates for the major equipment, pre -commissioning test reports, field quality checklists verified through the FQP documents of all equipment and works along with the calibration reports of all the instruments and sensors, wherever applicable**.**

2.1.3.3. Visual /Mechanical Test

Visual checks shall be done on all the components that form part of the plant including the grid connection equipment in compliance with the field quality plans. The following critical elements as a minimum shall be subjected to visual inspection:

- Module mounting structure and foundations.
- PV module and DC installation.
- Inverters.
- Transformers.
  Switchgear.
- Lightning protection systems.
- Earthing protection systems.
- Electrical protection systems, junction boxes and cabling.
- Grid connection compliance protection and disconnection systems.
- Monitoring systems (including meteorological sensors).

2.1.3.4. Electrical Tests

Subsequent to mechanical completion and visual testing of the plants, following functional electrical tests shall be performed. These tests also referred as start-ups tests shall be the first step for PG guarantee of the plant. These tests shall essentially include:

2.1.3.5. Open circuit voltage (VOC) test.

This test verifies that strings are properly connected (module and string polarity) and that strings are producing the expected voltage according to the module data sheet, as observed in the SCADA. If any abnormality is observed in the DC bus Voltage of SMU in SCADA, the following procedure shall be used:

a. DC string combiner box is opened; fuses leading to the sub main junction box are removed.
b. The voltage is measured with a calibrated, industry accepted instrument from the negative bus bar to the string positive lead.

2.1.3.6. Functional Guarantee Test shall commence immediately after all issues arising from the functional/ start-up test have been rectified.

Note:

a. All measurement(s) procedure should be carried out taking proper safety precaution.

b. Also it should be ensured that to avoid any loose connection at the terminal points for which measurement procedure is conducted.

c. Ensure proper functioning (e.g. Multimeters shall be calibrated) of all measuring instruments before conducting above measurement procedure.

d. The above test procedure shall be conducted in presence of site in-charge.

2.1.4. PR Test Procedure

2.1.4.1. The date of commencement of the PR Test shall be communicated in advance and agreed upon by both parties i.e. NMMC and EPC Contractor. Any consecutive 30 days period (excluding interruptions that last entire day on account of grid outage or as per hindrance record maintained at site only) for the purpose of conducting PR test shall be mutually discussed and agreed between MGCM and EPC Contractor. It shall comprise of the following procedures.

2.1.4.2. Pre-test Procedure

1. Before the commencement of Performance Ratio (PR) test, the plant shall have achieved visual/mechanical/Electrical completion as per Clause 2.3 above and SCADA system and WMS shall be fully commissioned and functional.
2. Trial Run: The PG Test for Plant Facilities shall commence with a trial run for 7 consecutive days. The EPC Contractor shall provide the data in requisite formats (specified elsewhere in the document) to NMMC. NMMC shall vet the data for any discrepancies and systemic errors and revert within 3 working days. Post the trial run period, the 30 days PR test will commence after communication from NMMC in this regard.
3. Pyranometer Tilt Angle & Cleanness: The pyranometers & Tilt Angle shall be verified before the test commences and then visually inspected at regular intervals for cleanliness during the tests.
4. The average of all the Pyranometers (GTI) shall be considered for the calculation of PR. The average of module temperatures recorded by all the temperature sensors shall be used for calculation of PR. The Pyranometers and Temperature sensors used for the purpose of the PR Test shall have valid calibration certificates.

2.1.4.3. Following the completion of the pre-test procedures, Performance Ratio Test of plant shall commence in accordance with the procedures, conditions and requirements provided in the next section.

2.1.4.4. General Procedure for the PR Test

The PR Test Procedure shall include the following components:

1. Data Collection: PV Power Plant test related parameters are collected in one-minute and 15 intervals for the 30 (Thirty) days (consecutive) reference period. The data shall consist of the following at a minimum:

- Irradiance at Collector's (i.e. PV Module) POA; (Source: SCADA, Temporal Resolution: 1 minute)
- Other Met Data received from installed WMS; (Source: SCADA, Temporal Resolution: 1 minute)
- Energy generated at Plant (kWh) (Source: Plant MFM Meter from SCADA, Temporal Resolution: 1 minute)
- Energy injected into grid (kWh) (Source: ABT Meter at GSS/injection point, Temporal Resolution: 15 minute)
- PV Module Temperature recorded from the temperature Sensors (oC) (Source: SCADA, Temporal Resolution: 1 minute)

2. Data Filtering: The data shall be filtered so that the data set is free of nuisance data points and bad data that exhibit a high degree of error (such as errors caused by faulty instrumentation). The EPC Contractor shall document data which is to be eliminated along with reasons. The following criteria shall be excluded from the dataset used for this test:

- Nuisance or bad data - Nuisance data points or bad data that clearly exhibit a high degree of error including required meteorological measurement equipment that is identified as being out of calibration or requiring adjustment. A 15-minute time-block shall be explicitly flagged through a flag parameter on account of this factor after recording reasons thereof (Note: no filtration shall be done at site level). The same shall be corroborated/verified by NMMC.
- Time blocks with insufficient (less than equal to 10) 1-minute records.
- Grid Interruptions - Time periods (in 15-minute time blocks) of the grid interruptions at the utility substation, recorded manually jointly by EPC Contractor and NMMC representatives shall be eliminated. Grid outage period, if any, shall be verified from SCADA.
- Any Force majeure conditions
- Radiation Criteria - Radiation on Plane of Array (POA) less than 200 W/m^2
- Shutdown explicitly demanded by the Owner/DISCOM/STU.
- As per the hindrance record maintained at site.

Note: Minimum 24 Nos of 15-minute time blocks shall be considered to account the day for PR measurement. Otherwise the PR test shall be extended to another day.

2.1.5. Determination of PR Test

Daily PR shall be calculated as the average of the PR calculated for valid 15-minute time blocks (Refer Clause 2.1.4.3) for the 30-day duration. If the ABT Meter data is not available on daily basis,

PR shall be calculated based on the MFM data and shared for record. However, at the end of the PR test period, the daily PR shall be re-calculated with the ABT Meter data

for sign-off.

If the If the EPC Contractor is not able to demonstrate guaranteed PR during this period, two more chances shall be given to demonstrate the same after incorporation of suitable corrective measures. In case the contractor fails to achieve guaranteed PR even after the two more chances, further action shall be taken as per the provisions of contract.

The test shall be repeated for 30 days in case of any outage of following equipment (as applicable) for more than 7 days.

- Power Transformer/Inverter Duty Transformer
- Power Conditioning Unit
- HT Switchgear Panel
- SCADA and data logger combined
- Tilted pyranometer
- Other WMS sensors.

2.1.6. Raw Data Formats and Reports

The EPC Contractor shall submit to NMMC the raw data from the Plant SCADA on daily basis in the following format.

Temporal Resolution: 1 Minute

Date & Time dd/mm/yyyy hh:mm:ss format	Wind Speed (m/s)	Module Temp. (°C)	Ambient Temp. (°C)	Horizontal Irradiance (W/m²)	POA Irradiance (W/m²)	POA Radiation (kWh/m²)	Humidity (%)	Wind Direction (°)	Generation (kWh) (Source:

Temporal Resolution: 15 Minute (Every 15th Min record from the 1 Min Data)

Date & Time Dd/mm/yyyy	Wind Speed (m/s)	Module Temp. (° C)	Ambient Temp. (° C)	Horizontal Irradiance	POA Irradiance (W/m²)	POA Radiation (kWh/m²)	Humidity (%)	Wind Direction (°)	Generation (kWh) (Source:	Explicit Removal Flag*	Remarks

* Explicit Removal Flag: 0 indicates time block considered; 1 indicates time block not considered.

PR Test Report shall be generated from the Raw Data (Sample Report provided in the Annexure) after data filtering as per criteria laid out in (2). The Report shall contain the signature of both representatives (NMMC/**Employer & EPC Contractor).**

2.2. CAPACITY UTILIZATION FACTOR (CUF)

Capacity Utilization Factor for Solar Plant shall be calculated as per the following formula.

$$\mathbf{CUF} = \frac{\mathbf{E_{ac}}}{\mathbf{8760 \times P_{ac} \times (1 - DF \times (N - 1)) x}\ RCF}$$

where,

Eac is the number of units recorded in the plant end ABT meter excluding auxiliary consumption during the operation year, kWh

8760 refers to the number of hours in non-leap year. It shall be replaced by 8784 hours during leap year

Pac is the plant AC capacity, kW

DF is module degradation factor, 0.7% per year

N is the number of years of operation after operational acceptance of the plant RCF is the Radiation Correction Factor:

RCF = $\frac{Ma - Iaiai}{}$, $Iaiai$

where Reference Irradiation (GHIref) = 1862 kWh/m^2 and Measured Irraditation (GHImes) shall be recorded from the Pyranometer installed in horizontal plane at the site location. The radiation data of the Pyranometer shall be compared with the Reference Irradiation mentioned above. The radiation data from the Plant Pyranometer shall be used for computation of CUF, except in case of any discrepancy (i.e. more than ± 10% variation from the Reference Radiation, GHIref), in which case the radiation data from the nearest available Solar Radiation Resource Assessment (SRRA) station data will be used for computation of CUF. Missing data (GHImes) from the Plant Pyranometer shall be substituted by average of GHI measured for the same period in the past three (3) days. The plant Pyranometer has to be under CCTV coverage.

CUF shall be calculated on annual basis from the date of operational acceptance of the plant till the end of O&M period. Module degradation factor will not be considered for first year CUF calculation. It is the Contactor's responsibility to envisage and install extra DC capacity to accommodate any degradation during first year. 0.7% per year will be considered from second year of operation. Grid outage hours shall be subtracted from total number of hours in a year. The Contractor shall submit grid outage certification from competent authority of STU/DISCOM.

ESTIMATE TO BE SUBMITTED IN DPR [SOR-2] [OPERATION AND MAINTENANCE]							
Design, Engineering, Supply, Construction, Erection, Testing, commissioning and O&M of 100 MW (AC) Floating Solar PV Power Plant at Middle Vaiterna Dam - NMMC							
Sl. No.	Description of Item	Year	PRICES (INR)				
			Yearly O&M Price (Excluding GST)	Total value of Applicable GST (in figures)	Yearly O&M Price including GST	Present Value Factor (PVF)	NPV of O&M Price
1	2	3	4	5	6=4+5		7 = 6* PVF
OPERATION & MAINTENANCE							
1	Operation and Maintenance of the Floating Solar PV Project for FIRST YEAR	1	INR 0.00		INR 0.00		INR 0.00
2	Operation and Maintenance of the Floating Solar PV Project for SECOND YEAR	2	INR 0.00		INR 0.00		INR 0.00
3	Operation and Maintenance of the Floating Solar PV Project for THIRD YEAR	3	INR 0.00		INR 0.00		INR 0.00
4	Operation and Maintenance of the Floating Solar PV Project for FOURTH YEAR	4	INR 0.00		INR 0.00		INR 0.00
5	Operation and Maintenance of the Floating Solar PV Project for FIFTH YEAR	5	INR 0.00		INR 0.00		INR 0.00
6	Operation and Maintenance of the Floating Solar PV Project for SIXTH YEAR	6	INR 0.00		INR 0.00		INR 0.00
7	Operation and Maintenance of the Floating Solar PV Project for SEVENTH YEAR	7	INR 0.00		INR 0.00		INR 0.00
8	Operation and Maintenance of the Floating Solar PV Project for EIGHTH YEAR	8	INR 0.00		INR 0.00		INR 0.00
9	Operation and Maintenance of the Floating Solar PV Project for NINTH YEAR	9	INR 0.00		INR 0.00		INR 0.00
10	Operation and Maintenance of the Floating Solar PV Project for TENTH YEAR	10	INR 0.00		INR 0.00		INR 0.00
11	Operation and Maintenance of the Floating Solar PV Project for ELEVENTH YEAR	11	INR 0.00		INR 0.00		INR 0.00
12	Operation and Maintenance of the Floating Solar PV Project for TWELTH YEAR	12	INR 0.00		INR 0.00		INR 0.00
13	Operation and Maintenance of the Floating Solar PV Project for THIRTEENTH YEAR	13	INR 0.00		INR 0.00		INR 0.00
14	Operation and Maintenance of the Floating Solar PV Project for FOURTEENTH YEAR	14	INR 0.00		INR 0.00		INR 0.00
15	Operation and Maintenance of the Floating Solar PV Project for FIFTEENTH YEAR	15	INR 0.00		INR 0.00		INR 0.00
16	Operation and Maintenance of the Floating Solar PV Project for SIXTEENTH YEAR	16	INR 0.00		INR 0.00		INR 0.00

17	Operation and Maintenance of the Floating Solar PV Project for SEVENTEENTH YEAR	17	INR 0.00		INR 0.00		INR 0.00
18	Operation and Maintenance of the Floating Solar PV Project for EIGHTEENTH YEAR	18	INR 0.00		INR 0.00		INR 0.00
19	Operation and Maintenance of the Floating Solar PV Project for NINTEENTH YEAR	19	INR 0.00		INR 0.00		INR 0.00
20	Operation and Maintenance of the Floating Solar PV Project for TWENTYTH YEAR	20	INR 0.00		INR 0.00		INR 0.00
21	Operation and Maintenance of the Floating Solar PV Project for TWENTY FIRST YEAR	21	INR 0.00		INR 0.00		INR 0.00
22	Operation and Maintenance of the Floating Solar PV Project for TWENTY SECOND YEAR	22	INR 0.00		INR 0.00		INR 0.00
23	Operation and Maintenance of the Floating Solar PV Project for TWENTY THIRD YEAR	23	INR 0.00		INR 0.00		INR 0.00
24	Operation and Maintenance of the Floating Solar PV Project for TWENTY FOURTH YEAR	24	INR 0.00		INR 0.00		INR 0.00
25	Operation and Maintenance of the Floating Solar PV Project for TWENTY FIFTH YEAR	25	INR 0.00		INR 0.00		INR 0.00
	TOTAL NPV OF O&M FOR 25 YEARS (1+2+3+4+5+6+7+8+9+10+11+12+13+14+15+16 +17+18+19+20+21+22+23+24+25)		**INR 0.00**		**INR 0.00**		**INR 0.00**

SCHEDULE OF CAPITAL INVESTMENT FOR MATERIALS, DIMENSIONS & WEIGHTS

OF MAJOR COMPONENTS OF EQUIPMENTS

(To be Filled-in by the Concessioner)

COMPONENT	MATERIAL	THICKNESS	STANDARD
SPV Panels			
Transformers			
Inverters/ power conditioners			
Floating / Floating platform / floaters			
Cables (Power & Communication)			
Switches/ circuit breakers /connectors			
Junction boxes / enclosures for inverters /charge controllers / luminaries			
Batteries			

The Concessionaire shall be responsible for disposal or recycle all material related to Floating Solar Plant & Hydro – Electric Plant after its useful life, waste, affluent during the entire Concession Term and after Expiry of Concession Period. The Concessionaire shall dispose all the material as mentioned in this clause within 60 (sixty) days from Expiry of Concession Term to meet its obligation under Clause 18.5, 18.7, 18.9 & 18.11.

TECHNICAL SPECIFICATION OF GRP CABLE MANAGEMENT SYSTEM

Project: Hydro Power & Floating Solar Combine Generation

Design Consultant: Tandon And Associates

Item:- GRP Cable management system is proposed for Hydro Power & Solar Combine Generation project. GRP non-metallic cable management system is proposed to have long - over 25 Years - of maintenance free life. All the support structure are also proposed to be of GRP (Non-metallic) which has high strength & corrosion resistance.

It is recommended that GRP material must have good flame retardant with very low smoke generation. Accordingly the following specification is proposed:-

Sr No	SPECIFICATION	STANDARD	
1	**Standard**	ERCON GRP Cable Tray to be manufactured as per NEMA FG1, 1993 standard.	
2	**Type**	GRP Perforated Type Cable Trays & Ladder Type Cable Trays	
3	**Resin**	Polyester	
4	**Standard Length**	3Mtr	
5	**Mfg. Process**	Pultrusion	
6	**Material**	Ultra Violet Resistant, Corrosion Resistant and Fire Retardant GRP	
7	**Coupler Plate**	GRP Coupler Plate	
8	**Support Structure**	GRP Strut Channel of 43x43 with SS316 Base Plate	
9	**Hardware**	SS316 Hardware	
10	**Color**	Grey	
11	**Glass Content**	Min. 60%	
12	**Radius**	**a)** 300mm For Perforated Cable Tray Fittings **b)** 600mm For Ladder Type Cable Tray Fittings	
13	**Rung Spacing for Cable Ladder**	300mm	
14	**Following Type test report from reputed government laboratories / international laboratories, IIT or NABL approved laboratories are required from manufacturer of GRP Cable Tray:-**		
a)	**Flame Spread and Smoke density index**	As per **ASTM E-84**, Meets Flame spread ≤ 25 and smoke density Index ≤ 200	
b)	**Fire Retardancy**	Class 1 as per BS 476 Part 7	
c)	**U.V. Resistance**	Test Report for weathering as per ASTM G-154 for 1000 Hours min. (Min. 10 Yr guaranteed life), with testing Flexural & Tensile strength test which shall not reduce by more than 7% after UV Exposure	
d)	**Toxicity Index & Zero Halogen**	As per NES 713 Toxicity Index < 1.0 & Halogen - NIL	
e)	**Coefficient of Thermal Expansion**	Not more than $8x10^{-6}$/°C	
15	**Perforated Cable Tray Sizes**	**Uniform Distribution Load**	**Max. Support Span**
a)	50mmW x 50mmH	7Kg/m	1.5 mtr
b)	100mmW x 50mmH	20Kg/m	1.5 mtr
c)	150mmW x 50mmH	30Kg/m	1.5 mtr
d)	300mmW x 80mmH	60Kg/m	1.5 mtr
e)	450mmW x 80mmH	75Kg/m	1.5 mtr
f)	600mmW x 80mmH	90Kg/m	1.5 mtr
16	**Cable Ladder Sizes**	**Uniform Distribution Load**	**Max. Support Span**
a)	150mmW x 100mmH	20Kg/m	1.5 mtr
b)	300mmW x 100mmH	60Kg/m	1.5 mtr
c)	450mmW x 100mmH	75Kg/m	1.5 mtr
d)	600mmW x 100mmH	90Kg/m	1.5 mtr
e)	900mmW x 100mmH	120Kg/m	1.5 mtr
17	**Approved Make**	Ercon Composites , Jodhpur	

TECHNICAL SPECIFICATIONS OF GRP GRATING, HAND RAILS & WALKWAY

Material of Construction	:	Non Metallic Heavy Duty UV Resistant, Fire Retardant, weather Resistant, Light Weight, High Strength and Saline Water Resistant, GRP Material
Project	:	Hydro Power & Floating Solar Combine Generation
Design Consultant	:	Tandon And Associates
Process	:	Pultrusion
Resin	:	Polyester Resin
Hardware	:	SS316
GRP Material Properties:- Type Test Reports Required along with tender otherwise tender will be loaded with 10% for each report. All type test reports must be from Govt. Institutions & international lab.		
U.V. Resistant	:	Type Test Report for weathering as per ASTM G154 for 2500 Hours (Equivalent to 25 Years) minimum with testing tensile strength test & flexural strength which shall not reduce by more than 10% after UV exposure.
Flame Spread and Smoke density index	:	Type test report as per ASTM E-84 meeting Flame Spread ≤25 & Smoke Density Index ≤200
Glow Wire Test	:	As Per IEC-60695 at 960^0 C, to prevent fire in case of welding nearby.
Toxicity Index & Zero Halogen	:	As per NES 713 Toxicity Index < 1.0 & Halogen - NIL
Fire Retardancy	:	As per BS476 Part 7 class-1
Fire Propagation Index	:	As per BS476 Part 6 of GRP material not more than the 8.5
Coefficient of Thermal Expansion	:	Not more than $8x10^{-6}$/°C
Water absorption		≤0.6% as per ASTM D570
Approved Make	:	Ercon Composites, Jodhpur
Routine Test:-		
1. Tensile Strength	:	Min 300 N/mm2 as per ASTM D-638
2. Flexural		Min 300 N/mm2 as per ASTM D-790
3. Flammability	:	As per UL 94 V0
4. Glass Content	:	Min. 65% as per IS-10661
Load & Dimensions of GRP Products		
1. GRP Gratings		

a. Construction Details	:	GRP Pultruded Grating of panel size 5 Mtr. (I-bar) x 1Mtr. (Cross Rod) in Polyester Resin of 50mm Height, I-Bar with inbuilt antiskid serrations with Spacing 60mm (Clear Opening 35mm) with Cross Rod at 150mm spacing.
b. Loading Criteria	:	500 kg/sqm load to be applied on largest span panel of min. 300mm width, up to 1.5 mtr. Span, with max. 6mm deflection as per BS-4592 Part 4 1992.
2. GRP Handrails		
a. Construction Details	:	Pultruded handrail consisting with top rail, mid rail & vertical post all of Ø50mm OD x Ø42mm ID GRP Round tube to fabricate handrail at site including top rail, mid rail & vertical posts having following accessories, as listed below:- a. Supply of Pultruded GRP Handrail tube having dia of 50mm OD x 42mm ID in 5Mtr. Length b. Supply of GRP Post base size of 200x100x120 (LWH) with inbuilt hole for bolting with M12 SS316 anchor fasteners/Bolt & Nuts, Fasteners to be included with supply c. Supply of SS316 side mount clamps with SS Fasteners for Ø50mm round post d. Supply of 90 degree split type Elbows with SS316 Fasteners, with 2 nos. of holes e. Supply of GRP Split type 3 way connector with SS316 Fasteners with 3 nos. of holes f. Supply of GRP Split type 4 Way connector with SS316 Fasteners, with 4 Nos. of holes g. Supply of GRP Kick plate of Ω Shape size of 80mmW x 3000mmL x 3mmT along with SS316 Fasteners h. Supply of GRP Straight Coupler Set
b. Loading Criteria	:	500 kg/sqm load to be applied on largest span panel of min. 300mm width, up to 1.5 mtr. Span, with max. 6mm deflection as per BS-4592 Part 4 1992.
3. GRP Walkway		
a. Construction Details		GRP Walkway is to be constructed using GRP grating & GRP Hand rails of above specifications & GRP support structure using Pultruded Channel, Beam, Angle, Pipe profiles having same material properties as above specifications & all hardware to be used should be of SS316 MOC.
b. Loading Criteria		The Walkway should be designed to withstanding load of min. 300kg/sqm.

TECHNICAL SPECIFICATION OF GRP SOLAR STRUCTURE

Project: Hydro Power & Floating Solar Combine Generation

Design Consultant: Tandon And Associates

Item:- The structural support member for supporting solar panels on top of floating pontoons must be made of light weight & non corrosive GRP (Fiber Glass Structure) profile as per below specifications:-

Sr No	SPECIFICATION	STANDARD
1	**Item**	Light weight GRP Solar Structure for fixing on floating Pontoons
2	**Profile Size**	Main Support Structure should be fabricated from GRP strut channel size 41x41 with provision of sliding SS spring Nut for fixing the panels.
		Other profile such as GRP Angle tubes, channel Section may be used as per design & strength requirements.
3	**Resin**	Polyester
4	**Mfg. Process**	Pultrusion
5	**Material**	Ultra Violet Resistant, Corrosion Resistant and Fire Retardant GRP
6	**Hardware**	SS316 Hardware
7	**Color**	Grey
8	**Glass Content**	Min. 60%
9	**Following Type test report from reputed government laboratories / international laboratories, IIT or NABL approved laboratories are required from manufacturer of GRP Solar Structure:-**	
a)	**Flame Spread and Smoke density index**	As per **ASTM E-84**, Meets Flame spread ≤ 25 and smoke density Index ≤ 200
b)	**Fire Retardancy**	Class 1 as per BS 476 Part 7
c)	**U.V. Resistance**	Test Report for weathering as per ASTM G-154 for 1000 Hours min. (Min. 10 Yr guaranteed life), with testing Flexural & Tensile strength test which shall not reduce by more than 7% after UV Exposure
d)	**Toxicity Index & Zero Halogen**	As per NES 713 Toxicity Index < 1.0 & Halogen - NIL
e)	**Coefficient of Thermal Expansion**	Not more than $8x10^{-6}$/°C
10	**Approved Make**	Ercon Composites , Jodhpur

SECTION – C – A – TECHNICAL SPECIFICATIONS CIVIL WORKS

TECHNICAL SPECIFICATIONS FOR CONSTRUCTION POWER HOUSE, TAIL POOL, RISING APPRON & ANCILIARY WORKS

Contents

CHAPTER - 1 315

INTRODUCTION AND SCOPE OF WORK 315

1.1 INTENT OF TECHNICAL SPECIFICATIONS 315

1.2 SCOPE OF WORK 315

1.3 TESTS FOR MATERIAL / WORKMANSHIP 316

1.4 SPECIFICATIONS FOR WORK, QUALITY AND WORKMANSHIP 316

1.5 LAYOUT AND LEVELS 316

1.6 CONSTRUCTION METHODS 317

1.7 GENERAL 317

1.8 CONSTRUCTION METHODOLOGY 317

1.9 PERTINENT CONDITIONS OF CONTRACT 318

1.10 POWER SUPPLY 318

1.11 WATER SUPPLY 319

1.12 WATCHING AND LIGHTING 319

1.13 CONSTRUCTION PLANT 319

1.14 CLEARING UP DURING PROGRESS AND DELIVERY 319

1.15 SCAFFOLDING 320

1.16 SCOPE OF RATES QUOTED IN BILL OF QUANTITIES 320

1.17 PROTECTION OF ADJOINING AND EXISTING PREMISES 320

CHAPTER - 2 321

PROPERTIES, STORAGE & HANDLING OF COMMON CONSTRUCTION MATERIALS 321

2.1 SCOPE 321

2.2 MATERIALS 321

2.3 STORAGE & HANDLING OF MATERIALS 323

2.4 BRICKS 324

2.5 STONES 324

2.6 CEMENT 324

2.7 COARSE AND FINE AGGREGATE 324

2.8 STEEL 324

2.9 ENGINEER'S AUTHORITY TO REJECT MATERIALS 324

CHAPTER - 3 325

BACKFILLING 325
3.1 SCOPE 325
3.2 GENERAL REQUIREMENT 325
3.3 MEASUREMENTS AND PAYMENTS 326
CHAPTER - 4 327
DRILLING AND ANCHORING 327
4.1 SCOPE 327
4.2 PAYMENT 327
CHAPTER - 5 328
CEMENT CONCRETE 328
5.1 LIST OF APPLICABLE INDIAN STANDERED SPECIFICATIONS: 328
5.2 GENERAL 330
5.3 SCOPE 330
5.4 DEFINITIONS 331
5.5 COMPOSITION OF CONCRETE 331
5.6 CONCRETE AND CONCRETE CONSTITUENTS 331
5.7 CEMENT 332
5.8 TRANSPORTATION OF CEMENT 332
5.9 STORAGE 332
5.10 AGGREGATES - GENERAL 332
5.11 FINE AGGREGATES 333
5.12 COARSE AGGREGATES 333
5.13 AGGREGATE STORAGE 334
5.14 WATER 334
5.15 CONCRETE MIX DESIGN 334
5.16 MINIMUM CEMENT CONTENT 335
5.17 PRODUCTION OF CONCRETE: 335
5.18 MIXING: 336
5.19 WORKABILITY: 336
5.20 SLUMP TEST TO CHECK WORKABILITY: 336
5.21 QUALITY CONTROL 337
5.22 TEMPERATURE OF CONCRETE 337

5.23 CONVEYING 338
5.24 PLACING - GENERAL 338
5.25 PREPARATION FOR PLACING 339
5.26 PLACING AND COMPACTING CONCRETE 339
5.27 PARTS EMBEDDED IN CONCRETE 340
5.28 FINISHING OF CONCRETE 340
5.29 CURING AND PROTECTION OF CONCRETE 341
5.30 CONSTRUCTION JOINTS 341
5.31 REPAIR OF CONCRETE 342
5.32 MEASUREMENT AND PAYMENT 344
CHAPTER - 6 345
CONCRETE ADDMIXTURES AND WATER STOPS 345
6.1 GENERAL REQUIREMENTS 345
6.2 MATERIALS AND APPLICATION 345
6.3 TECHNICAL SPECIFICATION FOR WATER PROOFING CEMENT ADDITIVE 345
6.4 WATER STOPS 346
CHAPTER - 7 349
FORMWORKS 349
7.1 GENERAL 349
7.2 CLEANING AND TREATMENT OF FORMS 350
7.3 REMOVAL OF FORMS 350
7.4 TOLERANCE IN FINISHED CONCRETE 352
7.5 RE-USE OF FORMS 352
7.6 CLASSIFICATION OF FORM WORK 352
7.7 ACCEPTANCE OF FORMWORK AND FINISHED CONCRETE 353
7.8 METHOD OF MEASUREMENT AND PAYMENT 353
CHAPTER - 8 354
REINFORCEMENT 354
8.1 SCOPE: 354
8.2 LIST OF IS CODES: 355
8.3 STEEL REINFORCING BARS 355
8.4 MATERIAL 356

8.5 CUTTING, BENDING AND BINDING OF REINFORCEMENT. 356
8.6 SPLICING 357
8.7 PLACING OF REINFORCEMENT 358
8.8 COUPLING OF BARS 359
8.9 CARE OF PLACED REINFORCEMENT AND CONCRETE 360
8.10 TOLERANCES 360
8.11 DOWELS 360
8.12 MEASUREMENT AND PAYMENT: 360
CHAPTER - 9 361
FABRICATION AND ERECTION OF STRUCTURAL STEEL WORKS 361
9.1 SCOPE: 361
9.2 CODES AND STANDARDS 361
9.3 FABRICATION AND ERECTION OF STRUCTURAL STEEL: 365
9.4 DESIGN OF CONNECTIONS 366
9.5 SPLICING 367
9.6 FABRICATION 367
9.7 WELDING 369
9.8 ELECTRODES 370
9.9 EDGE PREPARATION FOR WELDING 371
9.10 PRE HEATING AND POST HEATING 371
9.11 WELDING SEQUENCE 372
9.12 TESTING OF WELDERS 373
9.13 PRODUCTION TEST PLATE 374
9.14 RECTIFICATION AND CORRECTION 374
9.15 CORRECTION OF DEFECTIVE WELDS 374
9.16 PRIMER PAINTING 374
9.17 ERECTION AND ALIGNMENT 375
9.18 EMBEDDING IN CONCRETE 375
9.19 PROTECTION AGAINST DAMAGE IN TRANSIT 376
9.20 STABILITY OF STRUCTURES 376
9.21 TEMPORARY STRUCTURES 376
9.22 SETTING COLUMN BASES 376

9.23 ALIGNMENT 376
9.24 HIGH PERFORMANCE PAINTING SYSTEM 377
9.25 PREPARATION OF SURFACE 377
9.26 APPLICATION OF PAINT 377
9.27 ACCEPTANCE CRITERIA 378
9.28 ELECTRO FORGED STEEL GRATINGS 378
9.29 FABRICATION DRAWINGS 379
9.30 FABRICATION 379
9.31 ERECTION, ALIGNMENT AND INSTALLATION: 379
9.32 PAINTING 380
9.33 GALVANIZATION 380
9.34 PERMANENT BOLTS, NUTS AND WASHERS 381
9.35 PERMANENT MILD STEEL WASHERS 381
9.36 PERMANENT HIGH STRENGTH STRUCTURAL BOLTS 381
9.37 HIGH STRENGTH STRUCTURAL NUTS 382
9.38 WASHERS FOR HIGH STRENGTH STRUCTURAL BOLTS AND NUTS 382
9.39 INSTALLATION 382
9.40 DISMANTLING 382
9.41 ADDITIONS TO, ALTERATIONS IN AND / OR MODIFICATION 382
9.42 ADDITIONS TO, ALTERATIONS IN 382
9.43 RE-ERECTION OF ERECTION MARKS AFTER ADDITIONS, ALTERATIONS AND MODIFICATIONS 383
CHAPTER - 10 384
BRICK MASONARY WORK 384
10.1 SCOPE 384
10.2 LIST OF IS CODES APPLICABLE: 384
10.3 MATERIALS 385
10.4 MORTAR 386
10.5 BRICK MASONRY 386
10.6 Pointing of the Brick Work 387
10.7 Scaffolding 388
10.8 Curing and Protection 388

10.9 Embedment of Reinforcement anchorages 388
10.10 Embedding of Fixtures 388
10.11 METHOD OF MEASUREMENT AND PAYMENT 388
CHAPTER - 11 389
PLASTERING AND POINTING TO MASONARY AND CONCRETE 389
11.1 SCOPE 389
11.2 GENERAL : 389
11.3 INSTALLATION 389
11.4 PLASTERING 390
11.5 Mortar 390
11.6 APPLICATION OF PLASTER 390
11.7 CURING 391
11.8 WATER PROOFING ADMIXTURES 391
11.9 FINISH 391
11.10 Standard Finish 391
11.11 Neat Cement Finish 391
11.12 Rough Cast Finish 391
11.13 ACCEPTANCE CRITERIA 392
11.14 RATES 392
11.15 METHOD OF MEASUREMENT AND PAYMENT 392
11.16 I.S. CODES 392
CHAPTER - 12 393
FLOOR FINISH AND ALLIED WORKS 393
12.1 SCOPE 393
12.2 Base 393
12.3 Sequence 393
12.4 INSTALLATION 393
12.5 IN-SITU FINISHES 394
12.6 TILED FINISHED 395
CHAPTER - 13 401
CORRUGATED GALVANIZED STEEL SHEET ROOFING 401
13.1 SCOPE 401

13.2 CORRUGATED GALVANIZED STEEL (C. G. S.) SHEETS 401
13.3 PURLINS 401
13.4 SLOPE 401
13.5 LAYING AND FIXING 401
13.6 WIND TIE 403
13.7 FINISH 403
13.8 MEASUREMENT 403
13.9 RATE 403
CHAPTER - 14 404
METALS DOORS, WINDOWS, VENTILATORS AND LOUVERS 404
14.1 SCOPE 404
14.2 INSTALLATION 404
14.3 FABRICATION OF STEEL DOORS, WINDOWS, VENTILATORS, LOUVERS ETC. 405
14.4 FABRICATION OF ALUMINIUM DOORS, WINDOWS, FRAMES ETC. 405
14.5 SHOP COAT OF PAINT 406
14.6 HANDLING AND STORAGE OF FABRICATED MATERIALS 406
14.7 ASSEMBLY AND ERECTION AT SITE 406
14.8 ACCEPTANCE CRITERIA 407
14.9 INFORMATION TO BE SUBMITTED 408
14.10 RATES 408
14.11 METHOD OF MEASUREMENTS 408
14.12 ROLLING STEEL SHUTTERS / GRILLS 409
14.13 Manually Operated Shutters/Grills 409
14.14 Shop Coat 410
14.15 Acceptance Criteria 410
14.16 Rates 410
14.17 Measurement 410
14.18 I.S. CODES 410
CHAPTER - 15 411
GLASS AND GLAZING 411
15.1 SCOPE 411
15.2 INSTALLATION 411

15.3 MATERIALS 411
15.4 GLAZING SETTING AND FINISHING 411
15.5 ACCEPTANCE CRITERIA 412
15.6 RATES 412
15.7 MEASUREMENT& PAYMENT 412
CHAPTER - 16 413
STEEL HAND RAILING 413
16.1 SCOPE OF WORK FOR STEEL HAND RAILING 413
16.2 Fabrication and Fixing 413
16.3 Measurement and Payment 413
CHAPTER - 17 414
PAINTING 414
17.1 SCOPE 414
17.2 EPOXY PAINTING (SUBMERGED STRUCTURE) 414
17.3 Measurement and Payment 416
CHAPTER - 18 417
STONE PITCHING AND STONE MASONARY 417
18.1 STONE MASONRY 417
18.2 Measurement and Payment 417
18.3 R. R. MASONRY 418
CHAPTER - 19 420
WIRE CRATES (GABBIONS) 420
19.1 SCOPE 420
19.2 MATERIAL 420
19.3 EXECUTION OF WORK 420
19.4 MEASUREMENT AND PAYMENT 421

CHAPTER - 1

INTRODUCTION AND SCOPE OF WORK

1.1 INTENT OF TECHNICAL SPECIFICATIONS

1.1.1. These General Technical Specifications (hereinafter called GTS) give general information about excavation, masonry, concrete, steel, construction materials and general requirements and cover the specifications and regulations for all work included in the contract documents as well as the conditions for measurements and payments.

1.1.2. These specifications are part of the requirements for various items related to the works, which 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 bidding documents issued for the works. Addenda to these specifications may be issued, as required, during bidding, which will form part of these specifications.

1.1.3. These specifications shall be read in conjunction with the General & Special Conditions of Contract, the drawings and the Bill of Quantities (BOQ) enclosed with the Bid Documents. While quoting the price, the Contractor shall comply with all provisions contained within the bidding documents and instructions of the Engineer.

1.1.4. It is the intent of these specifications, together with other relevant documents issued as part of the bidding documents or to follow later on, to provide the Contractor with complete and detailed information and subsequent instructions necessary to enable him to submit a well planned bid and to execute properly the works prescribed.

1.1.5. It is the intent of these specifications to establish acceptable standards of quality. Minor deviations in details due to manufacture's standard shop process will be considered for acceptance provided that, in the opinion of the Engineer, the proposed substitutions are equal or better in quality to those specified.

1.1.6. All works shall be executed according to the drawings issued / approved by the Employer or his Consultants for construction, in a professional and diligent manner and all supplies and works shall comply with the quality requirements defined in the relevant sections of these specifications and other bidding documents. The Contractor shall endeavor to provide all such necessary efforts in order to comply with the intent of these specifications to the satisfaction of the Engineer.

1.2 SCOPE OF WORK

1.2.1. The work to be performed under this specification shall include the execution of the work including providing all labour, construction materials, shuttering & scaffolding, gantries of concrete lining of tunnels & underground structures, Petrol Oil Lubricants (POL), construction equipment, DG sets of adequate capacity capable of supplying required power for operating various machinery, concrete batching & mixing plant, dewatering pumps, lighting the project areas for three shift working, tools and plants, supplies including supply of spare parts of Contractor's equipment etc., transportation, all incidental items not shown or specified but reasonably implied or necessary for successful completion of the works including Contractor's supervision in strict accordance with the drawings and Technical specifications and as directed by the Engineer.

1.2.2. The work shall generally involve open shallow and deep excavation in all types of soil mixed with Boulders, medium and hard rock requiring and not requiring blasting, shoring, sheet piling, strutting, transportation, backfilling with available excavated earth and / or sand-gravel mixture / sand around completed structures, plinth filling, disposal of surplus muck, concreting including reinforcement and form work, gantry girders & roof trusses in powerhouse, providing necessary steel embedment, embedment anchorages of pipes, turbines, generators, valves, gates, cranes, etc. and other inserts, brick masonry, plastering and architectural surface finishes, flooring including acid-proof flooring for battery room of powerhouse, construction of sumps, civil works of switchyard structures, bridge/ culvert, abutments, etc., supply, erection finishing of doors, windows, louvers, rolling shutters and horizontal sliding doors, miscellaneous floors, paving, skirting, dado and wall finish, steel structures, painting of steel surfaces, false ceiling, glass and glazing, roof insulation, waterproofing on roofs, water tank, water supply piping from supply point to the fixtures, drainage line up to the nearest disposal point as directed and sanitary work complete with soil lines, septic tanks, etc. all complete as per details and specifications.

1.2.3. It may be noted that while each area will be handed over to the Contractor as it exists on the site, the Employer does not take the responsibility of providing the area other than shown in the tender drawings.

1.3 TESTS FOR MATERIAL / WORKMANSHIP

All tests required for all materials, quality of workmanship or any other tests as desired by the Engineer shall be at Contractor's cost. Quality of workmanship shall be as per relevant IS Codes and to the satisfaction of the Engineer. For this purpose, the Contractor shall set-up a well-equipped quality control laboratory at the project site at his own cost, meeting the requirements of relevant Indian Standard Codes and as acceptable to the Engineer.

1.4 SPECIFICATIONS FOR WORK, QUALITY AND WORKMANSHIP

The specifications are intended for the general descriptions of the works, quality and workmanship. The specifications are not, however, intended to cover the minute details and the work shall be executed according to the relevant Indian Standard Codes. Alternatively, the work shall be executed according to the best prevailing local Public Works Department Practices or to the recommendations of relevant American and British Standards or as per the instructions of the Engineer.

Wherever reference to Indian Standard Codes and practices is made, they shall be referred to the latest edition / revision of the same, issued up to Seven (7) days prior to the date of opening of this tender.

The Bidder is expected to get clarified any doubts about the technical specifications etc. during the pre bid conference before submitting his bid, in writing with the Employer in respect of interpretation of any portions of these Documents.

1.5 LAYOUT AND LEVELS

The layout and levels of all structures, etc. shall be made by the Contractor at his own cost from the general grid of the plot and bench marks given by the Engineer. The Contractor shall also give all help in the form of instruments, materials and men to the Engineer for checking the detailed layout and correctness of the layout and levels, at his own cost.

Irrespective of the checking by the Engineer, the Contractor shall remain solely responsible for correctness of layout and levels.

1.6 CONSTRUCTION METHODS

The Bidder shall submit drawings, Work Programme, Schedules, Proforma for Quality Control, periodical progress reports etc., list of construction equipment to be deployed and a write-up to indicate in a broad outline how he intends to execute the work. These shall form part of his Bid.

1.7 GENERAL

The general layout drawings indicate the locations and approach paths, which are available up to the dam, intake towers, portal for the tunnels, the powerhouse, the tail pool, cut & cover and tailrace channel. However, it may be noted that while each area will be handed over to the Contractor, as it exists on the site, the Employer does not take the responsibility of providing the area other than shown in the tender drawings. Further, the responsibility of modifying / strengthening of the approaches to various components of the project, if considered necessary by the Contractor, lies solely with the Contractor himself. The Bidders are strongly advised to visit the project site before bidding to ascertain the existing approaches to various components of the project.

1.8 CONSTRUCTION METHODOLOGY

1.8.1. General

The construction programme of a hydroelectric project involves the planning, management of personnel, material, equipment and financial resources, strict adherence to time schedule and foresightedness. The entire work should be divided into different planned activities to manage efficiently for their timely completion. The inter-phasing between different activities should be carefully identified and monitored. The practical hindrances and unavoidable shortfalls should be critically examined and carefully monitored to overcome any bottle necks. All the different activities should be assigned their due share of importance in over all construction and management of the scheme. The Employer expects that the Contractor shall follow the above mentioned philosophy for timely completion of the construction activities of Gosikhurd H.E. Project

1.8.2. Working Period

MVD H. E. Project is located in an area of heavy rainfall, bulk of which occurs during the months of June, July, August and September. Temperatures are moderate during the winter months of December, January and February whereas summer months are very hot. Keeping the above in view, construction of MVD H. E. Project has been planned in such a manner that works does not suffer on account of adverse weather conditions during the monsoon months.

1.8.3. Construction Schedule

Taking into account the volume of work involved and the constraints imposed due to heavy rainfall, an innovative work schedule has been evolved by the Project Consultants to ensure project completion within 18 months period.

The main civil works include construction of approach channel, intake towers, deep seated powerhouse & tail pool, rising apron of tail race, transition to TRC, cross over bridge and the

switchyard. These shall be constructed using required machinery and by deploying required labour force.

1.8.3.1 Main Civil Works

The general arrangement drawings show the scope of work.

1.9 PERTINENT CONDITIONS OF CONTRACT

1.9.1. As mentioned earlier, MVD H. E. Project lies in the remote areas of Maharashtra. The Employer shall, in no way, be held responsible for any loss suffered by Contractor in respect of material, machinery equipment or human life.

1.9.2. All construction material including cement, reinforcement steel (TMT bars), structural steel members, coarse & fine aggregate, bricks, boulders, wires, rock bolts including their accessories, door & window frames including their glass panes, fixtures etc., all paints, polishes, distempers etc., all shuttering & form work including gantries required for tunnel lining etc. shall be procured, arranged, transported to site and stored by the Contractor at his own cost.

1.9.3. The quantities of various works mentioned in the BOQ are tentative and may vary from + 30% to - 30% of the indicated values. The Contractor shall quote his rates taking into consideration the above-mentioned variation in quantities. No extra claim whatsoever shall be entertained by the Employer on account of variation in quantities of work within the above mentioned limits.

1.9.4. The Employer and the Contractor shall mutually resolve the following thru' discussions / negotiations:

- Payment of Extra / Substituted Items, if any, which are not covered in the BOQ but are necessary for completion of works.
- Adjustment of rates if quantities vary beyond the limits stipulated in Para 1.9.3 above.
- Payment of analogous & substituted items, if any and as necessary as per requirementsof the Project.

1.10 POWER SUPPLY

1.10.1. For construction power and power for colonies, the contractor will be permitted to draw power from the transformer and or DG set to be erected near dam site.

1.10.2. He has to lay all internal lines from the distribution board/s at his own cost and he should bear the cost of power consumption as per bills of electricity authority or as specified.

1.10.3. The contractor shall satisfy all the conditions of rules required as per Indian Electricity Act 1910 and under rule 45 (i) of the Indian Electricity rules 1956 as amended from time to time and other pertinent rules.

1.10.4. The power shall be used for bonafide works only

1.10.5. The contractor shall take all precautions to ensure safety to the workers. The owner will not take any responsibility for any accidents that may occur on the Contractor's installations.

1.10.6. The contractor shall take action to rectify the defects if any in the installations pointed out by

the owneral Engineers in a reasonable time.

1.10.7. The following particulars should be furnished in quadruplicate by the Contractor to the employer before the power is released to the equipment.

1.10.8. A schematic diagram of the installation from the point of commencement of supply to the points of utilization showing therein the various electrical equipment, switch gear, cables with their sizes etc.,

1.10.9. Transformer sub station's drawings.

1.10.10. Layout plan indicating there in the position of motors and other electrical equipment, their switch gear and earthing arrangements. The contractor shall give the particulars of his power load, if so desired by the Engineer and he shall make necessary arrangements for the Engineer to check these loads if so desired. The total power requirements and the percentage of diesel power proposed to be engaged by the Contractor out of this total power requirement shall be furnished by the Contractor.

1.10.11. The owner is not responsible for any sort of power failures and power break down etc. and no compensation of any kind will be paid by the owner on account of such failures and no extension of time will be granted under such reasons.

1.11 WATER SUPPLY

It is the responsibility of the Contractor to make own arrangements for water supply for work and labour and drainage from the work site, at his own cost. But the contractor has to lay pumping line from available water source to site and colony at his own cost. The pumps have to be installed by him at his own cost and pumping charges will be borne by him. The distribution system, measures for purification of water, shall be the responsibility of the Contractor and shall be in accordance with rules and regulations of the Public Health Department. No compensation will be allowed to the Contractor on this account.

1.12 WATCHING AND LIGHTING

The Contractor shall in connection with the works provide and maintain at his own cost all lights, guards, fencing and watching when and wherever necessary or required by the Engineer or Engineer's Representative, or by any duly constituted authority for the protection of the work, or for the safety and convenience of the public or others.

1.13 CONSTRUCTION PLANT

The Contractor shall provide and install all necessary construction tools and plant, equipment, machinery and shall use such methods and appliances for the performance of all the operations connected with the work embraced under the contract as will secure a satisfactory quality of work and rate of progress which will ensure the completion of the work within the time specified.

1.14 CLEARING UP DURING PROGRESS AND DELIVERY

All rubbish shall be cleared and put in a thoroughly complete, clean, sound and workman like state to the satisfaction of the Engineer before the work is finally handed over. All rubbish and surplus materials not required shall be removed by the

Contractor. The Contractor is responsible for its maintenance until it is taken over by the Owner.

1.15 SCAFFOLDING

All requisite scaffolding shall be provided at the Contractor's expense and shall be double i.e. it must have two sets of upright supports. Care shall be taken to ensure the safety of the work people and the Contractor must comply with such instructions as the Engineer may issue to ensure such safety. The Contractor will be entirely responsible for any damage or injuries to persons or property resulting from ill-erected scaffolding, defective ladders, or otherwise arising of his fault in this respect.

1.16 SCOPE OF RATES QUOTED IN BILL OF QUANTITIES

The Contract unit rates or Bid Price in Bill of Quantities for different items of the work shall be payment in full for completing the work as per the drawings and to the requirements of the specifications including full compensation for all the operation detailed in the relevant sections under measurement and payment. The rates of the Bid are to be considered as the full inclusive rate for finished work covering all labour materials, transport, wastage, temporary work, plant, over head charges, and toll fee, seignorage charges, all kinds of taxes, octroi and expenses imposed by out side authority such as local body as well as the general liabilities, obligations and risks arising out of the General Conditions of the Contract.

1.17 PROTECTION OF ADJOINING AND EXISTING PREMISES

The contractor shall protect the whole of the adjoining and existing premises, and all works and all fittings to all Buildings and adjoining the site against structural and decorative damages caused by the Execution of these works and make good in all respects all such damage done or occurring to the same, and leave such reinstatement in perfect order. He is also to make good any damage done in the execution of the work, the existing public or private property, foot ways and road ways, other over head power lines or Telecommunication lines

CHAPTER - 2

PROPERTIES, STORAGE & HANDLING OF COMMON CONSTRUCTION MATERIALS

2.1 SCOPE

The scope of this chapter covers the properties, storage & handling of common construction materials unless otherwise mentioned in drawings or Bill of Quantities.

2.2 MATERIALS

2.2.1. Bricks

- Bricks for general masonry work shall conform to IS: 1077 and for face brick workshall conform to the specifications in IS: 2691.
- Bricks for general masonry work shall be well burnt, of uniform size, shape and colour, free from cracks, flaws or nodules of free lime and emit clear ringing sound when struck. Bricks shall be of uniform deep red cherry or copper colour, thoroughly burnt without being verified.
- Fractured surface shall show uniform texture free from grits, lumps, holes etc. Compressive strength shall correspond to class designation 75 as per IS: 1077 giving minimum compressive strength of 75 kg/cm2 for general masonry work. Water absorption after 24 hours immersion shall not exceed 20% by weight for common bricks and 15% for face bricks. Dimensional tolerance shall not exceed 8% of the size mentioned in drawings for common bricks and 3% for face bricks. All bricks shall have rectangular faces and sharp straight edges. Maximum permissible chippage for face bricks shall be 6 mm at the edges and 10 mm for corners. The bricks shall show no efflorescence when soaked in water and dried under shade.
- Each brick shall have the manufacturer's identification mark clearly marked on the frog.
- Representative samples shall be submitted to the Engineer for approval before bulk purchase. The representative samples shall be retained by Engineer for future comparison and reference. The colour and texture of face bricks shall be limited to the range of samples submitted. Any brick not found up to the satisfaction shall be removed immediately from site at the Contractor's own cost.

2.2.2. Stone

All stones shall be from approved quarries, hard, tough, durable and compact grained uniform in texture and colour and free from decay, flaws, veins, cracks and sand holes. The surface of a freshly broken stone shall be bright, clean and sharp and shall show uniformity of texture, without loose grains and free from any dull, chalky or earthy appearance. Stones showing stained colours shall not be used for face work. A stone shall not absorb more than five percent (5%) of its weight of water after 24 hours immersion. The type of stone shall be as specified on drawings and/or instructed by the Engineer. Samples shall be submitted by the Contractor and approved samples shall be retained by the Engineer for comparison of bulk supply.

All material coming out from excavation shall be deposited in stacks as desired by the Engineer. In case any material is found useful for construction, the same shall be used but only after obtaining necessary permission from concerned authorities.

2.2.3. Cement

Ordinary Portland Cement of Grade 43 conforming to IS: 269 (latest revision) procured from reputed Manufacturers (subject to Employer's approval) shall be used. Contractor shall satisfy himself at the time of taking delivery that the quality, quantity and freshness of cement are up to the specified standards. As soon as the cement is received in the project store the Contractor shall arrange for sampling and testing the same at laboratory as approved by the Engineer and send the results to the Engineer duly indicating the type, brand, quantity in each consignment, date of receipt and any other information required by the Engineer. No cement shall be used until notice has been given that test results are satisfactory. Adequate stock of tested and approved cement shall be maintained in the Contractor's stockyard at all time during the contract period.

2.2.4. Coarse Aggregates

- Coarse aggregates shall be as per IS: 383 consisting of hard, strong, dense and durablepieces of crushed stone, having angular shape & rectangular surface and shall be free from organic or clay coatings and other impurities like disintegrated stones, soft flaky particles, adherent coatings, clinkers, slag, mica and any other materials liable to affect the strength, durability or appearance of concrete. The amount of different undesirable constituents in coarse aggregates shall not exceed the percentage limits by weight as specified in relevant IS code but in no case the total amount of all the undesirable substances shall exceed 5%.
- Aggregate other than crushed stone conforming to the provisions of this specification may be used if permitted by the Engineer.
- Washing of aggregates by approved means and approved quality of water shall be carried out, if desired by the Engineer, at no extra cost to the Employer.
- Grading of coarse aggregates shall generally conform to IS: 383 and shall be such as to produce a dense concrete of the specified proportions and strength and of consistency that will work readily into position without segregation.
- The maximum size of aggregate shall be 40 mm unless specified otherwise or as directed by Engineer.
- Samples of aggregates proposed to be used shall be submitted free of cost in sufficient quantities to the Engineer with sieve analysis data for his approval. Approved samples will be preserved by Engineer for further reference. This approval will not in any way relieve the Contractor of his responsibility of producing concrete of specified quality and strength.

2.2.5. Fine Aggregate (Sand)

- Sand shall be hard, durable, clean and free from adherent coatings or organic matter and shall not contain clay balls or pellets. The sand shall be free from impurities such as iron pyrites, alkalis, salts, sulphates, coal, mica, shale or other laminated materials, in such forms or quantities as to affect adversely the hardening, strength, durability or appearance of mortar, plaster or concrete or to cause corrosions to any metal in contract with such mortar, plaster or concrete. In no case the cumulative percentage of impurities in sand shall be more than 5% by weight. Samples of sand proposed to be used shall be submitted by the Contractor free of cost in sufficient quantities to the Engineer with sieve analysis for his approval. Approved samples will be preserved by Engineer for further reference. Sand shall be washed with water before use if directed by Engineer. All sand shall be properly graded. Unless otherwise directed by the Engineer, all sand shall pass through IS sieve No. 240 and fifteen percent (15%) to Thirty Five percent (35%) of sand for masonry mortar and Five percent (5%) to Fifty percent (50%) of sand for plaster shall pass through IS sieve No. 30. Sand for concrete shall conform to IS: 383. Fineness modulus shall not vary by more

than plus or minus 0.20 from that of the approved sample.

For the purpose of backfilling locally, available sand such as riverbed sand as approved by Engineer may be used. For all other work, sand as specified shall be used.

2.2.6. Test Requirements for Fine and Coarse Aggregates

All sampling and testing of fine and coarse aggregate from time to time shall be in accordance with the recommended Indian standard specification. All tests shall be arranged by the Contractor at his end. All routine tests shall be carried out at site in the presence of Engineer. No aggregate shall be used on works until notice has been given that the test results are satisfactory. The quoted finished item rates shall include all costs relating to testing of fine and coarse aggregate.

2.2.7. Water

Water shall be clean, fresh and free from organic matters, acids, or soluble salts and other deleterious substances which may cause corrosion, discoloration, efflorescence etc. Water to be used shall comply with the requirements of Clause of 4.3 of IS: 456. Average Twenty Eight (28) days compressive strength of at least three 15 cm. cubes of concrete prepared with proposed water shall not be less than 90% of average strength of three similar cubes prepared with distilled water. pH value of water shall generally be not less than 6.

2.2.8. Reinforcement Steel

Thermo-mechanically treated (TMT) steel reinforcement bars of Grade Fe 500 procured from a reputable manufacturer (subject to Employer's approval) shall be used. The binding wire for tying the reinforcement bars in position shall be 1.25 mm diameter soft annealed steel wire having yield point strength of not less than 3500 kg/cm.^{2}

2.2.9. Structural Steel

Structural steel elements (beams, channels, angles, flats, plates etc.) conforming to IS : 2062 procured from a reputable manufacturer (subject to Employer's approval) or supplied by the Employer, shall be used for Civil Works viz. tunnel supports, steel plate lining of bottom outlet, gantry girders, roof trusses etc. for the powerhouse etc.

2.3 STORAGE & HANDLING OF MATERIALS

All materials shall be stored by the Contractor in a manner affording convenient access for identification and inspection at all times. The storage arrangements shall be subject to the approval of the Engineer. Storage of materials shall be as described in IS: 4082.

All materials shall be so stored as to prevent deterioration or intrusion of foreign matter and to ensure the preservation of their quality and fitness for the work. Any material, which has deteriorated or has been damaged or is otherwise considered defective by the Engineer shall be removed and replaced by the Contractor at his own cost with material of specified standard. The Contractor shall maintain up to date accounts of receipt, issue and balance (stock-wise) of all materials for checking by the Engineer.

2.4 BRICKS

Bricks shall be stacked in regular tiers, even as they are unloaded, to minimize breakage and defacement of bricks. Bricks selected for different situation of use in the work shall be stacked separately. Each stack shall contain equal number of bricks, preferably not more than 3000.

2.5 STONES

Stones shall be stored at site in stacks resembling frustum of a rectangular pyramid or as approved by the Engineer. Dressed stone for wall facing, paving etc. shall be stored with special care to avoid defacement of faces and edges, damp and rust strains.

2.6 CEMENT

The Cement shall be stored in dry enclosed shed, well away from the walls and insulated from the floor to avoid contact with moisture. The cement shall be stacked in easily countable stacks and to facilitate removal of “first in first out” basis. The cement bags shall be gently kept on the floor to avoid leakage of cement from the bags. Sub-standard or partially set cement shall be immediately removed from the site after obtaining the necessary clearance from Engineer. Cement stored for a period beyond 90 days shall be tested before use.

2.7 COARSE AND FINE AGGREGATE

Aggregates shall be stored on brick soling or on equivalent platform so that they do not come in contact with dirt, clay, grass or any other injurious substance at any stage. Aggregate of different sizes shall be kept in separate and easily measurable stacks. If so desired by the Engineer, aggregates from different sources shall be stacked separately with proper care to prevent intermixing. Stacks of fine and coarse aggregates shall be kept sufficiently apart with proper arrangement for drainage. The aggregates shall be stored like stones, in easily measurable stacks of suitable depths, as directed by Engineer.

2.8 STEEL

Steel shall be stored consignment wise and size wise, off the ground and under cover. It shall be protected from rusting, oil, grease, distortions and water. If directed by the Engineer, the reinforcing steel may have to be coated with cement wash before stacking to prevent scale and rust at no extra cost to the Employer. The stacks shall be easily measurable. Only steel needed for immediate use shall be removed from storage.

Fabricated steel shall be painted with one coat of primer after inspection and shall be carefully stored to prevent damage, distortion, corrosion and deterioration.

2.9 ENGINEER’S AUTHORITY TO REJECT MATERIALS

Any material considered to be objectionable / unsuitable or not up to specifications by the Engineer, shall not be used by the Contractor and shall be removed from the site immediately at his own cost, failing which, the Engineer will get the material removed and cost thereof shall be realized from the Contractor's dues.

CHAPTER - 3

BACKFILLING

3.1 SCOPE

The Contractor shall furnish all labour, equipment and materials required for complete performance of the work in accordance with the drawings and as described herein.

3.2 GENERAL REQUIREMENT

3.2.1 After completion of foundations, footings, foundation of allied structures, walls and other construction below the elevation of the final grades, and prior to backfilling, all forms of temporary shoring, timber etc. shall be removed and the excavation cleaned of all trash, debris and perishable materials. Backfill shall begin only with the approval of the Engineer. The backfilling shall be carried out by the Contractor simultaneously with each staging of concreting as per the direction of Engineer.

3.2.2 The backfilling material shall consist of selected excavated soils, free of organic material. The angle of repose of back-fill material coarse sand shall not be less than 30^0. The rate quoted for back-fill material should include the lead involved and no extra payment shall be made on this account. The quality of back-fill material shall be got confirmed and approved from the Engineer before placing the same at the site of backfill. The back-fill material shall be properly well compacted to achieve a Procter's density of 90% as per relevant Indian Standard.

3.2.3 Backfill shall not be dropped directly upon or against any structure or facility where there is danger of displacement or damage.

3.2.4 Backfill shall be placed in horizontal layers not to exceed 200 mm in thickness. Each layer shall be compacted properly to the satisfaction of Engineer. Trucks or heavy equipment for depositing backfill shall not be used within 5 m of walls, piers, or other facilities, which may be damaged by their weight or operation. The methods of compaction shall be subject to the approval of the Engineer. Pushing of earth for backfilling shall not be adopted under any circumstances. The working area shall be kept dry by de-watering during the entire operation of backfilling.

3.2.5 Backfill adjacent to pipes shall be hand placed and compacted uniformly on both sides of the pipe and to depth and specified over the top of pipes. While tamping around piping, care should be taken to avoid unequal pressures.

3.2.6 On completion of structures, the earth surrounding them shall be accurately finished to line and grade as shown on the drawings. Finished surface shall be free of irregularities and depressions and shall be within 50 mm of the specified level.

3.2.7 Any additional quantity of backfilling, if required, beyond the excavation payment line necessary for the case of working shall be done by the Contractor at his own expense.

3.3 MEASUREMENTS AND PAYMENTS

3.3.1 Measurements shall be based on the volume between the structure neat line/outline of pipe and the excavated payment lines. Measurement shall be in cubic metre rounded off up to 2nd place of decimal and the unit rate shall include all the necessary operations required to complete the work as per drawing, specification and for all leads and lifts and to the satisfaction of Engineer.

3.3.2 If any test indicates less than the specified degree of compaction for the backfill, then the Engineer in exceptional circumstances may accept such backfill, provided always that the payment for all backfill done subsequent to the last successful test, be made at a reduced rate prorate to the degree of compaction obtained, with respect to the specified compaction.

CHAPTER - 4

DRILLING AND ANCHORING

4.1 SCOPE

4.1.1 These works comprise supply of all labour, equipment, material and performance of all works necessary for Drilling, washing and grouting of all holes of 45 mm to 50 mm diameter, vertical and inclined up to 10^{o} to vertical in all formations of rock / concrete masonry / soil by percussion method, cleaning by air and water jet providing, fabricating and fixing in the drilled holes TMT steel anchor rods / dowels using resin filled capsules and where ordered by the Engineer, grouting the same in position thereby filling the entire space between the anchor and the drill hole with cement slurry. The cement used for grouting shall be Ordinary Portland Cement (OPC) conforming to IS-269 with minimum compression strength of grout of 43 N/mm^2 at 28 days.

4.1.2 Holes for rock anchors shall be drilled to the exact depth required by the length of anchors at locations shown on the drawings or as directed by the Engineer.

4.1.3 Immediately prior to installation of anchors, the hole shall be flushed and cleaned of all drill cuttings, debris and water by inserting a rigid tube to the bottom of the hole and blowing compressed air through the tube as it is slowly withdrawn.

4.1.4 The installation of the rock anchors shall be done when and where instructed by the Engineer.

4.1.5 Resin capsules used shall be of best quality, of approved make and having good remaining shelf life. Contractor shall submit the details to the Engineer for approval before purchasing and supplying the capsules.

4.1.6 Cement grout shall be as specified having a water cement ratio of less than 0.42. The grout shall be injected at the lowest point of banded length after grouting and the anchor shall remain undisturbed until the necessary grout strength has been achieved.

4.2 PAYMENT

4.2.1 Payment shall be made at the unit price per meter stated in the Bill of Quantities and Price shall include the cost for drilling holes, resin capsules and cement grout for grouted rock anchors / dowels complete in all respects at the unit rates specified in the Bill of Quantities.

4.2.2 No payment shall be made for rock anchors, which do not meet the requirement of these specifications.

CHAPTER - 5

CEMENT CONCRETE

5.1 LIST OF APPLICABLE INDIAN STANDERED SPECIFICATIONS:

5.1.1. All concrete, its constituents, methods and procedures of manufacture shall conform to the specifications prescribed in the codes published by the Bureau of Indian Standards. In addition to below IS codes the specifications of MJP & CPWD and manual for quality control and inspection shall also be complied with.

S.NO	I.S. Number	Short title
1	383 - 1970	Specification for coarse and fine aggregate from natural sources for concrete.
2 (a)	456- 2000	Code of practice for plain and reinforced concrete.
2 (b)	457-1963	Code of practice for plain and reinforced concrete for
3	516-1959	Method for test for strength of concrete
4	650-1991	Specification for standard sand for testing cement.
5	1199 - 1999	Method of sampling and analysis of concrete.
6	1200-1974	Method of measurement of building & engineering works, concrete works.
7	1489- 1991 (part 1)	Specification of Portland pozzolana cement - fly ash based.
8	1791-1985	Specification for batch type concrete mixers
9	1838	Specification for performed fillers for expansion joints in concrete pavements and structures.
10	2062 - 2006	Steel for general structural purpose.
11	2330-1986	Methods for sampling of aggregate for concrete
12	2386-1977 (part 1 to 8)	Methods of test for aggregates for concrete
13	2502 - 1999	Code of practice for bending and fixing of bars for concrete reinforcement.
14	2505-1980	General requirement for concrete vibrators, immersion type.
15	2506-1985	General requirement for concrete vibrators screed board type.
16	2722-1964	Specification for portable swing weigh batchers for concrete (single and double bucket type)
17	2750	Specification for steel scaffolding.
18	2751 - 1979	Code of practice for welding of mild steel plain and deformed bars for reinforcement concrete structures.
19	3085-1965	Method of test for permeability of cement mortar and concrete.
20	3363-1965	Specification for pan vibrators.

21	3370-1965 &1967 (Part 1 to 4)	Code of practice for concrete structures for the storage of liquids
22	3558-1983	Code of practice for use of immersion vibrators for consolidating concrete.
23	3696-1991	Safety code of scaffolds and ladders.
24	3812 - 1981	Specification for fly ash for use as pozzolana and admixture.
25	3873-1978	Code of practice for laying in-situ cement concrete lining of canals
26	4634-1991	Batch type concrete mixers-methods test performance
27	4656-1968	Specifications for form vibrators for concrete
28	4925-1968	Specification for concrete batching and mixing plant.
29	4926 - 2003	Specification for ready mixed concrete.
30	4990-1981	Specifications for plywood for concrete shuttering works.
31	5515-1983	Specification for compacting factor apparatus
32	5640-1970	Method of test for determining aggregates impact value of soft & course aggregates
33	5751-1984.	Specifications for precast concrete coping blocks
34	5816-1970	Method of test for splitting tensile strength of concrete cylinder.
35	5889-1970	Specification for vibratory plate compactor
36	5892-1970	Specification for concrete transit mixers and agitators.
37	6461-1972 & 1973 (Part 1 to 12)	Glossary of terms relating to cement concrete aggregates, materials etc.,
38	6505-1985	Code of practice for installation of joints in concrete pavements.
39	6925-1973	Method of test for determination of water soluble chlorides in concrete admixtures
40	7293 - 1974	Safety code for working with construction machinery.
41	7320-1974	Specifications for concrete slump test apparatus
42	7861-1975 &1981 (Part 1&2)	Code of practice for extreme weather concreting
43	8142-1976	Method of test for determining setting time of concrete by penetration resistance
44	8989-1978	Safety code for erection of concrete framed Structures.
45	9013-1978	Method of making curing and determining Compressive strength of accelerated cured concrete
46	9284-1979	Method of test for abrasion resistance of concrete
47	9417 - 1989	Recommendation for welding cold - work steel bars for reinforced concrete construction.
48	13311- 1992 (part -1)	Non - destructive testing of concrete.

5.2 GENERAL

5.2.1. M 15 grade concrete shall be used for plain cement concrete for laying screed layer (i.e. bed concrete) under the foundations of structures.

5.2.2. M 25 and above grade of concrete shall be used for plain cement concrete for casting the structural components of foundations and super structures.

5.2.3. M 25 and above grade of concrete shall be used for Reinforced cement concrete for casting the structural components of foundations and superstructures and for all concrete components of water retaining structures.

5.2.4. In all the above cases, the mix shall be of DESIGN MIX. For design mix, the mix proportions shall be evolved in the laboratory and for the later, the proportions given in the specifications shall be adopted to produce the required grade of concrete.

5.2.5. All concrete work, production, testing and placement shall be performed in strict conformance with the Indian Standard Code of Practice for Plain and Reinforced Concrete IS: 456 latest revisions.

5.2.6. Equipment and methods for the production, transportation, placing, consolidating, curing and finishing of concrete shall be subject to acceptance by Engineer.

5.3 SCOPE

5.3.1. The specifications cover the requirements of plain and reinforced concrete for various structures and comprised of:

5.3.2. Cost of all materials of approved quality such as specified quality of cement, sand, graded coarse aggregate specified, MSA, admixture (if necessary), water, including the cost of seignior age charges, sampling, testing of materials sales tax and. any other taxes imposed by the Government, required to manufacture a structural component of specified grade but excluding the cost of steel and its fabrication charges

5.3.3. Conveyance of all materials with all leads, and getting the mix designs conducted.

5.3.4. Mixing of all ingredients by weigh batching for the mix.

5.3.5. Hire and operations charges of all machinery (Tools, plant and equipment)

5.3.6. Preparation of surface for placing of concrete.

5.3.7. Cost of initial dewatering, and dewatering during execution, diversion of stream, and protection works as may be necessary during or after concrete works.

5.3.8. Designing and construction of form work for the structural component including scaffolding, shuttering and removing after curing.

5.3.9. Transporting, the concrete with all leads, lifts, delifts either by labour or by placing in position, vibrating, compacting, finishing and curing of the cement concrete, plain or reinforced and performing all other operations necessary and ancillary thereto, complete for finished item of works as specified in drawings and designs.

5.3.10. Sampling testing, green cutting, repairing and finishing of concrete.

5.4 DEFINITIONS

5.4.1. "Cement" shall mean Ordinary Portland Cement (OPC) as specified herein, supplied in bulk or in 50 kg paper / jute bags.

5.4.2. "Water-cement ratio" shall mean the ratio of the weight of water contained in a freshly mixed batch of concrete to the weight of cement contained in the same batch. The weight of water shall mean that weight in the batch, which is free to combine with the cement, but does not include water absorbed by aggregates.

5.4.3. The "Cement Content" shall mean the number of kilograms of cement per cubic metre (kg/m^3) of concrete in place complete.

5.4.4. “Secondary Concrete” shall mean concrete placed in block-outs and used to embed items such as sill beams, first and second stage embedment for gates & stop logs and other Hydro-mechanical and Electro-mechanical equipments etc., after primary concrete has been placed. “Primary Concrete” shall mean all concrete, which is not classified as secondary concrete.

5.4.5. “IS” shall mean Indian standards Code of Practice. Wherever a particular standard is specified its latest revision / edition shall be referred to.

5.5 COMPOSITION OF CONCRETE

Concrete shall be composed of cement, fine aggregate, coarse aggregate, water and permitted admixtures, as specified herein and as required by Engineer.

5.6 CONCRETE AND CONCRETE CONSTITUENTS

5.6.1. Concrete and concrete constituents and all materials and operations relating to concrete shall meet the requirements of the Indian Standards Code of Practice for Plain and Reinforced Concrete IS: 456, and as required by Engineer.

5.6.2. Concrete constituents shall be batched and mixed at site using suitable equipment to determine and control accurately the amount of each ingredient entering the mix. The amount of each ingredient shall be batched correctly with sufficient accuracy to obtain concrete of the quality specified in these specifications.

5.6.3. Facilities for storage of concrete constituents and batching and mixing of concrete shall be available for inspection by Engineer at all times.

5.6.4. The use of a water-reducing admixture to improve workability without reducing the strength or durability of the mix will be considered by Engineer. If acceptable to Engineer, it shall be used in strict conformance with manufacturer's instructions.

5.6.5. An acceptable air-entraining agent conforming to the requirements of IS: 9103 - 1979 shall be added to all concrete mixes to provide an in-place air content of between 4 and 6 percent.

5.6.6. Water proofing agents and admixtures to make the concrete “quick setting” shall be permitted with written acceptance of Engineer.

5.6.7. Surface hardening compound required for boulder weir concrete facing shall be subject to the approval of the Engineer.

5.7 CEMENT

Cement shall be Ordinary Portland Cement (Grade - 43 or 53) conforming to the requirements of IS 269-1976.

5.8 TRANSPORTATION OF CEMENT

All bulk tanks, trucks and other bulk carriers shall be clean and dry prior to loading with cement. All carriers for both bulk and bagged cement shall be equipped with weatherproof closures on all openings.

5.9 STORAGE

5.9.1. Sufficient storage facilities shall be provided at the batch point to enable each new shipment of cement to be stored separately from the cement stored from earlier shipments.

5.9.2. Cement shall be stored above ground, adequately protected against rain, sun and moisture. Bulk storage bins and silos shall be emptied completely and cleaned of all cement accumulations every 3 months.

5.9.3. Arrangements shall be made such that stocks of approved cement are adequate to meet the program of work at all times. The program shall allow time for testing and approval of each shipment before such cement is incorporated in the work.

5.9.4. Cement shall be used in the order in which it is received on site. Cement stored by the Contractor and found unfit for use shall not be allowed to be used on works and shall be removed from the site immediately by the Contractor at his own cost.

5.10 AGGREGATES - GENERAL

5.10.1. Unless otherwise specified, concrete aggregates shall conform to the requirements of IS 456- 2000 and IS 383-1970

5.10.2. Aggregates shall be supplied only from sources approved by Engineer. Approval of a source shall not be construed as constituting acceptance of all materials to be taken from that source.

5.10.3. The quality of all aggregates used in the work, including processing such as washing, classifying, screening, re-screening, crushing and blending, necessary to meet the required specifications, shall all be subject to acceptance of Engineer.

5.11 FINE AGGREGATES

5.11.1. Fine aggregates shall have uniform and stable moisture content and shall conform to the grading requirements of IS 383-1970.

5.11.2. If necessary, fine aggregate shall be washed to remove excess fines.

5.11.3. The percentage of deleterious substances in the fine aggregates shall conform to IS 383-1970, except that the fine aggregate shall contain not more than 0.10 percent by weight of deleterious (reactive) ferrous sulphates. The total percentage of deleterious substances must not exceed 5 percent of weight.

5.11.4. Fine aggregate having a specific gravity of less than 2.60 shall be rejected. Fine aggregate, when submitted to a soundness test with a solution of sodium sulphates, after five cycles of tests, shall not suffer a loss of weight in excess of 10 percent.

5.12 COARSE AGGREGATES

5.12.1. Coarse aggregate shall consist of screened natural gravel or crushed rock and shall conform to the requirements of IS 383-1970.

5.12.2. Coarse aggregate shall be well-graded and supplied in two sizes, 40 mm to 20 mm, and 20 mm to 10 mm. Coarse aggregate shall be washed at the aggregate source; however, further washing at the batch plant may be required if the aggregate is found to be unacceptable to Engineer.

5.12.3. Coarse aggregate shall have a loss of less than 5%, as determined by Los Angeles abrasion test as specified in IS 2386 (Part IV) 1963.

5.12.4. When subject to the sodium sulphate soundness test, coarse aggregate shall not suffer more than 10 percent loss of weight after five cycles.

5.12.5. Coarse aggregate shall be separated into two nominal sizes, which shall conform to the grading requirements of the following table when tested in accordance with IS 383-1970 for the nominal size specified.

IS Sieve Designation	% Passing for graded aggregate of nominal size	
	40 mm	20 mm
73 mm	100	100
40 mm	95 to 100	100
20 mm	30 to 70	95 to 100
10 mm	10 to 35	25 to 55
4.75 mm	0 to 5	10

5.12.6. As far as possible, coarse aggregate shall be of angular shape and free of flat or elongated particles. The volumetric coefficient C, which defines the ratio of the total volume

of a number of particles taken at random and the volume of spheres having a diameter equal to the greatest dimension of each element, shall be greater than or equal to the greatest dimensions of each element and shall be greater than or equal to the following values:

Aggregate size	Ratio
6.7 / 26.5 mm	C = 0.15
26.5 / 150.0 mm	C = 0.11

5.12.7. Coarse aggregate delivered to the batching plant shall have uniform and stable moisture content.

5.12.8. The percentage of deleterious substances in any size of coarse aggregate shall conform to IS 383 - 1970, except that the coarse aggregate shall contain not more than 0.30 percent by weight of deleterious (reactive) iron sulphides.

5.12.9. The sum of the percentages of all deleterious substances in any size shall not exceed 3 percent by weight. Coarse aggregates may be rejected if, the specific gravity (saturated surface-dry basis), is less than 2.60.

5.13 AGGREGATE STORAGE

Aggregates shall be stored in such a manner so as to prevent contamination and segregation and to facilitate cooling and drainage of excessive moisture as required. Storage arrangement shall be subject to acceptance by Engineer.

5.14 WATER

5.14.1. A reliable water supply shall be installed and maintained for washing of aggregate and the manufacture and curing of concrete.

5.14.2. Water to be used in washing of aggregates and manufacturing and curing shall be clean and free from injurious amounts of oil, acids, alkalies, sugar, salt and organic matter and shall conform to IS 456- 2000.

5.14.3. Water for manufacturing of concrete shall be approved by Engineer.

5.14.4. Adequate water storage facilities shall be provided at the batching plant to ensure that no part of the concreting operations shall be hindered by temporary break down in the main supply system.

5.15 CONCRETE MIX DESIGN

5.15.1. The mix shall be designed in a laboratory to produce the grade of concrete having the required workability and a characteristic strength not less than value given in the following table. The procedure to design and produce the concrete, the standards given in IS: 10262-1982- Recommended guide lines for concrete mix design and SP: 23- Hand book on concrete mixes published by .I.S. shall be adopted.

Class of Concrete	Maximum size of aggregate (mm)	Maximum Slump (mm)	Air % of Volume	Minimum specified compressive strength at 28 days (N/mm^2)
M25	20	100	5 to 7	25
M20	20	100	5 to 7	20
M15	20	50	5 to 7	15

5.15.2. Prior to commencement of permanent concrete work, trial mixes shall be prepared for each class of concrete listed above. The trial mixes shall be prepared with the batching and mixing plant to be used for the work and using cement and aggregates, etc., which have been approved by Engineer.

5.16 MINIMUM CEMENT CONTENT

5.16.1. The minimum cement content for each grade of concrete shall be as shown below:

Grade of Concrete	Aggregate (well graded) size	Minimum Cement Content per cubic meter (m^3) of Finished Concrete
M-15	40 mm	270 kg
	20 mm	300 kg
M-20	40 mm	300 kg
	20 mm	330 kg
M-25	40 mm	300 kg
	20 mm	330 kg

The minimum cement contents mentioned above are for the average conditions. The Contractor shall design the mixes for 10% higher compressive strength over and the above those specified.

5.16.2. The amount of water to be added to the mix shall be adjusted to compensate for any variation in the free-moisture content of the aggregates as they enter the batch plant.
Water shall not be added to the mix beyond the water-cement ratio specified without the written authority of Engineer.

5.16.3. Engineer will prepare from these mixes, samples for compression testing.

5.17 PRODUCTION OF CONCRETE:

5.17.1. BATCHING OF MATERIALS:

- All materials entering in to the concrete shall be matched by weight except waterwhich shall be in liters. When the weight of cement is determined on the basis of weight of cement per bag, a reasonable number of bags should be weighed periodically to check the net weight. Admixtures if permitted by the Engineer-in-charge should be added to the concrete by weight.

- All measuring equipment and weigh batching machinery shall be approved by the Engineer-in-charge and maintained in a clean serviceable condition and their accuracy shall be periodically checked. The batching and mixing plant for concrete is to be designed to suit the local conditions and output requirements as per IS: 4925-1968 specifications of batching and mixing plant for concrete.
- The aggregates of different sizes should be stocked in separate stock piles; the same shall be blended in right proportions to ensure a uniform grading of aggregate as determined by the Engineer-in-charge.
- In case uniformity in the materials used for concrete making has been established over a period of time, the proportioning may be done by volume batching after getting approval from the Engineer, provided periodic checks are made on weight/volume relationships of materials.
- Where weigh batching is not practicable, the quantities of fine coarse aggregate (not cement) may be determined by volume.
- If fine aggregate (sand) is moist and volume batching is adopted, allowance shall be made for bulking in accordance with IS: 2386 (Part.III)-1963 methods of test for aggregate for concrete.
- The amount of the added water to concrete shall be adjusted to compensate for any observed variations in the moisture contents determined by the above tests for both design and nominal mix of concrete making for weigh and volume batching.

5.18 MIXING:

5.18.1. Concrete shall be mixed in a mechanical mixer complying with IS: 1791-1968 specification of batch type concrete mixtures. The mixing shall be continued until there is a uniform distribution of the materials and the mass is uniform in colour and consistency. If there is segregation after unloading from the mixer, the concrete should be remixed.

5.18.2. The mixing time may be 1.5 to 2 minutes for all normal cements.

5.18.3. In exceptional circumstances, such as (i) mechanical breakdown, (ii) work in the remote areas, (iii) when the quantity of concrete work is small, hand mixing is permitted subject to adding 10 percent extra cement.

The Hand mixing shall be carried out on a water tight platform and care shall be taken to ensure that mixing is continued until the concrete is uniform in colour and consistency.

5.19 WORKABILITY:

Workability of concrete should be controlled by direct measurement of water cement ratio. Workability should be frequent intervals as per the procedure laid down in IS: 1199-1959 methods of sampling and analysis of concrete.

5.20 SLUMP TEST TO CHECK WORKABILITY:

5.20.1. The slump test for concrete shall be adapted only for concretes of medium to high workability (i.e. slump 25to 100mm). For very stiff mixes having zero slumps, the slump test does not indicate any difference in concrete of different workability.

S.No.		Type	Slump
1	(a)	Structure with exposed inclined surface requiring low slump concretes to all for proper compaction	25 mm
	(b)	Plain cement concrete	25 mm
2		RCC structures with widely spaced reinforcement ie solid columns, piers, abutments putting well steining	40 - 50 mm
3		RCC Structures with fair degree of congestion of reinforcement e.g., pier and abutment caps box culverts well curbs, and caps, walls with thickness greater than 300mm.	50-75mm.
4		RCC and PSC structures with highly congested reinforcement e.g. Deck slab girders, box girder, walls with thickness less than 300mm	75- 125 mm
5		Underwater concreting through tremie e.g., bottom plug, cast-in-situ piling	100 -200 mm

5.21 QUALITY CONTROL

5.21.1. A system of quality control shall be provided, operated and maintained at the batching and mixing plants to ensure that the standards specified for concrete herein are met.

5.21.2. The weights of the components of every batch shall be recorded and the records will be submitted to Engineer daily.

5.21.3. Compressive strength shall be tested in accordance with IS 516-1959, samples being taken from every 100 m^3 for each class of concrete, with a minimum of one group of samples per shift. Each test group shall consist of nine cubes.

5.21.4. In the event the specified strength criteria are not met, Engineer may, if he deems it necessary, order that the unacceptable concrete be cut out and replaced.

5.21.5. In the event quality control tests indicate that concrete below the specified standards is being produced, Engineer may order such adjustment of mix design, additional quality control, or other measures as he may deem necessary to raise quality to specified standards.

5.22 TEMPERATURE OF CONCRETE

5.22.1. Every effort shall be made to minimize the temperature of concrete during manufacture, placement and curing as per IS 7861 (Part I & II).

5.22.2. Any or all of the following means shall be adopted, as required by Engineer to produce concrete of minimum temperature:

- protect all freshly placed concrete from exposure to direct sunlight.
- employ continuous moist curing
- spray forms and reinforcement with water where they are exposed to direct sunlight.
- spray water on aggregate piles
- keep mixing time and the time required to convey to point of placement to a minimum.
- shade batching, mixing and conveying equipment
- paint pipes, storage bins and tanks white

5.23 CONVEYING

5.23.1. Concrete shall be conveyed from the delivery point to the place of final deposition by methods, which will prevent segregation or loss of ingredients or damage, by exposure to the elements. Plant such as buckets, cars, conveyors, transit mixers of 6 m^3 capacity and pumping equipment which may be used for conveying concrete shall be of such size, design and condition as to ensure an even and adequate supply of concrete at the placement area. All methods used shall be checked and approved by Engineer.

5.23.2. Particular attention shall be paid to prevent segregation at the ends of chutes, at hopper gates and at all other points of discharge.

5.23.3. In general, the use of chutes to convey concrete shall not be permitted, except that chutes less than 3 m in total length may be used immediately adjacent to or in the forms, with acceptance of Engineer. Where chutes are used, they shall be so constructed and arranged as to permit continuous flow of concrete without separation of ingredients. Chutes shall not have a slope steeper than 1V: 2 H.

5.23.4. There shall be no vertical drop greater than 1.5 m except where equipment satisfactory to Engineer is used to confine and control the falling concrete.

5.23.5. Concrete may be dropped through flexible elephant-trunk chutes, provided some method is used at the lower end to retard the speed of the falling concrete and prevent it from segregating. Where it is necessary to drop concrete more than 1.5 m, it shall fall into a hopper with a capacity of 1m^3 more than the total capacity of the full tank.

5.23.6. Buckets for transporting concrete shall be manufactured as low-slump concrete buckets.

5.23.7. All conveying plant shall be supported independently of the forms, except as specifically permitted by Engineer.

5.23.8. The conveying plant shall be kept free from hardened concrete and foreign materials and shall be cleaned at frequent Intervals.

5.24 PLACING - GENERAL

5.24.1. Contractor shall provide Engineer with a bi-weekly placing schedule giving the detailed location of the pours, the approximate extent of pours, and the date on which the concrete will be placed.

5.24.2. Prior to placing concrete in any location, Contractor shall provide Engineer with written notice, using a standard notice or accepted by Engineer that the preparation of form work, reinforcing steel, embedments, piping etc. for such pour have been completed. No concrete placement shall be started until pour preparation has been inspected and approved by Engineer.

5.24.3. No concrete shall be placed under water, except where shown on the drawings, unless specifically so required by Engineer and then the method of depositing the concrete shall be entirely in accordance with requirements of Engineer. No concrete shall be placed in running water. Water shall, generally, not be allowed to rise over freshly poured concrete until final set has been achieved.

5.24.4. Contractor shall place concrete in a given location only after Engineer agrees for placement of such concrete. All concrete shall be placed in presence of Engineer. Concrete placed without prior knowledge and agreement of Engineer may be required to be removed and replaced at no additional cost to the Employer.

5.24.5. All concrete - placing plant and methods shall be subject to acceptance by Engineer.

5.24.6. In order to reduce bleeding, slump shall be no higher than necessary to achieve proper placement and consolidation.

5.25 PREPARATION FOR PLACING

5.25.1. All surfaces on which or against which concrete is to be placed, including surface of construction joints between successive concrete placements, reinforcing steel and embedded parts, shall be thoroughly cleaned of dirt, mud, debris, grease, oil, dried mortar or grout, laitance, loose particles or other deleterious matter.

5.25.2. Surface, seepage and other water shall be so controlled, to the satisfaction of Engineer, that at no time during the placement or hardening of the concrete will it wash, mix with, or seep into the concrete.

5.25.3. The attention of Contractor is directed to the requirements for construction joints, as specified herein.

5.26 PLACING AND COMPACTING CONCRETE

5.26.1. Concreting shall be done as a continuous operation until placing in the lift, section or monolith is completed and Contractor shall make all arrangements necessary to maintain continuity of concrete placing in any particular pour during meal periods, shift changes, or any other such interruptions.

5.26.2. Concrete shall be placed in the forms as quickly as possible; but not later than half an hour after delivery. These limits may be modified by Engineer to suit working or weather conditions. Concrete, which is not placed within the above-specified time limit, shall be wasted, as required by Engineer.

5.26.3. In all cases, concrete shall be deposited as nearly as practicable directly in its final position and shall not be caused to flow by vibrator or otherwise in a manner which will permit or cause segregation.

5.26.4. Concrete shall be placed in lifts to construction joints as shown on the drawings or as directed by Engineer. The height of concrete lifts shall be as shown on the detailed construction drawings or as otherwise agreed upon between Engineer and Contractor before placing the concrete. The lifts shall generally not exceed 3 m in height, unless specifically so permitted or required by Engineer. The concrete shall be deposited in horizontal layers, the thickness of which shall generally not exceed 500 mm. If, in the opinion of Engineer, 500mm layers of concrete cannot be placed satisfactorily, Engineer may require layers of lesser depths

5.26.5. Each layer of concrete shall be consolidated to the maximum practicable density, be free from pockets of coarse aggregate, completely fill all recesses in forms and around embedded parts, and be free of all voids. The concrete shall be compacted and worked into all corners and angles of the forms, around reinforcement and embedded items without permitting the component concrete materials to segregate.

5.26.6. No layer of concrete shall be placed until the previous layer in the same lift has been thoroughly consolidated, as specified. Each layer of concrete within a lift shall be covered with fresh concrete, preferably as soon as possible, but certainly within the period when the lower layer is still capable of being re-vibrated so that successive layers can be thoroughly worked together.

5.26.7. The maximum permissible time between placing successive layers shall not exceed 45 minutes and shall be reduced, as required by Engineer to suit the temperature, humidity and job conditions. Concrete shall not be piled up in the forms in a manner that causes movement of the unconsolidated concrete, or permits mortar to escape from the coarse aggregate.

5.26.8. Concrete shall be consolidated with the aid of approved immersion type mechanical vibrators complying with IS 2505 - 1968 or electric or air-driven vibrators operating at a speed of at least 7000 cycles/minute when immersed in the concrete. The vibrating equipment shall at all times be adequate in number of units and power to properly consolidate all concrete as

it is being placed, to the satisfaction of Engineer. Vibrators with flexible operating shafts shall be used for reinforced concrete and for concrete in restricted forms. At least one extra vibrator in working condition shall be constantly on hand at each point of placement for emergency use.

5.26.9. Application of the vibrators shall be made systematically and at such intervals that the zones of influence overlap and the concrete is properly compacted.

5.26.10. Every vibrator shall be operated in a near-vertical position and the vibrating head shall be allowed to penetrate under the action of its own weight. In consolidating each layer of concrete, the vibrating head shall be allowed to penetrate and re-vibrate the concrete in the upper portion of the underlying layers. Extreme care shall be taken to ensure that the vibrators do not touch or disturb the reinforcing embedded steel or forms.

5.26.11. To ensure even and dense surfaces which are free from aggregate pockets, honey combing or air holes, it may be necessary to supplement internal vibration with hand spading along the boundaries of the concrete and around embedded parts while the concrete is plastic under the vibratory action. Should slip forms be used, the equipment and methods shall be such that the finished concrete will be well consolidated and homogeneous.

5.26.12. . Contractor shall use any or all of the above methods of consolidation, if required, to produce the necessary finish. Form vibrators shall not be used unless the forms are designed for form vibration or unless specifically authorized by Engineer.

5.27 PARTS EMBEDDED IN CONCRETE

5.27.1. Anchors, anchor bolts, structural shapes, plates and bearings required in connection with the embedment of steel plate in bottom outlet invert & sides, installation of gates, gate hoists, valves, E&M machinery and other apparatus shall be installed in the concrete by Contractor, as shown on the drawings or as required by Engineer. Wherever practicable, anchors shall be installed before the concrete is placed and, except as specified, drilling for installation of anchors in the concrete after concrete is placed will not be permitted. Before being placed in position, all anchors and embedded parts shall be thoroughly cleaned of rust, grease, paint, splashed concrete, or other coatings that will reduce bond. Where the installation of the anchors is not practicable before the concrete is placed, formed openings shall be provided, and the anchors grouted into the openings at a later time in a manner acceptable to Engineer.

5.27.2. Embedded anchors shall be supported during embedments and embedded so that the tolerances will not be exceeded. Care shall be taken not to disturb or displace embedment items during concrete placement.

5.28 FINISHING OF CONCRETE

5.28.1. Any damage to finished concrete resulting from the action of removing formwork or any other cause shall be repaired to the satisfaction of Engineer.

5.28.2. The finished surfaces of concrete shall be true, sound, smooth and free from fins, offsets, pits, depressions, voids, blemishes and others defective concrete and surface irregularities, and shall be in accordance with the requirements for the particular class of finish specified herein or shown on the drawings.

5.28.3. Finishing work shall be done only by skilled workmen in the presence of Engineer and shall be performed within 4 weeks of placing. Before final acceptance of the work, Contractor shall clean all exposed concrete surfaces of all encrustation of cement, mortar or grout, to the satisfaction of Engineer. Concrete shall not be considered finished until required repair work and finishing have been completed.

5.28.4. Surface finishes shall generally conform to the types and tolerances indicated in Table I unless otherwise specified herein, as shown on the drawings, or as required by Engineer.

- Type 1 tolerances shall apply to departure from alignment and grade shown on the drawings.
- Type 2 tolerances shall apply to variation in cross sectional dimensions of structural members, such as tunnel linings, walls, piers, beams etc.
- Type 3 tolerances shall apply to abrupt irregularities such as offsets and fins, caused by displaced or misplaced form work sheathing, lining or supports, by loose knots in forms or by otherwise defective form material.
- Type 4 tolerances shall apply to gradual irregularities caused by misalignment of form work from the dimensions shown on the drawings and measured from 3.0 m long straight template.

5.28.5. Positive tolerance shall be measured outside and negative inside the lines and grades defining the structure on the drawings.

5.29 CURING AND PROTECTION OF CONCRETE

5.29.1. Plant for curing and protection of concrete shall be available at the location of each concrete placement before concrete placement is started, and the water used for curing shall meet the requirements for water used for mixing concrete. Curing water temperature shall not exceed 25^{o}C or above the expected minimum ambient temperature of the 28 day curing period.
Minimum anticipated ambient temperatures shall be based on climatological records and forecasts approved by Engineer.

5.29.2. Exposed surface of concrete, which have been finished as specified herein shall be protected from the direct rays of the sun for at least 3 days after placing. Freshly placed concrete shall be protected from damage by rainfall.

5.29.3. Exposed surfaces shall be kept moist or the moisture in the concrete shall be prevented from evaporating for at least 10 days after placing by means of continuous sprinkling or spraying with water, or by other methods authorized by Engineer.

5.29.4. Curing shall be done by means of jute bags for vertical faces of piers, abutments, column, beams etc. without disturbing the steel reinforcement bars projecting from any placement for at least 24 hours after the completion of such placement.

5.30 CONSTRUCTION JOINTS

5.30.1. "Construction joints" are defined as concrete surfaces on or against which concrete is to be placed and to which new concrete is to adhere and which have become so rigid that the new concrete cannot be incorporated integrally with that previously placed.

5.30.2. Construction joints shall be located in the positions shown on the drawings or as required by Engineer. Contractor shall not be permitted to form any additional joints or deviate from the joints indicated on the drawings, without the written authorization of Engineer. Joints at exposed surfaces of concrete shall be straight and continuous, as shown on the drawings or otherwise specified.

5.30.3. Horizontal construction joints shall be arranged wherever possible to coincide with joints in the formwork.

5.30.4. To prevent feather edges, the construction joints at the tops of horizontal lifts near sloping exposed concrete surfaces shall be inclined near the exposed surface so that the angle between such inclined surface and the exposed concrete surface will be not less than $50^{o.}$

5.30.5. Formed construction joints and the surface of horizontal joints and the surfaces against which new concrete are to be placed shall be wet sand-blasted or roughened by scrubbing or brush hammering to expose the aggregate.

5.30.6. Alternatively, horizontal and other unformed construction joints shall be treated as follows:

As soon as the concrete has been screeded to form the surface of the construction joints, it shall be covered with an approved liquid retarder. Application shall be as a low-pressure spray at a rate of 1 L/m^2 or such other coverage rate that will result in the setting of concrete being retarded to a depth of 3 mm at the time of removal of the retarded mortar. Immediately after the application of the retarder, the surface shall be wet cured by covering with wet burlap. The retarded mortar shall be removed 8 to 25 hours after placing by washing with low-pressure water jet (200 to 300 KPa) and by brushing with stiff brushes. Curing shall then be resumed as specified herein.

5.30.7. Immediately prior to placing new concrete, the surface of all construction joints shall be thoroughly cleaned with high pressure water jet or sand-blasting to remove any trace of laitance, loose sand, loose or undercut coarse aggregate, oil, grease of any foreign material of any kind.

5.30.8. The use of a retarder shall not relieve Contractor of the responsibility of producing surfaces at construction joints as specified and to the satisfaction of Engineer.

5.30.9. Disturbance of the surface at a joint during the early stages of hardening shall be avoided, and traffic on the concrete will not be permitted until the concrete has hardened sufficiently to withstand such treatment without injury.

5.30.10. All construction joints shall be kept continuously moist until they are covered with concrete, provided that, if it becomes necessary to delay the placement of new concrete on or against a construction joint for an extended period, moist curing of the surface of the joint may be discontinued at the expiration of the regular prescribed curing period. If the moist curing is so discontinued, it shall be resumed not later than 24 hours prior to the placement of new concrete against the joint.

5.30.11. All cold joints shall be treated like construction joints.

5.31 REPAIR OF CONCRETE

5.31.1. Repair of damaged or defective concrete shall be performed by skilled workmen only, and in the presence of Engineer. No repair work shall be carried out until Engineer, has inspected the location of the proposed repair and accepted the method of repair proposed by Contractor.

5.31.2. Contractor shall correct all imperfections on the concrete surface as necessary to produce surfaces that conform to the requirements specified in para 5.28 of this specification.

5.31.3. Where concrete is exposed to flowing water, to weather, porous and fractured concrete and surface concrete to which additions are required to bring it to prescribed lines shall be removed by chipping openings into the concrete to a minimum of 75 mm below the reinforcement or to the depth required by Engineer if sound concrete is not encountered at 75 mm. Repair areas shall be formed and area filled with fresh concrete. If the concrete section to be repaired contains no reinforcement, concrete shall be chipped to a minimum depth of 100 mm.

5.31.4. The chipped openings shall be sharp-edged and keyed and shall be filled to the required lines with fresh concrete or patching mortar, as required by Engineer. Where concrete is used for filling, the chipped openings shall not be less than 75 mm in depth and the fresh concrete shall be reinforced and doweled to the surface of the openings, as directed by Engineer.

5.31.5. Mortar for patching shall consist of 1 part cementing material, 2 parts of volume of regular concrete sand, and just enough water so that after thorough mixing of the ingredients the mortar will barely hold together when compacted by squeezing with the hand. The mortar shall be fresh when placed and any mortar that is not used within 2 hours after preparation shall be wasted. Just prior to mortar application, the surface to which the mortar is to bond shall be kept wet for at least 2 hours and then scrubbed with a small quantity of cement grout using a wire brush.

5.31.6. Where repairs are more than 25 mm deep, the mortar shall be applied in layers not more that 20 mm thick to avoid sagging. After each layer, except the last, is placed, it shall be thoroughly roughened by scratching with a trowel to provide an effective bond with the succeeding layers. The last or finishing layer shall be smoothened with a trowel to form a continuous surface with the surrounding concrete. All patches on exposed surfaces shall be neat and smooth and as nearly as possible the same colour as the adjoining concrete. All patches shall be thoroughly bonded to the surfaces of the chipped openings, shall be cured to the satisfaction of Engineer and shall be sound and free from shrinkage cracks and dummy areas.

5.31.7. Concrete surfaces where high velocity flows may occur, and as required by Engineer, repairs to surfaces having F3 to U3 finishes as shown in Table - 1 below, shall be bonded with an epoxy adhesive acceptable to Engineer and used in accordance with the manufacturer's instructions.

5.31.8. All repairs to the surface of concrete required for flowing water shall be ground smooth to meet the tolerances specified for that surface

TABLE - 1

TYPES AND TOLERANCES FOR FINISHING OF CONCRETE SURFACES

Type of Finish	General Areas of application and method of Forming	Tolerance in mm
F1	Formed surfaces of construction joints and other surfaces, which will not be permanently exposed. The surface will require no treatment after form removal, other than repair of defective concrete and specified curing or treatment as specified for construction joints.	+ 10 - 10
F2	All permanently exposed formed surfaces for which type F3 finish is not specified. For these surfaces sheathing or lining shall be placed so that joint marks on the concrete surface will be in general alignment, both horizontally and vertically and conform to a standard pattern. Immediately on the removal of forms, all unsightly ridges or lines shall be removed, all holes left by removal of ends of form rods shall be neatly filled with mortar and surfaces treated to meet the required tolerances by tooling and rubbing.	+ 5 - 5

F3	Formed surfaces, which will be exposed to flowing water. These surfaces shall be hard, smooth and dense, free from offsets, pits, voids, air holes and irregularities and shall be chipped, ground and thoroughly cleaned as necessary to conform to the required tolerances	+ 3 - 3
U1	Unformed, screeded surface, which will be covered by fill materials, static water or concrete. Type U1 finish shall be used as the first stage for Types U2 and U3 finishes. Finishing shall consist of sufficient leveling and screeded to produce an even, uniform surface meeting the required tolerance.	+ 10 - 10
U2	Unformed surfaces not permanently concealed by fill or concrete or not required to receive Type U3 finish. Floating by means of hand or power driven equipment shall be started as soon as the screeded surface has stiffened sufficiently, and shall be the minimum necessary to produce a surface that is free from screed marks and that is uniform in texture. If type U3 finish is to be applied, floating shall be continued until a small amount of mortar without excess water is brought to the surface so as to permit effective trowelling.	+ 5 - 5
U3	Unformed, screeded surfaces that will be exposed to flowing water. This finish shall be applied by steel trowelling after the concrete has hardened enough to prevent excess of fine materials and water from blemishes, ripples and trowel marks. After the surface has nearly hardened, it shall be trowelled once more until the surface is hard and glossy in appearance.	+ 3 - 3

5.32 MEASUREMENT AND PAYMENT

5.32.1. Measurement for payment for placing concrete shall be made of the volume, in cubic metre (m^3), within the neat lines of concrete placed in the various structures, as shown on the drawings or as required or determined by the Engineer.

5.32.2. The limit of the various pay items specified shall be as shown on the drawings and as required by Engineer. Payments shall be made as per unit rates in cubic metre (m^3) stated in the Bill of Quantities.

CHAPTER - 6

CONCRETE ADDMIXTURES AND WATER STOPS

6.1 GENERAL REQUIREMENTS

Concrete admixtures shall be added in order to make the concrete waterproof, alkali - resistant or to improve its workability. Addition of suitable admixtures in concrete or mortar for water bearing and underground structures shall be done at the time of mixing, as per direction of Engineer. Addition of hardening compounds shall render the surfaces of the concrete hard enough to resist the impact and effect of rolling riverbed load, angular or rounded boulders etc. likely to flow along with the river water during monsoon period and particularly during the occurrence of high floods. Addition of admixtures shall not reduce the specified strength of concrete in any case.

6.2 MATERIALS AND APPLICATION

6.2.1 The materials shall conform to the respective I.S. Codes wherever applicable. The Engineer's approval to the materials shall be obtained by the Contractor before procurement. Such an approval shall not relieve the Contractor of his responsibility with regards to the quality of the materials. If desired by the Engineer, test certificates for the materials shall be submitted by the Contractor and samples for testing by the Contractor shall be supplied free. The materials shall be of best quality available, fresh and thoroughly clean.

6.3 TECHNICAL SPECIFICATION FOR WATER PROOFING CEMENT ADDITIVE

6.3.1 Scope

The specification covers the technical requirements for furnishing, placing and mixing cement additive in all kinds of cement concrete, plain or reinforced and cement mortar for all kinds of structures at all levels, including encasement of steel sections, as shown in drawing or otherwise specified.

6.3.2 General Requirement

The Contractor shall furnish all labour and equipment to place and mix waterproofing cement additive in concrete of any grade and cement mortar and then complete the work as indicated on the drawing and as described herein.

6.3.3 Cement additive shall conform to Indian Standard Specifications IS: 2645 and approved by Engineer.

6.3.4 Additive shall as far as possible be free from aggressive chemicals like chloride, sulphides, etc. which can cause corrosion of steel reinforcement in R.C.C. work.

6.3.5 The Contractor shall have the service of the manufacturer's supervisor at no extra cost to the Employer to supervise the work, if desired by the Engineer.

6.3.6 Mixing

6.3.7 Additive shall be used at the rate specified by the manufacturer or as indicated in the drawings and shall be mixed as required by the Engineer.

6.3.8 Test of Samples

Samples of concrete in which admixture is added shall be tested for waterproofing, compressive strength, water absorption, density etc. The results shall conform to relevant IS Specifications.

6.3.9 Method of Measurement And Payment

Payment shall be made to the Contractor @ per kilogram of the approved additives used in the cement concrete.

6.3.10 IS. Codes

Important relevant IS for this section is:

IS: 2645 - Integral cement waterproofing compounds.

6.4 WATER STOPS

6.4.1 Scope

This section of the Specification covers the technical requirements for furnishing and installation of water-stops. Water stops could be of PVC or rubber.

6.4.2 General Requirements

The Contractor shall furnish and install water-stops at all joints as indicated on drawings and as required by these specifications.

6.4.3 Material

a. Water-stops shall be made of PVC or rubber as indicated in the drawings. Water-stops shall be of maximum practical length in order to keep the joints to a minimum; and all joints shall be made by an approved method in accordance with the manufacturer's instructions.

b. All materials (PVC / Rubber) are to be procured from reliable manufacturers and must have the approval of the Engineer. The Engineer may demand test certificates for the materials and / or instruct the Contractor to get tested in an approved laboratory at no extra cost to the Employer.

c. Water-stops can be of a shape having any combination of the following features:

(i) Plain
(ii) Central bulb
(iii) Dumb bell or flattened ends
(iv) Ribbed and corrugated wings
(v) V shaped

The actual shape shall be as approved by Engineer. Joints shall be made by an approved process of thermal welding. Jointing by splicing shall be allowed only under unavoidable circumstances and that too with the specific approval of Engineer.

d. The method of forming these joints shall be as specified by the manufacturer or as approved by Engineer taking particulars care to match the central bulbs and the edges accurately.

6.4.4 PVC Water Stops

The minimum thickness of PVC sealing strips will be 6 mm and the minimum width 225 mm.

The actual size and shape shall be as specified in drawings or as approved by Engineer. The material should be of good quality polyvinyl chloride highly resistant to tearing, abrasion and corrosion as well as to chemicals likely to come in contract during use. The physical properties will generally be as follows:

Specific Gravity	: 1.3 to 1.35
Shore Hardness	: 60A to 80A
Tensile Strength	: 100-150 kg/cm2
Maximum Safe Continuous Temperature	: 75oC
Ultimate Elongation	: Not less than 275%
Water absorption	: Not more than 5% by weight in a 7 day test

6.4.5 Rubber Water Stops

Rubber seals and water stops could be used in place of PVC water-seals & stops specified in technical specification. If used, rubber seals & water stops shall be moulded from natural or synthetic rubber containing not less than one percent by weight of copper inhibitor and shall have the following minimum physical properties:

Shore Durometer Hardness	:	65 + 5 A
Minimum elongation	:	450%
Ultimate tensile strength	:	14.5 N/mm^2

The rubber compound shall not absorb more than ten (10) percent, by weight of water in a seven-day test. The tensile strength of the test specimen after being subjected to an accelerated aging test of 48 hours in oxygen at 70 ^{o} C and 2.1 N/mm^2 pressure shall not be less than 90 percent of the strength of the test specimen before ageing. The material shall be properly cured in a manner to ensure a dense homogeneous cross section free from pitting & blisters.

Rubber seal / water stops shall be in accordance with IS 11855-1986.

6.4.6 Installation

(a) Particular care shall be taken for the correct positioning of the water-stops to prevent any faulty installation, which may result in joint leakage.

(b) Adequate provisions shall be made to support the water stops during progress of work and to ensure their proper embedment in the concrete. The symmetrical halves of the water-stops shall be equally divided between the concrete pours adjacent to the joints.

(c) Maximum density and imperviousness of the concrete shall be ensured by thoroughly working in the vicinity of joints. However, particular care should be exercised in use of vibrators in the proximity of joints to avoid dislodging of the water-stops.

6.4.7 Splices

Splices in the continuity or intersections of runs of water-stops shall be jointed by lapping or by other methods of jointing as per manufacturer's stipulation depending on the type of water-stops used. It is essential that the material is not damaged during the splicing operation and that the continuity of the entire water stops across the section be maintained.

6.4.8 Inspection

All water-stop installations shall be subject to inspection and approval of the Engineer before concreting operations for encasing water-stops are performed. Water-stops shall be installed with joint formed true to line, level, shape, dimension and quality as per drawings and specifications.

6.4.9 Method of Measurement and Payment

The measurement for this item shall be based upon the length of seal / water stop fixed in position in meters (m) including provision of Anchors / welding / splicing etc. complete.

Payment shall be made at the unit rates stated per metre length of the seal / water stop in the Bill of quantities and shall cover cost of all material, labour, equipment etc. for procurement, installation, jointing / splicing complete in all respect.

CHAPTER - 7

FORMWORKS

7.1 GENERAL

7.1.1 The Contractor shall prepare, before commencement of the actual work, design and drawings for form work and centering and get them approved by the Engineer. The formwork shall conform to the shape, lines and dimensions as shown on the drawings. The approval by the Engineer shall not, however, relieve the Contractor of his responsibilities for adequacy of design, safety of men, machinery, materials and for results obtained.

7.1.2 Formwork / shuttering for faces of concrete which shall remain visible after completion shall be made from densified shuttering plywood.

7.1.3 All other general formwork shall be composed of steel and / or best quality shuttering wood/plywood of non-absorbent type. Timber shall be free from significant knots and shall be of medium grain as far as possible and hard woods shall be used as caps and wedges under or over posts. Marine Plywood or equivalent shall be used where required to obtain smooth surfaces for exposed concrete work. Struts shall generally be mild steel tubes and / or strong Sal wood tree-trunks 150 mm in diameter or above. Bamboos, small diameter tree-trunks, etc. shall not be used unless approved by the Engineer in specific cases.

7.1.4 Supports or props should not bear on an un-propped lower suspended floor or beam unless calculations are submitted to the Engineer to confirm the strength of the lower floor or beam and no propping shall be taken out until the Engineer's approval has been given.

7.1.5 The centering shall be true and rigid and thoroughly braced both horizontally and diagonally. The forms shall be sufficiently strong to carry without undue deformation, the dead weight of the concrete as a liquid as well as working load. Where the concrete is vibrated, the formwork shall be strong enough to withstand the effects of vibration, without appreciable deflection, bulging, distortion or loosening of its components. The joints in the formwork shall be sufficiently tight to prevent any leakage of mortar. The formwork shall be such as to ensure a smooth uniform surface free from honeycombs, air bubbles, bulges, fins and other blemishes. Any blemish or defect found on the surface of the concrete must be brought to the notice of the Engineer immediately and rectified free of charge as directed by him. To achieve the desired rigidity, the bolts, space blocks, the wires and clamps as approved by the Engineer shall be used butthey must in no way impair the strength of concrete or leave stains or marks on thefinished surface. Where there are chances of these fixtures being embedded, only mild steel or concrete of adequate strength shall be used. Bolts passing completely through liquid retaining walls / slabs for the purpose of securing and aligning the formwork should not be used.

7.1.6 For exposed interior and exterior concrete surfaces of beams, columns and walls, plywood or other approved forms; thoroughly cleaned and tied together with approved corrosion-resistant devices shall be used.

Rigid care shall be exercised in ensuring that all columns are plumb and true and thoroughly cross-braced to keep them so. All floor and beam centering shall be crowned

not less than 8 mm for every 5 m span to counter act the effect of any deflection. Unless described on the drawing or elsewhere to the contrary, beveled strips 25 x 25 mm shall be provided, without any extra charge, to form fillets in corners of columns and beam boxes for chamfering of corners. Temporary openings for cleaning, inspection and for pouring concrete shall be provided at the base of vertical forms and at other places, where they are necessary and as may be directed by the Engineer. The temporary openings shall be so formed that they can be conveniently closed when required and must not leave any mark on the concrete.

7.2 CLEANING AND TREATMENT OF FORMS

7.2.1 All forms shall be thoroughly cleaned of old concrete, wood shavings, saw dust, dust and rush sticking to them before they are fixed in position. All rubbish loose concrete, chippings, shavings; sawdust etc. shall be scrupulously removed from the interior of the forms before the concrete is poured. Along with wire brushe s, brooms etc. compressed air jet and/or water jet shall be kept handy for cleaning, if directed by the Engineer without any extra cost to the Employer.

7.2.2 Before shuttering is placed in position, the form surface in contact with shall be treated with approved oil or creosotes composition. Care shall be taken that the oil or creosotes composition does not come in contact with reinforcing steel or existing concrete surfaces. They shall not be allowed to accumulate at the bottom of the shuttering.

7.2.3 The form work shall be so designed and so erected that the forms for slabs and the sides of beams, columns and walls may be removed first, leaving the shuttering to the soffits of beams and their supports in position.

Re-propping of beams shall not be done except with the approval of the Engineer, and props can be reinstated on anticipation of abnormal conditions. Wedges, spacer bolts, clamps or other suitable means shall be provided to allow accurate adjustment of the formwork and to allow it to be removed gradually without jarring the concrete.

7.3 REMOVAL OF FORMS

7.3.1 The Contractor shall record on the drawing or in other approved manner, the date on which the concrete is placed in each part of the work and the date on which the formwork is removed there from and have this record checked and countersigned by the Engineer.

The Contractor shall be responsible for the safe removal of the formwork, but the Engineer may delay the time of removal if he considers it necessary, without any extra cost to Employer. Any work showing signs of damage through premature removal of formwork of loading shall be entirely reconstructed without any extra cost to the Employer.

7.3.2 Forms for various types of structural components shall not be removed before the minimum number of days specified in Tables-I and II also be which shall also be subject to the approval of the Engineer on a daily basis.

TABLE - I

S. No	Part of Structure	Ordinary Portland Cement Concrete Temperature	
		Above 40^0 C	40^0C To 20^0C
a	Columns and walls	2	2
b	Beam sides and vertical faces of other structural members	3	2
c	Slabs, 125 mm thick or less	10	7
d	Slabs over 125 mm thick and soffit of minor beams	18	14
e	Soffit of main beams and Cantilevers	24	21

TABLE - II

S. No	Part of Structure	Rapid Hardening Portland Cement Concrete Temperature	
		Above 40^0 C	40^0C To 20^0C
a	Columns and walls	1	1.5
b	Beam sides and vertical faces of other structural members	2	1
c	Slabs, 125 mm thick or less	7	4
d	Slabs over 125 mm thick and soffit of minor beams	12	8
e	Soffit of main beams and Cantilevers	14	10

7.3.3 Where the exposed surface of concrete can be effectively sealed to prevent loss of water, the periods specified for temperature above 40^oC can be reduced to those for the temperature range 20^0C to 40^0C subject to the approval of the Engineer. Before removing any formwork, the Contractor must notify the Engineer well in advance to enable him to inspect the concrete, if he so desires.

7.3.4 However, in any case, formwork shall not be struck until the concrete has reached a strength at least twice the stress to which the concrete may be subjected to at the time of removal of formwork.

7.3.5 The number of props left under, their sizes and disposition shall be such as to be able to safely carry the full dead load of the slab beam or arch as the case may be together with any live load likely to occur during curing or further construction.

7.3.6 Where the shape of the element is such that the formwork has re-entrant angles, the formwork shall be removed as soon as possible after the concrete has set, to avoid shrinkage cracking occurring due to the restraint imposed.

7.3.7 In case of cantilever slabs the removal of forms shall begin from outer edge towards support and in case of slabs on four sides the removal of forms shall be going from centre to supports.

7.4 TOLERANCE IN FINISHED CONCRETE

7.4.1 The formwork shall be so made as to produce a finished concrete, true to shape, lines, plumb and dimensions.

7.4.2 Tolerances shall be as specified in inspection and testing standards. The Engineer may call for finished work at any time to set standards of workmanship. Once approved, these will become the accepted sample.

7.4.3 The tolerance specified for local aberrations in the finished concrete surface and should not be taken as tolerances for the entire structure taken as a whole or for the setting and alignment of formwork, which should be as accurate as possible and true to shape required to the entire satisfaction of the Engineer. Any error within the above tolerance limits or any other as may be specially set up by the Engineer, if noticed, in any lift of the structure after stripping of forms, shall be corrected in the subsequent work to bring the surface of the structure to its true alignment.

7.5 RE-USE OF FORMS

Before re-use all forms shall be thoroughly scrapped, cleaned, joints etc. examined, and when necessary repaired, and inside surface treated as specified herein before. Formwork shall not be used / re-used, if declared unfit or unserviceable by the Engineer.

7.6 CLASSIFICATION OF FORM WORK

7.6.1 Ordinary

These shall be used in places where ordinary surface finish is required and shall be composed of steel and / or approved good quality seasoned wood.

7.6.2 Plywood

(a) These shall be used in exposed surfaces, where a specially good finish is required and shall be made mostly of approved brand of heavy quality water resistant plywood to produce a perfectly level, uniform and smooth surface.

(b) Re-use may be permitted only after special inspection and approval by the Engineer. He may also permit utilization of used plywood for the Ordinary class.

7.6.3 Ornamental

These shall be special shapes and profiles, the details of which shall be as shown in drawings.

7.7 ACCEPTANCE OF FORMWORK AND FINISHED CONCRETE

7.7.1 Finished concrete shall be true to shape, lines, levels, plumb and dimensions as shown on drawings.

7.7.2 All embedded fixtures shall be of correct type and in correct position as shown in drawings.

7.7.3 Finished concrete surfaces shall be free from blemishes like honeycombs, air bubbles, fins etc.

7.7.4 Exposed decorative concrete surface shall be free from rust, stains, grease and mould, oil stains etc. and shall have uniform pleasing appearance to the satisfaction of the Engineer.

7.7.5 The finished concrete shall be of a standard at least equal to that of the accepted sample.

7.8 METHOD OF MEASUREMENT AND PAYMENT

No separate payment shall be made for the formwork and it will be deemed as included in the item rates for concrete.

CHAPTER - 8

REINFORCEMENT

8.1 SCOPE:

This section covers specifications for providing steel reinforcement to structures and ancillary works and the contractor has to make his own arrangements for the procurement of tested mild steel and H.Y.S.D Bars (Fe 500) required for the work only from the reputed manufacturers. Necessary I.S.I. test certificates are to be produced to Engineer before use on work Steel bars shall be stored in such a way as to avoid distortion and to prevent deterioration by corrosion. He shall make his own arrangements for transportation and storage.

High yield strength deformed bars shall conform to I.S: 1786-1985.

The diameter and weight of plain and HYSD Steel bars shall be as follows.

Sr.No.	Diameter of rod	Sectional weight in Kilogram per running
N		metre both for plain and HYSD Steel
O		
T1	6 Millimeters	0.22
E2	8 Millimeters	0.39
: 3	10 Millimeters	0.62
4	12 Millimeters	0.89
I 5	14 Millimeters	1.21
f 6	16 Millimeters	1.58
7	18 Millimeters	2.00
a 8	20 Millimeters	2.47
n 9	22 Millimeters	2.98
y10	25 Millimeters	3.85
11	28 Millimeters	4.83
r12	32 Millimeters	6.31
o13	36 Millimeters	7.99
d14	40 Millimeters	9.86
s		

other than those specified above are used, the weights shall be as per standard steel tables.

This work shall consist of furnishing and placing reinforcement of the shape and dimensions shown on the drawings and as specified in the specifications, including cutting, bending, cleaning, welding, placing, binding and fixing in position. A list of IS codes applicable are as follows:

8.2 LIST OF IS CODES:

IS:456-1978/2000	Code of practice for plain and reinforced concrete
IS:1786-1985	Specification for High strength deformed steel bars and wires for concrete reinforcement.
IS:432-1982 (Part I)	Specifications for mild steel and medium tensile steel bars for concrete reinforcement and hard drawn steel wire.
IS:280-1978	Mild steel wire for general engineering purposes
IS:2502-1963	Code of practice for bending and fixing of bars for concrete reinforcement.
IS:9417-1989	Recommendations for welding cold worked bars for reinforced concrete construction.
IS:2751-1979	Welding of mild steel plain and deformed bars for reinforced construction.
IS:814-1991	Covered electrodes for manual metal arc welding of carbon and carbon manganese steel.
IS:1278-1972	Filer rods and wires and gas welding.
IS 818 - 1968	Code of practice for safety and healthy requirement and gas welding and cutting operations
IS 3016 - 1986	Code of practice for fire precautions in welding and cutting operation .

8.3 STEEL REINFORCING BARS

8.3.1 Steel reinforcing bars shall be placed in concrete where shown on the drawings or directed by the Engineer. The Contractor shall prepare and furnish for approval drawings indicating the bar bending details and reinforcement bar lists for all structures.

8.3.2 Not less than 7 days prior to placement of reinforcement, the Contractor shall submit to Engineer, for approval three prints and a reproducible of each of his reinforcement detail drawings showing bar bending schedules. The Contractor's reinforcement detailed drawings shall be prepared in accordance with IS: 456 (latest edition) Code of Practice for Plain and Reinforced Concrete, IS: 2502 (latest edition) Code of Practice for Bending and Fixing of Bars for Concrete Reinforcement and IS: 5525 (latest edition) Recommendation for Detailing of Reinforcement in Reinforced Concrete Works. The Contractor's drawings shall show necessary details for checking the bars during placement and for use in establishing payment quantities. Reinforcement bars shall conform to requirements shown on the drawings or as directed by the Engineer. The approval of the Engineer to the Contractor's reinforcement detail drawings shall not relieve the Contractor of his responsibility for the correctness of details or for conformance with the requirements of these specifications.

8.3.3 The reinforcing bars shall meet the requirements of IS: 1786 (latest edition) and its

latest edition. However, in case of non-availability of such bars other steel barsconforming to IS: 432 (latest edition) and/or IS: 1139 (latest edition) will be used as per the directions of the Engineer.

8.4 MATERIAL

Steel shall be clean and free from loose rust or loose mill scale at the time of fixing in position and subsequent concreting.

The contractor shall procure high yield strength deformed bars, conforming to IS: 1786-1985. However, in case of non-availability of such bars, other steel bars conforming to IS: 432-1982 shall be used.

8.5 CUTTING, BENDING AND BINDING OF REINFORCEMENT.

8.5.1 Reinforcing steel shall conform accurately to the dimensions given in the bar bending schedules shown on relevant drawings.

8.5.2 Bars shall be bent cold to the specified shape and dimensions by a bar bender by hand or power to attain proper radii of bends as shown in drawings.

8.5.3 Bars shall not be bent or straightened in a manner that will injure the material.
Bars bent during the transport or handling shall be straightened before being used on work, they shall not be heated to facilitate bending.

8.5.4 "U" type hooks shall invariably be provided at the end of each bar, if specified in drawing. The radius of the bend shall not be less than twice the diameter of round bar and the length of the straight part of the bar beyond the end of the curve shall be at least four times the diameter of the round bar. In the case of bars which are not round and in the case of deformed bars, the diameter shall be taken as the diameter of a circle having an equivalent effective area.

8.5.5 The hook shall be suitably encased to prevent any splitting of the concrete.

8.5.6 The Contractor shall be responsible for the accuracy of the cutting, bending, binding and placing of the reinforcement. Reinforcement will be inspected for compliance with the requirements as to grade, size, shape, length, splicing locations, positions and amount after it has been placed. No concreting shall be started unless the reinforcement as placed in the work is finally checked, recorded and certified by the Engineer.

8.5.7 Before the reinforcement is placed, the surfaces of the bars and the surfaces of any metal bar supports shall be cleaned of heavy rust, loose mill scale, dirt, grease and other objectionable. After being placed, the reinforcement bars shall be maintained in a clean condition until they are completely embedded in the concrete.

8.5.8 Reinforcing bars shall be accurately placed and secured in position so that there will be a clear distance of at least 25 mm between the bars and any adjacent embedded metal work and the bars and fabric will not be displaced during the placing of concrete. The Contractor shall also ensure that there is no disturbance of the reinforcing bars in concrete that has already been placed.

8.5.9 Wire for binding reinforcement shall be of soft and annealed mild steel and shall conform to IS: 280 (latest edition). Binding wire shall have tensile strength of not less than 51

kg/mm^2. The wire shall have minimum diameter of 1 mm. Chairs, hangers, spacers and other supports for reinforcement may be of concrete, metal and other approved material. Where portion of such supports will be exposed on concrete surface designated to receive F2 or F3 finish, the exposed portion of support shall be galvanized or other corrosion - resistant material except that concrete supports will not be permitted. Unless otherwise shown on the drawings, the reinforcements in structures shall be so placed that there will be a clear distance of at least 25mm between the reinforcement and any anchor bolts from ties or other embedded metal work. The minimum allowable clearance between parallel round bars shall not be less than 1.5 times diameter of the larger bar and for square bars shall not be less than twice the side dimension of the larger bar or 1.5 times the maximum size of aggregate whichever is greater. Bars crossing each other, where required, shall be secured by binding wire in such a manner that they do not slip over each at the time of fixing and concreting. Wire used for biding reinforcement will not be measured for payment.

8.6 SPLICING

8.6.1 Where it is necessary to splice reinforcement, the splices shall be made by lapping, by welding or by mechanical means.

8.6.2 Joints or splices in reinforcing bars shall generally be made at the positions shown on the drawings, but the Contractor would be permitted to make joints or splices at positions other than those shown on the drawings, providing that such positions are approved by the Engineer and that joints and splices in adjacent bars are staggered as directed by the Engineer. Approval of such additional splices will generally be restricted to splices not closer than 8 m in horizontal bars or 4 m in vertical bars measured between mid points of laps. The number of splices shall be kept to a minimum.

8.6.3 If the Contractor proposes to use welded splices in reinforcing bars, the equipment, the materials and all welding and testing procedures shall be subject to the approval of the Engineer. The Contractor shall carry out test welds as required by the Engineer.

8.6.4 For welded splices for reinforcing bars conforming to IS: 1786 (latest edition), welding shall be done in accordance with IS 9417 (latest edition). Recommendations for Welding Cold-Worked Steel bars for reinforced concrete construction. For reinforcing bars conforming to IS: 432 (Part I - latest edition) and IS: 1139 (latest edition) welding shall be done in accordance with IS: 2751 (latest edition) Code of practice for welding of mild steel plain and deformed bars for reinforced concrete construction. Electrodes for manual metal arc welding shall conform to IS: 815 (Part I- latest edition)) and IS: 815 (Part II - latest edition)). Mild steel filler rods for Oxy-acetylene welding shall conform to type SFS7 of IS: 1278 (latest edition) provided they are capable of giving a minimum butt weld tensile strength of 41 kg/mm^2.

8.6.5 If the Contractor proposes to use mechanical couplings for reinforcing bars, he shall submit samples of the proposed coupling to the Engineer for approval not less than 60 days prior to their proposed use.

8.6.6 When permitted or specified on the drawings, joints of reinforcement bars shall be butt welded so as to transmit their full strength. Welding of bars shall be done as directed by the Employer and conforming to requirements of clause 11.4 of IS: 456-1978.

8.6.7 If it is proposed to use welded splices in reinforcing bars, the equipment, the material and all welding and testing procedures shall be subject to the approval of the Employer. The contractor shall also carryout test welds as required by the Employer. No extra rate will be paid for welding reinforcement, test-welds, as bid rate in bill of quantities is inclusive of this item.

8.6.8 Only electric arc welding using a process which excludes air from the molten metal and conforms to any or all other special provisions for the work shall be accepted. Suitable means shall be provided for holding the bars securely in position during welding. It must be ensured that no voids are left in welding and when welding is done in two or three steps, previous surfaces shall be cleaned well. Ends of bars shall be cleaned of all Iron scale, rust, grease, paint and other foreign matter before welding.

8.6.9 Reinforcing bars of 28 mm in diameter and larger may be connected by butt welding provided that lapped splices will be permitted if found to be more practical than butt welding and if lapping does not encroach on cover limitation or hinder concrete or reinforcement placing.

8.6.10 Reinforcing bars 25 mm in diameter and less may be either lapped or butt welded, whichever is the most practicable.

8.6.11 Butt welding of reinforcing bars shall be performed either by the gas pressure or flash pressure welding process or by the electric arc methods under cover from weather.

8.6.12 Welded pieces of reinforcement shall be tested at the rate of 0.5% of total number of joints welded. Specimen shall be taken from the actual site of work. Strength of the weld provided shall be at least 25% higher than the strength of bars.

8.6.13 Welded joints or splices shall preferably be located at points where steel will not be subject to more than 75% of the maximum permissible stresses and welds so staggered that at any section not more than 20% of rods are welded. Approval of such additional splices will generally be restricted to splices not closer than 8 meters in horizontal bars or 4 meters in vertical bars measured between mid-points of laps.

8.7 PLACING OF REINFORCEMENT

8.7.1 Before the reinforcement is placed, the surface of the bars and the surfaces of any metal bar supports shall be cleaned of the rust, loose mill scale, dirt, grease and other objectionable foreign substances.

8.7.2 All reinforcing bars shall be accurately placed in exact position shown on the drawing, and shall be securely held in position during placing of concrete by annealed binding wire, and by using stays, blocks or metal chairs, spacers, metal hangers, supporting wires or other approved devices at sufficiently close intervals.

8.7.3 Wire for binding reinforcement shall be soft and annealed mild steel of 16 SWG and shall conform to IS: 280-1978. Binding wire shall have tensile strength of not less than 5600 Kg/cm^2 and a yield point of less than 3850 Kg/cm2.

8.7.4 Bars shall not be allowed to sag between supports. They shall not be displaced during concreting or any other operation over the work.

8.7.5 The contractor shall also ensure that there is no disturbance caused to the reinforcing bars already placed in concrete.

8.7.6 All devices used for positioning shall be of non-corrodible material. Metal supports shall not extend to the surface of the concrete, except where shown on the drawings. Pieces of broken stone or brick ad wooden blocks shall not be used. Where portions of such supports will be exposed on concrete surfaces designated to receive F2 or F3 finish, the exposed portion of support shall be galvanized or coated with other corrosion resistant material without which the concreting will not be permitted. Such supports shall not be exposed on surfaces designated to receive F4 finish unless otherwise shown on the drawings.

8.7.7 Placing on layers of freshly laid concrete as work progresses for adjusting bar spacing shall not be allowed.

8.7.8 Layers of bars shall be separated by spacer bars, pre-cast blocks or other approved devices.

8.7.9 Reinforcement after being placed in position shall be maintained in a clean condition until completely embedded in concrete. Special care shall be taken to prevent any displacement of reinforcement in concrete already placed.

8.7.10 To protect reinforcement from corrosion, concrete cover shall be provided as indicated on the drawings. All bars protruding from concrete and to which other bars are to be spliced and which are likely to be exposed for an indefinite period shall be protected by a thick coat of neat cement grout.

8.7.11 Bars crossing each other, where required, shall be secured by binding wire (annealed) of size not less than 1mm dia and conforming to IS:280-1978 in such a manner that they do not slip over each other at the time of fixing and concreting.

8.7.12 As far as possible, bars of full length shall be used. In case this is not possible, overlapping of bars shall be done as directed by engineer. When practicable, overlapping bars shall not touch each other, but be kept apart by 25 mm or 1 ¼ times the maximum size of the coarse aggregate whichever is greater, by concrete between them. Where not feasible, overlapping bars shall be bound with annealed steel wire, not less than 1 mm thickness twisted tight. The overlaps shall be staggered for different bars and located at points, along the span where neither shear nor bending moment is maximum.

8.7.13 The minimum allowable clearance between parallel round bars shall not be less than 1½ times the diameter of the large bars and for square bars shall not be less than twice the side dimensions of the larger bars or 1½ times the maximum size of aggregate, whichever is greater.

8.7.14 Dissimilar diameter rods should not be joined together.

8.8 COUPLING OF BARS

Wherever indicated on the drawings or desired by the Engineer to use mechanical couplings for reinforcing bars, bars shall be joined by couplings which shall have across section sufficient to transmit the full strength of bars. The ends of bars that arejoined by couplings shall be upset for sufficient length, so that the effective crosssection at the base of treads is not less than the normal cross-section of the bars. The threads shall be standard whit worth threads. Steel for couplings shall conform to IS: 226. The contractor shall submit samples of the proposed coupling to the Engineer for approval not less than 60 days prior to their proposed use.

8.9 CARE OF PLACED REINFORCEMENT AND CONCRETE

Where reinforcement bars are bent aside at construction joints and afterwards bent back into their original position, care shall be taken to ensure that at no time the radius of the bend is less than 6 □diameter for deformed bars and 4 □ diameter for plain mild steel bars. Care shall also be taken, when bending such bars, to ensure that the concrete around the bars is not damaged.

8.10 TOLERANCES

As specified in clause 11.3 of IS: 456-1978 unless otherwise specified by the Engineer reinforcement shall be placed within the following tolerances.

For effective depth 200 mm or less = □10 mm
For effective depth more than 200 mm =□15mm

The cover shall in no case be reduced by more than one third of specified cover of 5 mm whichever is less.

8.11 DOWELS

The dowels shall be of the same HYSD bars of grade Fe 415 conforming to IS: 1786-1985 as used for reinforcement.
Details for dowels shall be as shown on the drawings or as directed by the Engineer.
Dowels shall be placed in the concrete where shown on the drawings or where directed and will be inspected for compliance with requirements as to size, shape, length, position and amount after they have been placed, but before being covered by concrete. Before the dowels are embedded in concrete, the surfaces of dowels shall be cleaned of all dirt, grease or other foreign substances which in the opinion of the Engineer are objectionable.
The dowels shall be accurately placed and secured in position so that they will not be displaced during the placing of the concrete.

8.12 MEASUREMENT AND PAYMENT:

8.12.1 Measurement:

- Measurement for payment, for furnishing and placing reinforcing bars will be made only on the calculated weight of the bars placed in concrete, in accordance with the drawings
- The calculated weight for reinforcing bars shall be determined as follows:
- Reinforcement shall be measured in length separately for different diameters as actually used in the work. Lengths shall include hooks at ends.
- Overlaps, chairs or distance bars used as necessary spacers or supports shall be separately measured.
- From the length measured, weight of reinforcing bars shall be calculated on the basis of weights specified in the table in section 7.1
- Wastage, couplings, welded joints and annealed steel wire for binding shall not be measured and the cost of these items shall be deemed to have been included in the rates for reinforcement.
- The unit for payment shall be one metric ton weight of steel.

CHAPTER - 9

FABRICATION AND ERECTION OF STRUCTURAL STEEL WORKS

9.1 SCOPE:

9.1.1 This section covers the technical requirements for foundation bolt, fabrication and erection of structural steel, painting, electro-forged gratings, mild steel and high strength permanent bolts, dismantling, addition to, alterations in and/ or modification, re-erection of cooling water ducts, hand-railing and similar works.

9.2 CODES AND STANDARDS

Some of the relevant applicable Indian Codes, Standards and Acts are referred to herein below:

9.2.1 Materials

SN	IS NO	SHORT TITLE
1	IS:808	Dimensions for Rolled Steel Beam Channel and Angle Sections.
2	IS:814	Covered Electrodes for Manual Metal Arc Welding of Carbon and Carbon Manganese Steel.
3	IS:1161	Steel Tubes for structural purposes.
4	IS:1363	Hexagon Head Bolts, Screws and Nuts of Production Parts 1 - 3 :Grade C.
5	IS:1364	Hexagon Head Bolts, Screws and Nuts of Production Parts 1 - 5 :Grade A and B.
6	IS:1367 Part -1	Technical supply conditions for Threaded Fasteners
7	IS:1367	Technical supply conditions for Threaded Fasteners Part - 2: Product Grade and Tolerances.
8	IS:1367	Mechanical Properties and Test Methods Part -3 For Bolts , Screws and Studs With full load ability
9	IS:1367	Mechanical Properties and Test Methods Part - 6 For Nuts with Specified Proof Load.
10	IS:1367	Surface discontinuities on Bolts. Part -9 (Sections 1 and 2)
11	IS:1367	Hot Dip Galvanized Coating on Threaded Part - 13Fasteners.

12	IS:1852	Specification for Rolling and Cutting Tolerances for Hot Rolled
13	IS:2016	Specification for Plain Washers.
14	IS:2062	Steel for General Structural Purposes.
15	IS:3063	Specification of Single Coil Rectangular Spring Washers for
16	IS:3502	Specifications for Steel Chequered Plate.
17	IS:3757	Specification for High Strength Structural Bolts.
18	IS:4218	Specification for Isometric Screw Threads.
19	IS:4923	Specification for Hollow Steel Sections for Structural use.
20	IS:5369	General requirements for Plain Washers and Lock Washers.
21	IS:5624	Specification for Foundation Bolts.
22	IS:6623	Specification for High Strength Structural Nuts.
23	IS:6639	Specification for Hexagon Bolts for Steel Structures.
24	IS:6649	Specification for Hardened and Tempered Washer for High Strength
25	IS:6911	Specification for Stainless Steel Plate, Sheet and Strip.
26	IS:8500	Specification for Structural Steel Micro - Alloyed (Medium and high
27	IS:13238	Specification for Epoxy Based Zinc Silicate Prime (Two Pack).
28	IS:13239	Epoxy Surface (Two Packs).
29	IS:13467	Chlorinated Rubber for Paints.
30	IS:14209	Epoxy Enamel Two Component Glossy.

9.2.2 CODES OF PRACTICE FOR FABRICATION

SN	IS NO	SHORT TITLE
1	IS:800	Code of Practice for General Construction in Steel.
2	IS:813	Scheme of symbols for welding.
3	IS:816	Code of Practice for Use of Metal Arc Welding for General Construction in Mild Steel.
4	IS:817	Code of Practice for Training and Testing of Metal Arc Welders.
5	IS:1024	Code of Practice for Use of welding in Bridges and Substructure subject to Dynamic Loading.
6	IS:1477	Code of Practice for Finishing of Ferrous Metals in Buildings- Painting and Allied Finishes.
7	IS:2629	Recommended Practices for Hot Dip Galvanizing of Iron and Steel.
8	IS:2811	Recommendations for Manual Tungsten Inert Gas Arc Welding of Stainless Steel.
9	IS:3696	Safety Code of Scaffolds and Ladders.
10	IS:4000	Code of Practice for High Strength Bolts in Steel Structure.
11	IS:4353	Recommendations for Submerged Arc welding of Mild Steel and Low Alloy Steels
12	IS:4759	Hot Dip Zinc Coating on Structural Steel and Other Allied Products.
13	IS:5206	Covered Electrodes for Manual Metal Arc Welding of Stainless Steel and other similar High Alloy Steels.
14	IS:7205	Safety Code for Erection of Structural Steel
`	IS:7215	Tolerances for Fabrication of Steel Structures.
16	IS:7293	Safety Code for working with Construction Machinery.
17	IS:7318	Fusion Welding of Steel-Approval Test for Welders.
18	IS:9178	Criteria for Design of Steel Bins for Storage of Bulk Materials.
19	IS:9595	Recommendations for Metal Arc Welding of Carbon and Carbon-Manganese Steels.
20	IS:12843	Tolerance for Erection of Structural Steel.
21	SP: 6 ISI Parts 1 - 7	Hand Book for Structural Engineers.

22	ISO : 898/2	Mechanical Properties of Nuts.
23	ISO :3269	Fasteners - Acceptance Inspection.

9.2.3 STANDARDS CODES FOR TESTING

SN	IS NO	SHORT TITLE
1	IS:228	Methods of Chemical Analysis of Steels.
2	IS:1181	Qualifying Tests for Metal Arc Welders (Engaged in welding structures other than Pipes).
3	IS:1182	Recommended Practice for Radiographic Examination of Fusion Welded Butt Joint in Steel Plates.
4	IS:1599	Method of Bend Test.
5	IS:1608	Mechanical Testing of Metals-Tensile Testing.
6	IS:2595	Code of Practice for Radiographic Testing.
7	IS:2614	Method of Sampling of Fasteners.
8	IS:3613	Acceptance Tests for Wire Flux Combination for Submerged Arc Welding.
9	IS:3658	Code of Practice for Liquid Penetrant Flaw Detection.
10	IS:3664	Code of Practice for Ultrasonic Testing by Pulse Echo Method.
11	IS:5334	Code of Practice for Magnetic Particle Flaw Detection of Welds.
12	IS:6821	Methods of Sampling of Non Threaded Fasteners.
13	IS:7307	Approval Test for welding Procedures. Part - 1: Fusion welding of Steel.
14	IS:7310	Approval Test for Welders working to approved welding Part - 1: Procedure: Fusion welding of Steel.

9.2.4 BS CODES

SN	IS NO	SHORT TITLE
1	BS : 4232	Sand Blast Cleaning.

2	BS : 5493	Protective Coating of Iron and Steel Structures against corrosion.
3	BS : 5502	Part 74 Code of Practice for Design and Construction of Bins and Silos for Combinable Crops.

9.3 FABRICATION AND ERECTION OF STRUCTURAL STEEL:

9.3.1 General Requirements

- This covers fabrication, erection, alignment, welding ,etc. of mild steel, medium and high tensile steel, at all levels, involving rolled sections including rounds, pipes / hollow sections, built-up sections fabricated out of plates, and / or rolled sections including pipes / hollow sections, chequered plates, in columns, beams, crane girder, gantry girders, roof trusses, portals, purlins, space frames, shear connectors, hangers, struts, monorail beams, galleries, stiffeners, wall beams, sheeting runners, brackets, stub columns, bracing, cleats, trestles, base plates, splice plates, chequered plate floorings, decking plates, floor plates, seal plates , diaphragm, steel frame grid over false ceiling, walkways , platforms, ladders, stairs, stringers, treads, landings, handrails, toe plates, M. S. rungs, insert plates, edge protection, embedment, lugs, posts, stays, gates, louvers, lacing, gusset plates, washers, bunkers, silos, hopper, strakes, all sampling and testing etc.all complete.
- The provisions of IS: 800 shall be followed as general guidance along with all other relevant Indian Standards, Codes and Acts, unless Otherwise specifically mentioned.

9.3.2 Material

- Mild Steel
- Rolled sections and plates up to and including 20 mm thickness shall conform to grade 'A' of IS: 2062 and shall be semi-killed. Plates beyond 20mm thickness shall conform to grade 'B' of IS: 2062.
- All steel upto and including 40mm thickness shall be in as rolled condition. Plates beyond 40mm Thickness shall be normalized and ultrasonically tested.
- Rolled sections and plates conforming to IS: 808 and IS: 226 respectively can also be used as available in the stock of the owner.
- Pipes shall conform to IS: 1161.
- Hollow (square and rectangular) steel sections shall be hot formed conforming to IS: 4923 and shall be of Grade Yst 240.
- Chequered plate shall conform to IS 3502 and steel shall conform to grade A of IS 2062.

9.3.3 Medium and High Tensile Steel

- Medium and high tensile steel shall generally conform to grad
- 'Fe-490B' of IS 8500 or equivalent
- Rolled sections and plates up to and including 20 mm thickness shall be semi-skilled and plates beyond 20 mm thickness shall be killed
- All steels up to and including 40mm thickness shall be in as rolled condition. Plates beyond 40mm thickness shall be normalized and ultrasonically tested.

9.3.4 All other materials (nuts, lock nuts), consumables etc. shall be as per applicable standards and codes.

9.3.5 In case any defect like laminations is noticed in the steel sections and plates during fabrication and erection, same shall be immediately brought to the notice of the engineer, who shall direct the usage or non-usage of the same. In case of non-usage, the contractor shall return the same to the owner's store at his own cost. However, in case of usage, the contractor shall take necessary precautions such as plug welding etc. and as directed by the engineer, without any extra cost to the owner.

9.4 DESIGN OF CONNECTIONS

9.4.1 All connections shall generally be done through welding, unless otherwise specified in the design / scope drawings. Bolts when used for connections shall be of mild steel, high strength steel and / or friction grips, as indicated in the scope/ design drawings.

9.4.2 Fabrication drawings and design calculations shall be prepared according to the provision of IS: 800, IS: 816, IS: 1367, IS: 3757, IS: 4000, IS: 9178 and IS: 9595.

9.4.3 Connection of vertical bracing with connecting members and diagonals of truss members shall be designed for full tensile capacity of the bracing, unless actual loads are indicated on the design / scope drawings.

9.4.4 Size of fillet weld for flange to web connection for built-up section shall be as follows:

- For box section weld size shall be designed for 60% of full shear capacity or actual shear if indicated in design/scope drawings, whichever is more. Wherever fillet weld is not possible, full strength full penetration butt weld shall be provided.
- For built-up plated I-section, weld size shall be designed for 80% of full shear capacity or actual shear, if indicated in design / scope drawings, whichever is more. However, weld size shall not be less than 0.5 times the web thickness. Weld shall be of double fillet.
- All structural welds shall be continuous and the minimum size of the Fillet weld shall be 6 mm.

9.4.5 Erection bolts shall be provided to hold the steel members in position during erection and alignment.

9.4.6 Shear connections shall be designed for 60% of section strength for rolled sections and 80% of section strength for built-up plated I-section or combination of rolled section with cover plates. However, if the load actually applied is more than the above-specified value, the connection shall be designed for actual applied load.

9.4.7 Moment connections between beam and column shall be designed for 100% of moment capacity of the beam section. This can be achieved either by direct butt welding of the top flange of beam with column flange or by providing top moment plate with suitable notch for additional weld length, as directed by the engineer.

9.4.8 All butt welds shall be of full strength full penetration butt welds.

9.4.9 Connection between top flange and web of crane girder shall be of full penetration butt weld. Bottom flange connection with web can be of fillet weld or butt weld, as directed by engineer.

9.4.10 Connection of base plate and associated stiffeners with the columns shall be designed considering the total load transferred through welds. However, the minimum weld size (double fillet) shall not be less than 0.6 times the thickness of stiffeners.

9.5 SPLICING

9.5.1 All splicing works shall be for full strength.

9.5.2 Shop splicing of all plates shall be carried out by full strength full penetration butt welds. Shop splicing for all rolled sections (beams, channels, angles, hollow sections, etc.) shall be carried out using web and flange cover plates. Shop splicing for solid round sections shall be done by combination of butt weld and stiffening (splice) plates.

9.5.3 Field splicing of built-up section is generally not envisaged. However it can be provided only in exceptional cases, if indicated in the scope/ design drawings, with butt weld followed by splice cover plates. Splice cover plates shall be designed for the full strength.

9.5.4 In case any additional splices are needed than those indicated in the design / scope drawings by the contractor, on account of limitation of crane (i.e.by not mobilizing crane of specified capacity), then the same can be provided subject to a maximum penal recovery of steel sections used for such additional splicing, at the rates specified for reconciliation of structural steel consumption under relevant clauses of special conditions of contract.

9.6 FABRICATION

9.6.1 Site Fabrication

The fabrication of works shall be carried out generally in accordance with IS : 800 as well as with the stipulations contained in these specifications. IS: 9178 (Parts I and II) shall be followed as general guidance for fabrication and erection of bins / silos. All structures shall be completely site fabricated, in the fabrication/ pre-assembly yard developed by the contractor, at his own cost, within the project site.

9.6.2 Collection of Steel

The Contractor shall procure steel from their reputed manufactures like TATA STEEL, TELCO, SAIL. Contractor shall make all arrangements, whatsoever required for the procurement, loading, weighing, and transportation, protection against damage in transit, unloading and storage of steel.

9.6.3 Straightening

All steel materials shall be straight and free from bends or twists. If the sections are distorted or twisted during transit, storage, etc. they shall be straightened and / or flattened, as directed by engineer, at an ambient temperature. Minor kinks or bends may however be corrected by limited heating under careful supervision.

9.6.4 Preparation of Cutting Plans

The contractor shall prepare necessary cutting plans for all fabrication work taking into consideration the availability of materials and cut pieces generated during the work with the object of minimizing wastage.

9.6.5 Cutting

The cut edges of all plates/sections shall be perfectly straight and uniform throughout. Plates shall be cut with pug cutting machine only unless otherwise directed by the engineer. Gas cut edges shall be clean, square and free from distortion and burrs.

9.6.6 Bending and Rolling

Bending of plates and rolled sections to the specially required shapes for fabrication shall be done on plate bending machine or by cold bending process without resorting to heating, hammering, angle smithy and black smithy process.

9.6.7 Grinding

- All the edges cut by flame shall be ground before they are welded. Ends of all bearing stiffeners shall be ground to fit tightly at both top and bottom.
- In case of crane girders, the bottom of the knife-edge support shall be accurately ground to provide effective bearing on the column bracket. The top surface of column bracket shall also be ground similarly.
- The ends of column shafts together with attached gussets, stiffeners, angles, channels, etc. after welding together shall be accurately ground, so that the parts connected butt over the entire surface of contact.
- The column base slabs shall be similarly ground over the bearing surface and shall have effective contact with the end of the shaft. The bearing face that is to be grouted direct to a foundation need not be ground.

9.6.8 Clearances

The erection clearance for cleat ends of members connecting steel to steel shall not be greater than 2 mm at each end, unless approved by the Engineer.

9.6.9 Drilling

- Holes through more than one thickness of material for members, such as compound stanchion and girders, flanges, shall be drilled after the members are assembled and tightly clamped or bolted together.
- All holes in the washer plates shall be drilled using drilling/lathe machine. Small holes (having diameter up to and including 50 mm), provided in the base plate for grouting, shall be made by drilling Large holes (having diameter more than 50 mm), provided in the base plate and or horizontal brackets plates directly welded to the column flange, for passage of the foundation bolt can be made by gas cutting and all surfaces obtained by gas cutting shall subsequently be made smooth by grinding / filing.

9.6.10 Assembly

- The component parts shall be assembled in such a manner that they are neithertwisted nor

otherwise damaged and shall be so prepared that the specified camber, if any is provided. If the individual components are to be bolted, parallel and tapered drifts shall be used to align the parts so that the bolts can be accurately positioned.

- Items like roof trusses, galleries shall be trial assembled keeping in view the actual site conditions, prior to dispatch to site for erection so that they can be conveniently pre-assembled before erection or conveniently pre-assembled during erection. Necessary match marks shall be made on these components before disassembly in the shop and dispatching.
- For columns which are fabricated in two or more parts, controlled/trial assembly shall be carried out in the preassembly/fabrication yard before dispatch to the erection Site.

9.6.11 Bolting

- Bolting will involve the provision of bolts in clearance holes and/ or high strength friction grip fasteners.
- The diameter of the bolt hole shall be taken as the nominal diameter of the bolt plus 1.5 mm, unless noted otherwise.
- Every bolt shall be provided with a washer under the nut so that no part of the threaded portion of the bolt is within the thickness of the parts bolted together.
- Flat washers shall be circular of a diameter 2.5 times that of bolt and of suitable thickness. Where bolt heads / nuts bear upon the beveled surfaces they shall be provided with the square tapered washers of suitable thickness to afford a seating square with the axis of the bolt as per satisfaction of engineer.
- All boltsand nuts shall be of steel, with well-formed hexagonal heads. The nuts shall be good fit on the bolts and minimum two clear threads shall show through the nut when it has been finally tightened up.
- Notwithstanding anything to the contrary contained in IS:1363,IS:1364, and IS: 1367, the unthreaded length of the bolt shall be equal to total thickness of metal being bolted together plus 2 mm. The threaded length shall be equal to at least the diameter of bolt plus 6 mm.
- IS: 4000 shall be followed for high strength friction grip bolts.

9.7 WELDING

9.7.1 The works shall be done as per approved fabrication drawing which would clearly indicate various details of joints to be welded, type of weld, length and size of weld, whether shop or site weld.

9.7.2 Welding of structural steel shall be done by an electric arc process, submerged arc welding / MIG welding / manual metal arc welding. Welding shall conform generally to relevant acceptable standards viz. IS: 816, IS: 9595, IS: 814, IS: 1024, IS: 4354 and Indian Standard hand book for metal arc welding, and other standards, codes of practice internationally accepted. For welding of any particular type of joint, contractor shall give evidence acceptable to the owner of having satisfactorily completed appropriate tests as described in any of the Indian Standards - IS: 817, IS: 7307 and international standard as relevant.

9.7.3 Welding process employing semi-automatic welding machine and / or MIG welding and / or fully automatic welding machine shall be used for welding longitudinal fillet welds (connecting flange with web) and butt joints for fabrication of columns, framing beams

and crane girders, unless manual arc welding is specifically approved by the engineer. Necessary jigs and fixtures and rotation of structural shall be so arranged that vertically down-hand position of welding becomes possible. 'Open-arc-welding' process employing coated electrodes shall be employed for fabrication of other welded connections and field welding.

9.7.4 Wherever welding is done for assembling the components of structural, the job shall be so positioned that down-hand welding is possible.

9.7.5 Any structural joint shall be welded only by those welders who are qualified for all welding procedures and positions required in such a joint

9.7.6 The contractor shall maintain records of all the welders identification marks, the joints welded by each welder, the welding procedure adopted, welding machine employed, pre and post heating done and any non destructive test done and stress relieving/heat treatment performed on such joints. All such records for entire welding operation shall be accessible to the Engineer for scrutiny.

9.7.7 In fabrication of plated columns/ beams and built-up members all shop splices in each component part shall be made before such component part is welded to other parts of the member. Wherever weld reinforcement interferes with proper fitting between components to be assembled for welding, these welds shall be ground flush prior to assembly.

9.7.8 The members to be joined by fillet welding shall be brought and held as close together as possible and in no event shall be separated by more than 3mm. If the separation is 1.5mm or greater, the fillet weld size shall be increased by the amount of separation. The bins / silos shall be made of mild steel plates joined together with full strength butt weld and provided with stiffeners at regular intervals. Stiffeners shall be welded on the external face.

9.8 ELECTRODES

9.8.1 The electrodes used for welding shall be of suitable type and size depending upon specifications of the parent material, the method of welding, the position of welding and quality of welds desired. Only low hydrogen electrodes shall be used for welding of medium / high tensile steel and for mild steel plate thickness above 20 mm.

9.8.2 All low hydrogen electrodes shall be baked and stored before use as per manufacturer's recommendation. The electrodes shall be re-baked at 250° C - 300° C for one hour and later on cooled in the same oven to 100° C. It shall be transferred to a holding oven maintained at 60° C 70° C. The electrodes shall be drawn from this oven for use.

9.8.3 Where coated electrodes are used they shall meet the requirements of IS: 814 and relevant ASME - Sec. II. Covering shall be heavy to withstand normal conditions of handling and storage.

9.8.4 Only those electrodes that give radiographic quality welds shall be used for welds, which are subjected to radiographic testing.

9.8.5 Where bare electrodes are used these shall correspond to specification of the parent material. The type of flux-wire combination for submerged arc welding shall conform

to the requirements of F-60 class of AWSA5 17-69 and IS: 3613. The electrodes shall be stored properly and the flux shall be baked before use in an oven in accordance with the manufacturer's requirements as stipulated.

9.8.6 The contractor shall take specific approval of the weld for the various electrodes proposed to be used on the works before any welding is started.

9.9 EDGE PREPARATION FOR WELDING

Suitable edge as per weld joint detail shall be prepared either by machines or by automatic gas cutting. All edges cut by flame shall be ground before they are welded.

9.10 PRE HEATING AND POST HEATING

9.10.1 Mild steel and medium/high tensile steel plates thicker than 20 mm, will require Pre - Heating of the parent plate prior to welding as mentioned in Table- 1 for mild steel and Table-2 for medium/high tensile steel, however, higher pre heat temperature may be required as per approved welding procedure and it shall be followed. In welding materials of unequal thickness, the thicker part shall be taken for this purpose.

9.10.2 Base metal shall be preheated, not withstanding provisions of IS: 9595 to the temperature given in Table-1 for mild steel and Table-2 for medium/ high tensile steel, prior to welding or tack welding. When base metal not otherwise required being pre heated is at a temperature below 0°C it shall be pre heated to at least 20°C., prior to tack welding or welding. Pre heating shall bring the surface of the base metal to the specified pre heat temperature and this temperature shall be maintained as minimum inter-pass temperature while welding is in progress.

TABLE - 1

MINIMUM PREHEAT AND INTERPASS TEMPERATURE FOR WELDING MILD STEEL

Thickness of thicker part at Point of welding	Welding Using	
	Low hydrogen electrode or submerged arc welding	Other than low hydrogen electrode
Upto and including 20mm	None	None
Over 20mm and up to and Including	40 mm not allowed	20°C
Over 40mm and up to and Including	63 mm Not allowed	66°C

Over 63 mm	110°C	Not allowed

Note: Type of electrode and the preheating requirements for welding shall be as per approved welding procedure.

TABLE - 2

MINIMUM PREHEAT AND INTERPASS TEMPERATURE FOR WELDING MEDIUM / HIGH TENSILE STEEL

	Welding Using	
Thickness of thicker part at Point of welding	Low hydrogen electrode or submerged arc welding	Other than low hydrogen electrode
Upto and including 20mm	None	Not Allowed
Over 20mm	120°C - 140°C	Not Allowed

Note: Type of electrode and the preheating requirements for welding of medium and high tensile steel shall be as per approved welding procedure.

9.10.3 Pre heating may be applied by external flame which is non-carbonizing like LPG, by electric resistance or electric induction process such that uniform heating of the surface extending up to a distance of four times the thickness of the plate on either side of the welded joint is obtained.

9.10.4 Thermo-chalk, thermo-couple or other approved methods shall be used for measuring the plate temperature.

9.10.5 All butt welds with plates thicker than 50mm and all site butt welds of main framing beam supporting the bunker shall require post weld heat treatment as per procedure given in AWS D-1.1. Post heating shall be done up to 600° C and rate of application shall be 200° C per hour.

9.10.6 The post heat temperature shall be maintained for 60 minutes per 2.5 cm thickness. For maintaining slow and uniform cooling, asbestos pads shall be used for covering the heated areas.

9.11 WELDING SEQUENCE

9.11.1 The sequence of welding shall be carefully chosen to ensure that the components assembled by welding are free from distortion and large residual stresses are not developed. The distortion should be effectively controlled either by a counter effect or by a counter distortion.

9.11.2 The direction of welding should be away from the point of restraint and towards the point of maximum freedom.

9.11.3 Each case shall be carefully studied before finally following a particular sequence of welding.

9.11.4 Butt weld in flange plates and/or web plates shall be completed before the flanges and webs are welded together.

9.11.5 The beam and column stiffeners shall preferably be welded to the webs before the web and flanges are assembled unless the web and flanges of the beam or column are assembled by automatic welding process.

9.11.6 All welds shall be finished full and made with correct number of runs. The welds being kept free from slag and other inclusions. All adhering slag being removed from exposed faces immediately after such run.

9.11.7 Current shall be appropriate for the type of electrode used. To ensure complete fusion, the weaving procedure should go proper and rate of arc advancement should not be so rapid as to leave the edges unmelted.

9.11.8 Puddling shall be sufficient to enable the gases to escape from the molten metal before it solidifies.

9.11.9 Non-uniform heating and cooling should be avoided to ensure that excessive stresses are not locked up resulting ultimately in cracks.

9.11.10 The ends of butt welds shall have full throat thickness. This shall be obtained on all main butt welds by the use of runoff and run on pieces adequately secured on either side of main plates. The width of these pieces shall not be less than the thickness of the thicker part joined. Additional metal remaining after the removal of extension pieces shall be removed by grinding or by other approved means and the ends and surface of the welds shall be smoothly finished. Where the abutting parts are thinner than 20mm the extension pieces may be omitted but the end of the butt welds shall then be chipped or gouged out to sound metal and side welded to fill up the ends to the required reinforcement.

9.11.11 The fusion faces shall be carefully aligned. Presetting shall control Angle shrinkage. Correct gap and alignment shall be maintained during the welding operation.

9.11.12 All main butt welds shall have complete penetration and back surface of the weld being gouged out clean before first run of the weld is given from the back. However, partial penetration butt weld shall be permitted, when specifically shown in the fabrication drawings.

9.11.13 Intermittent welds shall be permitted only when specifically approved in the fabrication drawings.

9.11.14 The welding shrinkage shall be minimized by adopting the correct welding procedure and method. In long and slender member extra length should be provided at the time of fabrication for shrinkage.

9.12 TESTING OF WELDERS

9.12.1 On the basis of the welding procedure, the contractor shall conduct qualification test. All the welders to be employed for the job shall have to qualify the appropriate tests laid down in IS: 817 and IS: 1181 and ASME IX / AWS D1.1.

9.12.2 All necessary arrangements required for the testing of welders are to be provided by the contractor.

9.13 PRODUCTION TEST PLATE

Test plates shall be incorporated on either side of at least one main butt weld of each flange plate and web plate of every main frame column. The weld shall be continuous over the test plate. The test plate shall be cut from extensions of the main plates and shall be fixed so that metal lies in the same direction as that of the main plate. Test plates shall be prepared and tested in accordance with the accepted standards, in the presence of the weld or his authorised representative. The contractor shall provide all testing equipment and facilities for carrying out these tests . Should any of these tests fail, further radiographic examination of the welds shall be done. These tests for the test plates and radiographic examination are additional to those contemplated under part -C of this specification.

9.14 RECTIFICATION AND CORRECTION

Wherever defects like improper penetration, extensive presence of blow holes, undercuts, cracking, slag inclusion, etc. are noticed by visual Inspection / other tests, the welds, in such location shall be removed by gouging process. The joints shall be prepared again by cleaning the burrs and residual matters with wire brushes and grinding, if necessary, and re-welded. The gouging shall as far as possible be done using gouging electrodes.

9.15 CORRECTION OF DEFECTIVE WELDS

Correction of defective welds shall be carried out as directed by owner without damaging the parent metal. When a crack in the weld is removed magnetic particle inspection or any other equally positive means shall be used to ensure that the whole of the crack and material up to 25 mm beyond each end of the crack has been removed. Cost of all such tests and operation incidental to correction shall be to contractor's account.

9.16 PRIMER PAINTING

9.16.1 Anti corrosive / chlorinated rubber based zinc phosphate primer shall be with non saponificable plasticiser. The primer shall have high build formulation, as per BS: 5493 (One pack chemical resistant primer).

9.16.2 Unless specified otherwise in the schedule of items, surface preparation shall be done in accordance with IS: 1477 (Part - I). The surface shall be cleaned and degreased in accordance with one or more of the methods given in IS: 1477 (Part - I). The surface shall be de-rusted and de-scaled either mechanically or chemically by one or more of the methods given in IS: 1477. However flame cleaning and blast cleaning shall be resorted to wherever specifically mentioned in the schedule of items. While cleaning with power wire-brush, care shall be taken not to do it excessively, since mill scale easily gets burnished to a smooth even surface to which paints does not adhere, and this will be detrimental to the performance of paint. Power tools shall remove all accessible weld flux and splatter.

9.16.3 Primer paint shall be applied by spray / brushing as applicable. Dry film thickness (DFT) of the chlorinated rubber based zinc phosphate shall be minimum 50 microns.

9.17 ERECTION AND ALIGNMENT

9.17.1 Erection marks

- Erection marks in accordance with approved fabrication drawing shall be clearly painted on the fabricated steelwork. Each piece shall be marked in at least two places. Each piece shall also have its weight marked thereon.
- The center lines of all columns, elevations and beam bearings shall be marked on the sections to ensure proper alignment and assembly of the pieces at site.

9.17.2 Erection Scheme

- The contractor shall submit for review to the owner his erection scheme for the erection of all types of structural.
- The contractor before commencement of fabrication work, to avoid any future modification shall check the erect-ability of the structural. The erection scheme shall indicate the approximate weight of the structural members, position of lifting hook, crane boom length, crane capacity at different boom length and at different boom inclination etc.
- The erection scheme shall also give details of the method of handling, transport, hoisting, including false work/staging, temporary bracing, guying, temporary strengthening etc. It will also give the complete details of the number and capacity of the various erection equipment that will be used such as cranes, winches, etc. along with disposition at the time of erection of column, trusses etc.
- The contractor shall examine the site conditions and transportation clearances before deciding whether columns, trusses, beams are to be transported in one piece or in more than one piece. All those steel members which are to be required to be erected in single piece but are transported in more than one piece shall be assembled, aligned bolted, welded, tested etc. on the proper assembly bed before erection at site.
- The erection of columns, trusses, trestles, portals, beams etc. shall be carried out in one single piece as far as practicable unless specified otherwise in the design drawing. Conveyor galleries shall generally be erected as box pieces i.e. the bottom chord and bracing, top chord and bracing, side vertical posts and tracing, end portals and roof trusses shall be completely welded prior to erection and if required temporary strengthening during erection shall be made.
- The sheeting runners and roof sheeting purlins may be erected individually. When erection joints are provided in columns, their location shall generally be just above a floor level.
- The structural steel shall be erected frame-wise. Thereafter, the frames shall be progressively aligned and all erection welding completed. The secondary beams shall thereafter be erected, aligned and welded bay wise / floor-wise.

9.18 EMBEDDING IN CONCRETE

All embedments shall be placed true to level and location. It shall be ensured by the contractor by provision of the temporary members and if required by welding of embedment lugs with nearby reinforcement. The embedments shall not be disturbed during concreting.

9.19 PROTECTION AGAINST DAMAGE IN TRANSIT

9.19.1 All steelwork shall b efficiently and sufficiently protected against damage in transit from fabrication yard to erection site from any cause whatsoever. All projecting plates and all ends of members at joints shall be stiffened.

9.19.2 If the steel has been unduly bent in transit or during handling by the contractor which cannot be rectified in the opinion of the weld, such steel shall not be used.

9.20 STABILITY OF STRUCTURES

The contractor shall be responsible for the stability of the structures at all stages of its erection at site and shall take all necessary measures by the additions of temporary bracing sand guying to ensure adequate resistance to wind and also to loads due to erection equipment and their operations. Guying and bracing shall be done in such a way that it does not interfere with the movement or working of other agencies working in the area. For the purpose of guying, the contractor shall not use other structural in the vicinity, which is likely to be damaged by the guy.

9.21 TEMPORARY STRUCTURES

The stipulations contained in the Indian standard safety code for erection of structural steel work IS:7205 shall be followed, for ensuring safety of men and material. This shall include provision of temporary structures by the contractor, at his own cost for proper approach and working platforms during the erection of structures to the satisfaction of weld. The contractor at his own cost shall provide any temporary strengthening needed. Temporary structures shall include access ladders, working platforms, railings etc. All temporary structures shall be subsequently dismantled and removed.

9.22 SETTING COLUMN BASES

Column bases shall be set so that the column load is uniformly transmitted to the foundation. The contractor shall carefully check the location and layout of anchor bolts embedded in foundations to ensure that the structures can be properly erected as shown on the drawing. In some cases the bolts may be provided in the pipe sleeves / pockets in foundations for subsequent adjustment in final alignment of the foundation bolt. Before erection of columns on their foundations, the top surface of base concrete shall be thoroughly cleaned with wire brushes and by chipping to remove all laitance and loose material. The contractor shall be responsible to provide all packing and shim plates whatsoever required for erection of the structural at his own cost.

9.23 ALIGNMENT

The contractor shall be responsible for the correct alignment and leveling of all steelwork on site to ensure that the columns are in plumb and all the structures are erected conforming to the specified permissible erection tolerances. Welding works shall be done only after the approval of alignment of erected structures by the Engineer.

9.24 HIGH PERFORMANCE PAINTING SYSTEM

9.24.1 Materials

- Zinc silicate primer (minimum 75 microns Dry Film Thickness DFT) shall be inorganic (Ethyl) self curing high built (Solid by volume minimum 60) formulation as per BS: 5493 (Inorganic Zinc rich systems).
- Intermediate (Under) coat (minimum 75 micron DFT) shall be of polyamide cured titanium di-oxide/micaceous iron oxide pigmented high performance (solid by volume minimum 60%) epoxy coating as per BS:5493(two pack chemical resistant under coats).
- Finish coat(minimum 75 micron DFT) shall be of polyamide cured colored pigmented high performance (solid by volume minimum 60%) epoxy coating as per BS:5493 (two pack chemical resistant finishes).
- Final finish coat (minimum 25 Micron DFT) shall be of polyurethane colour pigmented (solid by volume minimum 40%) as per BS: 5493 (two pack chemical resistant finishes).

9.24.2 All paints including primer shall be of reputed brand / manufacturer and as approved by the engineer.

9.25 PREPARATION OF SURFACE

9.25.1 The surfaces shall be blast cleaned to near white metal surface (Sa 2½) i.e.2nd quality (requiring at least 95% of the surface completely cleaned) as given in BS: 4232. For blast cleaning dry method as approved shall be used.

9.25.2 Approved type of abrasives shall only be used for blast cleaning of steel surfaces. To avoid contamination of the adjoining areas with abrasive, suitable enclosure shall be provided to carry out the blast cleaning operation. If required prior approval from the factory inspector / pollution control board etc. shall be obtained regarding the method of blast cleaning and abrasives used therein.

9.25.3 Steel may be blast cleaned either before or after fabrication. Immediately after blast cleaning of the steel surfaces, primer coat shall be applied onto the surfaces.

9.26 APPLICATION OF PAINT

9.26.1 The contractor shall submit the total painting scheme and works shall be started after the approval of the scheme, from the engineer.

9.26.2 Painting works shall be carried out on structures as per the approved scheme. The total painting scheme to be submitted to the engineer shall include the following:

- Method of blast cleaning giving the details and sizing of various equipment required, abrasive used,enclosure provided to avoid contamination of the adjoining area, expected productivity on an eight (08) hour shift working etc.
- Arrangement of airless spray with the equipment rating.
- Drying time to be allowed before the application of subsequent coat.
- Recommended paint for primer, intermediate (under) coat, finish coat and final finish coat with their brand name and designation, considering the requirements of BS:5493 for long range (typical time to first maintenance 10 to 20 years), life for exterior exposed non polluted inland atmosphere.

- Number of coat and the thickness of each coat to be applied to achieve the specified thickness of each coat i.e. Primer, intermediate (under), finish and final finish coats.
- Environmental conditions i.e. ambient temperature and humidity at the time of application of the paint.
- Quality control setup for painting i.e. Checking of surface preparation, thickness of each coat, quality of applied paints vis-a-vis the approved sample etc.
- Method of touch up painting for surfaces damaged during handling, transit, erection, welding, subsequent to painting, removal of the temporary supports etc.
- Reference of relevant Indian/International standards for the testing and acceptance.

9.26.3 Before application of inorganic zinc silicate primer, the steel surfaces shall be blast cleaned to near white metal surface (Sa 2 ½).

9.26.4 Primer paint and intermediate (Under) coat shall be done by airless spray. However finish coat and final finish coat can be applied either by spray and or brush.

9.26.5 All subsequent coats shall be applied only after acceptance of the previous applied coat. Inaccessible surfaces shall be primer painted before shop assembly.

9.26.6 For final touch up painting of surfaces, which are damaged during handling, transit, erection, etc surfaces shall be well prepared, by rubbing the entire damaged area using wire brush, emery paper etc. and shall be provided with minimum 100 micron (DFT) of self priming high build epoxy based primer followed by intermediate, finish and final finish coats as described elsewhere in this document. Touch up painting of areas welded subsequent to painting and areas exposed after removal of temporary supports shall also be carried out in same way.

9.26.7 Rectification of the damaged painted surfaces on account of welding / handling etc. of each coat shall be done by touch up painting, before the application of next coat,

using minimum 100micron (DFT) self priming high build epoxy based primer followed by various coats in sequence of thickness as specified elsewhere.

9.27 ACCEPTANCE CRITERIA

9.27.1 All painted surfaces shall be uniform and pleasing in appearance.

9.27.2 Dry film thickness of each coat shall be checked and measured by using elcho-meter. The thickness as measured shall not be less than the minimum thickness specified for the coat of paint under relevant clauses of the technical specification.

9.27.3 Colour, texture shall match exactly with the approved sample.

9.27.4 Sampling, testing and quality assurance requirements are given elsewhere.

9.28 ELECTRO FORGED STEEL GRATINGS

9.28.1 General Requirements

This covers the provision of gratings in floorings, platforms, drain covers, trench covers, walkways, passages, structural treads with edge binding strips and anti skid nosing, etc.

9.28.2 Material

Steel used in electro-forged gratings unit shall conform to grade 'A' of IS: 2062.

9.29 FABRICATION DRAWINGS

9.29.1 For gratings the engineer shall release the design drawing indicating the openings required and load intensity on the grating. Based on these drawings, the contractor shall submit the grating design drawing for different spans and load intensities, along with the fabrication drawings. Thickness of all gratings shall be kept as 40 mm uniform, unless specified otherwise.

9.29.2 Preparation, submission checking and approval of the drawing shall be done in the same manner as specified for fabrication drawings elsewhere in this document.

9.30 FABRICATION

9.30.1 All gratings shall be fabricated in a factory outside the project area, however fabrication of grating at site will be permitted with due permission of engineer in charge.

9.30.2 All grating units shall be rectangular in pattern and electro-forged. The size and the spacing of the bearing bars and cross bars shall be as detailed in fabrication drawings. The contractor shall submit the grating design for different spans and loading intensities, along with fabrication drawings.

9.30.3 The grating unit shall be accurately fabricated and finished, free from warps, twists or any defects that would impair their strength, serviceability and appearance.

9.30.4 The gratings shall be of reputed make and manufacturer, as approved by the engineer. Contractor shall provide all facilities and access to the engineer or his representative to carry out Inspection during all stages of manufacturing of gratings.

9.30.5 Grating units shall be provided with all necessary clips, bolts, self drilling and tapping screws, nuts and lock washers required for proper assembly and rigid installation and fastening to abutting units / supporting structural steel framing members. Wherever required edge binding strip and anti-skid nozing shall be provided.

9.31 ERECTION, ALIGNMENT AND INSTALLATION:

9.31.1 Grating work shall include making cut outs and clear openings for all columns, pipes, ducts, conduits or any other installation penetrating through the grating work. Such cut outs and clearances shall be treated as specified in subsequent clauses.

9.31.2 The gratings shall be notched, trimmed and neatly finished around flanges and webs of the columns, moment connections, cap plates and such other components of the steel structural encountered during the placement of the gratings. In all such cases, the trimming shall be done to follow the profile of the components encountered. After trimming, the binding strip shall be provided on the grating to suit the profile so obtained.

9.31.3 Opening in gratings for pipes or ducts that are 150 mm (in size or diameter) or larger shall be provided with steel bar toe plates of not less than 5 mm thickness and appropriate width, set flush with the bottom of the bearing bars.

9.31.4 Penetrations in gratings that are more than 50 mm but less than 150 mm in size or diameter shall be welded with plates of size shown in the detailed drawing set flush with the bottom of the grating panel.

9.31.5 Unless otherwise indicated on the drawing , grating units at all penetrations shall be made up in split section, accurately fitted and neatly finished to provide for proper assembly and erection at the job site.

9.31.6 Grating shall preferably be installed in position by self drilling and tapping screws.

9.32 PAINTING

9.32.1 Grating shall be provided with high performance painting system as given hereunder.

9.32.2 Surface preparation of grating along with accessories shall be done by blast cleaning to near white metal surface (Sa 2 ½) i. e. 2nd quality (requiring at least 95 % of the surface completely cleaned), as given in BS: 4232.

9.32.3 Inorganic zinc silicate primer (minimum 75 Micron DFT) shall be applied above the blast-cleaned surfaces.

9.32.4 Primer shall be followed by polyamide cured Titanium Di Oxide/Micaceous iron pigmented high performance epoxy coating as an intermediate (Under) coat (minimum 75 micron DFT).

9.32.5 Intermediate coat shall be followed by polyamide cured colour pigmented high performance epoxy coating as a final coat (minimum 75 Micron DFT).

9.32.6 All other provisions as mentioned for high performance painting system with regard to preparation of surface, application of paint and acceptance criteria shall also be applicable.

9.33 GALVANIZATION

9.33.1 Wherever specified gratings shall be provided with galvanization. The weight of the zinc coating shall be at least 610 g. /Sq.M. unless noted otherwise.

9.33.2 Purity of zinc to be used for galvanizing shall be 99.5% as per IS: 209.

9.33.3 After the shop work is complete, the structural material shall be punched with erection mark and be hot double dip galvanized. Before galvanizing the steel section shall be thoroughly blast cleaned to near white metal surface (Sa 2 ½) or chemically cleaned.

9.33.4 The galvanized surface shall consist of a continuous and uniformly thick coating of zinc, firmly adhering to the surface of steel. The finished surface shall be cleaned and smooth and shall be free from defects like discoloured patches, Bare spots, unevenness of coating, spelter which is loosely attached to the steel, blistered surface, flaking or peeling off etc. The presence of any of these defects noticed on visual or microscopic inspection shall render the material liable to rejection.

9.33.5 There shall be no flaking or loosening when structural squarely with a chisel faced hammer. The galvanised steel member shall withstand minimum four one minute dips in copper sulphate solution as per IS: 2633.

9.33.6 When the steel section is removed from the galvanizing kettle, excess spelter shall be removed by 'Bumping'. The processes known as 'wiping' or 'scrapping' shall not be used for this purpose.

9.33.7 Defects in certain members indicating presence of impurities in the galvanizing bath in quantities larger than that permitted by the specifications or lack of quality control in any manner in the galvanizing plant, shall render the entire production in the relevant shift liable to rejection.

9.33.8 All gratings shall be treated with sodium dichromate or an approved equivalent solution after galvanizing, so as to prevent white storage stains.

9.33.9 If the galvanizing of any member is damaged, the engineer shall be shown of the extent of damage, if so directed the galvanizing may have to the redone in the similar manner as stated above at no extra cost to the owner.

9.34 PERMANENT BOLTS, NUTS AND WASHERS

9.34.1 General Requirements

- Permanent bolts shall be used for field connections only for those joints where so specified in the design document.
- All bolts, nuts, washers shall be of reputed make as approved by the engineer.

9.34.2 Material

- Permanent Mild Steel Bolts

  The permanent mild steel bolts shall be of carbon steel of product Grade 'C' as per IS 1363 (part - 2). The technical supply condition shall be as per IS: 1367 (part - I). The threads shall be of class 8g as per metric screw threads of IS: 4218 (part - 6). The bolts shall be of diameter up to 39mm and shall conform to mechanical properties class 4.6 as per IS 1367 (part - 3).
- Permanent Mild Steel Nuts

  The permanent mild steel nuts shall be of carbon steel of product grade C meeting the requirements of IS: 1363 (part - 2). The technical supply condition shall be as per IS: 1367(part-1). The Threads shall be of tolerance class 7H as per metric screw threads as per IS: 4218(part-6). The nuts up to diameter 16mm shall be of property class 5 and for diameters beyond 16mm and up to 39mm shall conform to property class either 4 or 5 as per the provisions of IS: 1367(part- 6) or ISO 898/2.

9.35 PERMANENT MILD STEEL WASHERS

The permanent mild steel washers shall be of ordinary grade conforming to the requirements of IS: 5369 and IS: 2016. The washers shall be supplied in natural finish.

9.36 PERMANENT HIGH STRENGTH STRUCTURAL BOLTS

The permanent high strength structural bolts shall be either of carbon steel with additives (e.g. Boron or Mn or Cr) quenched and tempered or carbon steel quenched and tempered of product grade C meeting the provisions of IS: 3757.

The technical supply condition shall be as per IS: 1367 (part-1). The threads shall conform to tolerance class 6 g of IS: 4218 (part-6). The bolts shall conform to mechanical properties class 8.8 as per IS: 1367 (part - 3).

9.37 HIGH STRENGTH STRUCTURAL NUTS

High strength structural nuts shall be of product grade B meeting the requirements of IS: 6623. The technical supply condition shall be as per IS: 1367. The threads shall confirm to tolerance class 6H as per metric screws threads of IS: 4218 (part - 6). The nuts shall conform to property class 8 of IS: 1367 (part - 6)/ISO: 898 / 2 and all nuts shall be hardened and then tempered at temperature of at least 425º C.

9.38 WASHERS FOR HIGH STRENGTH STRUCTURAL BOLTS AND NUTS

The various types of washers for use with high strength structural bolts and nuts shall be of ordinary grade as per IS:5369 and shall meet all the requirements of IS: 6649. The washer shall be made according to IS: 1570 (part-2).The washer shall be thorough hardened and tempered. Washer shall be supplied in dull back heat-treated condition with residual coating of light oil.

9.39 INSTALLATION

9.39.1 Installation of the high strength bolts/ high strength friction grip bolts shall be as per the requirements specified in IS: 4000.

9.39.2 Mild steel bolts shall be installed and placed in position as per IS: 1363 / IS: 1367.

9.40 DISMANTLING

9.40.1 Dismantling of Steel Work

- In case it is found that certain erection marks already erected at any elevation are to be dismantled for any reason whatsoever, this shall be done only on the written orders / permission of the engineer.
- Such dismantling shall be done carefully without damaging other structural and lowered to ground. Thereafter, it shall be carried to the field fabrication shop, if modifications are to be carried out or return to the project stores if the dismantled member is not to be re-erected at all. This operation may involve temporary dismantling, cutting, re-welding, supporting and restoring to correct position all temporarily dismantled members, realigning of all other adjacent connected members, to their correct positions as well.

9.41 ADDITIONS TO, ALTERATIONS IN AND / OR MODIFICATION

9.40.2 Modification of Erection Marks

- In case, it is found that certain erection marks as already detailed and approved in fabrication drawings, require additions, alterations and modifications; this shall be done on the written orders of the engineer. Wherever a modification is ordered, the contractor shall request the engineer in writing to examine the stage of completion of the erection mark. The weight of the erection mark (i.e. the calculated weight as per approved bill of materials) shall be recorded and termed as the unmodified weight of the erection mark.

9.42 ADDITIONS TO, ALTERATIONS IN

9.40.3 If additions to, alterations in and/or modifications are intimated before completion and acceptance of fabrication of erection marks as per originally approved fabrication drawings, such changes shall not be classified as additions to, alterations in and/or modifications of erection marks and no payment shall be due to the contractor for such additions, alterations and modification. If additions to, alterations in and/or modifications is ordered after completion and acceptance of fabrication and/or erection, payment shall be due to the contractor for additions to, alterations in and / or modifications.

9.40.4 Normally the work of additions to, alterations in and / or modifications of erected erection marks shall be carried out in the erected position. Only in exceptional cases, where the engineer specifically approves that modification cannot be carried out in the erected position, the erection mark shall be dismantled.

9.40.5 The work of additions to, alterations in and/or modifications may involve cutting of certain portions and parts, gouging of welds, cuttings, grinding, fabrication, welding, drilling holes specifically required for the work, straightening, raising to the required level, removal of bends, painting and touch up painting, transporting the cut and removed parts/items, pieces re-utilized out of cut and removed parts/items new steel to be added. Wherever modification is involved it shall be done carefully without damaging other structural. In case of cutting from an erected member, the cut portion shall be safely lowered to the ground. Modification may involve temporary dismantling, cutting, re-welding, supporting and restoring to the correct position of all temporarily dismantled members realigning of other adjacent connected members as well. Modifications to erection marks at erection site shall involve transporting the fabricated part/items (pieces re-utilized out of cut and removed parts/items and or new steel added) to erection site, raising to required level and welding in position. Modifications to erection marks in fabrication yard shall involve turning and handling of structural.

9.40.6 Additions to, alterations in and/or modifications may be ordered either before erection or after erection and may have to be carried out either in erected position at erection site on the ground or in the fabrication shop. The scheme of dismantling and modification wherever required shall be got approved by the engineer before the work is taken up.

9.43 RE-ERECTION OF ERECTION MARKS AFTER ADDITIONS, ALTERATIONS AND MODIFICATIONS

9.43.1 The items, where additions to, alterations in and / or modifications or change of erection mark have been ordered and such operations have necessarily to be carried out after dismantling, shall require re-erection.

9.43.2 The work of re-erection includes carriage of modified erection marks from the field fabrication shop to erection site, lifting of same to the required position, aligning, and erecting in position, inclusive of erection bolts, tack welding and final welding and touch up painting etc., all complete to the satisfaction of the engineer. The work shall also involve the re-erection of members which had to be temporarily dismantled including temporary dismantling, cutting, re-welding, supporting and restoring to the correct position of all temporarily dismantled members, realignment of other adjacent connected members including gouging of welds, realigning, re-welding, etc. of such members.

CHAPTER - 10

BRICK MASONARY WORK

10.1 SCOPE

This part of the specification covers the requirement for masonry work (with or without RCC band / reinforcement) in all kind of works such as foundation, walls, drains, manhole, pits, gully chambers, trenches, partition wall, enclosures, coping, parapet, culverts, risers, treads, etc. masonry work shall be true to line & level as shown on drawings. All such masonry shall be tightly built against structural members and bonded with dowels, anchors, inserts, etc. as shown on drawings.

10.2 LIST OF IS CODES APPLICABLE:

IS: 1121-1974	Methods of test for determination of strength properties of (part 1 to 4) natural building stones
IS: 1122-1974	Method of test for determination of true specific gravity of natural building stones.
IS: 1123-1975	Method of identification of natural building stones.
IS: 1124-1974	Method of test for determination of water absorption apparent specific gravity and porosity of natural building stones.
IS: 1125-1974	Method of test for determination of weathering of natural building stones.
IS: 1126-1974	Method of test for determination of durability of natural building stones.
IS: 1127-1970	Recommendation for dimensions and workmanship of natural building stones for masonry work.
IS: 1129-1972	Recommendation of dressing of natural building stone.
IS: 1542-1977	Specification for sand for plaster
IS: 1597-1967	Code of practice for construction of stone masonry Part I & II Part - Rubble Stone Masonry part II-Ashlar Masonry.
IS: 2116-1980	Specification for sand for masonry mortars.
IS: 2250-1981	Code of practice for preparation and use of masonry mortars.

IS: 4101-1967 (part -I):	Code of practice for external facing and veneers stone masonry.
IS: 4121-1967	Method of test for determination of water transmission rate by capillary action through natural building stones.
IS: 4122-1967	Method of test for surface softening of natural building stones by exposure to acidic atmosphere.
IS: 4348-1973	Method of test for determination of permeability of natural building stones.
IS: 5218- 1969	Method of test for toughness of natural building stones.
IS: 8381- 1977	Recommended practice for quarrying stones for construction purposes.
IS : 1200-1976	Measurement of building and civil Engineering works stone masonry part -IV
IS :11216-1985	Code of practice for permeability test for masonry (during and after construction)
IS 3696-1978 (Part-I)	Safety code of scaffolds and ladders.
IS: 3696-1991	Safety code of scaffolds and ladders.
IS:1077-1992	specification for burnt clay bricks.
IS:1905-1987	code of practice for structural safety of buildings-masonry walls.
IS:2212-1991	code of practice for brickwork.
IS:3150	hexagonal wire netting for general

- In addition to the above I.S. codes, the specifications of CPWD/PWD (MAHARASHTRA) and manual for Quality control and inspection shall also be complied with.

10.3 MATERIALS

- Cement shall be ordinary Portland cement (grade 43) conforming to IS: 8112 and / or fly ash based Portland pozzolana cement conforming to IS: 1489 (Part 1) and or any other types of cement supplied by the engineer meeting the IS: 456 requirement.
- Brick shall be table moulded / machine made of uniform size, shape and sharp edges and shall have minimum compressive strength of 75 kg/cm^2. Burnt clay fly ash brick any fly

ash lime brick shall conform to IS: 13757 and IS: 12894 respectively. Minimum fly ash content in fly ash based brick shall be minimum 25%. Common burnt clay bricks shall conform to IS: 1077.

10.4 MORTAR

- IS: 2250 shall be followed as general guidance for preparation and use of mortar. Only cement -sand mortar shall be used.
- Unless otherwise specified, mortar for brickwork having one or more brick thickness shall be 1 part cement and 6 parts sand by volume. Mortar for half-brick with thick walls shall be 1 part cement and 4 parts sand by volume.
- Mortar shall meet the compressive strength requirement as per IS:2250 and IS:1905.
- Sand shall conform to IS: 2116 and grading shall be tested as per IS:2386.
- Cement and sand shall be thoroughly mixed dry in a mechanical mixer and water shall then be added to obtain a mortar of the consistency of a stiff plate, hand mixing may be allowed by the engineer on clean approved platform in special cases only.
- The unit for measurement for cement shall be a bag of cement weighing 50 kg and that shall be taken as 0.035 m3. Other ingredients in specified proportions shall be measured in boxes of suitable size. Sand shall be measured on the basis of its dry volume. In case of damp sand its quantity shall be increased suitably to allow for bulkage.
- Mortar shall be used as early as possible after mixing and before it has begun to set and in any case within Thirty (30) minutes after water is added to dry mixture. Mortar unused for more than Thirty (30) minutes shall be rejected and removed from site of work.
- Surplus mortar droppings from masonry, if received on surface free from dirt, may be mixed with fresh mortar if permitted by the Engineer who may direct addition of additional cement without any cost compensation. No mortar which has stood for more than half an hour shall be used.

10.5 BRICK MASONRY

- All workmanship shall be of best standard as approved by Engineer.
- IS: 2212 shall be followed as general guidance for construction of brick masonry.
- Bricks shall be soaked by submergence in fresh water for at least six (6) hours in approved vats before use.
- The Contractor shall provide tanks of sufficient capacity to allow the specified immersion. Bricks shall be laid in water by hand and not thrown. The bricks shall not be too wet at the time of use, as they are likely to slip on the mortar bed and there will be difficulty in ensuring plumbness of the wall. Bricks shall be laid in English bond unless specified otherwise. Broken bricks shall not be used. Cut bricks shall be used if necessary to complete bond or as closures. Bricks shall be laid with frogs upwards over full mortar beds. Bricks shall be pressed into mortar and tapped into final position so as to embed fully in mortar. Inside faces shall be buttered with mortar before the next brick is placed and pressed against it. Thus, all joints between bricks shall be fully filled with mortar. Mortar joints shall be kept uniform and to the thickness shown on drawings or as specified by Engineer, but shall not be more than 12 mm in thickness in any case.
- All joints at their face shall be raked to minimum 10 mm depth using raking tools while the mortar is still green to provide bond for plaster or painting. Where plaster or

painting is not provide joints shall be struck flush and finished immediately. Brick works one and a half brick thick or more shall have both faces in true plane. Brick works of lesser thickness shall have one selected face in true plane.

- All brick work shall be built tightly against columns, floor slabs or other structural parts as indicated on the drawings and door frames with proper distance to permit caulked joint. Where drawings indicate that structural steel column and spandrel beams are to be partly or wholly covered with brickwork, the bricks shall be built closely against all flange and webs with all space between the steel and brickwork filled solid with setting mortar with not less than 10 mm in thickness.

10.6 Pointing of the Brick Work

- The joints of the brickwork shall be raked out to a depth of 20 mm and the surface ofthe wall washed and cleaned and kept wet for two days before pointing.
- The materials of mortar cement and sand, or lime and surkhi (brick powder) or sand, or kankar lime as specified, shall be standard specifications. The materials of mortar shall be first dry mixed by measuring with boxes to have the required proportion as specified (1:2 or 1:3 for cement sand mortar, 1:1 for lime surkhi mortar or kankar lime mortar) and then mixed by adding water slowly and gradually and thoroughly mixed. □Mortar shall then be applied in the joints slightly in excess and pressed by a proper tool of the required shape. Extra mortar if any is removed and surface finished. Mortar shall not spread over the face of bricks, and the edges of bricks shall be clearly defined to give a neat appearance. After pointing the surface shall be kept wet for seven days. □Flush pointing - The mortar shall be pressed into the raked, cleaned and wet joints and shall be finished off flush and level with edges of brick to give a smooth appearance. The edges shall be neatly trimmed with a trowel and straight edge.
- Ruled Pointing - The mortar shall be pressed into the raked, cleaned and wet joints and a groove of shape and size of 5 to 6 mm deep shall be formed running a forming tool of steel along the center line of joint. The vertical joints also shall be finished in a similar way at right angle to the horizontal lines. The finished work shall give a neat and clean appearance with straight edge.
- Weather or Trucked pointing - The mortar shall be applied on the raked, cleaned and wet joints and horizontal joints shall be pressed and finished with a pointing tool so that the joint is sloping from top to bottom. The vertical joint shall be finished at ruled pointing.
- Raised or Trucked pointing - The mortar shall be applied in the raked, cleaned and wet joints in excess to form raised bands. The mortar shall be pressed and run with proper tool to form bands of 6mm raised and 10 mm width or as directed.
- For pointing in brickwork the total dry volume of materials is taken as 0.60 m^3 for 100 m^2
- Materials required for pointing with different mortars of various proportions for 100 m^2:

1. Cement Mortar 1: 2	-	0.2 m^3 cement and 0.4 m^3 sand
2. Cement Mortar 1: 3	-	0.16 m^3 cement and 0.48 m^3 sand.
3. White lime and Surkhi	-	0.32 m^3 lime (slaked) and 0.32 Mortar 1: 1m^3 Surkhi.
4. Kankar lime mortar	-	0.5 m^3 Kankar lime alone

- For all types of pointing the quantity of materials may be taken same as above, except raised pointing where the quantity many be increased by 10%.

10.7 Scaffolding

- Scaffolding shall be strong enough to withstand all the dead, live and impact loads which are likely to come upon it. It shall also be so designed as to ensure the safety of the workman using them.
- For all brick masonry except for exposed brickwork, single scaffolding shall be permitted. In such cases, the inner end of the horizontal scaffolding pole shall rest in a hole provided only in header course for the purpose. Only one header for each pole shall be left out. Such holes for scaffolding shall, however, not be allowed in pillars / columns less than one meter in width. The holes left in masonry works for scaffolding purposes shall be filled and made good before plastering.

10.8 Curing and Protection

Green work shall be protected from rains by suitably covering the same. Masonry in cement mortar or composite mortar shall be kept constantly moist on all the faces for a period of at least seven days. The top of masonry shall be flooded at the close of the day.

10.9 Embedment of Reinforcement anchorages

Reinforcing anchorage for external walls, the anchors in the form of flats or rods from spandrel beams and columns and any other anchoring and reinforcement as shown on drawing shall be adequately embedded in the masonry.

10.10 Embedding of Fixtures

All fixtures shall generally be embedded in mortar and masonry units shall be cut as required.

10.11 METHOD OF MEASUREMENT AND PAYMENT

Brickwork shall be measured by volume and paid for at the unit prices per cubic metre (m^3) quoted in the Bill of quantities and the unit prices shall cover cost of all labour, materials and equipment required to complete the work and nothing extra shall be paid on any account.

- Deductions for all openings, lintels, sills, conduits, ducts, pipes etc. shall be made. Voids filled with concrete shall be deducted and the concrete measured separately.
- No deduction shall be made for embedded fixture nor any extra be paid for the mortar used for fixing or for necessary cutting of blocks or bricks.
- No extra payments shall be made for cutting of bricks, masonry and allied works.
- For the purpose of measurement for masonry in plinth and foundation and for masonry in superstructures, the plinth level shall be taken as ground floor level or 1.5 m above ground level whichever is more.
- Thickness of brick walls shall be measured in nominal brick sizes
- Form work required for and frame work embedded in the opening shall be deemed to have been included in the quoted rate for masonry and nothing extra shall be paid for the same.

CHAPTER - 11

PLASTERING AND POINTING TO MASONARY AND CONCRETE

11.1 SCOPE

- This specification covers furnishing, installation, repairing, finishing, curing, testing, protection and maintenance till handling over of plastering and allied finishes to masonry and concrete. This shall also include the work to be done to make surfaces suitable for receiving the finishing treatment and any further finishing treatment over base finishing treatment.
- Before commencing work on the finishing items the Contract or shall obtain the approval of the Engineer regarding the scheduling of work to minimize damage by other Contractor. He shall also undertake normal precaution to prevent damage of disfiguration to work of other Contractors and other installations.
- The surface of Masonry shall be finished by “pointing” or by “plastering”. For a surface which is to be subsequently pointed or plastered, the joints shall be squarely raked out to depth not less than the width of the joints or as directed while the mortar is still green. The raked joints shall be well brushed to remove dust and loose particles and the surface shall be thoroughly washed and cleaned and wetted.

11.2 GENERAL :

Plastering of specified thickness with specified mortar proportion to the exposed faces of R.R. masonry/ brick masonry/concrete including cost and conveyance of cement and all other materials, sampling, testing mixing of mortar, labour charges, all leads, lifts, delifts, seignior age charges, scaffolding, curing, all water leads, and all other operations necessary to complete the finished item of work as per drawings and as directed by the Engineer-in-charge.

S. NO	IS CODE	Description
1	IS 1542	Grading of sand (as per table 1)
2	IS 2250	Code of practice for preparation & use of masonry mortar.
3	IS 2116	Sand quality
4	IS 2386 (part 1)	Test of particle size and shape (sand)
5	IS 1905	Code of practice for structural use of un reinforced masonry.
6	IS 2402	Code of practice for rendered finishes.

11.3 INSTALLATION

- PREPARATION OF SURFACE

All joints in masonry walls shall be raked out to a depth of at least 10 mm with a hooked tool made for the purpose while the mortar is still green. Walls shall be brushed down with stiff wire brush, to remove all loose dust from joints and thoroughly washed with water. All laitance shall be removed from concrete to be

plastered. Prior to commencement of actual finishing work, the approval of the Engineer shall be taken as to the acceptability of the base.

11.4 PLASTERING

11.5 Mortar

- Mortar for plastering shall be as specified in the drawings and in the Bill of quantities.
- For sand cement plaster, sand and cement in the specified proportion shall be mixed dry on a watertight platform and minimum water added to achieve working consistency.
- No plaster, which has stood for more than half an hour, shall be used; plaster that has shown tendency to become dry before this time shall have water added to it.
- Plaster on Smooth Faces of Brick Work

This plaster shall be laid in a single coat of 12 mm thickness. The mortar shall be dashed on the prepared surface with a trowel and finished smooth by trowel on the surface. The standard of finish expected is high and shall conform to IS: 2394. Wall plaster shall be carried out on jambs, lintel and sill faces, top, sides and undersides of openings, pillars, fins, facia, beams etc. as shown in the drawings or as directed by Engineer. Rate quoted for plasterwork shall be deemed to include plastering of all these surfaces.

- Internal Ceiling & Wall Plaster

Ceiling plaster shall be done in a manner similar to above and applied before wall plaster. Wall plaster shall commence at top and work downwards. The thickness of mortar and its grade shall be as per the Bill of Quantities.

- Plaster on Rough Faces of Brick Work

Exterior plasterwork shall be carried out in 2 layers, the first layer being 12 mm thick and the second layer being 6 mm thick. The first layer shall be dashed against the prepared surface with a trowel to obtain an even surface. The second layer shall then be applied and finished having an even and uniform surface.

11.6 APPLICATION OF PLASTER

- Plaster when more than 12 mm thick, shall be applied in two coats, i.e. a base coat followed by the finishing coat. Thickness of the base coat, however, shall not exceed 12 mm in thickness unless otherwise specified. The lower coat shall be thicker than the upper coat. The over all thickness of the coats shall not be less than the minimum thickness shown on the drawings. The undercoat shall be allowed to dry and shrink before applying the second coat of plaster. The under coat shall be scratched or roughened before it is fully hardened to form a mechanical key. The method of application shall be `thrown on' rather than `applied by trowel'.
- To ensure even thickness and true surface, patches of plaster about 100 mm to 150 mm square or wooden screed 75 mm wide and of the thickness of the plaster shall be fixed vertically about 2 m to 3 m apart, to act as gauges. The finished wall surface shall be true to plumb, and the Contractor shall, without any extra coat to the Employer, make up any irregularity in the brickwork with plaster. All vertical edges of brick pillars, door

jambs etc. shall be chamfered or rounded off as directed by the Engineer. All drips, grooves, moulding and cornices as shown on drawing or instructed by the Engineer shall be done with special care to maintain true lines, levels and profiles. After the plastering work is complete, all debris shall be removed and the area left clean. Any plastering that is damaged shall be repaired and left in good condition at the completion of the job.

11.7 CURING

Curing of plaster shall be started as soon as the applied plaster has hardened enough so as not to be damaged. The decision as to when the plaster has hardened will be given by the Engineer. Curing shall be done by continuously applying water in a fine spray and shall be carried out for at least seven (7) days. Each individual coat of plaster shall be kept damp continuously for a minimum period of two (2) days and then dried thoroughly before applying the next coat. Final coat shall be kept damp continuously for seven (7) days.

11.8 WATER PROOFING ADMIXTURES

- Whenever the specification or the item of work calls for waterproofing, the Contractor shall provide the percentage of water proofing compound as specified in the items of work.
- If directed by the Engineer, the Contractor shall use approved waterproofing admixtures made by reputed manufacturer in the mortar for plasterwork.
- The quantity to be used etc. shall be in accordance with the manufacturer's instructions subject however to the approval of the Engineer. These admixtures shall not contain calcium chloride unless specifically allowed by Engineer and shall conform to IS: 2645. The admixtures used shall be measured under relevant clauses as specified elsewhere in this specification.

11.9 FINISH

Generally, the standard finish shall be used unless otherwise shown on drawing or directed by the Engineer. Wherever any special treatment to the plastered surface is indicated, the work shall be done exactly as shown on the drawings, to the entire satisfaction of the Engineer regarding the texture, colour and finish.

11.10 Standard Finish

Wherever punning is indicated, the interior plaster shall be finished rough. Otherwise the interior plaster shall generally be finished to a smooth surface. The exterior surface shall generally be finished with a wooden float.

11.11 Neat Cement Finish

Immediately after achieving a true plastered surface with the help of a wooden straight edge, the entire area shall be uniformly treated with a paste of neat cement at the rate of one kg per sqm (1 kg/m^2) and rubbed smooth with a trowel.

11.12 Rough Cast Finish

A wet plastic mix of 3 parts Ordinary Portland Cement (OPC) mixed with approved colour pigment, 6 parts sand and 4 parts aggregate by volume (gravel or crushed stone of size from 6 mm to 12 mm, as approved by the Engineer) shall be thrown on to the wall by means of plaster's trowel and left in the rough condition. The mix shall again be bashed over the vacant spaces, if any, so that the surface represents a homogeneous surface of sand mixed with gravel.

11.13 ACCEPTANCE CRITERIA

Finish to masonry and concrete shall fully comply with the drawings, specifications, approved samples and instructions of the Engineer with respect to lines, levels, thickness, colour, texture, pattern and any other special criteria as mentioned in the specification or as shown on drawings.

11.14 RATES

Rates shall be for the complete work as detailed out in the specification unless any particular portion is specifically excluded in the Bill of Quantities. Rates shall include cost of all labour, materials, implements, scaffolding, curing, finishing etc.

11.15 METHOD OF MEASUREMENT AND PAYMENT

- All surface finishes shall be measured in square metre (m^2) on actual area plastered correct to the second place of decimal. No deductions shall be made for openings, pipes, sleeves etc. up to 0.1 m^2 in area and no additions shall be made for plastering sides of such openings. Deduction shall be made for openings, pipes and sleeves more than 0.1 m^2 in area and sides of such openings, if plastered, shall be measured. Payment shall be made at the quoted rates per square metre (m^2) in the Bill of Quantities (BOQ).
- No separate payment shall be made for special corner or edge finish, moulding, curbs etc. These shall be deemed to be the part of plastering work.
- No separate payment shall be made for finishing round openings, sleeves, pipes etc. No separate payment shall be made for form work, templates etc. required for achieving true lines and profiles as shown on drawing. These shall be deemed to be the part of plastering work.
- Finishes applied integrally with walls, floors, steps and ceilings shall be measured separately under relevant clauses as specified elsewhere in the specification.
- Any reinforcement incorporated in the finish shall be measured under relevant clauses as specified elsewhere in this specification.
- Grooves in plaster shall not be paid separately. Where specified, these shall be deemed to be part of plastering work.
- Drip courses shall be measured and paid for in running metres.

11.16 I.S. CODES

Important relevant I.S. Codes for this section:

- IS: 1661: Code of practice for cement and cement-lime plaster finish on walls and ceilings.
- IS: 4101: Code of practice for external facings and veneers.

CHAPTER - 12

FLOOR FINISH AND ALLIED WORKS

12.1 SCOPE

This specification covers furnishing, installation, finishing, curing, testing, protection and maintenance till handing over of various type of floor finishes and allied items of work. The different types of the in-Situ Finishes and Tiled Finishes are as given below:

(a) In situ Finishes

(i) Metallic Hardener such as 'Ironite' finish

(b) Tiled Finishes

(i) Glazed tiles

(ii) Acid resistant tiles

(c) Miscellaneous Floors

(i) Terrazzo flooring

(ii) Dividing metal strips.

12.2 Base

The base to receive the finish, which shall generally be of plain or reinforced cement concrete, is covered under other relevant specifications.

12.3 Sequence

Commencement, scheduling and sequence of the finishing works shall be planned in detail and must be specifically approved by the Engineer keeping in view the activities of other agencies working in that area. However, the Contractor for the finishing items shall remain fully responsible for all normal precautions and vigilance to prevent any damage whatsoever, till handing over.

12.4 INSTALLATION

Special Materials

Basic materials are covered in Chapter 2, SECTION-5 of Technical Specifications for "Properties, Storage and Handling of Common Construction Materials". Special materials required for individual finishing items are specified under respective items. In general, all such materials shall be as per relevant IS Codes where available. In all cases these materials shall be of the best quality available indigenously, unless specified otherwise. The materials for finishing items must be procured from well reputed specialized manufacturers and on the basis of approval of samples by the Engineer, the materials shall be ordered, procured and stored well in advance to maintain the construction schedule. All material shall confirm to relevant IS Codes.

Contractor shall supply the test certificate with each batch of material. When desired by Engineer, Contractor will get the sample of material tested in a laboratory approved by Engineer and submit the report for his approval. The materials shall be as per the following:

White cement shall be white Portland cement in accordance with IS: 8042 (white Portland cement). Sand shall be coarse, screened, washed, free of organic materials, in accordance with IS: 2116 (sand for masonry mortars).

Marble chips shall be standard quarry product or machine crushed of size 3 mm or above unless specified otherwise and of specified colour uniform grade.

Glazed tiles shall conform to the relevant IS Standards as specified under Clause 14.4.0 of this specification.

- Workmanship

Only workers specially experienced in particular items of finishing work shall be engaged. Where such workers are not readily available, with the permission of the Engineer, experienced supervisors recommended by the manufacturer shall be engaged. In particular cases where the Engineer so desires the Contractor shall get the finishing items installed by the Manufacturer without any extra cost to the Employer. Workmanship shall conform to relevant Indian Standards.

- Preparation of the Base Surface

The surface to be treated shall be thoroughly examined by the Contractor. Any rectification necessary shall be brought to the notice of the Engineer and his approval shall be taken regarding method and extent of such rectification work. For all types of flooring, skirting, dado and similar works, the base to receive the finish shall be adequately roughened by chipping, raking out joints and cleaning thoroughly all dirt, grease etc. with water and hard brush and detergent if required, unless otherwise directed by the manufacturer of any special finishing materials, or specifically indicated in this specifications under individual item.

To prevent absorption of fresh water from the finishing treatment, the base shall be thoroughly soaked with water unless otherwise specified and all excess water mopped up. The surfaces shall be dry where adhesives are used for fixing the finishes.

Prior to commencement of actual finishing work the approval of the Engineer shall be taken as to the acceptability of the surface.

12.5 IN-SITU FINISHES

- Metallic Hardener such as `Ironite Finish', will consist of sub-grade 38 mm thick of cement concrete 1:2:4 (1 cement: 2 coarse sand: 4 stone aggregate, 20 mm nominal size) and a topping (incorporating iron particles) to bond with the concrete sub-grade while the latter is `green'.
- Unless otherwise specified the metallic hardener finish shall be of 12mm depth. The total thickness including the finish shall be 50 mm.
- MATERIAL: The hardening compound shall comprise of uniformly graded iron particles, free from non-ferrous metal impurities, oil, grease, and soluble alkaline compounds or other injurious materials. When required by the Engineer, actual samples shall be tested.
- MIX: Proportion of the metallic hardener shall be as specified by the manufacturer, or in the absence of any such direction, 1 part of metallic hardener shall be mixed dry with 4 parts cement, by weight. To this mixture 6 mm nominal size stone chips shall be added in the proportion of 1 part of cement (mixed with hardener) to 2 parts of stone chips by volume and uniformly mixed. The minimum quantity of fresh water to make it workable shall be added.

- LAYING: The concrete sub-grade floor shall be laid as specified for terrazzo finish and leveled to the required grade. The forms, if any shall remain sufficiently projecting to take the finish. The surface shall be roughened by wire brush as soon as possible. The finish shall be laid while the concrete under bed is still very

  `green'(within about 3 hours of laying of the latter). The finish shall be of uniform thickness, even, dense surface and without trowel marks, pin holes etc. This topping layer shall be pressed firmly and worked vigorously and quickly to secure a full bond with the concrete base. When the initial set starts, the surface shall be smoothed with a steel trowel. The finish floor shall be cured for 7 days by keeping it wet by fresh water.

12.6 TILED FINISHED

- Terrazzo Tiles

The finish will consist of manufactured terrazzo tiles and under bed.

- Thickness

  The total thickness of tiles shall be at least 20 mm for floors and for walls, unless otherwise specified.

  Skirting, dado and similar vertical surface shall not project from the adjacent plaster or other wall finishes. Cutting into the surface receiving the tiled finish, to accommodate the specified thickness, shall be done as necessary.

- Tiles: Terrazzo

  The tiles shall, unless specifically permitted in special cases, be machine made under quality control in a workshop. The tiles shall be pressed hydraulically to a minimum of 140 kg. per cm^2. Each tile shall bear, on its back a permanent and legible trade mark of the manufacturer. All angles of the tiles shall be at right angles, all edges sharp and true, colour and texture of the wearing face shall be uniform throughout. The maximum tolerance allowance along the **length and breadth shall be □ 1 mm and in thickness □ 3 mm**.

  The wearing face of the tiles shall be plane, free from pin-holes and other blemishes.

  The tiles shall be composed of a backing and topping. The topping shall be of uniform thickness not less than 10 mm. The total thickness including the topping shall be as specified but not less than 20 mm in any case. The backing shall be composed of 1 part of ordinary gray cement, 2 parts of sand and 4 parts of stone chips by weight, mixed with water.

  The tile topping shall be as specified for in-situ Terrazzo finish except that cement used shall be white Portland cement.

  The tiles shall be cured at the workshop for at least 14 days before delivery to the site. A first grinding shall be given to the tiles at the workshop before delivery. Tiles shall be packed properly to prevent damage during transit and storage. The tiles must be stored carefully to prevent staining by damp, rust, oil, grease or other chemicals.

  Tiles made in any one batch shall be kept and used separately so that the colour of each area of the floor remains uniform.

The manufacturer shall supply, along with the tiles, the grout mix containing cement and pigment in exact proportions as used in the topping of the tiles. The containers for the grout mix shall be suitably marked to relate them to the particular type and batch of tiles.

- Mix: Under bed

The under bed for floors and similar horizontal surfaces shall be about 30 mm thick and composed of 1 part of cement, 2 parts coarse sand and 4 parts 10 mm and downgrades stone chips by volume, mixed with sufficient water to form a stiff workable mass. For skirting, dado and all vertical surfaces it shall be about 10 mm thick and composed of 1 part of cement and 3 parts of coarse sand by volume.

- Laying

The under bed mortar shall be evenly spread, brought to a proper grade and consolidated to a smooth surface. The surface shall be roughened to ensure a good bond. Before the under bed has had time to set and while it is still fairly moist but firm, cement shall be hand dusted over it or cement slurry applied and the tile shall immediately be placed upon and firmly pressed by wooden mallet on the under bed until the desired level is achieved. The tiles shall be kept socked for about 10 minutes immediately prior to laying.

The joints between tiles shall be as close as possible and not more than 1.5 mm wide. Special care shall be taken to check the level of the surface and the line of the joints frequently so that they are perfect. When tiles have to be cut to match the required dimensions they shall be sawn and their edges rubbed smooth. The location of cut tiles shall be planned in advance and approved by the Engineer. At the junction of horizontal surfaces with vertical surface the tiles on the former shall enter at least 12 mm under the latter. After fixing, the floor shall be kept moist and allowed to cure undisturbed for 7 days. Traffic shall not be allowed on it for a further 14 days.

- Curing

The day after the tiles are laid, all joints shall be cleared of the grey cement grout with a wire brush or trowel to a depth of 5 mm and all dust and loose mortar removed and cleaned. Joints shall then be grouted with grey or white cement mixed with or without pigment to match the shade of the topping of the wearing layers of tiles. The same cement slurry be applied to the entire surface of the tiles in a thin coat with a view to protect the surface from abrasion and fill pinholes that may exist on the surface.

The floor shall then be kept wet for a minimum period of 7 (seven) days.

- Grinding and Polishing

The procedure shall be the same as for in-situ terrazzo finish but grinding shall not commence earlier than 14 days after the laying of the tiles.

If any tile is disturbed or damaged, it shall be refitted or replaced, properly jointed and polished. The finished floor shall not sound hallow when tapped with a wooden mallet.

- ACID RESISTANT TILES

- Location

  The finish will consist of acid resistant tiles conforming to IS: 4457 laid over the RCC floor and side walls of battery room. The walls shall be provided with acid resistant tiles up to a height of 2 m above the floor level.

- Thickness

  Thickness including 38 mm thick RCC slab and 7 mm thick mortar for fixing the tiles shall be at least 65 mm for floor and 142 mm for walls including 115 mm thick brick wall and 7 mm thick mortar for fixing the tiles. Vertical surfaces finished with acid resistant tiles shall not project from the adjacent plaster of the wall finish. Cutting into wall surface, for receiving the acid resistant tiles to accommodate the specified thickness shall be permitted as necessary.

- Tiles

  The tiles shall be machine made under strict quality control in a workshop. The tiles shall be composed of a backing and a topping. The topping shall be acid resistant and shall be of uniform thickness not less than 10 mm. The backing shall be composed of 1 part of ordinary gray cement, 2 parts of sand and 4 parts of stone chips by weight, mixed with water. The total thickness of tile including topping shall not be less than 20 mm.

  Tiles shall be manufactured by pressing hydraulically to a minimum of 14 N/mm^2 and cured at the workshop for at least 14 days before delivery to site.

  Acid proof topping shall be composed of a chemically inert material, duly tested and approved by the Engineer.

  The topping shall also be scratch proof, non-toxic and anti-skid.

  Along with the tiles, the manufacturer shall supply the grout mix as used in the topping of the tiles so that all joints constructed at site are also adequately acid-resistant.

  Each tile on its back shall bear a permanent and legible trademark of the manufacturer. All angles of each tile shall be at right angles, all edges sharp and true, and texture of the wearing face shall be uniform throughout. The wearing face shall be plane, free from pinholes and other blemishes.

  The tiles shall be cured in the manner explained under Sub-Clause14.4.1 (e).

  If any tile is disturbed or damaged, it shall be refitted or replaced and properly jointed. The finished floor & walls shall not sound hollow when tapped with a wooden mallet.

- Terrazo Flooring

  The terrazzo flooring wherever required to be provided shall consist of two layers of cement concrete, the lower layer being 20 mm thick plain cement concrete, and the upper layer 6 mm thick cement concrete composed of marble chips and cement.

  The concrete for the lower layer shall consist of: one (1) part cement, two (2) parts sand and two and a half (2 ½) parts of 5 mm to 12.5 mm stone ballast by weight.

The concrete for the upper layer shall consist of: one (1) part cement, and two (2) parts marble chips. The marble chips shall be of quality and of colours as directed by the Engineer.

If in accordance with the general specification or the drawing the whole or any portion of the floors is to be coloured, the cement for the upper layers of that portion of the floor shall be coloured cement as approved by the Engineer. The use of ordinary cement with colouring mater added locally is prohibited.

To ensure uniform colour, cement from one stock shall be used on a particular work. The sand shall be well washed, clean and sharp and shall be well graded from 4.75 mm down to dust. It shall be screened into two portions through a screen having 64 meshes to the square inch and the sand used in the lower layer of concrete shall consist of equal parts of these portions. The coarse aggregate for the lower layer of concrete shall consist of ballast broken from stone of approved quality and shall be well graded from 3 mm to 12.5 mm.

The marble chips shall be machine or hand broken as specified or ordered by the Engineer to such a size that all pass through a 1/8" screen but are retained on a 1/16" screen.

The ingredients, inclusive of water, shall be accurately measured; cement will be measured by volume, the unit being one bag and the volume taken per bag as specified by the manufacturer. The other ingredients shall also be measured by volume.

In order to ensure uniformity of colour, it is important to keep the same proportion of cement, sand and stone ballast and the same quantity of water throughout. The proportions must not be changed. It is important that the same brand of cement be used for the whole floor of one room.

The quantity of cement required in one room should be calculated in bag units, counting any portion of a bag as full bag. Then all these bags should be opened and the cement in these should be well mixed together till the whole mass of cement is of uniform colour and this mixed cement should be refilled in bags and stored in a dry place and used as expeditiously as possible.

When laying the floor, the cement and sand in the prescribed proportion will first be mixed dry, being turned over by spades several times till the whole mass is well mixed and assumes a uniform colour. This mixture is then added to the prescribed quantity of "stone ballast" and the whole turned over by appropriate implements at least six times till all pieces of stone ballast are well coated with dry mixed cement and sand.

After the mixture is thus well mixed and dry, water is to be added gently through rose-cans and in quantities only enough to make the mixture of plastic consistency, the entire mix being continuously turned over by using appropriate implements during this process of sprinkling water by rose-can till it assumes a uniform colour and consistency. The quantity of water to be added shall not exceed
38 litres per 50 kg of cement, the quantity of water per bag being kept constant. For the same room the same quantity of water shall be strictly adhered to. Only that quantity of concrete as can be mixed and laid within the setting time should be wet mixed at one time. No more material should be wet mixed. No concrete which has begun to cake or set shall be used even after mixing. Such mortar shall be immediately removed from the site of the work.

The concrete bed over which the flooring is to be laid shall be kept under water for two days

shall be left undisturbed for about six days when heavy grinding will be started. This shall be continued until the entire surface shows a uniform granular appearance. The final grinding shall then be done and continued until the floor present an absolutely uniform appearance, each marble chip showing clear and clean against the cement background and there shall be no "cloudiness" in any part of the floor. The floor shall then be washed thoroughly and left undisturbed for about a week. Finally oxalic acid powder shall be well rubbed on the surface for producing the required glass on the surface.

Terrazzo work to wall base (skirting) shall be 100 mm high and shall be mixed and laid in the same fashion as mentioned above. The rubbing, however, shall be by hand held pumic stones.

- Vinyle Floor Tiles

Vinyl Floor tiles of size 300 x 300 x 2 mm thick shall be provided in Control Room.

Floor surfaces upon which tiles are to be laid shall be covered with cement plaster bed 30 mm thick bonded to the structural concrete as specified in Chapter - 8. The plastered surfaces shall be dry, clean and free from dirt, oil and moisture. The back

surfaces of tiles shall be clean. Vinyl floor tiles shall be applied with adhesives upon the plastered surface in such a manner as to produce a tiled surface tightly bonded to the floor. Adjacent tiles shall be butted tightly together to form straight continuous joints and uniform regular patterns as directed by the Engineer.

The Contractor shall furnish all tiles including such shapes as are necessary to produce the required patterns and surface finish, curved and rounded tiles for corners and salient angles. The colour and pattern of tiles shall be selected by the Engineer.

- Dividing Metal Strips

These shall be 4 mm thick, 50 mm wide and made of Aluminum or glass strips. These shall be laid fixed in position as shown in drawings. At all time during flooring work, these shall be properly secured to remain fixed in position and be true to line and plumb.

- Acceptance Criteria

The finish shall be checked specially for:

(a) Level, Slope, plumb as the case may be

(b) Pattern and symmetry.

(c) Alignment of joints, dividing strip etc.

(d) Colour, texture

(e) Surface finish

(f) Thickness of joints

(g) Details of edges, junctions etc.

(h) Performance

(i) Precautions specified for durability

(j) Material specification and workmanship.

- Rates

  Rates shall be for the complete finishing work including all necessary forms, under bed, adhesives and preparation of the surface including cutting and chipping to receive the finish indentations, laying in desired patterns and in panels but exclusive of the base.

  All necessary cutting of tiles, slabs etc. and the cost of specials, if any, shall be included in the rates. Similarly, cost of dividing strips shall be included in the quoted rates.

  Nothing extra shall be paid for rounding of corners and edges and the same rates will apply to floor, skirting, dado, treads, nosing etc.

- Method of Measurement and Payment

  The finished surface shall be measured and paid at the unit prices in sq. metre (m^2) on actual area finished correct to second place of decimal. No deduction shall be made for openings, pipes, sleeves, etc. upto 0.1 m^2 in area and no addition shall be made for

  finishing sides of such openings. Deduction shall be made for opening pipes, sleeves more than 0.1 m^2 in area and sides of such opening of plastered shall be measured. Rate shall include cost of all material, implements, labour and equipment and nothing extra shall be paid on this account.

  No separate payment shall be made for dividing strips.

- I.S. Codes

  Important relevant codes applicable to this section are:

IS: 777	Glazed earthenware tiles
IS:1237	Cement concrete flooring tiles.
IS:2571	Code of practice for laying in-situ concrete flooring.
IS: 8042	White Portland cement
IS: 4457	Ceramic unglazed vitreous acid resistant tiles.

CHAPTER - 13

CORRUGATED GALVANIZED STEEL SHEET ROOFING

13.1 SCOPE

This specification covers furnishing, installation and finishing of corrugated galvanized steel sheet roofing for powerhouse of Gosikhurd H. E. Project.

13.2 CORRUGATED GALVANIZED STEEL (C. G. S.) SHEETS

These shall be of 1.0 mm thickness or as specified in the drawings and shall conform to IS : 277. The sheets shall be of 750 grade of coating as per CPWD specifications 1996, Volume IV.

The sheets shall be free from cracks, split edges, twists, surface flaws etc. They shall be clean, bright and smooth. The galvanizing shall be non-injured and in perfect condition. The sheets shall not show signs of rust or white powdery deposition on the surface. The corrugations shall be uniform in depth and pitch and parallel with the side.

13.3 PURLINS

Purlins of M. S. rolled sections of size specified in the drawings shall be fixed over the principal rafters. These shall not be spaced at more than the distances shown in Table - 1 below: `

TABLE -1

Thickness of C. G. S. sheet	Maximum Spacing of Purlins
1.60 mm	2.80 m
1.25 mm	2.40 m
1.00 mm	2.00 m
0.80 mm	1.80 m
0.63 mm	1.60 m

The top surfaces of the purlins shall be uniform and plane. They shall be painted before fixing on top. Embedded portions of wooden purlins shall be coal tarred with two coats.

13.4 SLOPE

Roof shall not be pitched at a flatter slope than 1 vertical to 5 horizontal. The normal pitch adopted shall usually be 1 vertical to 3 horizontal.

13.5 LAYING AND FIXING

The sheets shall be laid and fixed in the manner described below, unless otherwise shown in the working drawings or directed by the Engineer.

The sheets shall be laid on the purlins to a true plane, with the lines of corrugations parallel or normal to the sides of the area to be covered unless otherwise required.

The sheets shall be laid with a minimum lap of 15 cm at the ends and 2 ridges of corrugations at each side. The above minimum end lap of 15 cm shall apply to slopes of 1 vertical to 2 horizontal and steeper slopes. For flatter slopes the minimum permissible end lap shall be 20 cm. The minimum lap of sheets with ridge, hip and valley shall be 20 cm measured at right angles to the line of the ridge, hip and valley respectively. These sheets shall be cut to suit the dimensions or shapes of the roof, either along their length or their width or in a slant across their lines of corrugations at hips and valleys. They shall be cut carefully with a straight edge chisel to give a smooth and straight finish.

Lapping in C. G. S. sheets shall be painted with a coat of approved steel primer and two coat of painting with approved paint suitable for G. S. sheet, before the sheets are fixed in place.

Sheets shall not generally be built into gables and parapets. They shall be bent up along their side edges close to the wall and the junction shall be protected by suitable flashing or by a projecting drip course, the later to cover the junction by at-least 7.5 cm.

The laying operation shall include all scaffolding work involved.

Sheets shall be fixed to the purlins or other roof members such as hip or valley rafters etc. with galvanized J or L hook bolts and nuts, 8 mm diameter, with bitumen and G. I. Limpet washers or with a limpet washer filled with white lead as directed by the Engineer. While J hooks are used for fixing sheets on angle iron purlins, and L hooks are used for fixing to R. S. joists, timber or precast concrete purlins. The length of the hook bolt shall be varied to suit the particular requirements. The bolts shall be sufficiently long so that after fixing they project above the top of the nuts by not less than 10 mm. The grip of J or L hook bolt on the side of the purlin shall not be less than 25 mm. There shall be a minimum of three hook bolts placed at the ridges of corrugations in each sheet on every purlin and their spacing shall not exceed 30 cm. Coach Screws shall not be used for fixing sheets to purlins.

The galvanized coating on J or L hooks, and bolts shall be continuous and free from defects such as blisters, flux stains, drops, excessive projections or other imperfections, which would impair serviceability.

The galvanized coating shall conform to IS : 1367 and as per CPWD specifications 1996, Volume IV.

Where slopes of roofs are less than 21.5 degrees (1 vertical to 2.5 horizontal), sheets shall be jointed together at the side laps by galvanized iron bolts and nuts 25 x 6 mm size, each bolt provided with a bitumen and a G. I. Limpet washer or a G. I. Limpet washer filled with white lead. As the overlap at the sides extends to two corrugations, these bolts shall be placed zig zag over the two overlapping corrugations, so that the ends of the overlapping sheets shall be drawn tightly to each other. The spacing of these seam bolts shall not exceed 60 cm along each of the staggered rows. Holes for all bolts shall be drilled and not punched in the ridges of the corrugations from the underside, while the sheets are on the ground.

13.6 WIND TIE

Wind ties shall be of 40 x 6 mm flat iron section or of other size as specified. These shall be fixed at the eaves of the sheets. The fixing shall be done with the same hook bolts, which secure the sheets to the purlins. The ties shall not be paid for separately and their cost shall be deemed included in the quoted unit rate.

13.7 FINISH

The roof when completed shall be true to lines and slopes and shall be leak proof.

13.8 MEASUREMENT

The length and breadth shall be measured correct to a centimeter (cm). Area shall be worked out in square metre (m^2) correct to two places of decimal.

The superficial area of roof covering shall be measured on the flat without allowance for laps and corrugations. Portion of roof covering overlapping the ridge or hip etc. shall be included in the measurements of roof.

13.9 RATE

The rate shall include the cost of all the materials and labour involved in all the operations described above including a coat of approved steel primer and two coats of approved steel paint on overlapping of C. G. S. Sheets. This includes the cost of roof sheets, galvanized iron J or L hooks, bolts and nuts, galvanized iron seam bolts and nuts, bituminous and galvanized iron limpet washers etc.

CHAPTER - 14

METALS DOORS, WINDOWS, VENTILATORS AND LOUVERS

14.1 SCOPE

The work in general shall consist of supplying, erecting and installing of all metal doors, windows, ventilators, louvers, glazed partitions, etc. as shown on the drawings with all materials complete excluding supply of glass and glazing. Supplying and / or fixing of all door and window accessories and hardware are also included in the scope.

14.2 INSTALLATION

- Materials

Steel sections used for fabrication of doors, windows etc. shall be standard rolled steel sections specified in IS: 1038 and IS: 1361 or as specified in drawing / bill of quantities. Steel sheets for frames, shutters, louvers, blades etc. shall be of a gauge mentioned in this specification. Hot rolled steel sections for doors, windows and ventilators shall conform to IS: 7452.

Aluminium sections for fabricating doors, windows, partitions etc. shall be the extruded sections conforming to IS: 1948 and IS: 1949 or as manufactured by Indian Aluminium Company Limited or approved equivalent. The alloy used shall conform to IS Designation HE 9-WP of IS: 733.

Hardware and fixtures shall be as specified in "Bill of Quantities" and the best quality from approved manufacture shall only be used. The bidders shall specifically state the particular manufacture’s materials he proposes to use. Improper alignment or fixture shall entirely be the Contractor’s responsibility.

All hardware and fixtures shall be able to withstand repeated use. Door closers shall conform to IS: 3564 and shall be as stated in Bill of Quantities. Each closer shall be guaranteed against manufacturing defect for one year and any defect found within this period shall be rectified or the closer replaced free of charge. Concealed door closer shall be either floor mounted or transom mounted, suitable for installation with metal doors. It shall conform to the performance requirements and endurance test stated in IS: 3564 Appendix `A' and shall be suitable for doors weighing 61 to 80 kg unless otherwise stated in bill of quantities

Heavy duty double acting floor springs, where specified shall conform to IS: 6315 and shall be suitable for door shutters weighing up-to 125 kg. The door closer shall be hydraulically regulated and constructed of cast brass casing cover and shoe, gun metal piston player and all other parts of mild steel.

The Contractor shall submit samples of each type of hardware to the Engineer. The approved sample shall be retained by the Engineer for comparison of bulk supply. The samples shall be returned to the Contractor towards the end for incorporation in the job.

Mastic for caulking shall be of best quality from a manufacturer approved by the Engineer. In general, the mastic for fixing of metal frames shall be as per IS: 1081 and / or approved by the Engineer.

14.3 FABRICATION OF STEEL DOORS, WINDOWS, VENTILATORS, LOUVERS ETC.

- Door Frames

Frames shall be pressed steel frames fabricated from 16-G sheets. They shall be mortised, reinforced, drilled and tapped for hinges and lock and bolt strikes. These shall be as per IS: 4351. Where necessary, frames shall be reinforced for door closers. Welded construction with mitred corners shall be used. Rubber door silencers shall be furnished for striking jamb. Loose "T" masonry anchors shall be provided. Frames shall finish flush with floor and adjustable floor anchors shall be supplied. Frame shall be brought to site with floor ties/weather bars installed in place.

- Door Threshold

Door threshold shall be provided as shown on drawing or as directed by Engineer. Doors without threshold shall have bottom tie of approve type.

- Steel Windows, Sashes, Ventilators etc.

These shall conform in all respects to IS: 1038 and IS: 1361 and as shown on drawings. The details as called for in the above codes shall be applicable for couplings, mullions, transoms, weather bars, pivot arrangements for ventilators etc. or as shown on drawings.

All welds shall be dressed flush on all exposed and contact surfaces.

Where composite unit openings are shown on drawings, the individual window units shall be joined together with requisite transoms and mullions as shown on drawings. All windows shall be outside glazed, fixed with putty or metal glazing beads as shown on the drawings and/or specified under Bill of Quantities.

Where aluminium glazing beads are specified they shall be extruded aluminium channel 9.5 mm x 9.5 mm x 1.6 mm (Indal Section no. 2209) unless otherwise shown on drawings. Aluminium beads shall be given one coat of zinc chromate primer before fixing to window.

14.4 FABRICATION OF ALUMINIUM DOORS, WINDOWS, FRAMES ETC.

- Single or double glazed aluminium doors, windows and frames of Extruded sections shall have a minimum 3 mm wall thickness. All sections shall be approved by the Engineer before fabrication is taken up. Door, frames, mullions, transoms etc. shall be anodized in bath of sulphuric acid to provide a clear coating of minimum 0.6 mm thickness. The anodized materials shall then be sealed by immersing in boiling water for 15 minutes. A protective transparent coating shall be applied to the sections.
- All works shall be fitted and shop assembled to a first class job and ready for erection. Shop-joints shall be made to hair lines and then welded or braced by such method as will produce a uniform colour throughout the work. Work on the above, other than described, shall be carefully fitted and assembled with neat joints with concealed fasteners. Wherever possible, joints shall be made in concealed locations and on edges of doors.

  Glazing beads shall be snap fit type without visible screws and shall be of sizes to accommodate 6 mm thick glazing. All work shall be adequately braced and reinforced as necessary for strength and rigidity.

14.5 SHOP COAT OF PAINT

The shop paint for steel doors, windows, etc. shall be zinc chromate primer paint from approved manufacturer. Primer shall be as per IS: 2074. All surfaces shall be thoroughly cleaned of rust, grease, loose mill scales etc. by adopting the one or more method as specified in IS: 1477 (Part I) and given one coat of shop paint.

Portions like mullions, transoms, etc. which will be inaccessible after assembly of units, shall be given an extra coat of paint before assembly.

Where called for in the Bill of Quantities, all steel doors, windows, etc. shall be hot dip galvanized to give a coating weight of 460g to 610g per Sq.m. One coat of zinc chromate primer shall then be applied as shop paint.

Portions of aluminium frame, which come in contact with masonry construction, shall, before transport from workshop, be protected with a heavy coat of alkali resistant paint. Aluminium coming in contact with other incompatible metals shall be coated with zinc chromate primer. Surfaces shall be prepared as specified in IS: 2524 (Part 1).

14.6 HANDLING AND STORAGE OF FABRICATED MATERIALS

All metal doors, windows etc. shall be packed and crated properly before dispatch, to ensure that there will be no damage to the fabricated materials. Loading into wagons and trucks shall be done with all care to ensure safe arrival of materials at site in an undamaged condition.

All metal doors, windows, etc. shall be stored under cover in a way to prevent damage or distortion. Special care shall be taken to prevent staining of aluminium products by rust, mortar etc.

14.7 ASSEMBLY AND ERECTION AT SITE

- In general, the fixing of steel doors, windows, ventilators, louvers, etc. shall conform to IS: 1081 and as shown on drawings. The Contractor shall assemble and install all steel doors, windows, sashes, fixed metal louvers, etc. including transoms and mullions for composite units in respective places as shown on drawings, keeping proper lines and levels, and in approved workman like manner, to give trouble free and leak-proof installation. The installation shall be done according to the instructions of the manufacturer, and/or approved by the Engineer. The installation shall have to be carried out under the supervision of the manufacturer's staff. The Contractor shall take every precaution against damage of the components during installation. Necessary holes, chases, etc. required for fixing shall be made by the Contractor and made good again as per original, after installation without any extra charge.

  After installation of steel doors, windows etc. all damages to shop-coat of paint shall be retouched and made good with the same quality of paint used in shop-coat.

  All couplings, mullions, transoms, frames etc. in contact with adjacent steel and other members, shall be embedded in mastic.

  The Contractor shall bring to the site the mastic cement in original sealed containers of manufacturer and shall apply it as per the instructions. For all frames mastic shall be supplied by the Contractor and caulking done properly as per drawings, specifications and as per instruction of the Engineer.

  Doors shutters, partitions, hardware, fixtures etc. shall be fixed only after major equipments have been installed in rooms. Wherever required, nylon cords of approved

quality shall be supplied along with pivoted sashes and shall be of adequate length to terminate one metre from the floor. Loose ends of cords shall end in metal or plastic pull as approved by the Engineer.

14.8 ACCEPTANCE CRITERIA

- For Fabricated Items

(a) Overall dimensions shall be within 1.5 mm of the size shown on drawings.

(b) Mullions, transoms, etc. shall be in one length and permissible deviations from straightness shall be limited to 1.5 mm from the axis of the member.

(c) Door and window shutters shall operate without jamming. The clearance at head and jamb for door shutters shall not exceed 1.5 mm. For double lead doors, the gap at the meeting styles shall not be more than 1.5 mm.

(d) Doors leaves shall be undercut where shown on drawings.

(e) Doors, windows, frames etc. shall be in a true plane, free from warp or buckle.

(f) All welds shall be dressed flush on exposed and contact surfaces.

(g) Correctness of location and smoothness of operation of all shop installed hardware and fixture shall be insured by the Contractor.

(h) Provision for hardware and fixture to be installed at site.

(i) Glazing beads shall be cut with mitred corners.

(j) Glazing clips, fixing devices etc. shall be supplied in adequate numbers.

(k) Shops coats shall be properly applied.

(l) Exposed aluminium surfaces shall be free from scratches, stains and discolouration. Anodised surfaces shall present a uniform and pleasing look.

(m) Steel and aluminium section are as specified in this specification or in respective I.S. Codes.

(n) All fittings and fixtures as specified have been fixed according to relevant I.S. Codes.

- For Installed Items

(a) Installation shall be at correct location, elevation and in general in a true vertical plane.

(b) Fixing details shall have the approval of Engineer.

(c) Assembly of composite units shall be strictly as per drawings, with mastic caulking at transoms and mullions, gaskets, weather strips etc. complete.

(d) All frames on external wall shall be mastic caulked to prevent leakage through joint between frame and masonry.

(e) All openable sections shall operate smoothly without jamming.

(f) Locks etc. shall engage positively, keys shall be non-interchangeable. Each lock shall have duplicate key.

(g) Cutting of concrete or masonry shall be made good and all abrasions to shop paint shall be touched up with paint of same quality as shop paint.

(h) Aluminium doors, windows etc. shall be free from scratches, stain or discoloration. It will be the responsibility of the Contractor to see that the material

is protected from mortar, paint, plaster, terrazzo, etc. during construction, and to thoroughly clean all framing members to the satisfaction of the Engineer before handing over to the Employer.

14.9 INFORMATION TO BE SUBMITTED

- With Tender

(a) Name of manufacture for doors, windows etc.

(b) Manufacturer's catalogue for all hardware and fixture proposed to be used.

- After Award

(a) The Contractor shall take permission from the Employer before ordering any internal fixtures etc.

(b) Before starting fabrication of all metal doors, windows, etc. the Contractor shall submit detailed fabrication drawings to the Engineer for approval. The fabrication shall be started only after approval of drawings.

(c) The Contractor shall submit a programme of work to be done for the approval of the Engineer.

(d) Before bulk supply, he shall submit for the approval of the Engineer samples of all bought out items and samples of each type of fabricated item. The each sample shall be retained by the Engineer for comparison with bulk supply and returned to the Contractor towards the end for final incorporation in the job.

14.10 RATES

Rates shall be unit rates for items described in Bill of quantities.

14.11 METHOD OF MEASUREMENTS

- Supply and installation of doors shall be measured in net outer-to-outer area of frames of each type used. The type and size shall be as shown on drawings and described in Bill of Quantities.
- Supply and installation of windows shall be measured in net outer-to-outer area of frames of each type of unit used either singly or in combination mentioned in Bill of Quantities.
- Supply and installation of louvers shall be measured for area of opening in which the louvers are to be installed.
- Supply of mullions and transom shall be deemed included in rate for steel doors, window, and ventilators. No extra payment shall be made for end or cover plates.
- Vision panels, louvers, doors and insulation between door shall be deemed included in the basic rate of doors.
- Glazing beads, weather stripping, fixing devices etc. shall not be measured separately but shall be deemed included in the supply rate of respective items.
- Any curing or grouting to concrete and masonry or welding and drilling to steel required for installation shall be included in the installation rate. No separate payment shall be made for caulking and jamming of frames or making good to concrete or masonry.
- Glass and glazing shall not be measured and its cost shall be deemed included in the rate for doors and windows.

- All door and windows fixtures shall be deemed included in the supply rate of respective item.

14.12 ROLLING STEEL SHUTTERS / GRILLS

- Scope

This specification covers the design, supply of materials, fabrication, delivery and erection of Rolling Shutters / grills with or without motor drives and / or manual operation including all accessories as hereinafter specified.

- Installation

(i) Slates for rolling shutters shall be made from tested bright cold rolled annealed M.S. strips, not less than 0.9 mm thick for shutters upto 3.5 m wide and not less than 1.25 mm thick for Shutters above 3.5 m wide, machine rolled at 75 mm rolling centres and interlocking with each other. The profile shall be such as so to prevent excessive deflection under specified wind load.

(ii) Rolling grills shall be constructed out of 6mm diameter rods at 35mm on centres, running horizontally, flexibly connected with vertical links spaced not more than 200 mm centres. Alternatively, rolling grills shall be made from perforated slates of approved design, reinforced with 6mm diameter rods.

(iii) End locks shall be of heavy type M.S./C.I. and shall be provided at each end of alternate slates unless specified otherwise in the bill of quantities.

(iv) Guides shall be of such depth as to retain the shutter under a wind pressure of 150 kg/m^2, which can act on either side of opening. The thickness of guide shall be of 12 gauge minimum.

(v) Shafts shall be of steel pipe of sufficient size to carry the torsional load with a maximum deflection of $1/360^{th}$ of span. Grease packed ball bearing or bushings shall be provided for smooth trouble free operation.

(vi) Hoods shall be formed of not less than 20 gauge steel, suitably reinforced to prevent sag.

(vii) Locks shall be slide bolt and hasp or cylinder lock operable from one or both sides. Provision for securing hand chain with pad lock, provision for removable handle for hand cranks etc. shall be made as desired by the Engineer.

(viii) Operating chains shall be of tested quality, heavily galvanized and with all ends rounded to assure smooth operation and hand protection.

(ix) Reduction gears shall be high strength grey cast iron, machine moulded from machine cut patterns.

14.13 Manually Operated Shutters/Grills

Manually operated shutters shall be easily operable by one person. The speed of operation shall be about 0.3 m per second. In general, manually operated shutters shall be push pull type for openings up to 9 m^2 in area. Larger shutters shall be either chain or gear operated or crank and gear operated. The crank handle shall be removable. All shutters shall be lockable from one or both sides, as desired by the Engineer.

14.14 Shop Coat

Shutters shall be painted with one coat of zinc chromate primer. Where specified, doors shall be galvanized and subsequently painted one coat of zinc chromate for adhesion of field coat.

14.15 Acceptance Criteria

- Shop Inspection

  After completing the manufacture of the different components of the rolling shutters, an arrangement for shop inspection by the Engineer shall be made to check the conformity with approved shop drawings.

- Field Inspection

  After installing the shutters, the Contractor shall test the performance of the shutter in the presence of Engineer and/or his authorized representative. The doors shall be smoothly operable under all ambient conditions. All control and locking devices shall give fault-free performance.

- Guarantee

  The Contractor shall give one year's guarantee for the successful operation of the shutters.

14.16 Rates

Rates shall be unit rates for complete items for supply and erection of rolling shutters, including all drives, accessories, hardware etc. as per Bill of Quantities. No extra payment shall be made for cutting, drilling, welding, grouting etc. (to structure) for installing the shutters.

14.17 Measurement

Rolling shutters or grills shall be measured for area of opening in which they shall be installed. Payment shall be made in square metre (m^2) of the area of opening.

14.18 I.S. CODES

IS:1948	Aluminium doors, windows and ventilators
IS:1949	Aluminium windows for industrial buildings
IS: 7452	Hot rolled steel sections for doors, windows and ventilators
IS: 6248	Metal rolling shutters and rolling grills
IS: 4351	Steel door frames
IS: 1038	Steel doors, windows and ventilators
IS: 1361	Steel windows for industrial buildings
IS: 3564	Doors closers (Hydraulically regulated)
IS: 6315	Floor springs (Hydraulically regulated) for heavy doors.
IS: 1477	Painting of ferrous metal in buildings.
IS: 2529	Painting of non-ferrous metal in buildings.
IS: 1081	Fixing and glazing of metal (Steel and aluminium) doors, windows and ventilators.

CHAPTER - 15

GLASS AND GLAZING

15.1 SCOPE

The works in general shall consist of supplying and fixing all glass and glazing including all clips, putty, mastic cement etc., wherever required or as shown on drawings.

15.2 INSTALLATION

- General

The Contractor shall supply and install all glass and glazing as required for various doors, windows, sashes, ventilators and fixed louvers, miscellaneous glazing and partitions. Unless otherwise stated, glass used shall be from CPWD approved manufacturers, having uniform refractive index and free from flaws, specks and bubbles. The glass shall be brought to site in the original packing from the manufacturer and cut to size at site. The cut edges shall be straight and free from chips, spalls or any other damages.

15.3 MATERIALS

- Glare reducing (tinted) or heat absorbing glass shall be "Calorex" of Hindustan Pilkington or approved equivalent and special care shall be taken to grind smooth and round off the edges before fixing.
- Clear glass shall be flat drawn sheet glass and shall be at least 4 mm thick, sheet glass for doors shall be minimum 6.3 mm thick.
- Wired glass shall be thick rolled glass with centrally embedded 24 gauge wire mesh of Georgian type. This may be of clear or coloured glass, as shown in drawings.
- In general, the putty shall conform to IS: 419 (putty for use on window frames) and be of best quantity from approved manufacturer. It shall be brought to site in manufacturer's original packing. Quick setting putty shall be used for window and sashes except when glare reducing glass is used where it shall be of non-setting type.
- Neoprene gaskets with snap fit glazing shall be fixed as per manufacturer's instructions and shall fit firmly against the glass to give a leak-proof installation.

15.4 GLAZING SETTING AND FINISHING

All glazing, clips, bolts, nuts, putty, mastic cement etc. as required shall be supplied by the Contractor. All glasses shall be thoroughly cleaned before setting in position. Each glass pane shall be held in place by special glazing clips of approved type. Four glazing clips shall be provided per glass pane, except for large panes where six or more clip shall be used as per the instruction of the Engineer. All holes that may be necessary for holding the clips glazing heads and all other attachments shall be drilled by the Contractor.

Glass panes shall be set without springing and shall be bedded in putty and back puttied, except where moulding or gaskets are specified. Putty, mastic cement etc. shall be smoothly finished to a true even line. Obscure and figured glass shall be set with smooth side out.

After completion of glazing work, the Contractor shall remove all dirt, strains, excess putty

etc., clean the glass panes and leave the work in perfectly acceptable condition.

All broken, cracked or damaged glass shall be replaced by new ones at the Contractor's cost.

15.5 ACCEPTANCE CRITERIA

(a) All installation shall be free from cracked, broken or damaged glass. Edges of large panes of thicker glass and heat absorbing glass shall be inspected carefully for chipped, cracked or un-ground edges.

(b) Glazing shall be carefully done to avoid direct contract with metal frames.

(c) All glasses shall be embedded in mastic or fixed by neoprene gaskets to give a leak-proof installation.

(d) At completion, the panes shall be free from dirt, stains, excess putty etc. to the complete satisfaction of the Engineer.

15.6 RATES

(a) Rates shall be unit rates for supply and installation of glazing / glass mentioned in the Bill of Quantities including the cost of scaffolding, if required.

(b) Rates shall include cost for glazing clips, mastic cement, putty, nails, etc. or for drilling holes in frames for inserting glazing clips.

(c) Rates shall include cost for cutting of glass to required size, edge finishing etc.

(d) Rates shall include cost for cleaning the glass after installation.

15.7 MEASUREMENT& PAYMENT

No extra payment for glass and glazing shall be made and the cost shall be deemed to have been included in the unit rates quoted for doors and windows.

CHAPTER - 16

STEEL HAND RAILING

16.1 SCOPE OF WORK FOR STEEL HAND RAILING

These specifications cover the items of providing, fabricating delivering and erecting steel pipe railing made of 40 mm NB Pipe with two horizontal rails, one at 500 mm and another 1000 mm above the base level with vertical pipes at maximum spacing of 2000 mm including provisions of all auxiliaries, cost of all materials labour, leads and lifts etc. and providing two coats of approved Synthetic paint over a cost of primer etc. Providing and fixing mild steel railings to stairs, balconies and around openings shall conform to the latest revisions of the following BIS specifications or other internationally recognized standard specifications.

IS - 432 Mild Steel and Medium Tensile Steel Bars (Part - 1)

IS - 1239 Mild Steel Tubes (Part - 1)

IS - 1731 Dimensions of Steel Flats

IS - 1732 Dimensions of Round and Square Steel Bars (Part - 1)

16.2 Fabrication and Fixing

- The railing shall be fabricated as per detailed design provided by the Engineer. M.S. Pipe of 40 mm NB shall be fixed firmly to the floor in concrete and horizontal rails shall be welded to the vertical MS pipe posts.
- All spurs / lesions of welding shall be ground smooth.
- Railing and posts shall be given a coat of primer and then finishing coat of paint of approved colour and make.

16.3 Measurement and Payment

- The payment will be made for the furnished item of work based on the length of railingwork done, including, posts, finishing, etc. in running metres, at the unit-rate quoted in the Bill of Quantities and payments and shall include cost of all material, labour, fixing in cement concrete, welding, grinding & painting etc. including all leads and lifts complete. It should be clearly understood that individual lengths or runner posts etc. will not be measured for purpose of payment.

CHAPTER - 17

PAINTING

17.1 SCOPE

This covers the finish painting of all types of concrete surface and /or plastered masonry / concrete surface in all kind of work.

Before commencing painting / finishing, the contractor shall undertake normal rectification to prevent damage, disfiguration or staining of the painting / finishing by other trades.

Paints shall be kept covered at all times and mixing shall be done in suitable containers. All necessary precautions shall be taken against fire hazards.

- IS CODES TO BE FOLLOWED:

IS 13238 IS 13239 IS 13467	Epoxy based zinc phosphate primer.
IS 14209	Code of practice for Epoxy enamel, two components, glassy.
IS 428	Distemper, oil emulsion, and colour as required.
IS 2395	Code of practice for painting concrete masonry and plaster surfaces.
IS 2402	Code of practice for external rendered finishes.
IS 5411	Code of practice for plastic emulsion paint.

17.2 EPOXY PAINTING (SUBMERGED STRUCTURE)

- Preparation of surface - Remove grease oil and other contaminants preferably by usingbison degreasing solvent blast clean to a minimum of surface finish sa-2½ with a surface profile not exceeding 65 microns. If blasting is not practical, make use of mechanical tools along with manual chipping and wire brushing to remove loose material. Thoroughly dust down all surfaces. Best result can be achieved if the manually cleaned surface is primed with protectomastic - self priming surface tolerant coating. (The surface shall be clean and dry before application of appropriate primer coat.) Concrete/new concrete-insure that the concrete is cured and dried for minimum period as per IS requirement. Ensure all dust or other particle are fully removed by suction or air blast and the surface is fully cleaned and dry before application of paint. In noncritical areas where blasting is not possible, water jet washing and hard wire brushing are minimum requisites.

- DISTEMPERING

  The surface to be distempered shall be cleaned of dust, oil grease. All cracks, holes and surface defects shall be repaired with gypsum and allowed to get hard. All irregularities shall be sand papered smooth and wiped clean. The surface so prepared must be completely dry and free from dust before distempered is commenced. In the case of walls newly plastered, special care shall be taken to see that it is completely dry before any treatment is attempted. For the old surface which had earlier been distempered, the surface shall be cleaned of grease, dust etc. The flecking of previous coatings, if any, shall be taken off. All cracks, holes and surface defects shall be repaired with gypsum and allowed to set hard and then sand papered smooth and wiped clean. But in case, with surfaces are coloured or while washed, the wash must be removed thoroughly first.

- Priming Coat

  Priming coat shall be applied over the completely dry surface in the manner recommended by the makers in the case of patent distempers. When no priming coast is specified by the manufacturers, a finely powered chalk mixed with a thin solution of glue shall be applied to prepare a good, hard back ground, the coating when dry being sand papered, as clean and smooth as possible.

- Application of Distemper

  The instructions of the makers shall be followed regarding the preparation of this surface and application of priming and furnishing coasts. The quantity of distemper mixed shall not be larger than what is actually required for a days work. That water should be used to prepare mixture, distemper shall be applied in dry weather with a broad, stiff brush in long parallel strokes. The treated surface shall be allowed to dry succeeding coats shall not be applied until the preceding coat has been passed by the Engineer. Two more coats of distemper shall be given in exactly the same manner as the first one but only after the earlier coat applied has thoroughly dried.

- Cement Paint

  The quality colour and brand of cement paint shall be got approved by the Engineer. The surface to be painted shall be cleaned to remove all dust or dirt, grease, oil etc. by means of stiff wire brushes and the surface thoroughly washed with water. All unevenness, cracks, pits etc. shall be made good by plaster of Paris. All irregularities shall be sand papered smooth and wiped clean. The surface so prepared must be completely dry and free from dust before painting is commenced. In the case of walls newly plastered, special care shall be taken to see that it is completely dry before any treatment if attempted. The mix for cement paint shall be prepared with one volume of water to two volumes of cement paint and stirred to a thick paste. This paste shall be further diluted to a suitable consistency by adding, while stirring, one more volume of water only required quantity of cement paint shall be prepared at a time which can be preparation. The mixed paint shall be applied with a good brush to the surface prepared as above. The first coat (premier coat) shall be well brushed into the surface to form a good band. The second coast shall be applied after a lapse of 24 hours and finally the third coat shall be applied after a lapse of 24 hours after the second coat is applied to give furnished surface. Each cement paint application shall be wetted at the end of the day by fine water spray. No external painting shall be done during wet or inclement weather. The painted surface shall

be kept wet for about 3 days or as directed by the Engineer. All paint stains / marks formed on floors, windows, doors ventilators and other surfaces during painting shall be cleaned as directed by the engineer.

- Plastic Emulsion Paint

  All the provisions of 16.2.5 above shall apply to the extent they are relevant to this item also. The plastic emulsion paint and primer shall be approved quality colour and make. The surface to be painted shall be cleaned to remove all dirt or dust, grease, oil etc. by means of stiff wire brushing. All surface unevenness, cracks, pits etc. shall be repaired with plaster of Paris. All irregularities shall be sand papered smooth and wiped clean. The priming coat of approved shade shall be allowed to dry. The second coat plastic emulsion paint shall be applied over the first coat (premier coat) evenly. The third coat shall be carefully applied to achieve smooth and even surface afterthe previous coat has dried up. Each coat of painting shall be allowed to dry and shall be got approved by the Engineer before next coast of paint is applied. After completing the painting work all paint marks / stains formed on floors, doors, windows, ventilators and other surfaces during painting shall be cleaned as directed by the Engineer.

17.3 Measurement and Payment

The payment shall be made for the area of painting carried out as per specifications at per m^2 unit rate stated in the Bill of Quantities, shall be for the finished item of work and shall include cost of all materials, labour, scaffolding, all leads and lifts etc. complete. No deduction shall be made for openings not exceeding 0.5 m^2 each andno additions shall be made for painting of beading, moulding, edges, joints, sills, etc. of such openings.

CHAPTER - 18

STONE PITCHING AND STONE MASONARY

18.1 STONE MASONRY

- Scope

These specifications cover the item of Stone Pitching including cost of collection & transportation of Stones and laying to the required lines and grades at locations shown in the drawings or as directed by the Engineer.

- Materials

All materials and workmanship for the Stone Pitching shall conform to the latest revisions of the following BIS specifications or other internationally recognized standard specifications.

IS - 383	Coarse and fine aggregates from natural sources
IS - 1597	Construction of Stone Masonry, Rubble (Part 1)
IS - 7779	Properties and availability of Stones for construction purpose
IS - 8237	Protection of Slope for reservoir embankments
IS - 8381	Quarrying stones for construction purposes

All stones shall be obtained from approved quarries only. Stones shall be clean, hard, durable, dense, tough and free from decay, weathered portion, soft skin, veins, flows, cracks, cavities, verticals and other defects and shall conform to IS - 1597 (Part 1). The stones shall break with clean fracture and shall make a ringing sound when struck with hammer and the specific gravity shall not be less than 2.6.

- Placement

The earth surface of the excavation and / or the slope to receive pitching shall first be prepared by scrapping the existing surface to the required lines and grades as shown on the drawings and as directed by the Engineer. The stone layer shall be formed in single layer and the stones on the face shall not be less than 25 cm x 20 cm and 25 cm deep at right angle to the slopes. The layer of the pitching shall be as per IS 8237.

The stones shall have fairly large flat surfaces as far as possible to ensure minimum voids and to obtain a fairly even surface.

Before placing, the stones shall be cleaned and shall be so placed by hand that each stone is well banded with squared quoins at joints and corners.

Stone pitching up to height of 3 m shall have 300 mm thick R. R. masonry bands in 1:4 cement mortar at top and bottom and vertical bands at 3 m interval.

Stone pitching of height more than 3 m shall have 300 mm thick R. R. masonry bands in cement mortar 1:4 at 3 m vertical and horizontal interval.

18.2 Measurement and Payment

Payment shall be made at unit price per square metre (m^2) stated in the "Bill of Quantities" for the quantity of stone pitching calculated from the dimensions shown in the drawings minus the openings of size 0.1 Sq.m or above. If the cross-sectional area of the stone pitching work actually constructed is less than the designed section and accepted by the Engineer, the quantity calculated on the basis of cross sectional area of the stone pitching work actually constructed shall be measured and paid.

18.3 R. R. MASONRY

- Scope

These specifications cover the construction of un-coursed Random Rubble (RR) stone masonry in cement mortar 1 : 4 with approved stones, including cost of all materials, pipes for weep holes, machinery, labour, scaffolding, ramps, cleaning, welding stones, curing with all leads and lifts etc complete as shown in the drawings and as directed by the Engineer.

- Placing

R. R. masonry shall be placed to the lines, grades and dimensions as shown on the drawings and as directed by the Engineer. Cement mortar used for jointing shall have cement - sand ratio of 1 : 4 (1 cement : 4 sand). The material for mortar except water shall be mixed until the mixture assumes a uniform colour, after which water shall be added and the mixing continued.

Mortar shall be mixed only in those quantities required for immediate use. Mortar that is not used within forty five (45) minutes after the water has been added, shall be discarded. Cement, sand and water used in the mortar shall conform to the respective requirements as laid out in Chapter - 8 "Cement Concrete" of these Technical Specifications. Before placing, the stone shall be cleaned and kept moistened appropriately. The masonry stones shall be so placed by hand that each stone is completely surrounded by mortar. The stone shall be filled into place in such a manner that the mortar is in complete liaison with the stone in all joints. The stones shall be laid carefully so as to break joints. The thickness of the joints in face work shall not exceed 25 mm and shall not be less than 12 mm. Atleast two band stones for every one square metre (1.0 m^2) of wall face shall be provided. These shall be through stones in walls 600 mm thick and under.In walls thicker than600 mm, the length of band stones shall be not less than 750 mm.

The stone shall be stuck and consolidated by means of a small steel hammer and those thereafter broken shall be removed, cleaned and reused with new mortar. The joints shall liberally be provided with mortar and shall be tightened by driving and wedging stone chips into joints. Care shall be taken that each stone is completely enveloped in mortar. 100 x 100 mm weep holes shall be left in the masonry at 1500 mm vertical and horizontal interval. Alternately, 100 mm diameter PVC pipes shall be left in the masonry at 1500 mm vertical and horizontal interval. The hillside of the weep holes /

PVC pipes shall be covered with inverted sand - gravel filter to release hydrostatic pressure, if any.

- Finishing

Each stone shall be laid so that the longer dimensions are parallel to the sloped surface. The surface of the stone masonry shall be finished smooth and clean. For achieving a smooth finish, joints on the face of all masonry exposed to view shall be neatly finished. The

mortar in the joints on the face of the stone masonry shall be removed to a depth of three (3) cm and the joints cleaned thoroughly with a wire brush and filled with cement mortar 1 : 2 (1 cement : 2 sand). The surface of all face stones shall be cleaned of all mortar after completion of the finishing operations.

- Contraction Joints

Vertical and horizontal contraction joints shall be provided in the R. R. masonry as shown on the drawing or as directed by the Engineer.

- Curing

During the construction of R. R. masonry works, the surface of the masonry shall be kept wet at least for five (5) days after completion of cementing works.

- Measurement and Payment

Payment shall be made at unit price per cubic metre (m^3) stated in the "Bill of Quantities" for the quantity of masonry calculated from the dimensions shown in the drawings minus the openings of size 0.1 Sq.m or above. If the cross-sectional area of the masonry work actually constructed is less than the designed section and accepted by the Engineer, the quantity calculated on the basis of cross sectional area of the masonry work actually constructed shall be measured and paid.

CHAPTER - 19

WIRE CRATES (GABBIONS)

19.1 SCOPE

These specifications cover the items of providing and laying of wire crates (Gabions) including cost of collection, transportation of stones and wire boxes and laying to the required lines and grades at locations shown in the drawings and / or as directed by the Engineer including cost of all materials, labour etc. with all leads and lifts.

19.2 MATERIAL

Gabions / wire crates are boxes of wire mesh which are filled with cobble stones. The size of cobbles shall be 15 cm (fifteen) to 25 cm (Twenty Five) and the quality of stones shall be in accordance with IS - 7779.

19.3 EXECUTION OF WORK

The Contractor shall construct gabions for protection works as per drawings or as directed by the Engineer. If not otherwise clearly specified on the drawings, the Contractor shall submit a proposal of the type and dimensions of gabions, schedule of delivery and construction. The Contractor shall not commence the construction of gabions before the approval of the Engineer.

The Gabions shall be of the following sizes.

Type I - Gabions of size 1m x 2m x 2 m using flexible steel wires having minimum tensile strength of 40 kg/mm^2.

Type II - Gabions of size 1 m x 1m x 1 m using flexible galvanized steel wires having minimum tensile strength of 40 kg/mm^2 and minimum weight of zinc coating of 275 g/m^2.

The mesh shall be hexagonal or square woven mesh and knots shall be formed by twisting each pair of wires preferably three and half turns or as directed and accepted by the Engineer.

The size of mesh shall be as approved by the Engineer and shall not be greater than the size of the smallest size stones filled in the Gabions.

The diameter of the wire shall be as specified or more. All edges of the Gabions including end panels and diaphragms, if any shall be mechanically adjusted in such a way as to prevent unraveling of the mesh and to develop the full strength of the mesh. The wire used for edge protection shall have diameter greater than that of the wire used to form the mesh.

Sufficient lacing and connecting wire shall be supplied with the Gabions for all wiring operations to be carried out in the construction of the Gabion works. The quantity of such wire is estimated to be eight percent (8%) by weight of the wire for Gabions.

The diameter of lacing wire shall be:

a. 2.5 mm for Gabions made of wire of diameter greater than 2.5mm.

b. 2.2 mm for the gabions made of 2.2 mm or 2.5mm in diameter.

The length of the Gabions is subject to a tolerance of around five (5%) percent.

19.4 MEASUREMENT AND PAYMENT

Measurement & Payment for Gabions shall be made at unit price per cubic metre (m^3) stated in the "Bill of Quantities" on the basis of actual volume placed in cubic metre (m^3) to the specified lines, grades and dimensions as shown the drawings or as directed by the Engineer.