

VOLUME-2
PART- I
Section-11
Grounding System

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11. Grounding and Lightning Protection System

11.1 Intent of Specification

This specification is intended to cover detailed scope of work, design, technical requirement, quality assurance, erection, testing, commissioning of grounding & lightning protection system complete with all accessories & spare parts.

11.2 Detailed Scope of Works

Scope of work under this section covers provision of labours, tools, plants, materials and performance of work necessary for the design, quality assurance, quality control, delivery at site, site storage and preservation, installation & commissioning, performance testing, acceptance testing, handing over to purchaser and guarantee for grounding & lightning protection system as per the specification furnished hereunder each complete with all accessories, spare parts and warranting a trouble free safe operation of the installation as detailed below.

The scope covers the above mentioned grounding protection system required in the following areas:

- (a) Powerhouse, transformer yard, switchyard, tailrace tunnels etc.

The scope covers the lightning protection system required in the following areas:

- (a) Powerhouse.
- (b) Outdoor switchyard, control room etc.

The scope also covers all the equipment & accessories required for completion of the system to give the desired performance & comprehensive functional requirement complete with every respect including but not limited to the followings.

Trench excavation and refilling for main earthing mat shall be in the scope of Civil Contractor.

11.2.1 Embedded Earthing

- i) Underground earth network:

The underground earthing network shall consist of underground earth mat in MIV area, powerhouse, tailrace, & other adjoining functional area. It shall be composed of interconnected mesh of grounding conductors suitably spaced and buried in raft and grounding rods driven vertically in ground connected to mesh.

- ii) Over ground earth network:

- a) The over ground earthing network shall consist of suitably spaced meshed grid embedded in
 - Generator/turbine floor.

- MIV floor.
- Control Block.
- Transformer yard.
- Switchyard.
- All other floors.
- Areas where earth fault current may flow.

b) Interconnection of all over ground meshed grid embedded in various floors and connection with powerhouse underground earth mat.

11.2.2 Grounding connections

- Embedded grounding points connected to over ground mesh grid at required locations for earthing of equipment.
- Connections of all steel structures and metal parts to embedded earthing network.
- An interconnected above ground/ above floor main earthing network of flats at the powerhouse, generator floor, transformer area, switchyard and to the other places wherever needed for earthing of machinery, equipment and other parts.
- Flexible copper braided connection of ground points of equipment to grounding network.
- Clamps, sheaths, terminals and other miscellaneous items for making ground connections.

11.2.3 Common supplies

- Spare parts as per clause no: "Spare Parts" of this section.
- Tools and instruments as per clause no "Tools and Instruments" of this section.
- Drawings, documents.

11.3 Codes and Standards

All equipment and materials shall be designed, manufactured and tested in accordance with the latest applicable Indian Standards (IS) / IEC as given below except where modified and/or supplemented by this specification.

- IEEE Std 80: 2000, "Guide for safety in AC substation Grounding"
- IS: 3043, Code of practice for earthing
- IEEE Std142, "Recommended Practice for Grounding of Industrial and Commercial Power Systems"
- IEEE Std 665, "IEEE Guide for Generating Station Grounding"
- IEEE Std 1050, "IEEE Guide for Instrumentation and Control Equipment Grounding in Generating Stations"

- IEEE 1100, "IEEE Recommended Practice for Powering and Grounding Electronic Equipment"
- ANSI/UL 467, "Safety Standard for Grounding and Bonding Equipment;"
- National Electrical Code (NEC)
- National Electrical Safety Code (NESC)
- IS: 2309, Code of practice for the protection of Building and allied structures against lightning
- CBIP publication no: 223.

Equipment and material conforming to any other standard, which ensures equal or better quality, may be acceptable. In such case, copies of the English version of the standard adopted shall be submitted along with the bid.

11.4 Reference drawings, documents & interfacing

- (a) Powerhouse layout drawings.
- (b) Overall layout plan.
- (c) Layout of outdoor switchyard.
- (d) For length, size & thickness of steel penstock, refer relevant civil drawings.

11.5 Special design and layout condition

The contractor shall design and construct the grounding system for protection of persons and materials to allow a safe service and maintenance work on the installations.

The earthing system shall be constructed to comply with the requirements of the applicable standards and connected equipment. The grounding system shall be designed to avoid dangerous step & touch voltages.

Moreover, the ground potential rise shall be limited to safe value.

More specifically and independent of the regulation and standards, the earthing system shall provide

- Adequate protection of personal against dangerous voltages, currents and arcs.
- Low earthing impedance for the transformer neutral and the generator neutrals and sufficiently low neutral conductor impedance.
- Fault current shall flow through the earthing system.
- Limiting the induced capacity transformed voltage on electronic cables, circuits, panels and other equipment to low voltage, weak current.

The mesh density of the ground mats shall not be greater than 4mX4m.

The concreting of the embedded grounding system shall be done by the Civil Contractor under the supervision of E/M Contractor.

Lightning spike shall be mounted on the top of lightning mast in the switchyard, powerhouse roof and connected to earthing system.

11.6 Basic dimensions & Rating

Unless otherwise stated, ratings, characteristics, test and test procedures etc. shall comply with the provisions and requirements of latest Indian and International standards as listed above. Earthing conductors shall be dimensioned to carry earth fault current in any section of the plant for at least one second without any harm to the conductor.

The following basic rated values shall be considered and offered.

Item	Value
Standards to be considered for design of earthing system: Earthing system design Measurement of earth resistivity	IEEE 80: 2000, IEEE 665 & IS: 3043, CBIP manual: 223 IEEE 81, IS: 3043 by Wenner four electrode method
Design system fault level to be considered for earthing design	31.5kA (rms)
Duration of fault current to be considered for selection of size of earth conductor	1 second
Fault duration for calculation of step & touch potential	0.5 second
Equivalent resistance of the earthing system to be achieved (except dam, valve house or such areas)	Not more than 1 ohm
Earth resistivity to be considered i) Powerhouse area. ii) Transformer yard area.	To be measured by the Contractor as per IS: 3043, IEEE 81 by Wenner four electrode method
Surface layer resistivity Dry Concrete Crushed gravel in transformer yard & thickness of layer Steel penstock	20000 ohm-m 3000 ohm-m/ 200mm 86 ohm-m
Maximum single line to ground fault current (I _g)	To be calculated as per the system

Laying depth of main earthing grid i) Power house, tailrace etc. ii) Outdoor transformer yard	Below 300mm of soil or flush to rock/concrete. Below 600mm of soil.
Size, length and thickness of steel penstock	As per drawing enclosed
Number of outgoing feeder & voltage grade	1 nos., 132kV feeder
Size & specification of ground wire of outgoing feeder	7/3.15mm GS wire
Minimum size of main earthing conductor	As per design calculation but minimum 8mmX75 mm dia. flat
Size of vertical earth electrode	MS rod of size 32mm dia. (minimum) & 3 m long
Size of main risers	Minimum 50X6mm GI flat.
Embedded earth mat at different floors	Minimum 50X6mm GI flat.
Equipment connection	50X6mm/25X6mm copper braided flexible depending on the equipments to be earthed.
Earthing along outdoor cable trenches, power house cable trays	Minimum 50X6mm GI flat.

For estimation of bill of material, the bidder may inspect the project site & if possible measure the earth resistivity, which may be considered for their estimation. However, the Contractor shall have to absorb the upward or downward variation in bill of materials due to change in measure value of earth resistivity from pre & post award period. As such, no variation in price shall be applicable. In case the Contractor has not conduct soil resistivity test at site an average soil resistivity of 500 Ohm- m may be considered. Any change in the earthing quantity due to upward or downward value of soil resistivity as per actual site measurement shall be adjusted at actual.

11.7 Design Criteria

As stated above, the equivalent resistance of whole earthing system shall be equal to or less than 1.0 ohm. Earth conductor embedded in ground shall be thermo welded to each other. Design fault level of the system such as powerhouse, switchyard, transformer yard etc. for earthing design shall be considered as 31.5kA (rms) for 1 second. These fault level is minimum for sizing of conductor. The contractor shall submit detailed calculation of fault current considered for design of earthing system as per the electrical system for review and approval.

The system shall be considered as effectively earthed except the neutral of generator, which shall be earthed to the earthing system through a resistor.

The equivalent earthing resistance of 1.0 ohm or less shall be achieved by interconnecting the earthing system of powerhouse, switchyard, transformer yard etc.

Also, steel penstock may also be considered for earthing system.

Any special treatment of soil or other means required to achieve the same shall be done by the Contractor.

Since this specific resistivity of the soil is important for calculating the earthing systems, the successful bidder shall execute measurements in due time. For the method it can be applied F. Wenner, a method of measuring Earth Resistivity as per IS: 3043/ IEEE 81.

11.8 Specific Technical Requirements

11.8.1 General

All structures of the plant site, including water intake, shall be analyzed to determine the zone of protection provided by the lightning system. The zone of protection shall depend on each structure height, overall shape, and physical location in relation to other structures. The lightning protection system shall be designed, furnished, and installed with the latest applicable standards listed in this specification.

Lightning protection for buildings and structures shall consist of air terminals installed around the top of the structure. The air terminals shall be connected together with copper cable and connected to the plant ground grid with copper down conductors. Air terminals shall be arranged to provide protection for roof penetrating devices such as air handling equipment. A grounding and lightning protection study shall be made to determine the exact detail required for these systems.

11.8.2 Equipment and Material

Grounding materials shall be as follows:

- (a) Rods shall be MS. Ground rod length and diameter shall be determined by soil resistivity and subsurface mechanical properties. The minimum rod diameter shall be as stated above.
- (b) Over ground earth conductor shall be MS flat of adequate size duly galvanized or epoxy bitumen painted as per standard.
- (c) Clamps, connectors, and other hardware used with the grounding system shall be made of steel and from acceptable manufacturers.
- (d) Minimum 150mm overlapping of joints between earthing flat/rods shall be maintained for welding. Earthing grid conductors shall be welded at all points of crossing by arc welding carried out with "low hydrogen content electrode".

11.8.3 Potential Gradient Control System

The Contractor shall provide a complete potential gradient control system for the Powerhouse, Transformers yard, Switchgear rooms etc all such locations where dangerous surface voltage gradients may occur, including all necessary connections to the plant earthing grid. Prior and during the concreting

stage the Contractor shall provide all information in sufficient details to enable the Civil Contractor connecting the reinforcement bars to form an adequate grid.

Within concrete structures (foundation, floors, columns) the Civil Contractor shall provide reinforcement bars of adequate cross section interconnected to a net with permissible mesh dimensions, with at least two connection pieces protruding at diagonal points into the ground floor of buildings. In the caverns several connection pieces with equal distances shall be provided.

The number and the location of these interconnection points shall be determined by the Contractor. The Contractor shall provide drawings showing the mesh dimensions and the extension of the earthing grid formed by the reinforcement bars.

11.8.4 Earthing Conductor Layout

Earthing conductors in outdoor areas shall be buried at least 600 mm below finished ground level unless stated otherwise. Wherever earthing conductor crosses cable trenches, underground service ducts, pipes, tunnels, railway tracks etc., it shall be laid minimum 300 mm below them and shall be circumvented in case it fouls with equipment/structure foundations.

Tap-connections from the earthing grid to the equipment/structure to be earthed shall be terminated on the earthing terminals of the equipment/ structure earthing conductors or leads along their run on cable trench, ladder, walls etc. shall be supported by suitable welding/cleating at intervals of 750 mm. Wherever it passes through walls, floors etc., galvanized iron sleeves shall be provided for the passage of the conductor and both ends of the sleeve shall be sealed to prevent the passage of water through the sleeves.

Earthing conductor around the building shall be buried in earth at a minimum distance of 1500 mm from the outer boundary of the building. In case high temperature is encountered at some location, the earthing conductor shall be laid minimum 1500 mm away from such location. Earthing conductors crossing the road shall be laid 300 mm below road or at greater depth to suit the site conditions. Earthing conductors embedded in the concrete shall have approximately 50 mm concrete cover.

11.8.5 Equipment and Structure Earthing

Earthing pads shall be provided for the apparatus/equipment at accessible position. The connection between earthing pads and the earthing grid shall be made by two short earthing leads (one direct and another through the support structure) free from kinks and splices. In case earthing pads are not provided on the item to be earthed, same shall be provided in consultation with Owner.

Whether specifically shown in drawings or not, steel/ RCC columns, metallic stairs etc. shall be connected to the nearby earthing grid conductor by two earthing leads.

Electrical continuity shall be ensured by bonding different sections of hand-rails and metallic stairs.

Metallic pipes, conduits and cable tray sections for cable installation shall be bonded to ensure electrical continuity and connected to earthing conductors at regular interval. Apart from intermediate connections, beginning points shall also be connected to earthing system.

Metallic conduits shall not be used as earth continuity conductor.

Wherever earthing conductor crosses or runs along metallic structures such as gas, water, steam conduits, etc. and steel reinforcement in concrete it shall be bonded to the same.

Light poles, junction boxes on the poles, cable and cable boxes/glands, lockout

switches etc. shall be connected to the earthing conductor running along with the supply cable which in turn shall be connected to earthing grid conductor at a minimum two points whether specifically shown or not.

Railway tracks within transformer yard area shall be earthed at a spacing of 30m and also at both ends.

Earthing conductor shall be buried 2000 mm outside the powerhouse fence. All the gates and every alternate post of the fence shall be connected to earthing grid.

The stone spreading shall also be done 2000 mm outside powerhouse fence. The criterion for stone spreading shall be followed in line with requirement specified elsewhere in the specification.

Flexible earthing connectors shall be provided for the moving parts.

All lighting panels, junction boxes, receptacles fixtures, conduits etc. shall be grounded in compliance with the provision of I.E. rules. The details of earthing & materials to be supplied for earthing of lighting system are included in the Illumination package.

50mm x 6mm MS flat shall run on the top tier and all along the cable trenches and the same shall be welded to each of the racks. Further, this flat shall be earthed at both ends and at an interval of 30 mtrs.

A 32 mm dia, 3000 mm long MS earth electrode with test link, CI frames and cover shall be provided to connect down conductor of surge arrester, capacitive voltage transformer, lightning mast and towers with peak.

11.8.6 Jointing Procedure

Earthing connections with equipment earthing pads shall be bolted type. Contact surfaces shall be free from scale, paint, enamel, grease, rust or dirt. Two bolts shall be provided for making each connection. Equipment bolted connections, after being checked and tested, shall be painted with anti corrosive paint/compound.

Connection between equipment earthing lead and main earthing conductors and between main earthing conductors shall be welded type. For rust protections, the welds should be treated with red lead and afterwards coated with two layers bitumen compound to prevent corrosion.

Steel to copper connections shall be brazed type and shall be treated to prevent moisture ingress.

Resistance of the joint shall not be more than the resistance of the equivalent length of the conductor.

All ground connections shall be made by electric arc welding. All welded joints shall be allowed to cool down gradually to atmospheric temperature before putting any load on it. Artificial cooling shall not be allowed. Bending of earthing rod shall be done preferably by gas heating. All arc welding with large dia. conductors shall be done with low hydrogen content electrodes.

11.8.7 Power Cable Earthing

Metallic sheaths and armour of all multi core power cables shall be earthed at both equipment and switchgear end. Sheath and armour of single core power cables shall be earthed at switchgear end only.

11.8.8 Specific Requirement for Earthing Systems

Each earthing lead from the neutral of the power transformer shall be directly connected to two pipe electrodes in treated earth pit (as per IS 3043) which in turn, shall be buried in cement concrete pit with a cast iron cover hinged to a cast iron frame to have an access to the joints. All accessories associated with transformer/reactor like cooling banks, radiators etc. shall be connected to the earthing grid at minimum two points.

Earthing terminal of each lightning arrester & capacitor voltage transformer shall be directly connected to rod earth electrode, which in turn, shall be connected to station earthing grid.

11.8.9 Lightning Protection System

The Main Powerhouse Building shall be provided with a lightning protection system composed of roof and down conductors sufficiently sized, spaced and connected to the main earthing loop or to separate earthing electrodes. Local conditions shall be strictly observed.

Direct stroke lightning protection (DSLPP) shall be provided in the switchyard by lightning masts and shield wires. The layout drawings enclosed indicate the tentative arrangement. The final arrangement shall be decided after approval of the DSLPP calculations. The lightning spike shall be of copper.

The lightning protection system shall not be in direct contact with underground metallic service ducts and cab.

Conductors of the lightning protection system shall not be connected with the conductors of the safety earthing system above ground level.

Down conductors shall be cleated on the structures at 2000 mm interval. Connection between each down conductor and rod electrodes shall be made via test joint (pad type compression clamp) located approximately 1500 mm above ground level. The rod electrode shall be further joined with the main earth mat. Lightning conductors shall not pass through or run inside G.I. conduits.

11.9 Design and Construction

The Contractor shall make the design and the calculation of the whole grounding system as described in this specification.

The entire earthing system shall be so structured that breaking of an earth conductor at any point in the network shall not disconnect any part of the network from the earth.

11.9.1 Embedded Earthing System

The embedded earthing system of the powerhouse, switchyard & transformer hall/yard and discharge area of tailrace shall consist of an interconnected earthing grid formed by MS rod, MS electrode, flats, copper conductor of adequate sizes.

The embedded earthing system of the powerhouse shall be connected to the penstock and to the earthing system of switchyard, switchyard & transformer yard and discharge area of tailrace. Ground conductor of underground earthing system shall have minimum cross section as specified in the specification. The sizes shall be finalised from the consideration of mechanical ruggedness and ease of installation. Risers from the grid to various floors and installation shall be embedded in the column/beam. At every floor an embedded grid of earth conductors shall be laid interconnecting all the risers.

Prior & during the concreting stages, the Contractor shall provide/ erect all materials and shall coordinate all appropriate information in sufficient details to enable the Civil Contractor to ensure concreting only after connection of reinforcement bar and to form the adequate grid.

The number and locations of these interconnecting points shall be determined by the Contractor and furnished for Employer's approval.

All connections of the embedded earthing conductors shall be thermo welded.

Sufficient nos. of vertical earth electrode shall be provided & connected to the main grid to limit the touch/step potential. The quantities & location shall be calculated and same shall be subject to the Employer's approval.

Interconnection of earth mat laid in separate areas/ installation shall be done by minimum 2 nos. of similar size of earthing conductors.

11.9.2 Above ground/ above floor earthing system

The earthing system shall consist of individual loops with connection to different equipments to be earthed and with connection to the embedded earthing grid. At certain location earthing measuring points shall be installed.

Within the powerhouse and transformer hall and other rooms and buildings containing other installation at least one main protective earthing bus shall be provided, approximately 300mm above floor at the circumference of the building room. This bus consisting of bare MS flat of adequate dimension shall be connected with the embedded earthing system. This protective earthing system shall be carried alongwith the cable trays to reach every electrical consumers in a convenient manner.

The connection straps from the embedded net to the main protective earthing buses shall be provided with disconnect terminal lugs for measuring, always visible for inspection.

All exposed ground conductor shall be galvanized steel.

11.9.3 Conductors and connections

All main conductors from the generator grounding system shall have individual connections as per the required standards. The Contractor shall supply all embedded conductor system and the connection rods/flats and design suitable connection facilities for connection of individual conductors of the system.

11.9.4 Schedule of connections

The connection shall include but not limited to the followings:

- Connection to all cubicle ground buses
- All transformer/reactor neutral (Generator & other main transformer by treated earth pit)
- All surge arresters by earthing rod
- Generator frame
- All secondary circuit of instrument transformers
- All metal equipment housing and all accessible metallic equipment and all steel structure parts.
- All cable screen, cable trays.
- Other equipment and electrical installation as per requirement and relevant standards
- Water pipes
- Metallic gates
- Transformer yard other fences
- All the connections shall be made as parallel connection to the main earth line. Each equipment shall be connected at two points by two independent risers.

In addition to the grounding through cable screen all equipment such as cubicles, motors etc. shall be connected directly to the grounding using MS flat/copper wires at two different points. In general, all iron parts such as supports, covers, railing etc. shall be connected to the grounding system. Each conductor shall have its own separate connection points. Pressed or closed shoes shall be used for connection to bars.

11.10 Performance criteria and Guarantees

The grounding system along with all auxiliaries and accessories shall be capable of performing intended duties under the specified conditions. It is the responsibility of the Contractor to supply the equipment as per the guaranteed technical particulars and shall also guarantee the reliability and performance.

The equivalent earth resistance of 1.0 ohm or less shall be guaranteed.

11.11 Spare Parts

The spare parts mentioned here under are meant for use by the Employer during operation and maintenance stage and shall not be used as erection spares required during installation.

11.11.1 Special Spare Parts

Mandatory spare parts shall be supplied in accordance with the list mutually agreed between the Owner and Contract, which is furnished by the Contractor in their final offers.

11.11.2 Recommended Spare Parts

The Bidder shall furnish the list of recommended spare parts as per "General Technical Particular (GTS)".

11.12 Tools and instruments

The contractor shall supply all necessary tools, devices, equipment, testing instruments etc. for installation, repair and maintenance as described in following sub clauses.

11.12.1 Tools for erection and installation

The contractor shall bring his own tools, devices, testing instruments/ equipment to site in order to erect and install the complete equipment delivered under this section. These shall remain the property of the contractor unless otherwise agreed to take over any/all of these at mutually agreed conditions.

For on-site assembly, the contractor shall use the same assembly tooling and procedures as those used in the shop.

11.13 Drawings, Documents and Design Calculations**11.13.1 Drawings**

The following minimum drawings shall be submitted by the contractor for review and approval.

- i. Complete earthing layout drawings.
- ii. Construction drawings of earth pits.
- iii. Welding details & recommendation.

11.13.2 Documents

The following minimum documents shall be submitted by the contractor, some of which are for review and approval.

- i. Quality Assurance Plan.
- ii. Data Sheets.
- iii. Earth resistivity test reports.

11.13.3 Design calculations

The contractor shall submit the design calculation minimum for the following for review and approval.

- i. Short circuit calculation.
- ii. Design calculation of earthing system.

11.14 Quality control and Assurance

To ensure quality during each stage of work, the Contractor shall establish a system defining quality assurance plan/procedures during various stages of work.

The contractor shall maintain quality control during manufacturing of equipment as per the approved quality assurance plan. Inspection and testing shall be carried out as per the approved quality assurance plan with due regard to the Quality Assurance Plan attached with the tender documents at various stages of manufacturing for assuring the full compliance of supply with the requirements of specification.

The Contractor shall follow approved site quality assurance plan and installation procedures. The contractor shall maintain the quality record during site installation and commissioning which shall be produced to the Owner for approval.

Inspection and tests shall be carried out at site by the Owner during installation and commissioning stages as described in the relevant clauses.

All subcontractors including vendors associated in completing the supply and work under this section shall have their own quality assurance system conforming to ISO: 9000 series and certified by an internationally acceptable organization.

11.15 Tests

11.15.1 Shop Test

Materials used in the earthing system shall be routine tested for dimension checking, corrosion protection, material properties/ strength as per relevant IEC/IEEE standards at the works of Contractor. The Contractor is required to submit routine test reports of materials.

11.15.2 Field tests

All field tests including tests during installation, pre-commissioning, commissioning, performance & field acceptance tests shall be conducted by the Contractor in the presence of representative of the Employer.

Procedure to be adopted for conducting pre-commissioning, commissioning, performance & field acceptance tests shall be submitted well in advance, at least 6 (six) months prior to the testing for Employer's approval.

The following minimum tests to be carried out to demonstrate operational capability as per agreed & guaranteed terms.

- Visual inspection of ground mat and connection before concreting
- Visual inspection of exposed system
- Electrical continuity test
- Measurement of earthing resistance as far as possible of individual loop and combined equivalent earthing resistance

At least the following tests shall be conducted as commissioning tests:

- Visual inspection
- Verification of equipment connections to the earth circuits

Field acceptance test:

The equivalent resistance of the entire grounding system of powerhouse and other major electrical installation shall be measured as 1.0 ohm or less.

11.16 Delivery, Installation and Commissioning

11.16.1 Packaging, Handling and site Storage:

The contractor shall follow the "General Technical Specification" for packaging, handling and storage requirement.

Proper handling and storage of earthing material shall be ensured by the Contractor.

11.16.2 Site installation and Commissioning

The contractor shall follow the requirements of installation elaborated in "General Technical Specification".

The contractor has to do all the work related to assembly, erection, testing and commissioning complete in all respects. All necessary tools, plants, labour, materials including consumables for performing installation, testing and pre-commissioning shall be provided by the contractor.

The contractor shall submit the necessary data/information, layout and foundation/support drawings well in advance.

The contractor shall provide and install the concrete inserts/embedment; support steels and/or components for supports purpose as per approved erection drawings and coordinate the activities with civil contractors to keep his activities in synchronism with civil works. All installation works shall be verified and accepted by the Owner.

Chipping of concrete and/or taking support from reinforcement bars shall not be allowed.

The contractor shall supply sufficient number of erection and commissioning spares based on their experience so that erection, testing and commissioning work progresses smoothly and is not hampered for want of such spares. These spares shall be in addition to the spare parts described under clause: "Spare Parts".