BIDDING DOCUMENTS
FOR
400 KV D/C TRANSMISSION LINE PACKAGES
A1 & A2
ASSOCIATED WITH 1147.5 MW SUGEN CCPP

Volume - II
Technical Specifications

May 2008

TORRENT POWER GRID LIMITED
[A Joint Venture between Torrent Power Limited and
Power Grid Corporation of India Ltd.]

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BIDDING DOCUMENTS

FOR

400 KV D/C TRANSMISSION LINE PACKAGES

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Volume - II

Technical Specifications

SPECIFICATION NOS.:
TOWER PACKAGE-A1: TPGL/SPTL/A1
TOWER PACKAGE-A2: TPGL/SPTL/A2

This document is meant for the exclusive purpose of bidding against this specification and shall not be transferred, reproduced or otherwise used for purpose other than that for which it is specifically issued.
TECHNICAL SPECIFICATIONS

FOR

TOWER PACKAGES A1 & A2

FOR

400 KV D/C TRANSMISSION LINES

ASSOCIATED WITH TORRENT POWER GRID LTD.

Volume – II

Specification Nos. :

Tower package : A1:TPGL/SPTL/A1

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TECHNICAL SPECIFICATION

CONTENTS

SECTION – I GENERAL INFORMATION & SCOPE
SECTION – II GENERAL TECHNICAL CONDITIONS
SECTION – III SURVEY & SOIL INVESTIGATION
SECTION – IV TOWER, FOUNDATION, ERECTION, STRINGING & COMMISSIONING
SECTION – V PILE FOUNDATION
SECTION – VI GALVANISED STEEL EARTH WIRE
SECTION – VII HARDWARE FITTINGS & ACCESSORIES
SECTION – VIII DRAWINGS
### SECTION – I

**CONTENTS**

<table>
<thead>
<tr>
<th>Clause No.</th>
<th>Description</th>
<th>Page No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0</td>
<td>General Information and Scope</td>
<td>1</td>
</tr>
<tr>
<td>2.0</td>
<td>Qualification requirement for Contractor’s supplied Line Materials</td>
<td>6</td>
</tr>
<tr>
<td>3.0</td>
<td>Transmission towers and Line data</td>
<td>8</td>
</tr>
<tr>
<td>4.0</td>
<td>Details of Line Materials</td>
<td>11</td>
</tr>
<tr>
<td>5.0</td>
<td>Service Conditions</td>
<td>12</td>
</tr>
</tbody>
</table>
SECTION-I
TECHNICAL SPECIFICATIONS

1. General Information and Scope

1.1 Scope

1.1.1 The following 400kV transmission lines are included in the scope of the Contractor.

Package – A1

1. 400kV D/C Sugen – LILO point of Jhanor – Dehgam part - 80kms of Sugen – Pirana TL

Package – A2

1. LILO point of Jhanor Dehgam to Pirana POWERGRID - 132kms with Torrent Pirana Sub-Station.

1.1.2 This Specification covers the following scope of works:

(i) Detailed survey including route alignment, profiling, tower spotting, optimisation of tower locations, soil resistivity measurement & geotechnical investigation (including special foundation locations, viz., pile foundation locations)

(ii) Check survey;

(iii) Right of way and way leave clearance including the payment of compensation (Rail, Road, Forest, Line crossing and any other approval/permission requirement for completing the job) shall be in the scope of Contractor

(iv) fabrication and supply of all type of 400kV transmission line towers, including River crossing towers (wherever applicable) as per Owner’s design/drawings including fasteners, anti theft fasteners, step bolts, hangers, D-shackles etc.

(v) All types of tower accessories like phase plate, circuit plate (wherever applicable), number plate, danger plate, anti climbing device, Bird guard (wherever applicable)

(vi) Supply of Earth wire, Hardware Fittings and Conductor & Earth wire Accessories,

(vii) Classification of foundation for different type of tower and casting of foundation for tower footings as per Owner’s foundations drawing;

(viii) erection of towers, tack welding of bolts and nuts including supply and application of zinc rich primer & two coats of enamel paint, tower earthing, fixing of insulator strings, stringing of conductors and earth wires along with all necessary line accessories,
(ix) painting of towers & supply and erection of span markers, obstruction lights (wherever applicable) for aviation requirements (as required)

(x) testing and commissioning of the erected transmission lines and

(xi) Other items not specifically mentioned in this Specification and / or BPS but are required for the successful commissioning of the transmission line, unless specifically excluded in the Specification.

1.1.2.1 Owner shall provide structural drawings, shop drawings & Bill of Materials of all type of transmission line towers and its extensions, river crossing towers/special towers as required to the Contractor after placement of award, in sequence, suit the project requirement. Similarly the drawings for all type of foundations for the towers shall also be provided by Owner to the Contractor. The scope of this specification also provides for fabrication of prototype tower, its assembly and proto-inspection, for which charges shall be indicated in the appropriate schedule of BPS.

1.1.2.2 (a) The provisional quantities of fabricated & galvanised steel parts as per specifications required for towers, concrete, excavation volume & reinforcement steel for foundation and other items are given in appropriate Schedule of Bid Proposal Sheet (BPS) for respective packages. However, the work shall be executed as per approved construction drawings.

(b) The various items of work are described very briefly in the appropriate Schedule of BPS. The various items of the BPS shall be read in conjunction with the corresponding sections in the Technical Specifications including amendments and, additions, if any. The Bidder’s quoted rates shall be based on the description of activities in the BPS as well as other necessary operations required to complete the works detailed in these Technical Specifications.

(c) The Unit rates quoted shall include minor details which are obviously and fairly intended, and which may not have been included in these documents but are essential for the satisfactory completion of the various works.

(d) The unit rate quoted shall be inclusive of all plant equipment, men, material skilled and unskilled labour etc. essential for satisfactory completion of various works.

(e) All measurements for payment shall be in S.I. units, lengths shall be measured in meters corrected to two decimal places. Areas shall be computed in square meters & volume in cubic meters. rounded off to two decimals.

1.1.2.3 The Bidder shall submit his offer taking into consideration that the tower and foundation designs/drawings shall be developed /provided by Owner and design rights will be strictly reserved with Owner. Bidder shall quote the unit rates for various items of towers and foundations as per units...
mentioned in appropriate schedule of (BPS). However, payment of these items identified in the schedule of prices shall be made as follows:

**TOWER**

Supply items : On supply of respective complete tower  
Erection items : On erection of respective complete tower  
Foundation items : On completion of respective foundation in all respect  

The payment to be made for towers/foundations shall be worked out based on the unit rates and approved Bill of Materials (BOM) for towers and quantities/volumes as per approved tower foundation drawings.

1.1.3 This specification also includes the supply of earth wire, hardware fittings and all type of accessories for conductor and earth wire as detailed in the specification. Contractor shall clearly indicate in their offer, the sources from where they propose to procure these materials in appropriate Schedule of BPS. The technical description of these items are given in SECTION - VI & VII of this Volume.

1.1.4 The Contractor shall take delivery of the Conductor and Insulators as Owner supplied materials at the stores established by the contractor in consultation with the Owner and ensure their safe custody and shall incorporate the same in the transmission lines as stipulated in this specification.

1.1.5 All the raw materials such as steel, zinc for galvanising, reinforcement steel, cement, coarse and fine aggregates for tower foundation, coke and salt for tower earthing etc. are included in the Contractor’s scope of supply.

1.1.6 Bidder shall also indicate in the offer, the sources from where they propose to procure the fasteners, anti theft fasteners, step bolts, hangers, D-shackles etc., tower accessories, aviation signal (if required) etc.

1.1.7 **Stringing**

a) **For transmission line with Single Conductor per phase:**

The entire stringing work of conductor and earth wire shall be carried out by standard stringing practice. The bidder shall indicate in the offer, the detail description of the procedure to be deployed for stringing operation.

b) **For transmission line with Bundle Conductor per phase:**

The entire stringing work of conductor and earth wire shall be carried out by tension stringing technique. The bidder shall indicate in their
offer, the sets of tension stringing equipment he is having in his
possession and the sets of stringing equipment he would deploy
exclusively for each package which under no circumstance shall be
less than the number and capacity requirement indicated in
Qualifying Requirements for Bidder. However, the Bidder having
requisite experience has freedom to use helicopter for stringing. The
Bidder intending to use helicopter shall furnish detailed description
of the procedure, type & number of helicopter & accessories etc., to
be deployed for stringing operation.

c) In hilly terrain and thick forest, where deployment of tension stringing
machine is not possible, manual stringing may be adopted after
getting approval of TPGL (Torrent Power Grid Limited) site
Engineer. The contractor shall deploy appropriate tools / equipments
/ machinery to ensure that the stringing operation is carried out
without causing damage to conductor / earth wire and conductor /
earth wire is installed at the prescribed sag-tension as per the
approved stringing charts.

1.2 Details of Transmission Line Routes and Terrain

Detailed survey including route alignment, profiling, tower spotting and
optimization of tower locations of lines have been carried out by the
Owner and these are not expected to vary substantially. However, during
execution if due to right of way constraints or any other unforeseen
circumstances the line route require changes detailed survey including
profiling, tower spotting, optimisation of tower locations, soil resistivity
measurement & geotechnical investigation etc. shall be undertaken by the
Contractor. For this part, quantity of detailed survey including route
alignment, profiling, tower spotting, optimization of tower locations, soil
resistivity measurement & geotechnical investigation etc. of lines have
been included in the BPS.

Bidders may however visit the line route to acquaint themselves with
terrain conditions and associated details of the proposed transmission
lines. For this purpose they are requested to contact the following
address:

Sh.K.K.Shah,Director,
Torrent Power Grid Limited.
Off Ashram Road
Ahmedabad – 380 009

The details collected through detailed survey viz. route alignment maps,
detailed survey reports etc. will be given to the contractor during
execution stage.
1.3 **Location Details and Terminal Points**

1.3.1 The transmission line shall emanate from SUGEN (TPGL) substation and terminate at PIRANA (Powergrid) substation with LILO at TPL Pirana substation in the State of Gujarat.

1.3.2 The Contractor shall have to construct the transmission lines completely up to dead end towers on either end. Stringing shall also be carried out from dead end tower to terminal arrangements/terminal points.

1.4 **Access to the Line and Right of Way**

Obtaining Right of way and way leave clearance for 46 mtr corridor, Rail, Road, Forest, Power Line crossing, PTCC, Defense Air Traffic safety, Airport Authority, ONGC, GAIL, R&B and/or any other approvals/permissions required for completing the job including the payment of compensation to farmer/land owner/occupier/concerned authorities shall be in scope of the contractor.

1.5 **Right of Way and Other Statutory Clearance**

1.5.1 Contractor has to issue notice to the land owner, wherever required and whenever circumstances so arise, prior to execution of work. The draft of the notice will be approved by TPGL. Necessary details like survey, address of land owner/occupier etc required for serving the notice are to be collected by contractor at their cost if necessary.

1.5.2 Contractor shall have to take all advance actions to sort out the problems of right of way (ROW), way clearance, clearing of any objection from farmer, owner, Occupier, and or any other objection and payment of compensation against any damages to crops/trees and or any other damage etc. all along the line route and corridor.

1.5.3 Way clearances and farmer's/owner/occupier and or any other objection involving collector office or if police protection is required during execution of work shall be arranged by contractor at his cost.

1.5.4 The legal procedure if any shall be routed through the appropriate authority of TPGL. However all the legal expenses will have to be borne by the contractor. Any expense incurred by TPGL in regards to legal procedure shall be reimbursed to TPGL on actual basis by the contractor.

1.5.5 Contractor shall have to take all possible care to avoid legal proceedings.

1.5.6 Contractor shall have to arrange for all approvals from concerned authorities like, Railway crossing, Highway Crossing, Electrical inspectorate, Defence air traffic safety, Forest department, Power lines crossings of various authorities, PTCC approvals, Airport authority, PWD,
R&B, ONGC, GAIL and or any other permission/approval required to complete the line at his cost.

1.5.7 The contractor shall have to bear all expenditures towards way clearance, ROW, field compensation, tree cutting/Trimming etc. However, this does not include any kind of expenditure/compensation or payment towards acquiring/purchasing any type of land/structure of any status.

1.5.8 The amount of compensation as well as any other costs to be incurred as above shall be solely decided and born by the contractor. The company will not bear any extra expenditure on this account, except the amount of compensation/payment for acquisition/purchase any type of land/structure of any status.

1.5.9 Right of way and way leave clearance including the payment of compensation (to farmer/land owner/occupier,) shall be in scope of contractor,. However the actual fees paid by the contractor for obtaining the statutory clearances from Railway, Road, Tower line crossing, Forest, CEA, PTCC etc, shall be reimbursed by TPGL on production of documentary proof of original receipt of amount paid to the respective authorities.

2.0 Qualification Requirement for Contractor’s Supplied Line Materials

The Bidder should have assured access to supply Earthwire, Hardware fittings and Conductor & Earthwire accessories from Qualified Manufacturers meeting the following minimum requirement and must demonstrate that based on known commitments they will be available for use in the proposed contract.

a) Earthwire

The qualified manufacturer should have manufactured, tested and supplied at least three hundred (300) kms. of galvanized steel ground wire/ACSR core wire of size 7/3.15mm or above.

b) Hardware Fittings

The qualified manufacturer should have designed, manufactured, tested and supplied hardware fittings for at least 450 sets of tension strings and 1,013 sets of suspension strings for 220 kV or above voltage transmission line and same should have been in satisfactory operation for a minimum period of three years as on date of bid opening. Further, qualified manufacturer should also have type tested tension & suspension strings for 345/400 kV or above application as on date of bid opening.
c) **Accessories for Conductor and Earth wire**

The qualified manufacturer(s) for any individual item(s) of accessories for conductor & earth wire covered under the package should have designed, manufactured, tested and supplied the item(s) of accessories for conductor & earth wire covered under the package or item(s) of similar/comparable nature. For Bundle spacers and vibration dampers for earth wire, the experience should include at least the supply of 7875 nos. of twin bundle spacers and 5850 nos. of vibration dampers for conductor and 1950 nos. of vibration dampers for earth wire for 220 kV or above voltage transmission line respectively and the same should have been in satisfactory operation for a minimum period of three years as on date of bid opening. (For accessories for galvanized steel earth wire, the requirement of voltage level shall not be applicable).

The manufacturer(s) meeting the above requirement for any individual item or items shall be considered qualified for the respective item or items only.

d) However, if the proposed manufacturer of Hardware fittings and Accessories for conductor and earth wire is not meeting the above requirements of its own, he should be qualified licensee of a qualified manufacturer meeting the above specified requirements.

i) Manufacturer/licensees shall have adequate design infrastructure and manufacturing facility and capacity and procedures including quality control.

ii) A qualified Licensee of a qualified manufacturer shall mean all of the following:

   a) any design undertaken by the licensee shall be approved by the licensor

   b) Manufacture by the licensee shall be done with the approval of the licensor and Owner under a quality assurance programme approved and monitored by the licensor.

   c) Licensee must furnish back-up guarantee from the licensor for individual and overall performance of all equipment and materials supplied under the contract.

   d) Licensor must guarantee sequential and timely supply of equipments and materials and submission of technical information and data as desired by the Owner so as to meet the overall construction schedule and
e) The agreement between licensee and licensor submitted along with the bid (Proforma enclosed as Annexure – A to this section) shall be valid for a period of at least five (5) years after the guarantee period of equipment and materials under supply is over.

3.0 Transmission towers and Line data

3.1 General Description of the Tower

3.1.1 The transmission towers are of self-supporting hot dip galvanised lattice steel type designed to carry the line conductors with necessary insulators, earth wires and all fittings under all loading conditions. Outline diagram of single circuit and double circuit towers are enclosed with the Specification.

3.1.2 The tower shall be fully galvanised using mild steel or/and high tensile steel sections as specified in clause no. 1.7 of Section -IV. Bolts and nuts with spring washer are to be used for connections.

3.1.3 The towers are of the following types:

A) Double Circuit (DA, DB, DC & DD)
B) Single Circuit (A, B, C & D )
C) Special towers.
D) Multi circuit

3.2 Classification of Towers

3.2.1 The towers for 400 kV Lines are classified as given below:

<table>
<thead>
<tr>
<th>Type of Tower</th>
<th>Deviation Limit</th>
<th>Typical Use</th>
</tr>
</thead>
<tbody>
<tr>
<td>A and DA</td>
<td>0 deg.</td>
<td>To be used as tangent tower.</td>
</tr>
<tr>
<td>B and DB</td>
<td>0 - 15 deg.</td>
<td>a) Angle towers with tension insulator string.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>b) Also to be used for uplift force resulting from an uplift span up to 200m under broken wire conditions.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>c) Also to be used for Anti Cascading Condition.</td>
</tr>
<tr>
<td>B and DB</td>
<td>0 deg.</td>
<td>To be used as Section Tower.</td>
</tr>
<tr>
<td>C and DC</td>
<td>15 - 30 deg.</td>
<td>a) Angle tower with tension insulator string.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>b) Also to be used for uplift forces resulting from an uplift span up to 200m under broken wire condition.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>c) Also to be used for anti cascading condition.</td>
</tr>
</tbody>
</table>
C and DC 0 deg. To be used for transposition of transmission lines with modification.

D and DD 30 - 60 deg. a) Angle tower with tension insulator string.

b) Also to be used for uplift forces resulting from an uplift span up to 300m under broken wire condition.

c) Dead end with 0 deg to 15 deg deviation both on line side and sub station side (slack span)

DE and DDE 0 deg. a) Complete Dead end

b) For river crossing anchoring with longer wind span & 0 deg. deviation on crossing span side and 0 deg to 30 deg. deviation on other side.

Note: the above towers can also be used for longer span with smaller angle of deviations without infringement of ground clearance.

3.2.2 Transposition tower for 400 KV Lines

C/DC type towers (Section Towers) with suitable modifications are to be used for transposition of the line maintaining all the required clearance and shielding. Two numbers of transposition towers shall be required for double circuit transmission line and three number of transposition towers shall be required for single circuit transmission line.

3.2.3 Special Towers

The towers which will be specially designed for very long spans (spans more than that of given in cl. 3.3) which can not be crossed by normal tower with extensions as given in cl.no.3.2.6, like Major River crossings etc. shall be treated as special towers.

3.2.4 Extensions

3.2.4.1 For 400 KV, the Single and Double Circuit towers are designed so as to be suitable for adding 3M, 6M and 9M body extensions/leg extensions for maintaining adequate ground clearances without reducing the specified factor of safety in any manner.

3.2.4.2 The provision for addition of 18/25M body extension to tower types A/DA and D/DD is also kept by the Owner. For Power Line Crossing or any other obstacle, tower types A/DA or D/DD can be used with 18/25 M extensions depending, upon the merit of the prevailing site condition. The maximum reduced spans for A/DA and D/DD type towers shall be mentioned in the tower spotting data.

3.2.4.3 The towers for 400 KV lines have been designed for providing unequal leg extensions. The details of unequal leg extensions provided in the design shall be indicated to the contractor during execution stage, so that proper optimization of benching / revetment requirement can be done accordingly
by the contractor. The towers are designed for unequal leg extensions of 3M, 6M and 9M generally with 3M maximum leg differential and in specific cases with 6m maximum leg differential. In exceptional situations where difference in leg differential does not suit the standard unequal leg extension provisions on the tower mentioned above, then suitable chimney extension shall be provided.

3.2.4.4 All above extension provisions to towers and foundations shall be treated as part of normal towers and foundations only.

3.2.4.5 The leg extensions, unequal leg extensions, chimney extensions and / or a combination of these suitable for a tower location shall be selected on the basis of techno-economics.

3.3 Span and clearances

3.3.1 Normal Span
The normal ruling span of the line is 400m for 400KV lines.

3.3.2 Wind Span
The wind span is the sum of the two half spans adjacent to the support under consideration. For normal horizontal spans this equals to normal ruling span.

3.3.3 Weight span
The weight span is the horizontal distance between the lowest point of the conductors on the two spans adjacent to the tower. For spotting of structures, the span limits given in Table 3.1 for 400 KV lines shall prevail.

<table>
<thead>
<tr>
<th>TOWER TYPE</th>
<th>NORMAL CONDITION MAX. (m)</th>
<th>MIN. (m)</th>
<th>BROKEN WIRE CONDITION MAX. (m)</th>
<th>MIN. (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>DA/A</td>
<td>600</td>
<td>200</td>
<td>360</td>
<td>100</td>
</tr>
<tr>
<td>DB/B, DC/C</td>
<td>600</td>
<td>0</td>
<td>360</td>
<td>-200</td>
</tr>
<tr>
<td>DD/D</td>
<td>600</td>
<td>0</td>
<td>360</td>
<td>-300</td>
</tr>
</tbody>
</table>

3.3.4 In case at certain locations where actual spotting spans exceed the design spans and cross-arms and certain members of towers are required to be modified/reinforced, in that case drawings for the modified/reinforced towers will be supplied to the Contractor as per requirement.
3.4 Electrical Clearances

3.4.1 Ground Clearance

The minimum ground clearance from the bottom conductor shall not be less than 8840 mm for 400KV at the maximum sag conditions i.e at 75°C*/85°C * and still air.

a) An allowance of 150mm shall be provided to account for errors in stringing.

b) Conductor creep shall be compensated by over tensioning the conductor at a temperature of 26°C, lower than the stringing temperature for ACSR “MOOSE” for 400KV transmission lines.

3.5 Electrical System Data for 400 kV Tr.Line

<table>
<thead>
<tr>
<th>No.</th>
<th>Description</th>
<th>Unit</th>
<th>Earth Wire</th>
<th>Conductor</th>
</tr>
</thead>
<tbody>
<tr>
<td>a</td>
<td>Nominal Voltage</td>
<td>KV</td>
<td></td>
<td>400</td>
</tr>
<tr>
<td>b</td>
<td>Maximum system voltage</td>
<td>KV</td>
<td></td>
<td>420</td>
</tr>
<tr>
<td>c</td>
<td>BIL(Impulse)</td>
<td>KV (Peak)</td>
<td></td>
<td>1550</td>
</tr>
<tr>
<td>d</td>
<td>Power frequency withstand voltage (Wet)</td>
<td>Kv (rms)</td>
<td></td>
<td>680</td>
</tr>
<tr>
<td>e</td>
<td>Switching surge withstand voltage (Wet)</td>
<td>Kv (rms)</td>
<td></td>
<td>1050</td>
</tr>
<tr>
<td>f</td>
<td>Minimum Corona extinction voltage at 50Hz AC system under dry condition</td>
<td>KV (rms) phase to earth.</td>
<td>320 Min</td>
<td></td>
</tr>
<tr>
<td>g</td>
<td>Radio interference voltage at one MHz for phase to earth voltage of 305 KV under dry condition.</td>
<td>Micro Volts</td>
<td></td>
<td>1000 Max</td>
</tr>
</tbody>
</table>

4.0 DETAILS OF LINE MATERIALS

A. Conductor and earth wire for 400 kV Twin Bundle line

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Description</th>
<th>Unit</th>
<th>Earth wire</th>
<th>Conductor</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Name/Type</td>
<td></td>
<td>Galvanised steel</td>
<td>ACSR Moose</td>
</tr>
<tr>
<td>2.</td>
<td>Size</td>
<td>mm</td>
<td>7/3.66</td>
<td>54/3.53 Aluminium +7/3.53 steel</td>
</tr>
<tr>
<td>3.</td>
<td>Conductor per phase</td>
<td>No.</td>
<td>N.A.</td>
<td>2</td>
</tr>
<tr>
<td>4.</td>
<td>Spacing between conductor of same</td>
<td>mm</td>
<td>N.A.</td>
<td>450</td>
</tr>
</tbody>
</table>
phase (sub conductor spacing)

5. Configuration  
- Two continuously to run horizontally on top of the towers and conductors.  
- Vertical (for D/C with 8000 mm min. inter phase spacing). Horizontal (for S/C with 9000 mm min. inter phase spacing).

6. Overall diameter  
- mm: 10.98  
- 31.77

7. Unit mass  
- Kg/Km: 583  
- 2004

8. Min. UTS  
- KN: 68.4  
- 161.2

9. Ruling Design Span  
- Meters: 400  
- 400

4.1 Details of Insulator Strings with disc insulator for 400 kV line

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Particulars</th>
<th>Single &quot;I&quot; suspension string</th>
<th>Double &quot;I&quot; suspension string</th>
<th>Double tension string</th>
<th>Single suspension pilot string</th>
<th>Single tension string</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Type of Disc</td>
<td>Antifog</td>
<td>Antifog</td>
<td>Antifog</td>
<td>Antifog</td>
<td>Antifog</td>
</tr>
<tr>
<td>2.</td>
<td>E&amp;M Strength of each insulator in the string in KN</td>
<td>120</td>
<td>120</td>
<td>160</td>
<td>120</td>
<td>120</td>
</tr>
<tr>
<td>3.</td>
<td>Nos. of insulator disc per string</td>
<td>1x23</td>
<td>2x24</td>
<td>2x23</td>
<td>1x23</td>
<td>1x24</td>
</tr>
<tr>
<td>4.</td>
<td>Size of disc in mm</td>
<td>280x145 or 255x145</td>
<td>280x145 or 255x145</td>
<td>280x170 or 255x145</td>
<td>280x145 or 255x145</td>
<td>280x145 or 255x145</td>
</tr>
<tr>
<td>5.</td>
<td>Size and designation of pin ball shank in mm.</td>
<td>20</td>
<td>20</td>
<td>20</td>
<td>20</td>
<td>20</td>
</tr>
<tr>
<td>6.</td>
<td>Minimum creepage distance of each disc in mm.</td>
<td>430</td>
<td>430</td>
<td>475</td>
<td>430</td>
<td>430</td>
</tr>
</tbody>
</table>

Note: i) As an alternative to disc insulators, porcelain long rod insulators may also be used  
ii) Owner may also decide to use polymer long rod insulators

5.0 Service Conditions:
Equipment/material to be supplied against this specification shall be suitable for satisfactory continuous operation under tropical conditions as specified below:

- Maximum ambient temperature (Degree Celsius) : 50
- Minimum ambient temperature (Degree Celsius) : 4
- Relative humidity (% range) : 10-100
- Wind zone (as per IS: 875) : 3
- Maximum wind velocity (m/sec.) : 44 m/sec
- Maximum altitude above mean sea level (Meters) : below 1000 meters
- Isoceraunic level (days/years) : As applicable for region

Moderately hot and humid tropical climate conducive to rust and fungus growth.
## SECTION – II

### CONTENTS

<table>
<thead>
<tr>
<th>Clause No.</th>
<th>Description</th>
<th>Page No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0</td>
<td>General Technical Conditions</td>
<td>1</td>
</tr>
<tr>
<td>2.0</td>
<td>Owner/Employer/Purchaser’s Environment and Social Policy and its Implementation</td>
<td>9</td>
</tr>
</tbody>
</table>
SECTION-II
TECHNICAL SPECIFICATIONS

1.0 General Technical Conditions

1.1 General

The following provisions shall supplement all the detailed technical specifications and requirements brought out herein. The contractor's proposal shall be based on the use of materials complying fully with the requirements specified herein.

1.2 Engineering Data

1.2.1 The furnishing of engineering data by the Contractor shall be in accordance with the Schedule as specified in the Bidding Document. The review of these data by the Owner will cover only general conformance of the data to the specifications and not a thorough review of all dimensions, quantities and details of the materials, or items indicated or the accuracy of the information submitted. This review by the Owner shall not be considered by the Contractor, as limiting any of his responsibilities and liabilities for mistakes and deviations from the requirements, specified under these specifications.

1.2.2 All engineering data submitted by the Contractor after review by the Owner shall form part of the contract document.

1.3 Drawings

In addition to those stipulated in clause regarding drawings in GCC/SCC, the following also shall apply in respect of Contractor Drawings.

1.3.1 All drawings submitted by the Contractor including those submitted at the time of Bid shall be with sufficient detail to indicate the type, size, arrangement, dimensions, material description, Bill of Materials, weight of each component break-up for packing and shipment, fixing arrangement required, the dimensions required for installation and any other information specifically requested in these specifications.

1.3.2 Each drawing submitted by the Contractor shall be clearly marked with the name of the Owner, the specification title, the specification number and the name of the Project. All titles, noting, markings and writings on the drawing shall be in English. All the dimensions should be to the scale and in S.I. units.

1.3.3 The drawings submitted by the Contractor shall be reviewed by the Owner as far as practicable within 15 days and shall be modified by the Contractor if any modifications and/or corrections are required by the Owner. The Contractor shall incorporate such modifications and/or corrections and submit the final drawings for approval. Any delays arising out of failure by
the Contractor to rectify the drawings in good time shall not alter the contract completion date.

1.3.4 The drawings submitted for approval to the Owner shall be in quadruplicate. One print of such drawings shall be returned to the Contractor by the Owner marked “approved/approved with corrections”. The contractor shall thereupon furnish the Owner additional prints as may be required along with one reproducible in original of the drawings after incorporating all corrections.

1.3.5 The work shall be performed by the Contractor strictly in accordance with these drawings and no deviation shall be permitted without the written approval of the Owner, if so required.

1.3.6 All manufacturing, fabrication and erection work under the scope of Contractor, prior to the approval of the drawings shall be at the Contractor’s risk. The contractor may incorporate any changes in the design, which are necessary to conform to the provisions and intent of the contract, and such changes will again be subject to approval by the Owner.

1.3.7 The approval of the documents and drawings by the Owner shall mean that the Owner is satisfied that:

(a) The Contractor has completed the part of the Works covered by the subject document (i.e. confirmation of progress of work).

(b) The Works appear to comply with requirements of Specifications.

In no case the approval by the Owner of any document does imply compliance with neither all technical requirements nor the absence of errors in such documents.

If errors are discovered any time during the validity of the contract, then the Contractor shall be responsible for consequences.

1.3.8 All drawings shall be prepared using AutoCAD software version 2000 or later only. Drawings, which are not compatible to AutoCAD software version 2000 or later, shall not be accepted. After final approval all the drawings (structural drawings, BOMs, shop sketches and tower accessories drawings) shall be submitted to the Owner in CDs.

A copy of each drawing reviewed will be returned to the Contractor as stipulated herein.

1.3.9 Copies of drawings returned to the Contractor will be in the form of a print with the Owner’s marking, or a print made from a microfilm of the marked up drawing.

1.3.10 The following is the general list of the documents and drawings that are to be approved by the Owner.

a) Work Schedule (Master Network) Plan.

b) Detailed survey report and profile drawings showing ground clearance and tower locations (as applicable).
c) Tower schedule and foundation classification for individual tower locations.

d) Tower structural drawing and bill of materials.

e) Soil Investigation report.

f) Foundation working drawings/excavation Plan.

g) Tower footing earthing drawing.

h) Stub and stub-setting template drawings.

i) Stringing procedure

j) Tower accessories drawings like danger plate, name plate etc.

k) Quality plans for fabrication and site activities including Quality System.

l) Sub-vendors approval, etc.

m) Line material drawings.

n) Type test report for line materials.

1.3.11 All rights of the design/drawing for all types of towers and foundations shall be strictly reserved with the Owner only and any designs/drawings/data sheets submitted by the contractor from time to time shall become the property of the Owner. Under no circumstances, the Contractor shall be allowed to user/offer above designs/drawings/data sheets to any other authority without prior written permission of the Owner. Any deviation to above is not acceptable and may be a cause for rejection of the bid.

1.4 Design Improvements

1.4.1 The Owner or the Contractor may propose changes in the specification and if the parties agree upon any such changes and the cost implication, the specification shall be modified accordingly.

1.5 Design Co-ordination

Wherever, the design is in the scope of Contractor, the Contractor shall be responsible for the selection and design of appropriate material/item to provide the best coordinated performance of the entire system. The basic design requirements are detailed out in this Specification. The design of various components, sub-assemblies and assemblies shall be so done that it facilitates easy field assembly and maintenance.

1.6 Design Review Meeting

The contractor will be called upon to attend design review meetings with the Owner, and the consultants of the Owner during the period of Contract.
contractor shall attend such meetings at his own cost at the Corporate Office of the Owner or at mutually agreed venue as and when required. Such review meeting will be held generally four times in a year.

1.7 Quality Assurance, Inspection & Testing

1.7.1 Quality Assurance

To ensure that the supply and services under the scope of this Contract whether manufactured or performed within the Contractor’s works or at his Sub-Contractor’s premises or at site or at any other place of work are in accordance with the specifications. The Contractor shall adopt suitable quality assurance programme to control such activities at all points necessary. Such programme shall be broadly outlined by the Contractor and shall be finalised after discussions before the award of Contract. The detailed programme shall be submitted by the contractor after the award of contract and finally accepted by the Owner after discussion. A quality assurance programme of the Contractor shall generally cover but not limited to the following:

(a) His organisation structure for the management and implementation of the proposed quality assurance programme.

(b) Documentation control System.

(c) Qualification data for Contractor’s key personnel.

(d) The procedure for purchase of materials, parts components and selection of sub-Contractor’s services including vendor analysis, source inspection, incoming raw material inspection, verification of material purchases etc.

(e) System for shop manufacturing including process controls and fabrication and assembly controls.

(f) Control of non-conforming items and system for corrective action.

(g) Control of calibration and testing of measuring and testing equipments.

(h) Inspection and test procedure for manufacture.

(i) System for indication and appraisal of inspection status.

(j) System for quality audits.

(k) System for authorising release of manufactured product to the Owner.

(l) System for maintenance of records.

(m) System for handling storage and delivery and

(n) A quality plan detailing out the specific quality control procedure adopted for controlling the quality characteristics relevant to critical and important items of supply.

The Quality plan shall be mutually discussed and approved by the Owner after incorporating necessary corrections by the Contractor as may be required.
1.7.1.1 **Quality Assurance Documents**

The Contractor shall be required to submit all the Quality Assurance Documents as stipulated in the Quality Plan at the time of Owner's inspection of equipment/material.

1.7.1.2 The Owner or his duly authorised representatives reserves the right to carry out Quality Audit and quality surveillance of the systems and procedures of the Contractor's/his vendor's Quality Management and Control Activities.

1.7.2 **Owner's Supervision**

1.7.2.1 To eliminate delays and avoid disputes and litigation to the Contract, all matters and questions shall be resolved in accordance with the provisions of this document.

1.7.2.2 The manufacturing of the product shall be carried out in accordance with the specifications. The scope of the duties of the Owner, pursuant to the contract, will include but not be limited to the following.

a) Interpretation of all the terms and conditions of these Documents and Specifications.

b) Review and interpretation of all the Contractor's drawings, engineering data etc.

c) Witness or authorise his representative to witness tests at the manufacturer's works or at site, or at any place where work is performed under the contract.

d) Inspect, accept or reject any equipment, material and work under the Contract, in accordance with the Specifications.

e) Issue certificate of acceptance and/or progressive payment and final payment certificate.

f) Review and suggest modification and improvement in completion schedules from time to time, and

g) Supervise the Quality Assurance Programme implementation at all stages of the works.

1.8 **Inspection and Tests**

1.8.1 **Inspection**

1.8.1.1 The Owner, his duly authorized representative and/or outside inspection agency acting on behalf of the Owner shall have, at all reasonable times, access to the premises and/or works of the contractor and/or their subcontractor(s)/sub-vendors and shall have the right, at all reasonable times, to inspect and examine the materials and workmanship of the product during its manufacture.

1.8.1.2 The Contractor shall give the Owner's Inspector fifteen (15) days (in case of domestic testing and thirty (30) days (in case of foreign testing), as the case
may be, written notice of any material being ready for testing. In case of turnkey contract, the turnkey contractor shall give the notice for inspection and shall associate in the inspection with Employee's inspector. All such inspections shall be to the Contractor's account except for the expenses of the Owner's inspector. The Owner's inspector, unless witnessing of the tests is virtually waived, will attend such tests within fifteen (15) days (in case of domestic testing) and thirty (30) days in (in case of foreign testing) of the date of which the equipment is notified as being ready for test/inspection or on a mutually agreed date, failing which the Contractor may proceed with the test in accordance with the technical specification after informing the Owner in writing and he shall forthwith forward to the inspector duly certified copies of test reports / certificates in triplicate.

1.8.1.3 The Owner's Inspector shall, within fifteen (15) days from the date of inspection, give notice in writing to the Contractor, of any objection to any drawings and all or any equipment and workmanship which in his opinion is not in accordance with the Contract. The Contractor shall give due consideration to such objections and shall make the modifications that may be necessary to meet the said objections.

1.8.1.4 When the factory tests have been completed at the Contractor's or Sub-Contractor's works, the Owner's inspector shall issue a certificate to this effect within fifteen (15) days after completion of tests but if the tests are not witnessed by the Owner's inspector, the certificate shall be issued within fifteen (15) days of receipt of the Contractor's Test Certificate by the Owner's Inspector. The completion of these tests or the issue of the certificate shall not bind the Owner to accept the equipment should it, on further tests after erection, be found not to comply with the Contract.

1.8.1.5 In all cases where the Contract provides for test whether at the premises or works of, the Contractor or of any Sub-Contractor, the Contractor except where otherwise specified shall provide free of charge such item as labour, materials, electricity, fuel, water, stores, apparatus and instruments as may be reasonably demanded by the Owner's inspector or his authorised representative to carry out effectively such tests of the equipment in accordance with the Contract and shall give facilities to the Owner's Inspector or to his authorised representative to accomplish testing.

1.8.1.6 The inspection by Owner and issue of Inspection Certificate thereon shall in no way limit the liabilities and responsibilities of the Contractor in respect of the agreed Quality Assurance Programme forming a part of the Contract.

1.8.1.7 a) The Contractor shall keep the Owner informed in advance about the time of starting and of the progress of manufacture and fabrication of various tower parts at various stages, so that arrangements could be made for inspection.

b) The acceptance of any part of items shall in no way relieve the Contractor of any part of his responsibility for meeting all the requirements of the Specification.
1.8.1.8 The Owner or his representative shall have free access at all reasonable times to those parts of the Contractor's works which are concerned with the fabrication of the *Owner's material for satisfying himself that the fabrication is being done in accordance with the provisions of the Specification.

1.8.1.9 Unless specified otherwise, inspection shall be made at the place of manufacture prior to dispatch and shall be concluded so as not to interfere unnecessarily with the operation of the work.

1.8.1.10 Should any member of the structure be found not to comply with the supplied design, it shall be liable to rejection. No member once rejected shall be resubmitted for inspection, except in cases where the Owner or his authorised representative considers that the defects can be rectified.

1.8.1.11 Defect which may appear during fabrication shall be made good with the consent of, and according to the procedure proposed by the Contractor and approved by the Owner.

1.8.1.12 All gauges and templates necessary to satisfy the Owner shall be supplied by the contractor.

1.8.1.13 The specified grade and quality of steel shall be used by the Contractor. To ascertain the quality of steel used, the inspector may at his discretion get the material tested at an approved laboratory.

1.8.2 Tests

1.8.2.1 The type, acceptance and routine tests and tests during manufacture shall be carried-out on the material and shall mean as follows:

1.8.2.2 Type Tests shall mean those tests which are to be carried out to prove the process of manufacture and general conformity of the material to this Specification. These tests shall be carried out on samples prior to commencement of commercial production against the order. The Bidder shall indicate his schedule for carrying out these tests.

1.8.2.3 Acceptance Tests shall mean those tests which are to be carried out on samples taken from each lot offered for pre-dispatch inspection, for the purposes of acceptance of that lot.

1.8.2.4 Routine Tests shall mean those tests, which are to be carried out on the material to check requirements which are likely to vary during production.

1.8.2.5 Tests During Manufacture shall mean those tests, which are to be carried out during the process of manufacture and end inspection by the Contractor to ensure the desired quality of the end product to be supplied by him.

1.8.2.6 The norms and procedure of sampling for these tests will be as per the Quality Assurance Programme to be mutually agreed to by the Contractor and the Owner.

1.8.2.7 The standards and norms to which these tests will be carried out are listed against them. Where a particular test is a specific requirement of this
Specification, the norms and procedure of the test shall be as specified in Annexure-A or as mutually agreed to between the Contractor and the Owner in the Quality Assurance Programme.

1.8.2.8 For all type and acceptance tests, the acceptance values shall be the values specified in this Specification.

1.9 Standard Technical Particulars

1.9.1 The Standard Technical Particulars of GS Earthwire, Hardware Fittings and accessories for Conductor & Earthwire are given in the relevant sections of the Technical Specification and the bidder is required to comply with the same.

1.10 Packing

1.10.1 All the materials shall be suitably protected, coated, covered or boxed and crated to prevent damage or deterioration during transit, handling and storage at Site till the time of erection. The Contractor shall be responsible for any loss or damage during transportation, handling and storage due to improper packing.

1.10.2 The Contractor shall include and provide for securely protecting and packing the materials so as to avoid loss or damage during transport by air, sea, rail and road.

1.10.3 All packing shall allow for easy removal and checking at site. Wherever necessary, proper arrangement for attaching slings for lifting shall be provided. All packages shall be clearly marked for with signs showing ‘up’ and ‘down’ on the sides of boxes, and handling and unpacking instructions as considered necessary. Special precaution shall be taken to prevent rusting of steel and iron parts during transit by sea.

1.10.4 The cases containing easily damageable material shall be very carefully packed and marked with appropriate caution symbols, i.e. fragile, handle with care, use no hook etc. wherever applicable.

1.10.5 Each package shall be legibly marked by the Contractor at his expenses showing the details such as description and quantity of contents, the name of the consignee and address, the gross and net weights of the package, the name of the Contractor etc.

1.10.6 Angle section shall be wire bundled.

1.10.7 Cleat angles, gusset plates, brackets, fillet plate, hanger and similar loose pieces shall be tested and bolted together in multiples or securely wired through holes.

1.10.8 Bolts, nuts washers and other attachments shall be packed in double gunny bags accurately tagged in accordance with the contents.

1.10.9 The packing shall be properly done to avoid losses & damages during transit. Each bundle or package shall be appropriately marked.
2.0 **Owner’s Environment and Social Policy and its Implementation**

2.1 Development and growth of mankind through Industrialization and unwarranted use of natural resources has inflicted considerable impact on Environment and Society. As a result, Environmental and Social issues have emerged as the focal point of global debate.

Owner’s activities by their inherent nature and flexibility have negligible impacts on environmental and social attributes. In order to address these issues and to match the rising expectations of a cleaner, safer and healthier environment, Owner has evolved its Environmental and Social Policy and Procedures (ESPP). The key principles of Owner’s Environmental and Social Policy are:

i) Avoidance of environmentally and socially sensitive areas while planning project activities.

ii) Minimisation of impacts when project activities occur in environmentally and socially sensitive areas.

iii) Mitigation of any unavoidable adverse impacts arising out of its projects.

2.2 Basic issues to be kept in mind while carrying out construction activities are to

i) Avoid socially sensitive areas with regard to human habitations and areas of cultural significance.

ii) Secure the interest of people affected by Owner’s projects.

iii) Involve local people affected by transmission line projects as per requirement and suitability.

iv) Consult affected people in decisions having implication to them if considered necessary.

v) Apply, efficient and safe technology/practices.

vi) Keep abreast of all potential dangers to people’s health, occupational safety and safety of environment and the respective mitigatory measures.

vii) Establish preventive mechanisms to guarantee safety.

viii) Mitigation measures in case of accidents.

ix) Avoid unwarranted cutting of trees in forest area.

2.3 While constructing the lines through forest stretches the contractor will provide alternate fuel to its employee e.g. working labours/supervisors etc. in order to avoid cutting of forest woods.

2.4 Contractor will ensure safety to the wild life, during working/camping near to the National park.
2.5 Contractor during construction of lines in agricultural fields will ensure minimum damages to the crops, trees, bunds, irrigation etc. If the same is un-avoidable, the decision of Engineer-in-charge shall be final.

2.6 The waste/excess material/debris should be removed from the construction site including agricultural field, forest stretches, river etc. immediately after construction work.

2.7 The Contractor will ensure least disturbance to the hill slope and natural drainage so as to avoid soil erosion. Natural drainage in plain area if disturbed is to be trained to the satisfaction of Engineer-in-charge.

2.8 As far as possible existing path/kutchha road/approach shall be used for the construction.

2.9 The Contractor will ensure supply of stone chips/sand from authorised/approved quarry areas.

2.10 Proper documentation of above, if any.

2.11 The Environment & Social Policy and Procedures (ESPP) evolved by POWERGRID is available at the POWERGRID’s website, powergridindia.com, which shall be referred by the Bidder for further information.
## SECTION – III

### CONTENTS

<table>
<thead>
<tr>
<th>Clause No.</th>
<th>Description</th>
<th>Page No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0</td>
<td>General information &amp; Scope Of Work</td>
<td>1</td>
</tr>
<tr>
<td>2.0</td>
<td>Route Alignment</td>
<td>2</td>
</tr>
<tr>
<td>3.0</td>
<td>Detailed Survey</td>
<td>4</td>
</tr>
<tr>
<td>4.0</td>
<td>Geotechnical Investigations</td>
<td>11</td>
</tr>
<tr>
<td>5.0</td>
<td>Statutory Regulations and Standards</td>
<td>31</td>
</tr>
<tr>
<td>6.0</td>
<td>Field Quality Plan</td>
<td>32</td>
</tr>
<tr>
<td>7.0</td>
<td>Completion Period</td>
<td>32</td>
</tr>
</tbody>
</table>
1. General Information & Scope Of Work

1.1 The technical specifications covers detailed survey including route alignment, profiling, tower spotting, optimization of locations, check survey, contouring, and soil investigation for the transmission lines / part of the transmission lines covered under this specification as included in the BPS.

1.1.1 The scope of work inter-alia shall include the following:-

a. Detailed Survey using GPS, Total Work stations, long range scanners & Digital theodolites of reasonable accuracies or alternatively using ALTM (Airborne Laser Terrain Modeling) techniques, inter-alia including:
   i. Digitised profiling along the selected route along with plan details.
   ii. Computer aided tower spotting & optimization
   iii. Soil resistivity measurement along the route

b. Check survey including digitised contouring at undulated / hilly tower locations.

c. Soil Investigation

d. Preparation of Survey reports including estimation of Bill of Quantities, identification and explanation of route constraints (like Forest, Animal/Bird sanctuary, reserve coal belt areas, oil pipe line/underground inflammable pipe lines etc.), infrastructure details available enroute etc.

e. Wherever, the scope of work is only for part of the line for route changes if any necessitated during execution on account of site constraints and done at the instance of Owner and where survey data for balance stretches have been provided by the Owner, the Contractor may use the satellite imageries/digitized maps already available with the Owner to the extent applicable.

1.2 The Provisional quantities for the scope of work are indicated in relevant Price Schedules of BPS. The final quantities for route alignment & detailed survey (quantities in "kms" unit) shall be the route length along the approved route alignment. For contouring at undulated/hilly tower locations and soil investigations (quantities in “Locs.” unit), the actual quantities to be executed shall be decided by Site Engineer-in-charge during execution stage and the final quantities shall be as approved by Site Engineer-in-charge. The route alignment, detailed survey, including profiling & tower spotting, contouring, soil investigation etc shall be carried out by the Contractor as per the technical specifications stipulated herein.

1.3 The Contractor must note that the Owner shall not be responsible for loss or damage to properties, trees etc. due to contractor’s work during survey. The
Contractor shall indemnify the Owner for any loss or damage to properties, trees etc. during the survey work.

1.4 The Contractor should note that Owner will not furnish the topographical maps prepared by survey of India but will make available any assistance that may be required in obtaining the topographical maps.

1.5 The bidder shall give along with their bid clause by clause commentary indicating their confirmation / comments/ observation in respect of all clauses of technical specification.

1.6 The work shall be carried out by the contractor using modern surveying techniques. The bidder shall indicate in his offer, the detailed description of the procedure to be deployed. The details of the equipment & facilities including soft wares for image processing, computer aided tower spotting etc. available with the bidder or his associates shall also be furnished with the bid.

1.7 The Contractor shall also engage services of a reputed geo-technical consultant or experts from independent educational/research institutions for examining stability aspects of the selected transmission line route/locations in hilly terrain wherever required.

1.8 After carrying out the detailed survey and soil investigations, the contractor shall estimate complete BOQ of the transmission lines and submit the same to the Owner.

2. Route Alignment

2.1 Wherever the route Alignment has already been carried out for the line using satellite imageries of NRSA (PAN & LISS-III merged product) and Survey of India topographical maps (scale 1:50000), any changes necessitated during execution stage in the route alignment, same shall be carried out by the contractor using satellite imageries / topographical maps.

2.2 Requirement of Transmission Line Routing (for changes if any necessitated on account of site constrains etc.):

2.2.1. The Re-alignment, if any required, of the transmission line shall be most economical from the point of view of construction and maintenance. The contractor shall identify & examine alternative route alignments and suggest to the Owner the optimal route alignment.

2.2.2. Routing/Re-routing of transmission line through protected/reserved forest area should be avoided. In case it is not possible to avoid the forests or areas having large trees completely and then keeping in view of the overall economy, the route should be aligned in such a way that cutting of trees is minimum.

2.2.3. The route should have minimum crossings of Major river, Railway lines, National/State highways, overhead EHV power line and communication lines.

2.2.4. The number of angle points shall be kept to minimum.

2.2.5. The distance between the terminal points specified shall be kept shortest possible, consistent with the terrain that is encountered.
2.2.6. Marshy and low lying areas, river beds and earth slip zones shall be avoided to minimize risk to the foundations.

2.2.7. It would be preferable to utilize level ground for the alignment.

2.2.8. Crossing of power lines shall be minimum. Alignment will be kept at a minimum distance of 300 m from power lines to avoid induction problems on the lower voltage lines.

2.2.9. Crossing of communication line shall be minimized and it shall be preferably at right angle. Proximity and parallelism with telecom lines shall be eliminated to avoid danger of induction to them.

2.2.10. Areas subjected to flooding such as naloh shall be avoided.

2.2.11. Restricted areas such as civil and military airfield shall be avoided. Care shall also be taken to avoid aircraft landing approaches.

2.2.12. All alignment should be easily accessible both in dry and rainy seasons to enable maintenance throughout the year.

2.2.13. Certain areas such as quarry sites, tea, tobacco and saffron fields and rich plantations, gardens & nurseries which will present the Owner problems in acquisition of right of way and way leave clearance during construction and maintenance should be avoided.

2.2.14. Angle points should be selected such that shifting of the point within 100 m radius is possible at the time of construction of the line.

2.2.15. The line routing should avoid large habitations, densely populated areas, Forest, Animal/Bird sanctuary, reserve coal belt areas, oil pipe line/underground inflammable pipe lines etc. to the extent possible.

2.2.16. The areas requiring special foundations and those prone to flooding should be avoided.

2.3 For examination of the alternatives & identification of the most appropriate route, besides making use of information/data/details available/extracted through Survey of India Topographical maps and computer-aided processing of NRSA’s satellite imagery, the contractor shall also carryout reconnaissance/preliminary survey as may be required for verification & collection of additional information/data/details.

2.4 The contractor shall submit his preliminary observations & suggestions along with various information/data/details collected and also processed satellite imagery data, scanned topographical map data marked with the alternative routes etc. The final evaluation of the alternative routes shall be conducted by the contractor in consultation with Owner’s representatives and optimal route alignment shall be proposed by the contractor. Digital terrain modeling using contour data from topographical maps as well as processed satellite data shall be done by the contractor for the selected route. A fly through perspective using suitable software(s) shall be developed for further refinement of the selected route, if required. Site visit and field verification shall be conducted by the contractor jointly with the Owner’s representative for the proposed route alignment.
2.5 Final digitized route alignment drawing with latest topographical and other details/features including all rivers, railway lines, canals, roads etc. up to 8 kms on both sides of selected route alignment shall be submitted by the contractor for Owner’s approval along with report containing other information/details as mentioned above.

2.6 Changes in the route alignment, if any, during detail survey, shall be incorporated in the final digitized route alignment drawings.

3. **Detailed Survey**

3.1 The detailed survey shall be carried out using GPS, Total stations, digital theodolites etc. along the approved route alignment. As an alternative, the contractor may also use ALTM (Airborne Laser Terrain Modeling) techniques of equal or better accuracy for the detailed survey.

3.2 Soil resistivity, along the route alignment shall be measured in dry weather by four electrode method keeping inter-electrode spacing of 50 mtrs. For calculating soil resistivity formula \(2\pi ar\) (Where \(a=50\ m\) and \(r=\) megger reading in ohms) shall be adopted. Measurement shall be made at every 2 to 3 km along the length of the route. In case soil characteristics changes within 2 to 3 km, values shall have to be measured at intermediate locations also. Megger reading and soil characteristics should also be indicated in the soil resistivity results.

3.3 **Route Marking**

3.3.1. The route of the transmission line shall be recorded using GPS of positional accuracy less than 3m.

3.3.2. The co-ordinates of all the angle points as well as other important crossings, landmarks etc. shall be recorded using GPS for easy relocating.

   At the starting point of the commencement of route survey the co-ordinates shall be recorded. A punch mark on the top section of the angle iron shall be made to indicate location of the survey instrument The co-ordinates of the location of the survey instrument shall also be recorded. Further, the co-ordinates at prominent position at intervals of not more than 750 meter along the transmission line to be surveyed up to the next angle point shall also be recorded. Teak wood peg 50 x 50 x 650mm size shall also be driven at prominent position at intervals of not more than 750 metre along the transmission line to be surveyed up to the next angle point. Wire nails of 100mm length should be fixed on the top of these pegs to show the location of instrument. The pegs shall be driven firmly into the ground to project 100 mm only above ground level. Wherever the line alignment crosses the EHT line, Railway line, P&T line or roads, the contractor shall record co-ordinates on the points of crossing. Wherever line route alignment passes over permanent land marks such as rock, boulders, culverts etc. suitable white paint marks with directional and TPGL markings shall be made and co-ordinates recorded. At angle position stone/concrete pillars of 150x150x1000mm in size with TPGL marked on them shall be embedded into the ground for easy identification.
3.4 Profiling

3.4.1. The complete profiling along the route shall be carried out using modern surveying equipments viz. total stations, GPS, digital theodolite, long range scanners etc. Reference levels at every 20 metres along the route are to be recorded. R/Ls at other undulations along the route as well as in the route plan and other enroute details viz. crossings, building & structures, trees & other infrastructure etc shall also be recorded. Areas along the route, which in the view of the contractor, are not suitable for tower spotting, shall also be marked.

3.4.2. The complete profiling details shall be digitized and the data shall be prepared & stored in the format compatible to computer-aided tower spotting software.

3.4.3. A printed/plotted output of the digitized profiling shall be submitted by the contractor to Owner’s site-in-charge for review before taking up computer-aided tower spotting.

3.5 Optimisation of Tower Location / Tower Spotting

3.5.1. Optimisation of tower locations shall be done by the contractor using computer-aided tower spotting software - PLSCADD and shall furnish sample calculations and manual tower spotting drawings for some typical sections. PLSCADD software is already available at Regional office of the Owner and limited access can be made available to the contractor for the same.

3.5.2. The sag-tension characteristics of the conductor as well as tower spotting data shall be furnished by the Owner to the contractor during execution stage. Sag template curves, if any required for tower spotting, shall be prepared by the contractor.

3.5.3. General description of towers is indicated in Section – I of this specification for information of the Bidders.

3.5.4. Tower Spotting

While profiling & spotting the towers, the following shall be borne in mind:

a) Span

The number of consecutive spans between the section points shall not exceed 15 spans or 5 Km in plain terrain and 10 spans or 3km in hilly terrain. A section point shall comprise of tension point with B/DB/QB type or C/DC/QC type or D/DD/QD type towers as applicable.

b) Extension/Truncation

An individual span shall be as near to the normal design span as possible. In case an individual span becomes too short with normal supports on account of undulations in ground profile, one or both the supports of the span may be extended by inserting standard body/leg extension. In case of locations where the ground clearance is available, truncated towers may be spotted. The provisions kept in the design of towers w.r.t. body/leg extns, truncations shall be intimated to the contractor by the Owner during execution stage.
c) Loading

There shall not be any upward force on suspension towers under normal working conditions and the suspension towers shall support at least the minimum weight span as provided in the designs. In case uplift is unavoidable, it shall be examined if the same can be overcome by adding standard body extensions to the towers failing which tension towers designed for the purpose shall be deployed at such positions.

d) Road Crossing

At all important road crossings, the tower shall be fitted with tension insulator strings but the ground clearance at the roads under maximum temperature and in still air shall be such that even with conductor broken in adjacent span, ground clearance of the conductor from the road surfaces will not be less than specified. At all national highways crossing span will not be more than 250 meters.

e) Railway Crossings

All the railway crossings coming-enroute the transmission line shall be identified by the Contractor. At the time of detailed survey, the railway crossings shall be finalised as per the regulation laid down by the Railway Authorities. The following are the important features of the prevailing regulations (revised in 1987)

i) The crossings shall be supported on D/DD/QD type tower on either side depending on the merits of each case.

ii) The crossing shall normally be at right angle to the railway track.

iii) The minimum distance of the crossing tower shall be at least equal to the height of the tower plus 6 meters away measured from the centre of the nearest railway track.

iv) No crossing shall be located over a booster transformer, traction switching station, traction sub-station or a track cabin location in an electrified area.

v) Minimum ground clearance above rail level of the lowest portion of any conductor under condition of maximum sag shall be maintained at 17.90m for 400KV & 220KV Transmission lines.

vi) The crossing span will be limited to 300 meters.

f) River Crossings

In case of major river crossing, towers shall be of suspension type along with anchor towers of D/DD/QD type tower on either side of the main river crossing. Alternately on the basis of economics and / or site/ execution constraints crossing of rivers using extended angle towers also shall be considered. For navigable rivers, clearance required by navigation authority shall be provided. For non navigable river, clearance shall be reckoned with respect to highest flood level (HFL).

g) Power line Crossings

Where the line is to cross over another line of the same voltage or lower voltage, A/DA/QA type tower with suitable extensions shall be used. Provisions to prevent
the possibility of its coming into contact with other overhead lines shall be made in accordance with the Indian Electricity Rules, 1956 as amended up-to-date & Electricity act 2003. In order to reduce the height of the crossing towers, it may be advantageous to remove the ground-wire of the line to be crossed (if this is possible, and permitted by the Owner of the line to be crossed).

Minimum clearance in metres between lines when crossing each other:

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Nominal System Voltage</th>
<th>110-132KV</th>
<th>220KV</th>
<th>400KV</th>
<th>765KV</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>220KV</td>
<td>4.58</td>
<td>4.58</td>
<td>5.49</td>
<td>7.94</td>
</tr>
<tr>
<td>2.</td>
<td>400KV</td>
<td>5.49</td>
<td>5.49</td>
<td>5.49</td>
<td>7.94</td>
</tr>
</tbody>
</table>

For power line crossings of voltage level of 132 kV and above, angle towers shall be provided adjacent to QA/DA/A type tower on either side of the Power line crossing which can be used in temporary dead end condition with proper guying to facilitate stringing of the power line crossing sections separately on obtaining line shutdowns.

h) Telecommunication Line Crossings

The angle of crossing shall be as near to 90 degree possible. However, deviation to the extent of 30 degree may be permitted under exceptionally difficult situations.

When the angle of crossing has to be below 60 degree, the matter will be referred to the authority in charge of the telecommunication System. On a request from the Contractor, the permission of the telecommunication authority may be obtained by the Owner.

Also, in the crossing span, power line support will be as near the telecommunication line as possible, to obtain increased vertical clearance between the wires.

i) Details Enroute

All topographical details, permanent features, such as trees, building etc. 23m for 400 KV on either side of the alignment shall be detailed on the profile plan.

3.6 Clearance from Ground, Building, Trees etc.

Clearance from ground, buildings, trees and telephone lines shall be provided in conformity with the Indian Electricity Rules, 1956 as amended upto date & as per Electricity act 2003. Tree cutting is in the contractor scope.

3.6.1. Contractor has to carry out tree/bush cutting, removal etc. The Contractor shall count, mark and put proper numbers with suitable quality of paint at his own cost on all the trees that are to be cut by the Contractor at the time of actual execution of the work as detailed below. Contractor may please note that Owner shall not
pay any compensation for any tree cutting and/or loss or damage to the properties or for tree cutting.

3.6.2. To evaluate and tabulate the trees and bushes coming within 23m for 400kV lines, on either side of the central line alignment the trees will be numbered and marked with quality paint serially from angle point 1 (I) onwards and the corresponding number will be painted on the stem of trees at a height of 1 meter from ground level. The trees list should contain the following:

a) Girth (circumstances) measured at a height of 1 meter from ground level.

b) Approximate height of the tree with an accuracy of +2 meters.

c) Name of the type of the species/tree.

d) The bushy and under growth encountered within the 46m for 400 KV line should also be evaluated with its type, height, girth and area in square meters, clearly indicating the growth in the tree/bush statement.

3.6.3. The contractor shall also intimate the Owner, his assessment about the likely amount of tree & crop compensation etc. required to be paid by the contractor during execution stage. This assessment shall be done considering prevailing practices/guidelines, local regulations and other enquiries from local authorities. These will be arranged by the contractor at their cost.

3.6.4. The Contractor shall also identify the forest/non forest areas involved duly authenticated by concerned authorities.

a) A statement of forest areas with survey/compartment Nos. (all type of forest RF/PF/Acquired forest/Revenue forest/Private forest/Forest as per dictionary meaning of forest etc.)

b) A statement of non-forest areas with survey/compartment nos.

c) Tree cutting details (Girth wise & specie wise)

d) Marking of forest areas with category on topo sheets 1:2,50,000 showing complete line route, boundaries of various forest divisions and their areas involved.

e) Village forest maps of affected line and affected forest area and marking of the same.

f) Forest division map showing line and affected forest area.

3.6.5 The Contractor shall finalize the forest clearance proposal on the prescribed format duly completed in all respects for submission by the Owner to the Forest Department.

3.7 Preliminary Schedule

The profile sheets showing the locations of the towers together with preliminary schedules of quantities indicating tower types, wind & weight spans, angle of deviation, crossing & other details etc. shall be submitted by the contractor for review & approval by Owner’s site-in-charge.
3.8 Check Survey of Tower Locations

3.8.1. The check survey shall be conducted to locate tower locations on ground conforming to the approved profile and tower schedule.

3.8.2. The co-ordinates of all the tower locations shall also be recorded using GPS of positional accuracy less than 3m for easy relocating. The position of all tower locations shall be marked in the final digitized route alignment drawing with relative distances from any permanent bench mark area.

3.8.3. The contractor shall also collect required data at each tower location in respect of soil strata, ground water level, history of water table in adjacent areas/surface water, distance from permanent bench mark (these details to be furnished in a tabulated form) and classify the suitable type of foundation at each tower location based on the data collected at each location and detailed soil investigations carried out at selected locations etc.

3.9 Contouring at hilly/undulated locations

3.9.1. The levels up or down of each pit centre with respect to centre of tower location shall be recorded at intervals of 2m using total stations/GPS/digital theodolite and digitized contour plans shall be made. Based on the digitized elevation plans, the quantities of benching & protection work vis-à-vis possible unequal leg extensions shall be optimized using suitable computer-aided techniques/softwares. Required tower and foundation details, cost data for comparative evaluation for benching & protection work vis-à-vis unequal leg extensions shall be provided by the Owner to the Contractor during execution stage.

3.10 The changes desired by the Owner in the preliminary tower schedule or as may be required based on detailed survey of tower locations & contouring by the contractor, shall be carried out by the contractor and the final tower schedule shall be submitted for approval of Owner. The tower schedule shall show position of all type of towers, span length, type of foundation for each tower, benching & revetment requirement, unequal leg extensions, deviation at all angles, crossings & other details etc.

3.11 Survey Methodology & Precision

3.11.1. All elevations shall be referenced to benchmarks established by the survey of India. Survey operations shall begin and end at benchmarks approved by the Owner.

3.11.2. During the leveling of the profile, check surveys will be effected at intervals not exceeding 50kms. with benchmarks of known elevations. The difference in elevations as surveyed by the contractor and as declared by Survey of India for these benchmarks shall not exceed the precision required for 3rd order surveys $e \leq 24k$ where $k$ is the distance between benchmarks in km and $e$ is the difference between elevations in mm.

3.11.3. In the absence of suitable benchmarks the leveling shall be done by two independent leveling parties working in opposite directions along the same line. The difference in elevations between the two surveys shall not exceed the precision required for 3rd order surveys as stated above.
3.11.4. All important objects and features along the transmission line centerline (railways, highways, roads, canals, rivers, transmission lines, distribution lines, telephone lines etc.) shall be surveyed and located with a positional accuracy of 1:2000 between points of known horizontal position.

3.12 Survey Report

3.12.1. Complete BOQ of the transmission lines shall be furnished in the survey report.

3.12.2. Each angle point locations shall be shown with detailed sketches showing existing close by permanent land marks such as specific tree(s), cattle shed, homes, tube wells, temples, electric pole/tower, telephone pole, canal, roads, railway lines etc. The relative distance of land marks from the angle points and their bearings shall be indicated in the sketch. These details shall be included in the survey report.

3.12.3. Information w.r.t infrastructure details available enroute, identification and explanation of route constraints, etc shall also be furnished in the Survey report and shall inter-alia include the following:

3.12.3.1. Information regarding infrastructural facilities available along the final route alignment like access to roads, railway stations, construction material sources (like quarry points for stone, sand and availability of construction water), labour, existing transport facilities, fuel availability etc. shall be furnished in the survey report.

3.12.3.2. All observations which the Contractor thinks would be useful to the construction of the transmission lines mentioned under scope of work are to be reported.

3.12.3.3. Suggestions regarding the number of convenient zones (line segments / portions) in which the entire alignment can be divided keeping in view the convenience of corporation are to be given.

3.12.3.4. Suggestions regarding location for setting up stores during line construction in consultation with Owner's representative shall also be provided by the contractor.

3.12.3.5. Working months available during various seasons along the final route alignment, with period, time of sowing & harvesting of different type of crops and the importance attached to the crops particularly in the context of way leave problems and compensation payable shall be stated by the Contractor.

3.12.3.6. Availability of labour of various categories and contractors of civil works shall also be reported.

3.12.3.7. Some portions of the line may require clearance from various authorities. The Contractor shall indicate the portion of the line so affected, the nature of clearance required and the name of concerned organizations such as local bodies, municipalities, P&T (name of circle), Inland navigation, Irrigation Department, Electricity Boards and Zonal railways, Divisional Forest Authorities etc. Contractor has to arrange for all the approvals.

3.12.4. All the requisite data for processing the case for statutory clearances such as PTCC, Forest and Railway shall be provided along with the report.

3.12.5. The contractor shall also collect & report (as per Formats enclosed at B) details pertaining to pollution levels envisaged along the transmission line.
3.12.6. Six copies of survey reports shall be furnished by the contractor to the Owner.

4. Geotechnical Investigations

4.1 General

4.1.1. Owner requires that a detailed Geotechnical investigation be carried out at various tower locations to provide the designer with sufficiently accurate information, both general and specific, about the substrata profile and relevant soil and rock parameters at site on the basis of which the foundation of transmission line towers can be classified and designed rationally.

4.1.2. These specifications provide general guidelines for geotechnical investigation of normal soils. Cases of marshy locations and locations affected by salt water or saltpeter shall be treated as special locations and the corresponding description in these specifications shall apply. Any other information required for such locations shall be obtained by Contractor and furnished to Owner.

4.2 Scope

4.2.1 The scope of work includes detail soil investigations and furnishing bore log data at various tower locations. The provisional quantities have been indicated in Bill Of Quantities. However, during actual execution of work, the quantities shall be decided by the Engineer-in-Charge, depending upon the soil strata and terrain. Based on the bore log data / soil parameter /soil investigation results, the Contractor shall recommend the type of foundations suitable for each locations and the same shall be got approved by the Owner. For other locations, trial pit is to be done in every locations for foundation classification upto foundation depth. No separate payment for trial pit shall be done.

4.2.2 These specifications cover the technical requirements for a detailed Geotechnical investigation and submission of a detailed Geotechnical Report. The work shall include mobilization of all necessary tools and equipment, provision of necessary engineering supervision and technical personnel, skilled and unskilled labour, etc. as required to carry out the entire field investigation as well as laboratory tests, analysis and interpretation of data collected and preparation of the Geotechnical Report. Contractor shall also collect data regarding variation of subsoil water table along the proposed line route. The aforementioned work shall be supervised by a graduate in Civil Engineering having at least 5 years of site experience in geotechnical investigation work.

4.2.3 Contractor shall make his own arrangements to establish the co-ordinate system required to position boreholes, tests pits and other field test locations as per the drawings/sketches supplied by Owner. Contractor shall determine the reduced levels (R.L's) at these locations with respect to benchmarks used in the detailed survey. Two reference lines shall be established based on survey data/details. Contractor shall provide at site all required survey instruments to the satisfactions of the Owner so that the work can be carried out accurately according to
specifications and drawings. Contractor shall arrange to collect the data regarding change of course of rivers, major natural streams and nalas, etc., encountered along the transmission line route from the best available sources and shall furnish complete hydrological details including maximum velocity discharge, highest flood level (H.F.L), scour depth etc. of the concerned rivers, major streams and nalas (canals).

4.2.4 The filed and laboratory data shall be recorded on the proforma recommended in relevant Indian Standards. Contractor shall submit to Owner two copies of field bore logs (one copy each to Owner site and Corporate Office) and all the field records (countersigned by the Owner) soon after the completion of each boreholes/test.

4.2.5 Whenever Contractor is unable to extract undisturbed samples, he shall immediately inform the Owner. Payment for boring charges shall be subject to Owner being satisfied that adequate effort has been made to extract undisturbed samples. Special care shall be taken for locations where marshy soils are encountered and Contractor in such cases shall ensure that specified number of vane shear tests are performed and the results correlated with other soil parameters.

4.2.6 One copy of all field records and laboratory test results shall be sent to Owner on a weekly basis. Owner may observe, at the laboratory testing procedures.

4.2.7 The Contractor shall interact with the Owner to get acquainted with the different types of structures envisaged and in assessing the load intensities on the foundation for the various types of towers in order to enable him to make specific recommendation for the depth, founding strata, type of foundation and the allowable bearing pressure.

4.2.8 After reviewing Contractor’s geotechnical investigation draft report, Owner will call for discussions, to be held normally within one week at Owners site Office, in order to comment on the report in the presence of Contractor’s Geotechnical Engineer. Any expenditure associated with the redrafting and finalising the report, traveling etc. shall be deemed included in the rates quoted for the geotechnical investigations.

4.2.9 Contractor shall carry out all work expressed and implied in these specifications in accordance with requirements of the specification.

4.2.10 The contractor shall prepare and submit soil profile along the transmission line route (in digitized form, with digitized route alignment drawing as base) indicating salient soil characteristics / features, water table etc based on detailed soil investigations and other details / information collected during detailed survey.

4.3 General Requirements

4.3.1. Wherever possible, Contractor shall research and review existing local knowledge, records of test pits, boreholes, etc., types of foundations adopted and the behavior of existing structures, particularly those similar to the present project.

4.3.2. Contractor shall make use of information gathered from nearby quarries, unlined wells excavation etc. Study of the general topography of the surrounding areas will often help in the delineation of different soil types.
4.3.3. Contractor shall gather data regarding the removal of overburden in the project area either by performing test excavations, or by observing soil erosion or land slides in order to estimate reconsolidation of the soil strata. Similarly, data regarding recent land fills shall be studied to determine the characteristics of such land fills as well as the original soil strata.

4.3.4. The water level in neighboring streams and water courses shall be noted. Contractor shall make enquiries and shall verify whether there are abandoned underground works e.g. worked out ballast pits, quarries, old brick fields, mines, mineral workings etc.

4.3.5. It is essential that equipment and instruments be properly calibrated at the commencement of the work. If the Owner so desires, Contractor shall arrange for having the instruments tested at an approved laboratory at its cost and shall submit the test reports to the Owner. If the Owner desires to witness such tests, Contractor shall arrange for the same.

4.4 Codes and Standards for Geotechnical Investigations

4.4.1. All standards, specifications and codes of practice referred to herein shall be the latest editions including all applicable official amendments and revisions. In case of conflict between the present specifications and those referred to herein, the former shall prevail. Internationally accepted standards which ensure equal or higher performance than those specified shall also be accepted.

4.4.2. All work shall be carried out in accordance with the following Indian Standards and Codes:

<table>
<thead>
<tr>
<th>Indian Standards (IS)</th>
<th>Title</th>
<th>International and Internationally Recognised Standard/Code</th>
</tr>
</thead>
</table>
| IS:1498-1992          | Classification and Identification of Soils for General Engineering purposes. | ASTM D 2487
| IS:1892-1992          | Code of Practice for Subsurface Investigation for Foundation           | ASTM D2488                                                |
| IS:1892-1992          | Code of Practice for Subsurface Investigation for Foundation
<p>| *Strikeout whichever is not applicable |                                                           |
| IS:2131-1992          | Method of Standard Penetration Test for Soils                          | ASTM D 1586                                               |
| IS:2132-1992          | Code of Practice for Thin Walled Tube Sampling of Soils               | ASTM D 1587                                               |
| IS:2720-1992          | Method of Test for Soils(Relevant Parts)                               | ASTM D 420                                                |
| IS:2809-1991          | Glossary of Terms and symbols Relating to Soil                        | ASTM D 653                                                |</p>
<table>
<thead>
<tr>
<th>Indian Standards (IS)</th>
<th>Title</th>
<th>International and Internationally Recognised Standard/Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>IS:3025</td>
<td>Methods of Sampling and Testing (Physical and Chemical) for water used in Industry</td>
<td></td>
</tr>
<tr>
<td>IS:3043-1991</td>
<td>Code of Practice for Earthing</td>
<td></td>
</tr>
<tr>
<td>IS:4078-1990</td>
<td>Code of Practice for Indexing and Storage of Drill Cores.</td>
<td></td>
</tr>
<tr>
<td>IS:4434-1992</td>
<td>Code of Practice for In-situ Vane Shear Test for Soils</td>
<td>ASTM D 2573, ASTM D 4648</td>
</tr>
<tr>
<td>IS:4464-1990</td>
<td>Code of Practice for Presentation of Drilling information and core description in Foundation investigation</td>
<td></td>
</tr>
<tr>
<td>IS:5313-1989</td>
<td>Guide for Core Drilling observations.</td>
<td></td>
</tr>
<tr>
<td>IS:6403-1990</td>
<td>Code of Practice for Determination of Allowable Bearing Pressure on Shallow Foundation.</td>
<td>ASTM D 194</td>
</tr>
<tr>
<td>IS:7422-1990</td>
<td>Symbols and Abbreviations for use in Geological Maps Sections and subsurface Exploratory Logs (Relevant parts).</td>
<td></td>
</tr>
<tr>
<td></td>
<td>*Strikeout whichever is not applicable</td>
<td></td>
</tr>
<tr>
<td>IS:8764-1991</td>
<td>Method of Determination of Point Load Strength Index of Rocks.</td>
<td></td>
</tr>
<tr>
<td>Indian Standards (IS)</td>
<td>Title</td>
<td>International and Internationally Recognised Standard/Code</td>
</tr>
<tr>
<td>----------------------</td>
<td>----------------------------------------------------------------------</td>
<td>----------------------------------------------------------</td>
</tr>
<tr>
<td>IS:9179-1991</td>
<td>Method of Preparation of Rock Specimen for Laboratory Testing.</td>
<td>ASTM D 4543</td>
</tr>
<tr>
<td>IS:11315(Part-II)-1991</td>
<td>Description of Discontinuities in Rock Mass-Core Recovery and Rock Quality.</td>
<td></td>
</tr>
</tbody>
</table>

4.5 Field Investigation for Soils

Tentative numbers of detailed soil investigation to be done is given in BPS

4.5.1. Boring

Boreholes are required for detailed soil investigations.

4.5.1.1. General Requirements

a) Boreholes shall be made to obtain information about the subsoil profile, its nature and strength and to collect soil samples for strata identification and for conducting laboratory tests. The minimum diameter of the borehole shall be 150mm and boring shall be carried out in accordance with the provisions of IS:1892 and the present specification:

b) All boreholes shall be 10m deep for normal soil conditions. The depth of boreholes at river crossings and special locations shall be 40m. If a strata is encountered where the Standard Penetration Test Records N values greater than 100, with characteristics of rock, the borehole shall be advanced by coring at least 3m further in normal locations and at least 7m further for the case of river crossing locations with prior approval of the Owner. When the boreholes are to be termination in soil strata an additional Standard Penetration Test shall be carried out at the termination depth. No extra payment shall be made for carrying out Standard Penetration Tests.

c) Casing pipe shall be used when collapse of a borehole wall is probable. The bottom of the casing pipe shall at all times be above the test of sampling level but not more than 15cm above the borehole bottom. In case of cohesionless soils, the advancement of the casing pipe shall be such that it does not disturb the soil to be tested or sampled. The casing shall preferably be advanced by slowly rotating the casing pipe and not by driving.
d) In-situ tests shall be conducted and undisturbed samples shall be obtained in the boreholes at intervals specified hereafter. Representative disturbed samples shall be preserved for conducting various identification tests in the laboratory. Water table in the bore hole shall be carefully recorded and reported following IS:6935. No water or drilling mud shall be used while boring above ground water table. For cohesion less soil below water table, the water level in the borehole shall at all times be maintained slightly above the water table.

e) The borehole shall be cleaned using suitable tools to the depth of testing or sampling, ensuring least or minimum disturbance of the soil at the bottom of the borehole. The process of jetting through an open tube sampler shall not be permitted. In cohesive soils, the borehole may be cleaned by using a bailer with a flap valve. Gentle circulation of drilling fluid shall be done when rotary mud circulation boring is adopted.

f) On completion of the drilling, Contractor shall backfill all boreholes as directed by the Owner.

4.5.1.2. Auger Boring

Auger boring may be employed in soft to stiff cohesive soils above the water table. Augers shall be of helical or post hole type and the cuttings brought up by the auger shall be carefully examined in the field and the description of all strata shall be duly recorded in the field borelog as per IS:1498. No water shall be introduced from the top while conducting auger boring.

4.5.1.3. Shell and Auger Boring

4.5.1.3.1. Shell and auger boring may be used in all types of soil which are free from boulders. For cohesion less soil below ground water table, the water level in the borehole shall always be maintained at or above ground water level. The use of chisel bits shall be permitted in hard strata having SPT-N value greater than 100 Chisel bits may also be used to extend the bore hole through local obstructions such as old construction. Boulders rocky formations, etc. The requirements in Clause 4.5.1.2 shall apply for this type of boring also.

4.5.1.3.2. Rotary method may be used in all types of soil below water table. In this method the boring is carried out by rotating the bit fixed at the lower end of the drill rod. Proper care shall be taken to maintain firm contact between the bit and the bottom of the borehole. Bentonite or drilling mud shall be used as drilling fluid to stabilise and protect the inside surface of the borehole. Use of percussion tools shall be permitted in hard clays and in dense sandy deposits.

4.5.2. Standard Penetration Test (SPT)

4.5.2.1. This test shall be conducted in all types of soil deposits encountered within a borehole, to find the variation in the soil stratification by correlating with the number of blows required for unit penetration of a standard penetrometer. Structure sensitive engineering properties of cohesive soils and silts such as strength and compressibility shall not be inferred based on SPT values.

4.5.2.2. The test shall be conducted at depths as follows:
### Location Depths (m)

<table>
<thead>
<tr>
<th>Location</th>
<th>Depths (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal Soils</td>
<td>2.0, 3.0, 5.0, 7.0, 10.0</td>
</tr>
<tr>
<td>River crossings and special Locations.</td>
<td>2.0, 3.0, 5.0, 7.0, 10.0 and thereafter at the rate of 3m intervals to 40m</td>
</tr>
</tbody>
</table>

#### 4.5.2.3. Spacing between Levels

The spacing between the levels of standard penetration test and next undisturbed sampling shall not be less than 1.0m. Equipments, accessories and procedures for conducting the test and for the collection of the disturbed soil samples shall conform to IS:2131 and IS:9640 respectively. The test shall be conducted immediately after reaching to the test depth and cleaning of bore hole.

#### 4.5.2.4. Driving Standard Split Spoon Sampler

The test shall be carried out by driving a standard split spoon sampler in the bore hole by means of a 650N hammer having a free fall of 0.75 m. The sample shall be driven using the hammer for 450mm recording the bumper of blows for every 150mm. The number of blow for the last 300mm drive shall be reported as N value.

#### 4.5.2.5. Test Discontinuation

This test shall be discontinued when the blow count is equal to 100 or the penetration is less than 25 mm for 50 blows. At the level where the test is discontinued, the number of blows and the corresponding penetration shall be reported. Sufficient quantity of disturbed soil samples shall be collected from the split spoon sampler for identification and laboratory testing. The sample shall be visually classified and recorded at the site as well as properly preserved without loss of moisture content and labeled.

#### 4.5.3. Sampling

**4.5.3.1. General**

a) Sufficient number of soil samples shall be collected. Disturbed soil samples shall be collected for soil identification and for conducting tests such as sieve analysis, index properties, specific gravity, chemical analysis etc. Undisturbed samples shall be collected to estimate the physical bearing capacity and settlement properties of the soil.

b) All accessories and sampling methods shall conform to IS:2132: all disturbed and undisturbed samples collected in the field shall be classified at site as per IS:1498

c) All samples shall be identified with date, borehole or test pit number, depth of sampling, etc. The top surface of the sample in-situ shall also be marked. Care shall be taken to keep the core and box samples vertical, with the mark directing upwards. The tube samples shall be properly trimmed at one end and suitably capped and sealed with molten paraffin wax. The Contractor shall be responsible for packing, storing in a cool place and transporting all the samples from site to the laboratory within seven days after sampling with probe, protection against loss and damage.

#### 4.5.3.2. Disturbed Samples
a) Disturbed soil samples shall be collected in boreholes at regular intervals. Jar samples weighing approximately 1 kg shall be collected at 0.5m intervals starting from a depth of 0.5m below ground level and at every identifiable change of strata to supplement the boring records. Samples shall be stored immediately in air tight jars which shall be filled to capacity as much as possible.

b) In designated borrow areas, bulk samples, from a depth of about 0.5m below ground level shall be collected to establish the required properties for use as a fill material. Disturbed samples weighing about 25kg (250N) shall be collected at shallow depths and immediately stored in polythene bags as per IS:1892. The bags shall be sealed properly to preserve the natural moisture content of the sample and placed in wooden boxes for transportation.

4.5.3.3. Undisturbed Samples

In each borehole undisturbed samples shall be collected at every change of strata and at depths as follows:

<table>
<thead>
<tr>
<th>Location</th>
<th>Depths (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal Soils</td>
<td>1.0, 4.0, 6.0, 8.0</td>
</tr>
<tr>
<td>Special Locations</td>
<td>1.0, 4.0, 6.0, 8.0, 11.0 and thereafter at the rate of 3 m intervals up to 33m</td>
</tr>
</tbody>
</table>

4.5.3.3.1. The spacing between the top levels of undisturbed sampling and standard penetration testing shall not be less than 1.0m. Undisturbed samples shall be of 100mm diameter and 450mm in length. Samples shall be collected in a manner to preserve the structure and moisture content of the soil Accessories and sampling procedures shall conform to IS:1892 and IS:2132

a) Undisturbed sampling in cohesive soil:

Undisturbed samples in soft to stiff cohesive soils shall be obtained using a thin walled sampler. In order to reduce the wall friction, suitable precautions, such as oiling the surfaces shall be taken. The sampling tube shall have a smooth finish on both surfaces and a minimum effective length of 450mm. The area ratio of sampling tubes shall be less than 12.5%. However, in case of very stiff soils area ratio up to 20% shall be permitted.

b) Undisturbed sampling in very loose, saturated, sandy and silty soils and very soft clays:

Samples shall be obtained using a piston sampler consisting of a cylinder and piston system. In soft clays and silty clays, with water standing in the casing pipe, piston sampler shall be used to collect undisturbed samples in the presence of expert supervision.

Accurate measurements of the sampling depth, dimensions of sampler, stroke and length of sample recovery shall be recorded. After the sampler is pushed to the required depth, the cylinder and piston system shall be drawn up...
together, preventing disturbance and changes in moisture content of the sample;

c) Undisturbed sampling in cohesion less soils

Undisturbed samples in cohesion less soils shall be obtained in accordance with IS:8763. Sampler operated by compressed air shall be used to sample cohesion less soils below ground water table.

4.5.4. Ground Water

4.5.4.1. One of the following methods shall be adopted for determining the elevation of ground water table in boreholes as per IS:6935 and the instructions of the Owner:

a) In permeable soils, the water level in the borehole shall be allowed to stabilize after depressing it adequately by bailing before recording its level. Stability of sides and bottom of the boreholes shall be ensured at all times.

b) For both permeable and impermeable soils, the following method shall be suitable. The borehole shall be filled with water and then bailed out to various depths. Observations on the rise or fall of water level shall be made at each depth. The level at which neither fall nor rise is observed shall be considered the water table elevation and confirmed by three successive readings of water level taken at two hours interval.

4.5.4.2. If any variation of the ground water level is observed in any specific boreholes, the water level in these boreholes shall be recorded during the course of the field investigation. Levels in nearby wells, streams, etc., if any, shall also be noted in parallel.

4.5.4.3. Subsoil water samples

a) Subsoil water samples shall be collected for performing chemical analysis. Representative ground water samples shall be collected when first encountered in boreholes and before the addition of water to aid boring or drilling.

b) Chemical analysis of water samples shall include determination of pH value, turbidity, sulphate, carbonate, nitrate and chloride contents, presence of organic matter and suspended solids. Chemical preservatives may be added to the sample for cases as specified in the test methods or in applicable Indian Standards. This shall only be done if analysis cannot be conducted within an hour of collection and shall have the prior written permission and approval of the Owner.

4.5.5. Dynamic Cone Penetration Test (only at Special locations)

a) With bentonite slurry

Dynamic cone penetration test shall be conducted to predict stratification, density, bearing capacity of granular soils, etc. The test shall be conducted to the specified depth or refusal, whichever comes first. Refusal shall be considered when the blow count exceeds 100 for 300mm penetration. Equipment, accessories test procedures, field observations and reporting of results shall conform to IS:4968, Part-II. The driving system shall comprise of a
650 N weight hammer having a free fall of 750mm. The cone shall be of 60° and of 65mm diameter provided with vents for continuous flow of bentonite slurry through the cone and rods in order to avoid friction between the rods and soil. On completion of the test the results shall be presented as a continuous record of the number of blows required for every 300mm penetration of the cone into the soil in a suitable chart supplemented by a graphical plot of blow count for 300mm penetration vs. depth. On completion of the test, the results shall be presented on the proforma approved by the Owner.

b) Without bentonite slurry

This test shall be conducted with 50mm diameter 60° cone fitted loosely to the driving rod through a cone adopter. The cone shall be driven in to the soil by allowing 650 N weight hammer top fall freely through a height of 750mm each time. The number of blows for every 75mm penetration shall be recorded. The process shall be repeated till the cone is driven to the required depth. The penetration depth shall be limited to 5m in cohesion less soil and 10m in mixed soil with some binding material. The cone driving rods, driving head, hoisting equipment shall conform to IS: 10589. The test report should be prepared as per guidelines of IS: 4968 (Part I).

4.5.6. Vane Shear Test. (required for boreholes where UDS is not possible) (Only at Special Locations)

Field vane shear test shall be performed inside the borehole to determine the shear strength and bearing capacity of cohesive soils, especially of soft and sensitive clays, which are highly susceptible to sampling disturbance. Equipment, accessories, test procedures, field observations shall correspond to IS:4434. Tests may also be conducted by direct penetration from ground surface. If the cuttings at the test depth in the borehole show any presence of gravel, sand shells, decomposed wood, etc., which are likely to influence the test results substantially, the test at that particular depth may be omitted with the permission of the Owner. However, the test shall be conducted at a depth where these obstructions cease to occur. On completion of the test, the results shall be reported in an approved proforma as specified in IS:4434, Appendix - A.

4.6 Field Investigation for Rock

4.6.1. Rock Drilling

4.6.1.1. If, during the investigations, large hard fragments or natural rock beds are encountered, work shall proceed with core drilling methods. The equipment and procedures for this operation shall conform to IS:1892. The starting depth of drilling in rock shall be certified by the Owner. At the end of the investigation, the hole drilled in rock shall be backfilled with grout consisting of 1 part cement and 3 parts sand by weight.

4.6.1.2. Drilling shall be carried out with NX size tungsten carbide (TC) or diamond tipped drill bits, depending on the type of rock and according to IS:6926. Suitable type of drill bit (TC/ Diamond) and core catchers shall be used to ensure continuous and good core recovery. Core barrels and core catchers shall be used for breaking off the core and retaining it when the rods are withdrawn. Double tube core barrels shall be used to ensure better core recovery and to retrieve cores from layers of...
bedrock. Water shall be circulated continuously in the hollow rods and the sludge conveying the rock cuttings to the surface shall be collected. A very high core recovery ratio shall be aimed at in order to obtain a satisfactory undisturbed sample. Attempt shall be made to recover cores of 1.5m in length. Normally TC bit shall be used. Change over to a diamond bit shall require the specific written approval of the Owner, and his decision as to whether a TC or a diamond bit is to be used shall be final and binding on Contractor.

4.6.1.3. No drilling run shall exceed 1.5 m in depth. if the core recovery is less than 80% in any run, the length of the subsequent run shall be reduced to 0.75m. During drilling operations observations on return water, rate of penetration etc. shall be made recorded and recorded as per IS:5313.

a) The colour of return water at regular intervals, the depth at which any change of colour of return water is observed, the depth of occurrence and amount of flow of hot water, if encountered, shall be recorded.

b) The depth through which a uniform rate of penetration was maintained, the depth at which marked change in rate of penetration or sudden fail on drill rod occurs, the depth at which any blockage of drill bit causing core loss, if any, shall be recorded.

c) Any heavy vibration or torque noticed during the drilling should be recorded together with the depth of occurrence.

d) Special conditions like the depth at which grouting was done during, drilling, presence of artesian conditions, loss of drilling fluid, observations of gas discharge with return water, etc., shall also be observed and recorded.

e) All the observations and other details shall be recorded as per daily drill and reported in a Performa as given in IS:5313, Appendix A.

4.6.2. Core Sampling

4.6.2.1. Core samples shall be extracted by the application of a continuous pressure at one end of the core with the barrel held horizontally without vibration. Friable cores shall be extracted from the barrel directly into a suitably sized half round plastic channel section. Care shall be taken to extrude the samples in the direction of coring to avoid stress reversal.

4.6.2.2. Immediately after withdrawal from the core barrel, the cores shall be placed in a tray and transferred to boxes specially prepared for this purpose. The boxes shall be made from seasoned timber or any other durably material and shall be indexed on top of the lid according to IS:4078. The cores shall be numbered serially and arranged in the boxes in a sequential order. The description of the core samples shall be recorded as instructed in IS:4464. Where no core is recovered, it shall be recorded as specified in the standard. Continuous record of core recovery and rock quality designation (RD/DD/QD) are to be mentioned in the bore log in accordance with IS:1 1315 (Part-II).

4.7 Laboratory Testing

4.7.1. Essential Requirements
a) Depending on the types of substrata encountered, appropriate laboratory tests shall be conducted on soil and rock samples collected in the field. Laboratory tests shall be scheduled and performed by qualified and experienced personnel who are thoroughly conversant with the work. Tests indicated in the schedule of items shall be performed on soil, water and rock samples as per relevant IS codes. One copy of all laboratory test data records shall be submitted to Owner progressively every week. Laboratory tests shall be carried out concurrently with the field investigations as initial laboratory test results could be useful in planning the later stages of field work. A schedule of laboratory tests shall be established by Contractor to the satisfaction of the Owner within one week of completion of the first borehole;

b) Laboratory tests shall be conducted using approved apparatus complying with the requirements and specification of Indian Standards or other approved standards for this type of work. It shall be checked that the apparatus are in good working condition before starting the laboratory tests. Calibration of all the instruments and their accessories shall be done carefully and precisely at an approved laboratory.

c) All samples, whether undisturbed or disturbed shall be extracted, prepared and examined by competent personnel properly trained and experienced in soil sampling, examination, testing and in using the apparatus in conformance with the specified standards;

d) Undisturbed soil samples retained in liners or seamless tube samplers shall be removed, without causing any disturbance to the samples, using suitably designed extruders just prior to actual testing. If the extruder is horizontal, proper support shall be provided to prevent the sample from breaking. For screw tube extruders, the pushing head shall be free from the screw shaft so that no torque is applied to the soil sample in contact with the pushing head. For soft clay samples, the sample tube shall be cut by means of a high speed hacksaw to proper test length and placed over the mould before pushing the sample into it with a suitable piston;

e) While extracting a sample from a liner or tube, care shall be taken to assure that its direction of movement is the same as that during sampling to avoid stress reversal;

4.7.2. Tests

4.7.2.1. Tests as indicated in these specifications and as may be requested by the Owner, shall be conducted. These tests shall include but may not be limited to the following:

a) Tests of undisturbed and disturbed samples
   - Visual and engineering classification;
   - Sieve analysis and hydrometric analysis;
   - Liquid, plastic and shrinkage limits;
   - Specific gravity;
− Chemical analysis
− Swell pressure and free swell index determination
− Proctor compaction test.

b) Tests of undisturbed samples:
− Bulk density and moisture content;
− Relative density (for sand),
− Unconfined compression test;
− Box shear test (for sand);
− Triaxial shear tests (depending on the type of soil and field conditions on undisturbed or remoulded samples):
  i. Unconsolidated undrained;
  ii. Consolidated drained test;
− Consolidation.

c) Tests on rock samples
− Visual classification;
− Moisture content, porosity and density;
− Specific gravity;
− Hardness

*Strikeout whichever is not applicable

− Stake durability
− Unconfined compression test (both saturated and at in-situ water content);
− Point load strength index;
− Deformability test (both saturated and dry samples).

d) Chemical analysis of sub soil water.

4.7.3. Salient Test Requirement

a) Triaxial shear tests shall be conducted on undisturbed soil samples, saturated by the application of back pressure. Only if the water table is at sufficient depth so that chances of its rising to the base of the footing are small or nil, the triaxial tests shall be performed on specimens at natural moisture content.
Each test shall be carried out on a set of three test specimens from one sample at cell pressures equal to 100, 200 and 300 KPa respectively or as required depending on the soil conditions:

b) Direct shear test shall be conducted on undisturbed soil samples. The three normal vertical stresses for each test shall be 100, 200 and 300 KPa or as required for the soil conditions;

c) Consolidation test shall have loading stages of 10, 25, 50, 75, 100, 200, 400 and 800 KPa. Rebound curve shall be recorded for all samples by unloading the specimen at its in-situ stress. Additional rebound curves shall also be recorded wherever desired by the Owner;

d) Chemical analysis of subsoil shaft includes determination of PH value, carbonate, sulphate (both SO$_3$ and SO$_4$), chloride and nitrate contents, organic matter, salinity and any other chemicals which may be harmful to the foundation material. Their contents in the soil shall be indicated as percentage(%));

e) Chemical analysis of subsoil water samples shall include the determination of properties such as colour, odour, turbidity, PH value and specific conductivity, the last two chlorides, nitrates, organic matter and any other chemical harmful to the foundation material. The chemical contents shall be indicated as parts per million (PPM) based on weight.

4.8 Geotechnical Investigation Report

4.8.1. General

a) Contractor shall submit a formal report containing geological information of the region, procedures adopted for geotechnical investigation, field observations, summarised test data, conclusions and recommendations. The report shall also include detailed bore logs, subsoil sections, field test results, laboratory observations and test results both in tabular as well as graphical form, practical and theoretical considerations for the interpretation of test results, supporting calculations for the conclusions drawn, etc. Initially, Contractor shall submit three copies of the report in draft form for Owner’s review;

b) Contractor’s Geotechnical engineer shall visit Owner’s Corporate Office for a detailed review based on Owner’s comments in order to discuss the nature of modifications, if any, to be done in the draft report. Contractor shall incorporate in the report the agreed modifications and resubmit the revised draft report for approval. Ten copies of the detailed final approved report shall be submitted to Owner together with one set of reproducible of the graphs, tables etc.

c) The detailed final report based on field observations, in-situ and laboratory tests shall encompass theoretical as well as practical considerations for foundations for different types of structures.

4.8.2. Data to be furnished

4.8.2.1. The report shall also include the following

a) A plot plant/location plan showing the locations and reduced levels of all field test e.g. boreholes, trial pits, static cone penetration tests, dynamic cone
penetration tests, etc., property drawn to scale and dimensioned with reference to the established grid lines;

b) A true cross section of all individual boreholes and test pits with reduced levels and co-ordinates showing the classification and thickness of individual stratum, position of ground water table, various in-situ tests conducted, samples collected at different depths and the rock stratum, if encountered;

c) Geological information of the area including geomorphology, geological structure, lithology, stratigraphy and tectonics, core recovery and rock quality designation (RD/DD/QD), etc.,

d) Observations and data regarding change of course of rivers, velocity, scour depths, slit factor, etc., and history of flood details for mid stream and river bank locations;

e) Past observations and historical data, if available, for the area or for other areas with similar soil profile, or with similar structures in the surrounding areas;

f) Plot of Standard Penetration Test (uncorrected and corrected N values) with depth for each test site;

g) Results of all laboratory test summarised according to Table 4.0 (i) for each sample as well as (ii) for each layer, along with all the relevant charts, tables, graphs, figures, supporting calculations, conclusions and photographs of representative rock cores,

h) For all triaxial shear tests, stress vs. strain diagrams as well as Mohr’s circle envelopes shall be furnished. If back pressure is applied for saturation, the magnitude of the same shall be indicated. The value of modulus of elasticity (E) shall be furnished for all tests along with relevant calculations;

i) For all consolidation tests, the following curves shall be furnished
   i. e vs. log p;
   ii. e vs. p;
   iii. Compression vs log t or vs √t

   depending upon the shape of the plot, for proper determination of coefficient of consolidation.

   The point showing the initial condition (e0, p0) of the soil shall be marked on the curves;

j) The procedure adopted for calculating the compression index from the field curve and settlement of soil strata shall be clearly specified. The time required for 50% and 90% primary consolidation along with secondary settlements, if significant, shall also be calculated.

**Table 4.0**

SUMMARY OF RESULTS OF LABORATORY TESTS ON SOIL
AND WATER SAMPLES

1. Bore hole test pit. no
2. Depth (m)
3. Type of sample
4. Density(kg/m³)
   a) Bulk
   b) Dry.
   c) **Submerged**
5. Water content (%)
6. Particle Size (%)  
   a) Gravel
   b) Sand
   c) Silt
   d) Clay
7. Consistency properties
   a) LL
   b) PL
   c) PI
   d) LI
8. Soil
   a) Classification -IS
   b) Description
   c) Specific gravity
9. Strength Test
   a) Type
   b) c (Cohesion)
   c) Ø (angle of internal friction)
   d) **Angle of repose**
10. Consolidation Test
    a) e0
    b) Pc
    c) Cc
    d) DP
    e) Mv
    f) Cv
11. Shrinkage limit(%)  
12. Swell Test
    a) S.Pr
    b) FS
13. Relative Density (%)  
14. Remarks
Notations:

I. For type of Sample:
   DB - Disturbed bulk soil sample.
   DP - Disturbed SPT soil sample
   DS - Disturbed samples from cutting edge of undisturbed soil sample.
   RM - Remoulded soil sample
   UB - Undisturbed block soil sample
   US - Undisturbed soil sample by sampler
   W - Water sample

II. For Strength Test:
   SCPT - Static Cone Penetration Test
   UCC - Unconfined Compression Test
   VST - Vane Shear Test
   Tuu - Unconsolidated Undrained Triaxial Test
   Note: Replace T by D for Direct Shear Test
   Tod - Consolidation Drained Triaxial Test

III. For Others:
   LL - Liquid Limit (%)
   PL - Plastic Limit
   PI - Plasticity Index
   LI - Liquidity Index
   C - Cohesion (kPa)
   Ø - Angle of Internal Friction (degrees)
   S-Pr. - Swelling Pressure (kPa)
   e0 - Initial Void Ratio
   Pc - Reconsolidation Pressure (kPa)
   Cc - Compression Index
   DP - Change in Pressure (kPa)
   m - Coefficient of Volume Compressibility (m2/KN)
   Cv - Coefficient of Consolidation (m2/hr)
IV. For Chemical Test

As per Specifications - Clause 4.8.4

4.8.3. Recommendations

4.8.3.1. Recommendations shall be provided for each tower location duly considering soil type and tower spotting data. The recommendations shall provide all design parameters and considerations required for proper selection, dimensioning and future performance of tower foundations and the following:

a) The subsurface material must provide safe bearing capacity and uplift resistance by incorporating appropriate safety factors thereby avoiding rupture under ultimate loads;

b) Movement of the foundation, including short and long term components under transient and permanent loading, shall be strictly controlled with regard to settlement, uplift, lateral translation and rotation:

c) Co-efficient of permeability of various sub soil and rock strata based on in-situ permeability tests.

Core resistance, frictional resistance total resistance, relation between core resistance, Standard Penetration Test N value, and settlement analysis for different sizes of foundation as specified in para 4.1.8.3 (I) based on static cone penetration test.

d) For shallow foundation the following shall be indicated with comprehensive supporting calculations:

i. Net Safe allowable bearing pressure for isolated square footing of sizes 4.0, 5.0, 6.0 & 7. m at three different founding depths of 1,2 and 3 & 3.5m below ground level considering both shear failure and settlement criteria giving reasons for type of shear failure adopted in the calculation.

ii. Net safe allowable bearing pressure for raft foundations of widths greater than 5m at 2.0, 3.0 and 4.0m below ground level considering both shear failure and settlement criteria.

iii. Rate and magnitude of settlement expected of the structure.

iv. Net safe bearing capacity for foundation sizes mentioned in para(i) above, modulus of sub grade reaction, modules of elasticity from plate load test results along with time settlement curves and load settlement curve in both natural and log graph, variation of Modulus of sub grade reaction with size, shape and depth of foundation.

e) The stable slopes for shallow and deep excavations, active and passive earth pressure at rest and angle of repose for sandy soils shall be furnished. The loading of the foundations shall not compromise the stability of the surrounding subsurface materials and the stability of the foundation shall be ensured against sliding or overturning:-
f) Depending on the subsurface material, water table level and tower type, either reinforced concrete isolated pad and chimney, cast-in-situ bored pile of special foundations shall be installed at a given location.

g) Net Safe allowable bearing pressure and uplift resistance shall be provided for the various sizes of isolated square footings founded at various depths below ground level considering both shear failure and movement criteria; rate and magnitude of movement expected of the structure (settlement, uplift, rotation) shall also be given.

h) In cases where normal open cast/pile foundations appear to be impractical, special pile foundations shall be given due consideration along with the following:

i. Type of pile foundation and reasons for recommending the same duly considering the soil characteristics.

ii. Suitable founding strata for the pile:

iii. Estimated length of pile for 500, 750 and 1000 KN and 4500 KN capacities; end bearing and frictional resistance shall be indicated separately:

iv. Magnitude of negative skin friction or uplift forces due to soil swelling.

i) Where the subsoil water and soil properties are found to be chemically aggressive. Contractor shall take suitable precautions during construction including any protective coating to be applied on the foundations; susceptibility of soil to termite action and remedial measures for the same shall be dealt with;

j) Suitability of locally available soils at site for filling, backfilling and adequate compaction shall be investigated.

k) If expansive soil such as black cotton soil is encountered recommendation of removal or retainment of the same shall be given in the latter case, detailed specifications of special requirements shall also be given;

l) Susceptibility of subsoil strata to liquefaction in the event of earthquake and remedial measures, if required, shall be considered.

m) Any other information of special significance such as dewatering schemes, etc. which may have a bearing on the design and construction shall be provided.

n) Recommendations for additional soil investigations, beyond the scope of the present work, shall be given if Contractor considers such investigations necessary.

4.8.4. Hydrogeological Conditions

4.8.4.1. The maximum elevation of ground water table, amplitudes of its fluctuations and data on water aggressivity with regard to foundation structure materials shall be reported. While preparing ground water characteristics the following parameters should be specified for each aquifier:

a) bicarbonate alkalinity mg-eq/(deg),

b) pH value
c) content of aggressive carbon dioxide, mg/l;

d) content of magnesia salts, mg/l, recalculated in terms of ions Mg+2;

e) content of ammonia salts, mg/l, recalculated in terms of ions NH4+

f) content of caustic alkalis, mg/l, recalculated in terms of ions Na+ and K+

g) contents of chlorides, mg/l recalculated in terms of ions Cl-
h) contents of sulphates, mg/l, recalculated in terms of ions SO4-2

i) aggregate content of chlorides, sulphates, nitrates, carbonates and other salts. mg/l.

4.9 Rates and Measurements

4.9.1. Rates

The contractor’s quoted rates shall be inclusive of making observations, establishing the ground level and co-ordinates at the location of each borehole, test pit etc. No extra payments shall be made for conducting Standard Penetration Test, collecting, packing, transporting of all samples and cores, recording and submittal of results on approved formats.

4.10 Specific Requirements for Geotechnical Investigation at River Crossings.

4.10.1. The entire soil investigation work at river crossing locations (if required) shall be carried out in accordance with the relevant parts of the specifications for geotechnical investigation modified to the extent given below.

4.10.2. Requirements

4.10.2.1. Boreholes shall be executed to specified depth of 40m (refer clause 4.5.1.1 b). If refusal strata is reached (i.e. SPT-N value is greater than 100 continuously for 5m depth) with characteristics of rock the borehole may be terminated at shallower depth i.e. at 5m in refusal strata, with prior approval of the Owner.

4.10.2.2. Laboratory testing shall be conducted on all soil samples to determine grain size distribution, liquid limit and plastic limit of the different soil strata encountered.

4.10.2.3. Geotechnical Report must furnish the following:

a) Geotechnical investigation scheme;

b) Bore-logs indicating soil stratification, with IS classification, sampling details and SPI ‘N’ values.

c) Soil cross-sections along various boreholes in two orthogonal directions indicating soil stratification based on field and laboratory tests;

d) Grain size distribution curves.

e) IS classification of soils.

f) Shear tests (UU) to be done on saturated soil samples;

g) Bearing capacity of soil at different levels;
h) Highest flood level (H.F.L.);

i) Maximum discharge, velocity etc. (from authenticated source such as CWC or appropriate State authorities)

j) Recommendations regarding type of foundation to be adopted at the location.

4.10.3. A check list for reporting results of river crossing locational details, detailed soil investigation and river values for river crossing locations is enclosed at Annexure-C.

4.11 Special Terms and conditions for Geotechnical Investigation in the River bed

4.11.1. Contractor is required to mobilise a suitable arrangement (floating pontoon, plant, equipment etc,) to carry out geotechnical investigation work in creek/river locations identified by the Owner.

4.11.2. In the event of storm or stoppage of work, etc., Contractor shall not be paid extra for mobilization / remobilisation of floating pontoon, plant, equipment, etc.

4.11.3. Contractor shall fully satisfy himself about the conditions of creek/river (depth of water, wave currents, wind conditions, etc.) prevailing in the area of proposed investigation and plan the necessary tools and plant to be deployed before quoting. Any claim resulting from lack of data collection in this respect shall not be entertained.

4.11.4. Contractor shall make his own arrangements for locating the coordinates and position of boreholes in creek/river with respect to two grid-lines indicated by Owner.

4.11.5. Boring in creek or river shall be payable only below the bed level and no payment shall be made for lowering the casing in water.

4.11.6. Contractor shall arrange for necessary transportation on water (e.g. motor boat) to facilitate the supervision of work by officials of Owner at its own cost.

4.11.7. Full details of the construction plant, proposed working method for boring and sampling in water shall be submitted along with the Tender.

4.11.8. The unit rate quoted for underwater boring shall include complete work required as per specification and no separate payment shall be made on any account.

5. STATUTORY REGULATIONS AND STANDARDS

5.1 Contractor is required to follow statutory regulations stipulated in Electricity (Supply) Act 1948, Indian Electricity Rules and other local rules & regulations.

5.2 The codes and standards referred to in these specifications shall govern. In case of a conflict between such codes/standards and these specifications, the provisions of the specifications shall prevail. Such codes, standards referred to shall mean latest revisions, amendments, changes adopted and published by relevant agencies.

5.3 Other Internationally acceptable standards which ensure equivalent or better performance than those specified shall also be acceptable.
6. **FIELD QUALITY PLAN**
   A standard Field Quality Plan is annexed to this specifications at D. The bidders are requested to convey their acceptance to the same along with their offer.

7. **COMPLETION PERIOD**
   The work as detailed in this specification shall be completed in all respects within the time schedule stipulated in letter of award (LOA).
### SECTION – IV

### CONTENTS

<table>
<thead>
<tr>
<th>Clause No.</th>
<th>Description</th>
<th>Page No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0</td>
<td>Transmission Tower</td>
<td>1</td>
</tr>
<tr>
<td>2.0</td>
<td>Foundations</td>
<td>18</td>
</tr>
<tr>
<td>3.0</td>
<td>Tower Erection, Stringing and Installation of Line Materials</td>
<td>26</td>
</tr>
<tr>
<td>4.0</td>
<td>Field Quality Plan</td>
<td>34</td>
</tr>
</tbody>
</table>
SECTION IV

TOWER, FOUNDATION, ERECTION, STRINGING AND COMMISSIONING OF LINE

1.0 Transmission Tower

The general description of towers applicable for the package and technical particulars thereof are indicated in Section – I of this Specification.

1.1 Design and Drawings

1.1.1 The relevant drawings for all the towers and their extensions shall be furnished to the Contractor by the Owner which shall include structural drawings/erection drawings and / or shop fabrication drawings, Bill of Materials for all the towers and their extensions as well as construction drawings for foundations.

1.1.2 The tower members can be directly fabricated from the structural/erection drawings wherever the required fabrication details are provided on the same or shop fabrication drawings. However, if the contractor is required to prepare shop fabrication drawings, of their own, in addition to the structural/erection drawings with required fabrication details, they may prepare the same without any additional financial implication to TPGL. Before taking up mass fabrication, the Contractor shall arrange for one number proto-assembly for each type of towers and extensions which shall be inspected by Owner. The rates for proto assembly of towers along with its extensions are to be quoted separately as given in the BPS. After assembly inspection the Contractor shall incorporate revisions in the drawings / documents if any on account of proto corrections, and make necessary endorsement with reference to the respective packages / Letter of Awards. The revised drawing/documents shall be submitted in 3 (three) copies for final approval by the Owner.

1.1.3 All the drawings shall have a proper name plate clearly displaying the name of TPGL on right hand bottom corner. The exact format of the nameplate shall be handed over to the successful bidder for incorporation of the same on all the drawings. Also all the drawings shall carry the following statement and shall be displayed conspicuously on the drawing:

**WARNING**: THIS IS PROPRIETORY ITEM AND DESIGN RIGHT IS STRICTLY RESERVED WITH POWERGRID. UNDER NO CIRCUMSTANCES THIS DRAWING SHALL BE USED BY ANYBODY WITHOUT PRIOR PERMISSION FROM THE OWNER IN WRITING.

1.1.4 While submitting the structural drawings, bill of materials, shop drawings and any other drawings pertaining to the subject transmission line, the Contractor shall clearly indicate on each drawing TPGL Specification No., Name of the specific Transmission line and project, letter reference no. and date on which the submission are made. The same practice is also to be followed while submitting distribution copies.

1.1.5 The tower accessories drawings like name plate, phase plate, anti climbing device, step bolt, D-shackle etc. shall be furnished to the Contractor by the Owner except the number plate & Danger plate drawing which shall be prepared by the Contractor and shall be submitted to the Owner, in three (3) copies for approval. This drawing shall be prepared in A4 size only.
1.1.6 The drawings submitted by the Contractor shall be approved/commented by the Owner as the case may be within fifteen (15) days of receipt of drawings in his office. If the designs/drawings are commented by the Owner, the Contractor shall submit revised design/drawings duly incorporating all comments within fifteen (15) days of date of issue of comments. The Contractor shall submit 15 copies of all approved structural drawings and BOM for tower extensions as well as for tower accessories for further distribution by the Owner.

The mass fabrication shall be taken up from the approved shop drawings. The overall responsibility of fabricating tower members correctly lies with the Contractor only and the Contractor shall ensure that all the tower members can be assembled/ fitted while erecting without any undue strain on them.

1.1.7 Other than the items indicated above some other drawings and documents, such as BOM, Shop drawings, structural drawings for towers/extensions based on single line diagram given by the Owner, which are required for the project shall also be developed by the Contractor. However, no extra cost on this account shall be payable to the Contractor.

1.2 Materials

1.2.1 Tower Steel Sections

IS Steel Sections of tested quality of conformity with IS:2062 (Designated Yield Strength. 250 MPa) and/or IS:8500 grade 490 (Designated Yield Strength 350 MPa) are to be used in towers, extensions, stubs and stub setting templates. The Contractor can use other equivalent grade of structural steel angle sections and plates conforming to latest International Standards. However, use of steel grade having designated yield strength more than that of EN 10025 grade S355 JR/JO (designated yield strength 355 MPa) is not permitted, unless otherwise indicated in this specification.

Steel plates below 6mm size exclusively used for packing plates/packing washers produced as per IS : 1079 -1994 (Grade -0) are also acceptable. However, if below 6mm size plate are used as load bearing plates viz gusset plates, joint splices etc. the same shall conform to IS : 2062 / IS-8500 or equivalent standard meeting mechanical strength/metallurgical properties corresponding to Fe-410 or above grade (designated yield strength not more than 355MPa), depending upon the type of grade incorporated into design. Flats of equivalent grade meeting mechanical strength/metallurgical properties may also be used in place of plates for packing plates/ packing washers. The chequered plates shall conform to IS : 3502. SALIMA 350Hi grade plate can also be accepted in place of HT plates (EN 10025 grade S355 JR/JO / IS 8500 – Fe 490B, as applicable) provide SALIMA 350Hi grade plate meet all the mechanical properties of plate as per EN 10025 grade S355 JR/JO (designated yield strength 355 MPa) / IS 8500 – Fe 490B.

For designing of towers, preferably rationalised steel sections has been used. During execution of the project, if any particular section is not available, the same shall be substituted by higher section. Any cost on account of the same shall be borne by the Contractor. However, design approval for such substitution shall be obtained from the Owner before any substitution and records of such substitutions shall be maintained by the Contractor.
1.2.2 Fasteners: Bolts, Nuts and Washers including Anti-theft Bolts & Nuts

1.2.2.1 All tower members shall be joined together with Bolts and nuts. The redundant members of first two (2) panels from ground level shall be connected with Anti-theft bolts and nuts along with spring washers whereas the balance joints shall be connected with hexagonal bolts and nuts. All hexagonal bolts and nuts shall conform to IS-12427. They shall have hexagonal head and nuts, the heads being forged out of the solid, truly concentric, and square with the shank, which must be perfectly straight.

Anti-theft bolts and nuts shall have round tapered heads with hexagonal shear nuts. They shall confirm to IS: 12427 and IS: 1367 for property class 5.6/5 except for dimensions which shall be as per enclosed drawing no. TDTL/400kV/ATB.

All bolts and nuts shall be galvanised as per IS:1367 (Part-13)/IS:2629.

1.2.2.2 The bolt shall be of 16/24 mm diameter and of property class 5.6 as specified in IS:1367 (Part-III) and matching nut of property class 5.0 as specified in IS:1367 (Part-VI).

1.2.2.3 Bolts up to M16 and having length up to 10 times the diameter of the bolt should be manufactured by cold forging and thread rolling process to obtain good and reliable mechanical properties and effective dimensional control. The shear strength of bolts for 5.6 grade should be 310 MPa minimum as per IS:12427. Bolts should be provided with washer face in accordance with IS:1363 (Part-I) to ensure proper bearing.

1.2.2.4 Nuts for hexagonal bolts should be double chamfered as per the requirement of IS:1363 Part-III. It should be ensured by the manufacturer that nuts should not be over tapped beyond 0.4mm oversize on effective diameter for size up to M16.

Nuts for anti-theft bolts should be round tapered with hexagonal shear nuts. The hexagonal portion of shear nuts shall break away at specified torque recommended by the supplier to ensure proper tightening of members and the fasteners shall not be opened subsequently with tools. The tightening torque and shearing of anti-theft nuts shall be verified during proto-assembly.

1.2.2.5 Fully threaded bolts shall not be used. The length of bolts shall be such that the threaded portion will not extend into the place of contact of the members.

1.2.2.6 All bolts shall be threaded to take the full depth of the nuts and threaded for enough to permit firm gripping of the members, but not further. It shall be ensured that the threaded portion of each bolt protrudes not less than 3mm and not more than 8mm when fully tightened. All nuts shall fit tight to the point where the shank of the bolt connects to the head.

1.2.2.7 Flat and tapered washers shall be provided wherever necessary. Spring washers shall be provided for insertion under all nuts. These washers shall be steel electrogalvanised, positive lock type and 3.5mm in thickness for 16mm dia bolt and 4.5mm for 24mm bolt.

1.6.2.8 To avoid bending stress in bolts or to reduce it to minimum, no bolt shall connect aggregate thickness of members more than three (3) times its diameter.

1.2.2.9 The bolt positions in assembled towers shall be as per structural drawing.

1.2.2.10 Bolts at the joints shall be so staggered that nuts shall be tightened with spanners without fouling.
1.2.2.11 To ensure effective in-process Quality control it is desirable that the manufacturer should have in house testing facility for all tests like weight of zinc coating, shear strength and other tests etc. The manufacturer should also have proper Quality Assurance System which should be in line with the requirement of this specification and IS:14000 series Quality System Standard.

1.3 Tower Accessories

Arrangement shall be provided for fixing of all tower accessories to the tower at a height between 2.5 meters and 3.5 meters above the ground level.

1.3.1 Step Bolts & Ladders

Each tower shall be provided with step bolts conforming to IS : 10238 of not less than 16mm diameter and 175mm long, spaced not more than 450mm apart and extending from 2.5 meters above the ground level to the top of the tower. However, the head diameter shall be 50mm as indicated in the enclosed drawing. For Single circuit tower the step bolt shall be fixed on one leg up to wrist level and on two diagonally opposite legs above wrist level up to top of the towers. For double circuit tower the step bolt shall be fixed on two diagonally opposite legs up to top of the towers. Each step bolt shall be provided with two nuts on one end to fasten the bolt securely to the tower and button head at the other end to prevent the feet from slipping away. The step bolts shall be capable of withstanding a vertical load not less than 1.5 KN. For special towers, where the height of the super structure exceeds 50 meters, ladders along with protection rings as per the Owner approved design shall be provided in continuation of the step bolts on one face of the tower from 30 meters above ground level to the top of the special structure. From 2.5m to 30m height of super structure step bolts shall be provided. Suitable platform using 6mm thick perforated chequered plates along with suitable railing for access from step bolts to the ladder and from the ladder to each cross-arm tip and the ground wire support shall also to be provided. The platform shall be fixed on tower by using counter-sunk bolts.

1.3.2 Insulator Strings and Earth wire Clamps Attachments

a) For the attachment of suspension Insulator string, a suitable dimensioned swinging hanger on the tower shall be provided so as to obtain specified clearances under respective swinging condition of the strings. The hanger, extensions links, D-shackles etc. as required and considered in the design of the tower shall have minimum ultimate tensile strength of 120KN for single suspension string and 240KN for double suspension string for 400KV suspension towers. The design and supply of hanger, D-shackles, strain plate, extension link etc. are also in the scope of Contractor.

b) At tension towers, strain plates of suitable dimensions under each cross-arm tip shall be provided for taking the hooks or D-shackles of the tension insulator strings. Full details of the attachments shall be provided to the contractor. To achieve requisite clearances, if the design calls for providing extra D-shackles, link plate etc. before connecting the insulator string the same shall be supplied by the Contractor.

1.3.3 Earth wire Clamps Attachments

a) Suspension Clamp
Wherever required, the Contractor shall supply U – bolts, D – Shackles etc. for attachment of Suspension clamp to the tower and take Owner’s approval for details of the attachments before the mass fabrication.

b) Tension Clamps

Earth wire peaks of tension towers shall be provided with suitable plates to accommodate the shackle of tension clamps. The contractor shall also supply the U-bolts wherever required and take Owner’s approval for details of the attachments before the mass fabrication.

1.3.4 Anti climbing Device

Barbed wire type anti climbing device shall be provided and installed by the Contractor for all towers. The barbed wire shall conform to IS-278 (size designation A1). The barbed wires shall be given chromating dip as per procedure laid down in IS:1340.

1.3.5 Danger, Number, Circuit and Phase plate

Danger Plates, Number plates and phase plates shall be provided and installed by the Contractor. Further circuit plates also shall be provided and installed by the contractor for Double circuit and Multi circuit towers.

a) Each tower shall be fitted with a danger plate, number plate and a set of phase plates for single circuit tower and two sets of phase plates for double circuit tower. The transposition towers should have provision of fixing phase plates on both the transverse faces. Circuit plates shall be provided on all the Double Circuit and Multi Circuit towers.

b) The letters, figures and the conventional skull and bones of danger plates shall conform to IS-2551 and shall be in a signal red on the front of the plate.

c) The corners of the danger, number and circuit plates shall be rounded off to remove sharp edges.

d) The letters of number and circuit plates shall be red enameled with white enameled background.

1.3.6 Aviation Requirements

1.3.6.1 Aviation requirements conforming to IS: 5613 shall be in the scope of Contractor, wherever indicated in BPS.

1.3.6.2 Night Markers (Obstruction lights)

1.3.6.2.1 The scope of night markers covers the design, manufacture, testing at manufacturers works, if any, supply, delivery, erection, testing and commissioning of medium intensity, low intensity, lights along with storage battery & solar panel, control panel, cables, clamps other accessories etc. as per the provision of IS-5613 (Part-II/ section-I), 1989, amendment no. 1, July’94 regarding night & day visual aids for denoting transmission line structures as per the requirement of directorate of flight safety.

1.3.6.2.2 The detail of each component of medium intensity, low intensity lights & associated accessories to be provided on the towers shall be as per the technical specifications given in the preceding clauses and IS/ICAO, International Standards recommended practices.
1.3.6.2.3 One set of Aviation Lights shall consists of one medium intensity light & two/four (as applicable) low intensity lights along with all accessories such as solar panel, control panel, batteries, cables etc.

1.3.6.2.4 **Medium Intensity Light**

Medium Intensity light shall be provided on the top of each tower. The medium light should have a night time intensity as per ICAO requirements in international Standards Recommended Practices. The light on top of the structure should flash at the rate of 20 sequence per minute. The effective intensity during night time for the medium flashing light shall be 1600 CD. The light shall conform to ICAO requirements/BS 3224a and shall have weather protection conforming to IP-55.

The above lights conforming to ICAO specifications flashing red lights shall be DC operated through a suitably sized battery bank at the operating voltage 12V/24V DC. The burning life of the lamps shall be maximum possible in view of the maintenance hazard of H.T live but in no case it should be less than 15,000 burning hours. In case of failure of the lamp before 15,000 burning hours, the same shall have to be replaced by the Contractor free of cost. The light shall be equipped with radio suppression facility conforming to BS800 in order to avoid any interference with signals of PLCC etc.

1.3.6.2.5 **Low Intensity Lights**

Two/four (as applicable) nos. of low intensity lights are required to be put on each of the towers. Placement drawing for the same shall be submitted by the bidder Contractor.

The light shall be stationary lamp with minimum effective intensity of 10 CD. of red light. The lamps shall conform to the ICAO requirement/relevant BS and shall have weather protection of minimum IP-55 class.

Two/four nos. of L.I. lamp required for each tower shall be operated through a suitable size common battery bank solar panel as per the requirement of operating voltage and load current of the type of lamps being offered.

The burning life of the lamps shall be maximum possible in view of the maintenance hazard of H.T live line, but in no case it should be less than 15,000 burning hours. In case of failure of the lamp before 15,000 hrs. the same shall have to be replaced by the Contractor free of cost even if the pendency of contract expires. Performance certificate of the lamps to be offered shall be furnished by the Contractor.

The low intensity lamp shall not generate any R.F. which can interfere with the PLCC signals.

1.3.6.2.6 **Storage Battery**

Storage Battery required for the above purpose shall be sealed maintenance free, valve regulate lead acid and suitable for mounting on the top of the transmission line towers. Contractors shall offer the most optimum capacity of the Battery Bank at 120 hour discharge rate (considering 80 % percentage usage) matching with the load requirement of the type of lamps being offered including any power loss in the associated cables. The battery sizing shall conform to JISC 8707/relevant Indian Standard or any other internationally recognized standard. The battery shall be hermetically sealed explosion proof and self-resealing type and free from orientation constraints. The working
temperature ranges shall be minimum 0 degree centigrade and maximum 50
degree centigrade. Performance certificate of the offered batteries shall be
submitted by the Contractor.

1.3.6.2.7 Battery Box
The battery box suitable for mounting on 400kV power transmission tower shall
be robust construction suitable to accommodate desired number of SOLAR
BATTERIES WITH proper clearance between the batteries. The sides and the
top of the battery box shall be made from MS sheets not less than 14 SWG
thickness duly mounted on MS angle frame. The bottom of the battery box shall
have suitably designed MS structure to freely hold the total weight of the
batteries. The batteries should be placed on insulated base with proper
drainage holes. Lifting lugs shall be provided. Dust and vermin proof lockable
doors shall be provided for safety and easy access to the batteries for the
maintenance. The battery box should incorporate the design for proper
ventilation system in order to prevent a gas concentration inside the box. The
ventilation opening shall be protected against rain/splash water and dust. The
inside of the battery box shall be lined with insulating polyurethane plating and
the exterior painted with weather proof polyurethane paint. The cable entry into
the battery box shall be through suitable cable glands.

1.3.6.2.8 Solar Modules
Solar module required for the system shall be suitable for mounting on the
transmission line towers and shall be designed for high performance, maximum
reliability and minimum maintenance and shall be installed below bottom cross
arms levels. The solar modules shall be IP 55 grade protection class. These
should be highly resistant to water, abrasion, nail, impact and other
environmental factors.

These should be placed on the tower at a most optimum angle so as to harness
the maximum solar energy and facilitate self cleaning and shall conform to
relevant Indian/International Standards.

Module mounting frames shall be weather proof suitable for mounting on tall
towers. Details of mounting frames shall be furnished by the Contractor.

Junction box shall be provided with weather proof hinged lid with provision for
cable glands entry and protections grade of class IP-55.

The Contractor shall submit the basis of selecting the numbers of solar modules.

The provision for design, supply & erection of mounting arrangements for
photovoltaic modules on the transmission towers in a suitable manner to
harness maximum solar energy shall be in the scope of the Contractor.

Provision for design, supply & erection of resting platform for the erection of
battery bank in a closed enclosure with safety arrangement on the transmission
towers shall also be in the scope of the Contractor the design and load
consideration for safety of towers due to additional plate form shall be kept in
view while designing, selecting the above.

1.3.6.2.9 Control Panels
Control panels shall consist of solar charge controller, flasher unit, sensor,
isolator, MCB, Voltmeter, Ammeter and other control gears. Panel enclosure
shall be fabricated out of 14 SWG CRCA sheet and thoroughly treated and
S suitable neoprene rubber gasket and pad locking device shall be provided and the protection class shall be of IP-55 class.

The Solar charge controller shall be most efficient and preferably fully solid state. It shall be provided with protection to load against increase in temperature. Surge, automatic low voltage and automatic disconnection and reconnection during high inrush current and normalcy respectively.

The flash regulator shall be provided for regulating light flashing. The same shall be completely solid state and provided with flash rate set points. The protection against overload current shall also be provided.

Necessary sensor/timer shall be provided in the system to “switch on” the light automatically in the evening and poor visibility period and switch off the same during day time and normal visibility period.

1.3.6.2.10 Cables, Cable Glands, Conduits and Accessories

The cable to be supplied and erected shall be of multi strands copper conductor, weather proof, PVC insulated PVC sheathed, armoured 1.1 KV grade. The same shall conform to IS:1554.

All the cable accessories such as thimble, glands etc. shall be in the scope of supply and erection of the Contractor.

Supply and erection of all the PVC conduits and accessories shall be in the scope of the contract. All the conduit and accessories shall be as per the relevant ISS or ISI brand.

The inter-connection cable/conduit will be clamped in a secured manner with the tower members and any interconnection should be made only inside the environmentally protected junction box.

1.3.6.2.11 Earthing

All the installations on the tower shall be securely and properly earthed with the tower body by using flexible copper braided wire. Cost of earthing material shall deemed to be included in the total cost.

1.4 Wind Measuring Instrument

1.4.1 Scope

The scope of the Specification covers for supply along with associated components, accessories, installation, testing & commissioning of the identified transmission line towers for wind measuring system including required softwares for recording and interpretation of results. The scope also includes to provide training to one batch of people of Owner for installation, maintenance, reading and interpretation of data.

1.4.2 Specifications for Wind Measuring System

a) Anemometer
b) Wind logger
c) Weatherproof enclosure
a) Anemometer
<table>
<thead>
<tr>
<th>Parameter</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wind speed sensor</td>
<td>3 cup Anemometer</td>
</tr>
<tr>
<td>Sensing</td>
<td>3 cup assembly mounted on friction free shaft and coupled to a chopper</td>
</tr>
<tr>
<td>Starting threshold</td>
<td>0.5 m/s</td>
</tr>
<tr>
<td>Range</td>
<td>0 to 65 m/s (preferably 0 to 75 m/s)</td>
</tr>
<tr>
<td></td>
<td>Fast response</td>
</tr>
<tr>
<td>Output</td>
<td>TTL pulse output proportional to wind speed. Suitable circuits incorporated to long line with cable loop resistance less than 50 ohms.</td>
</tr>
<tr>
<td>Accuracy</td>
<td>Better than 0.5 m/s</td>
</tr>
</tbody>
</table>

**b) Wind logger / Data logger**

- **Sampling time**: 2 seconds
- **Battery operated system. It can work Mains a. A suitable battery Charger provided**

- **LCD display, Real time clock calendar, Serial out put port (RS 232C) for connecting to Computer and parallel interface to printer or Memory Module**
- **Built in interface for sensors provided with the system**
  - Stores the following information in a battery backed RAM for later retrieval through a memory reader
  - Average wind speed (Averaging interval can be set)
  - Maximum wind speed during the set interval
  - Displays the current wind speed
  - Memory enough to store a months data

**c) Batteries**

- 2 nos. maintenance free batteries with suitable battery charger
- Solar panels for continuous charging of batteries

**d) Weather proof enclosure with arrangement of fixing**

**1.5 Tower Fabrication**

The fabrication of towers shall be in conformity with the following:

**1.5.1 Except where hereinafter modified, details of fabrication shall conform to IS:802 (Part-II) or the relevant international standards.**

**1.5.2 The tower structures shall be accurately fabricated to connect together easily at site without any undue strain on the bolts.**
1.5.3 No angle member shall have the two leg flanges brought together by closing the angle.

1.5.4 The diameter of the hole shall be equal to the diameter of bolt plus 1.5mm.

1.5.5 The structure shall be such that all parts are accessible for inspection and cleaning. Drain holes shall be provided at all points where pockets of depression are likely to hold water.

1.5.6 All steel sections before any work is done on them, shall be carefully leveled, straightened and made true to detailed drawings by methods which will not injure the materials so that when assembled, the adjacent matching surfaces are in close contact throughout. No rough edges shall be permitted in the entire structure.

1.5.7 Drilling and Punching

1.5.7.1 Before any cutting work is started, all steel sections shall be carefully straightened and trued by pressure and not by hammering. They shall again be trued after being punched and drilled.

1.5.7.2 Holes for bolts shall be drilled or punched with a jig but drilled holes shall be preferred. The punching may be adopted for thickness up to 16mm. Tolerances regarding punch holes are as follows:

   a) Holes must be perfectly circular and no tolerances in this respect are permissible.

   b) The maximum allowable difference in diameter of the holes on the two sides of plates or angle is 0.8mm. i.e. the allowable taper in a punched holes should not exceed 0.8mm on diameter.

   c) Holes must be square with the plates or angles and have their walls parallel.

1.5.7.3 All burns left by drills or punch shall be removed completely. When the tower members are in position the holes shall be truly concentric/matching to each other. Drilling or reaming to enlarge holes shall not be permitted.

1.5.8 Erection mark

1.5.8.1 Each individual member shall have erection mark conforming to the component number given to it in the fabrication drawings. The mark numbers shall be marked with marking dies of 16mm size before galvanising and shall be legible after galvanising.

1.5.8.2 Erection Mark shall be A-BB-CC-DDD

   A = Owner’s code assigned to the Contractors- Alphabet

   BB = Contractor’s Mark-Numerical

   CC = Tower Type Alphabet.

   DDD = Number mark to be assigned by Contractor - Numerical.

   Erection mark for high tensile steel members shall be prefixed by the letter “H”
1.6 Quantities and weights

1.6.1 The quantities of the following items have been envisaged in Metric Tonne (MT) in the relevant price Schedules for various types of towers:-

i) Basic Body.

ii) Body Extensions.

iii) Leg Extension.

iv) Stubs & Cleats

v) Bolts & Nuts including spring washers and step bolts etc.

During detail engineering, proto assembly of each of the above items shall be inspected and approved by TPGL and subsequently shall be released for fabrication and manufacturing as per the Technical Specification by the Contractor. The manufacturing of the above items shall be taken up in such a manner that the Equipment/Material offered for inspection to TPGL are on completed tower basis for each type of tower, completed Stubs & Cleats set basis so as to facilitate availability of erectable tower of each type and erectable stubs & cleats set for casting of foundation. After inspection of the offered Equipment/Material by TPGL representative(s), CIP shall be issued by TPGL for the material meeting the Technical Specification. However, MICC shall be issued only on Completed Tower Basis for each type of tower (comprising the required Basic Body, body extensions wherever required, four (4) equal or defined unequal Leg Extension, Bolts & Nuts along with Packing and Spring Washers) and on completed Stubs & Cleats set basis for each type of tower foundations (comprising a set of stubs & Cleats, required Bolts and Nuts along with Spring Washers).

Accordingly, the payment shall be released on completed Tower Basis for each type of tower (comprising the Basic Body, body extensions, wherever applicable, bolts & nuts along with spring washer and step bolts, unequal leg extensions wherever applicable for a completed tower) and on completed Stubs and Cleats set basis for each type of foundation (comprising a set of stubs & cleats, required Bolts and nuts along with Spring Washers) based on the weight of the tower parts as calculated as per Clause 1.9.3 and fasteners based on the unit rates incorporated in the contract.

1.6.2 The provisional quantities required are mentioned in the respective Schedules of BPS. Final quantities shall be determined after completion and approval of the detailed route survey. The final quantities of tower shall be confirmed by the Owner based on the requirement of quantities of various towers furnished by the Contractor after completion of detailed survey. Hence it will be responsibility of the Contractor to intimate the exact requirement of all towers and various line materials required for line immediately after the survey.

The Owner reserves the right to order the final quantities including reasonable quantities of spares for which the rates quoted in the Bid shall be valid. Regarding quantity variation the provisions of relevant clauses of SCC shall apply.

1.6.3 The estimated total weight of tower/tower parts as well as bolts & nuts along with spring washers and step bolts to be supplied by the Contractor under various packages have been envisaged in the relevant Price Schedule. Though fully galvanised tower parts are to be supplied, the weight of tower shall mean the
weight of tower calculated by using the black sectional (i.e. ungalvanised) weight of steel members of the size indicated in the approved fabrication drawings and bill of materials, without taking into consideration the reduction in weights due to holes, notches and level cuts etc. but taking into consideration the weight of the D shackles, hangers, strain plates, pack plates, gusset plates and pack washers etc. The weight of stub and cleats also shall be calculated in similar manner. The weight of gusset plates shall mean the weight of its circumscribing rectangle, without taking into considerations the reductions in weight due to holes, notches etc. For bolts and nuts along with spring washers and step bolts, the weight per tower shall be calculated from the bolt schedule applicable to each type of towers and body extensions as approved by the Owner. The rate quoted by the bidder for tower/tower parts supply, is deemed to be inclusive of galvanising charges including the cost of zinc.

1.6.4 The contractor is permitted to get inspected and supply upto 2.5% extra fasteners to take care of losses during erection. No payment shall be admissible for these extra supplies.

1.7 Galvanising

1.7.1 Fabricated Tower Parts & Stubs

The tower parts, stubs and pack washers shall be hot dip galvanized. The galvanization shall be done as per requirements of IS 4759 after all fabrication work is completed. The contractor shall also take guidelines from the recommended practices for hot dip galvanizing laid down in IS 2629 while deciding and implementing galvanizing procedure. The mandatory requirements however, are specified herein.

Unless otherwise specified the fabricated tower parts and stubs shall have a minimum overall Zinc coating of 610 gms per sq. m of surface except for plates below 5mm which shall have Zinc coating of 460 gms per sq. m of surface. The average zinc coating for sections 5mm & above shall be maintained as 87 microns and that for sections below 5mm shall be maintained as 65 microns.

The zinc coating shall be adherent, reasonably uniform, smooth, continuous and free from imperfections such as black/ bare spots, ash rust strains, bulky white deposits / wet storage strains and blisters.

The surface preparation for fabricated tower parts and stubs for hot dip galvanizing shall be carried out as indicated herein below:

(i) Degreasing & Cleaning of Surface: Degreasing and cleaning of surface, wherever required, shall be carried out in accordance with clause 4.1 of IS 2629-1985. After degreasing the article shall be thoroughly rinsed. However, if acidic degreasers are used rinsing is not required.

(ii) Pickling: Pickling shall be done using either hydrochloric or sulphuric acid as recommended at clause 4.3 of IS 2629-1985. The actual concentration of the acids and the time duration of immersion shall be determined by the Contractor depending on the nature of material to be pickled. Suitable inhibitors also shall be used with the acids to avoid over pickling. The acid concentration, inhibitors used, and maximum allowable iron content shall form part of plant standard to be formulated and submitted to employer along with Quality Assurance Program.
(iii) Rinsing: After pickling, the material shall be rinsed, preferably in running water to remove acid traces, iron particles or any other impurities from the surface. Two rinse tanks are preferable, with water cascading from the second tank to the first to ensure thorough cleaning. Wherever single tank is employed, the water shall be periodically changed to avoid acid contamination, and removal of other residue from the tank.

(iv) Fluxing: The rinsed article shall be dipped in a solution of Zinc ammonium chloride. The concentration and temperature of the flux solution shall be standardized by the contractor depending on the article to be galvanized and individual circumstances. These shall form part of plant standard to be formulated and submitted to employer along with Quality Assurance Program. The specific gravity of the flux solution shall be periodically monitored and controlled by adding required quantity of flux crystals to compensate for drag-out losses. Free acid content of the flux solution also shall be periodically checked and when it is more than two (2) grams of free acid per litre of the solution, it shall be neutralized. Alternatively, Ph value should be monitored periodically and maintained between 5.0 to 5.5.

(v) Drying: When dry galvanizing is adopted the article shall be thoroughly dried after fluxing. For the purpose of drying, the contractor may use hot plate, air oven or any other proven method ensuring complete drying of the article after fluxing and prior to dipping in the molten zinc bath. The drying process shall be such that the article shall not attain a temperature at which the flux shall get decomposed. The article thus dried shall be galvanized before the flux coating picks up moisture from the atmosphere or the flux layer gets damaged or removed from the surface. The drying procedure, time duration, temperature limits, time lag between fluxing, drying, galvanizing etc shall form part of plant standard to be formulated and submitted to employer along with Quality Assurance Program.

(vi) Quality of Zinc: Any one or combination of the grades of zinc specified in IS 209 or IS 13229 or other comparable international standard shall be used for galvanizing. The contractor shall declare the grade(s) of zinc proposed to be used by them for galvanizing. The molten metal in the zinc bath shall contain minimum 98.5 % zinc by mass. It shall be periodically measured and recorded. Zinc aluminum alloy shall be added as per IS 2629.

(vii) Dipping Process: The temperature of the galvanizing bath shall be continuously monitored and controlled. The working temperature of the galvanizing bath shall be maintained at 450+/ - 10 degree C. The article should be immersed in the bath as rapidly as possible without compromising on safety aspects. The galvanizing bath temperature, immersion angle & time, time duration of immersion, rate of withdrawal etc shall be monitored and controlled depending upon the size, shape, thickness and chemical composition of the article such that the mass of zinc coating and its uniformity meets the specified requirements and the galvanized surface is free from imperfections and galvanizing defects.

(viii) Post Treatment: The article shall be quenched in water. The quench water is to be changed / drained periodically to prevent corrosive salts from accumulating in it. If water quenching is not done then necessary
cooling arrangements should be made. The galvanized articles shall be dipped in chromating solution containing sodium dichromate and sulphuric acid or chromic acid base additive at a predetermined concentration and kept at room temperature to retard white rust attack. The temperature of the chromate solution shall not exceed 65 degree C. The articles shall not be stacked immediately after quenching and dichromating. It shall be ensured that the articles are dry before any further handling operation.

(ix) Storing, Packing and Handling: In order to prevent white rust formation sufficient care should be exercised while storing handling and transporting galvanized products. The articles shall be stored in an adequately ventilated area. The articles shall be stored with spacers in between them and kept at an inclination to facilitate easy drainage of any water collected on the articles. Similar care is to be taken while transporting and storing the articles at site.

The Contractor shall prepare a detailed galvanizing procedure including Flow Chart with control parameters and all plant standards as required above and submit to POWERGRID for approval as part of Quality Assurance Plan.

1.7.2. Fasteners.

For fasteners, the galvanizing shall conform to IS-1367(Part-13). The galvanizing shall be done with centrifuging arrangement after all mechanical operations are completed. The nuts, may however be tapped (threaded) or rerun after galvanizing and the threads oiled. The threads of bolts & nuts shall have a neat fit and shall be such that they can be turned with finger throughout the length of the threads of bolts and they shall be capable of developing full strength of bolts. Spring washers shall be electro galvanized as per Grade-IV of IS-1573.

1.8 Earthing

Each tower shall be earthed the tower footing resistance shall not exceed 10 ohms. The Contractor shall measure the tower footing resistance (TFR) of each tower during dry weather after it has been erected and before the stringing of the earth wire. Pipe type earthing and counterpoise type earthing shall be done as required in accordance with the following standards:


IS:5613  Code of practice for Design, Installation and maintenance (Part-II/Section-2) of overhead power lines.

1.8.1 The drawings for pipe & counterpoise type earthing are enclosed with these specifications.

1.8.2 For counterpoise type earthing the earthing will vary depending on soil resistivity. For soil resistivity less than 1500 ohms-meter, earthing shall be established by providing 4 lengths of 30m counterpoise wire. Otherwise, for soil resistivity greater than 1500 ohms meter earthing shall be established by providing 4 length of 70m counterpoise wire.

1.8.3 The provisional quantities for pipe type earthings and counterpoise earthing are indicated in the BPS. The bidders are required to quote unit rates for the same in appropriate schedule of BPS. The quoted price shall include fabrication, supply and installation of earthing material including supply of coke, salt etc. In
case of counterpoise type earthing, the unit rates shall correspond to 120 meters of counterpoise wire per tower.

1.8.4 Earthing for River Crossing Towers /Pile foundation

Galvanised earthing strip of flat 50 x 6 mm is to be provided in two legs of tower for each location with proper arrangement of connecting these strips by 16mm bolts shall be provided in the stubs. For pile foundation, the strip has to be taken up to scour level along the concrete of pile foundations. Only bolted connections are allowed for connecting this strip to achieve desired length. Contractor shall submit the detailed drawing for approval of Owner before installations.

1.9 Standards

1.9.1 The design, manufacturing, fabrication, galvanising, testing, erection procedure and materials used for manufacture and erection of towers, design and construction of foundations shall conform to the following Indian Standards (IS)/International Standards which shall mean latest revisions, with amendments/changes adopted and published, unless specifically stated otherwise in the Specification. In the event of supply of material conforming to Standards other than specified, the Bidder shall confirm in his bid that these Standards are equivalent to those specified. In case of award, salient features of comparison between the Standards proposed by the Bidder and those specified in this document will be provided by the Contractor to establish their equivalence.

1.9.2 The material and services covered under these specifications shall be performed as per requirements of the relevant standard code referred hereinafter against each set of equipment and services. Other internationally acceptable standards which ensure equal or higher performance than those specified shall also be accepted.

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Indian Standards (IS)</th>
<th>Title</th>
<th>Internationally recognised Standards/Guides</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.</td>
<td>IS 278-1991</td>
<td>Galvanised Steel Barbed wire</td>
<td>ASTM A131</td>
</tr>
<tr>
<td>3.</td>
<td>IS 800-1991</td>
<td>Code of Practice for General Building Construction in Steel</td>
<td>CSA 6.1</td>
</tr>
<tr>
<td>Sl. No.</td>
<td>Indian Standards (IS)</td>
<td>Title</td>
<td>Internationally recognised Standards/Guides</td>
</tr>
<tr>
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<td>---------------------------------------------</td>
</tr>
<tr>
<td>5.</td>
<td>IS:808-1991</td>
<td>Dimensions for Hot Rolled Steel Beam, Column, Channel and Angle Sections.</td>
<td>IEC 652</td>
</tr>
<tr>
<td>7.</td>
<td>IS:1363-1990</td>
<td>IS: 1363-1990 Hexagon Nuts (size range M5 to M36)</td>
<td></td>
</tr>
<tr>
<td>10.</td>
<td>IS:1573-1991</td>
<td>Electro-Plated Coatings of zinc on iron and Steel</td>
<td></td>
</tr>
<tr>
<td>11.</td>
<td>IS:1852-1993</td>
<td>Rolling and Cutting Tolerances of Hot Rolled Steel Products</td>
<td></td>
</tr>
<tr>
<td>14.</td>
<td>IS:2062-1992</td>
<td>Steel for general structural purposes</td>
<td></td>
</tr>
<tr>
<td>16.</td>
<td>IS:2551-1990</td>
<td>Danger Notice Plates</td>
<td></td>
</tr>
<tr>
<td>17.</td>
<td>IS:2629-1990</td>
<td>Recommended Practice for Hot Dip Galvanising of iron and steel.</td>
<td></td>
</tr>
<tr>
<td>Sl. No.</td>
<td>Indian Standards (IS)</td>
<td>Title</td>
<td>Internationally recognised Standards/Guides</td>
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<td>----------------------------------------------------------------------</td>
<td>---------------------------------------------</td>
</tr>
<tr>
<td>19</td>
<td>IS:3043-1991</td>
<td>Code of Practice for Earthing</td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>IS:3063-1994</td>
<td>Single coil Rectangular section Spring Washers for Bolts, Nuts Screws</td>
<td>DIN-127</td>
</tr>
<tr>
<td>21</td>
<td>IS:3757-1992</td>
<td>High Strength Structural Bolts</td>
<td></td>
</tr>
<tr>
<td>22</td>
<td>IS:4759-1990</td>
<td>Specification for Hot zinc coatings on structural steel and other Allied products</td>
<td></td>
</tr>
<tr>
<td>23</td>
<td>IS:5369-1991</td>
<td>General Requirements for Plain Washers</td>
<td></td>
</tr>
<tr>
<td>24</td>
<td>IS:5613-1993</td>
<td>Code of Practice for Design installation and Maintenance of Overhead Power Lines Section 1 Design Part 2, Section 2 Installation and Maintenance</td>
<td></td>
</tr>
<tr>
<td>26</td>
<td>IS:6623-1992</td>
<td>High Strength Structural Nuts</td>
<td></td>
</tr>
<tr>
<td>27</td>
<td>IS:6639-1990</td>
<td>Hexagon Bolts for Steel Structure.</td>
<td>ASTM A394, CSA B334</td>
</tr>
<tr>
<td>28</td>
<td>IS:6745-1990</td>
<td>Method for Determination of weight of Zinc coated iron and Steel Articles.</td>
<td>ASTM A90</td>
</tr>
<tr>
<td>29</td>
<td>IS:8500-1992</td>
<td>Specification for Weldable Structural Steel (Medium &amp; High Strength Qualities)</td>
<td></td>
</tr>
<tr>
<td>30</td>
<td>IS:10238-1989</td>
<td>Step Bolts for Steel Structures</td>
<td></td>
</tr>
<tr>
<td>31</td>
<td>IS:12427-1988</td>
<td>Bolts for Transmission Line Towers</td>
<td></td>
</tr>
<tr>
<td>32</td>
<td></td>
<td>Indian Electricity Rules.</td>
<td></td>
</tr>
<tr>
<td>33</td>
<td></td>
<td>Publication No. 19(N)/700 Regulation for Electrical Crossing of Railway Tracks</td>
<td></td>
</tr>
</tbody>
</table>
2.0 Foundations

2.1 Foundation includes supply of all labour, tools & machineries, materials such as cement, sand, coarse aggregates and reinforcement steel and all associated activities, such as, excavation, concreting etc.

2.2 Type of Foundations

The foundation shall be of open cast type. Plain Cement Concrete/Reinforced Cement Concrete footing shall be used for all type of normal towers. All the four footings of the tower and their extensions shall be similar for a particular location, except where soil condition and or water table are different at different legs. The total depth of foundation, below ground level shall be 3.0 to 3.5 meters. For Hard Rock type and also where specific site conditions / properties demand foundation of different depths (lower or higher), the same shall be adopted.

2.3 Classifications of Foundations:

The foundation designs shall depend upon the type of soil, sub soil water level and the presence of surface water which have been classified as follows (except pile foundations which is described in Section V of this specification).

2.3.1 Normal dry

To be used for locations where normal dry cohesive or non-cohesive soils are met. Foundations in areas where surface water encountered from rain runoff or agricultural fields (except paddy fields) shall also be classified as normal dry.

2.3.2 Sandy Dry Soil

To be used for locations where cohesion less pure sand or sand with clay content less than 10% met in dry condition.

2.3.3 Wet

To be used for locations:

a) Where sub-soil water is met between 1.5 meters and the depth of foundation below the ground level.

b) Which are in surface water for long period with water penetration not exceeding one meter below the ground level e.g. paddy fields.

2.3.4 Partially Submerged

To be used at locations where sub-soil water table is met between 0.75 meter and 1.5metre below the ground level.

2.3.5 Fully Submerged

To be used at locations where sub-soil water table is met at less than 0.75 meter below the ground level.

2.3.6 Black Cotton Soil
To be used at locations where soil is clayey type, not necessarily black in colour, which shrinks when dry and swells when wet, resulting in differential movement. For designing foundations, for such locations, the soil is considered submerged in nature.

2.3.7 Fissured - Rock

To be used at locations where decomposed or fissured rock, hard gravel, kankar, limestone, latemite or any other soil of similar nature is met. Under cut type foundation is to be used for fissured rock locations.

In case of fissured rock locations, where water table is met at 1.5M or more below ground level, wet fissured rock foundations shall be adopted. Where fissured rock is encountered with subsoil water table less than 0.75 meter below ground level, submerged fissured rock foundations shall be adopted. In case of dry locations dry fissured rock foundations shall be adopted.

2.3.8 Hard Rock

The locations where chiseling, drilling and blasting is required for excavation, Hard rock type foundations are to be used. For these locations rock anchoring is to be provided to resist uplift forces.

2.3.9 Where soil is of composite in nature, classification of foundation shall be according to the type of soil predominant in the footing.

2.4 Design of Foundations

2.4.1 Design of foundations as classified under Cl. 2.3 for all towers and towers with extensions shall be developed by the Owner based on the soil properties as given in Table below. The indicative shape of foundation is also enclosed in this specification.

2.4.2 Depending on the site conditions other types of foundations shall also be designed and provided by the Owner suitable for Intermediate conditions under the above classifications to effect more economy or to suit specific site conditions encountered.

2.4.3 The proposal for these types of foundations shall be submitted by the Contractor based on the detailed soil investigation and duly recommended by Engineer-in-charge.

2.4.4 The construction drawings/working drawings of all type of foundations classified as in clause 2.3 shall be provided to the contractor progressively during execution stage. The drawings for other foundations designed for specific site conditions shall be provided based on actual site requirements only.

2.4.5 The special foundations like pile foundations if required shall also be designed by the Owner based on detailed soil investigation report. The working drawing of these foundations shall be provided by the Employer to the Contractor during execution stage based on requirements. For detailed specification for pile foundations Section VIII of this specification shall apply.
2.4.6 The provisional quantities of excavation, concreting and reinforcement steel required for the project are furnished in the BPS.

2.5 Soil Investigation

The contractor shall take reference to the soil investigations already carried out by the Owner. However, the Contractor may be required to undertake soil investigation as per clause 3.5 of Section III at some tower locations as required by the Owner. The provisional number of soil testing locations are furnished in BPS.

2.6 Properties of Concrete

2.6.1 For open cast type foundation

The cement concrete used for the foundations shall be of grade M-20 having 1:1.5:3 nominal mix ratio with 20mm coarse aggregate for chimney portion and 40mm aggregates for pyramid or slab portion. All the properties of concrete regarding its strength under compression, tension, shear, punching and bending etc. as well as workmanship will conform to IS:456.

2.6.2 The Quantity of minimum cement to be used per unit quantity of consumption for different mix (nominal mix) of concrete should be as follows:

<table>
<thead>
<tr>
<th>Sl.no.</th>
<th>Description</th>
<th>Unit</th>
<th>Quantity of minimum cement to be used per Unit quantity of work (in kgs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>1:1.5:3 nominal mix concrete</td>
<td>Cu.m.</td>
<td>400</td>
</tr>
<tr>
<td>2.</td>
<td>1:2:4 nominal mix concrete</td>
<td>Cu.m.</td>
<td>320</td>
</tr>
<tr>
<td>3.</td>
<td>1:3:6 nominal mix concrete</td>
<td>Cu.m.</td>
<td>220</td>
</tr>
<tr>
<td>4.</td>
<td>Random Rubble Masonry with 1:6 cement mortar</td>
<td>Cu.m.</td>
<td>83</td>
</tr>
</tbody>
</table>

2.6.3 Cement used shall be ordinary Portland Cement, unless mentioned otherwise, conforming to the latest Indian Standard Code IS:269 or IS:8112 or IS:12269.

Alternatively, other varieties of cement other than ordinary Portland Cement such as Portland Pozzolana Cement conforming to IS:1489 (latest edition) or Portland Slag Cement conforming to IS:455 (Latest edition) can also be used. The Contractor shall submit the manufacturer’s certificate, for each consignment of cement procured, to the Employer. However, Employer reserves the right to direct the Contractor to conduct tests for each batch/lot of cement used by the Contractor and Contractor will conduct those tests free of cost at the laboratory so directed by the Employer. The Contractor shall also have no claim towards suspension of work due to time taken in conducting tests in the laboratory. Changing of brand or type of cement within the same structure shall not be permitted without the prior approval of the
Employer. Sulphate Resistant Cement shall be used if Sulphate content is more than the limits specified in IS:456, as per Geotechnical investigation report.

The curing time of cement will be decided at the time of execution of the work under the contract based on the certificate form a reputed laboratory which will be obtained and submitted by the Contractor.

2.6.4 Concrete aggregates shall confirm to IS:383.

2.6.5 The water used for mixing concrete shall be fresh, clean and free from oil, acids & alkalis, organic materials or other deleterious substances. Potable water is generally preferred.

2.6.6 Reinforcement shall confirm to IS:432 for MS bars and hard drawn steel wires and to IS:1139 and IS:1786 for deform and cold twisted bars respectively. Thermo Mechanically Treated (TMT) bars (equivalent grade ) in place of cold twisted bars are also accepted. All reinforcement shall be clean and free from loose mill scales, dust, loose rust and coats of paint, oil or other coatings, which may destroy or reduce bond. Contractor shall supply, fabricate and place reinforcement to shapes and dimensions as indicated or as required to carry out the intent of approved foundation drawings and Specifications.

2.7 Construction of Tower Foundation, Stub Setting and Earthing

2.7.1 Excavation

2.7.1.1 The excavation work for foundations shall be taken up by the contractor progressively stretch wise / section wise after obtaining approval from Owner for the proposed stretch wise / section wise tower schedule, profile etc. as per detailed survey along the approved route alignment.

2.7.1.2 Except as specifically otherwise provided, all excavation for footings shall be made to the lines and grades of the foundations. The excavation wall shall be vertical and the pit dimensions shall be based on an assumed clearance of 150mm on all sides of the foundation pad. For footings with undercut, care shall be taken to carry out excavation as per drawing without any side clearance. All excavation shall be protected so as to maintain a clean sub grade and provide worker safety until the footing is placed, using timbering, shoring, shuttering, dewatering etc. as approved by the Owner. Contractor shall especially avoid disturbing the bearing surface of the pad. Any sand, mud, silt or other undesirable materials which may accumulate in the excavated pit or borehole shall be removed by Contractor before placing concrete.

2.7.1.3 The soil to be excavated for tower foundations shall be classified as follows depending upon the physical state of the soil at the time of excavation irrespective of the type of foundation installed.

a) Dry Soil

Soil removable either manually, by means of a spade and shovel or mechanically by proclam, excavators etc.

Excavation done in dry soil for wet, partially submerged, fully submerged and wet black cotton type of foundations shall also be covered under this

b) Wet Soil
Where the subsoil water table is encountered within the range of foundation depth or land where pumping or bailing out of water is required due to presence of surface water shall be treated as wet soil. The excavation done in wet soil in case of wet, partially submerged, fully submerged and wet black cotton type of foundation shall also be covered under this.

c) **Dry Fissured Rock**

Limestone, laterite, hard conglomerate or other soft or fissured rock in dry condition which can be quarried or split with crowbars, wedges, pickaxes etc. However, if required, light blasting may be resorted to for loosening the material but this will not in any way entitle the material to be classified as hard rock.

d) **Wet Fissured Rock**

Above fissured rock, when encountered with subsoil water within the range of foundation depth or land where pumping or bailing out of water is required, shall be treated as wet fissured rock.

e) **Hard Rock**

Any rock excavation, other than specified under fissured rock above, for which blasting, drilling, chiseling are required. The unit rate quoted for hard rock excavation shall be inclusive of all costs for such drilling (including drilling required for anchoring), chiseling and blasting, etc.

2.7.1.4 No extra payment shall be admitted for the removal of fallen earth into a pit or borehole once excavated.

2.7.1.5 Where rock is encountered, the holes for tower footings shall preferably be drilled. Blasting where resorted to as an economy measure, shall be done with utmost care to minimise fracturing rock and using extra concrete for filling the blasted area. All necessary precautions for handling and use of blasting materials shall be taken. In cases where unnecessarily large quantities are excavated/blasted, resulting in placement of large volumes of concrete, payment of concrete shall be limited to design volumes of excavation, concreting, reinforcement etc. In case where drilling is done, the stubs may be shortened suitably with the approval of the Owner.

2.7.1.6 The Contractor shall arrange & supply requisite blasting material, and be responsible for its storage and use, without any extra cost to the Owner.

2.7.1.7 Indian Standard IS:3764 shall be followed regarding safety of excavation work.

2.8 **Unit Rates and Measurement for Foundation**

2.8.1 The indicative shape of foundations are enclosed in this Specification. The bidder is required to quote the unit rates for different foundation activity namely, excavation for different types of soils, concreting, supply and placement of reinforcement steel and stub setting in the BPS.

2.8.2 The unit rates of excavation for each type of soil shall include excavation along with all associated activities like shoring, shuttering, dewatering till completion of foundation work stock piling, dressing, back filling of foundations after concreting with excavated/borrowed earth (irrespective of lead) and consolidation of earth, carriage of surplus earth to the suitable point of disposal as required by the
Owner or any other activity required for completion of foundation work in all respects.

The measurement for excavation shall be made on the basis of design excavation volume arrived at considering dimension of pit leaving 150mm gap around (except for under cut foundations) the base pad or actually excavated whichever is less and the unit rate of this item as indicated in Letter of Award. The payment for excavation shall be made as per actual type of soil encountered at the time of excavation, but the total payment for excavation portion shall not exceed the amount as payable for excavation considering the soil type same as that of foundation classification. The decision of the Owner shall be final and binding with respect to classification of soil and foundations.

2.8.3 Form boxes shall be used for casting of foundations. The unit rate of concreting shall include the cost of supply, fabrication and placement of form boxes, cement, water, coarse and fine aggregates mixing and placing of concrete, curing of concrete and any other activities related / required for completion of concreting works of foundation. The payment for this item shall be made as per the actual volumes of concreting completed but limited to design volume based on unit rates indicated in the letter of award.

2.8.4 The unit rate of ‘Reinforcement Steel’ shall include supply and placement of reinforcement steel, stirrups, wire for binding the reinforcement, chairs, bolsters and spacers etc. as required to complete the foundation work. The measurement of reinforcement steel for payments shall be made based on the calculated weight of reinforcement steel in tones corrected to third place of decimal as per relevant Indian Standard and as per working drawing or the quantity of reinforcement steel actually used, whichever is less. No allowance permitted towards wastage.

2.9 Setting of Stubs

2.9.1 The stubs shall be set correctly and precisely in accordance with approved method at the exact location, alignment and levels with the help of stub setting templates and leveling instruments. Stubs setting shall be done in the presence of Owner’s representative available at site where required and for which adequate advance intimation shall be given to Owner by Contractor. Tolerances as per provisions of IS:5613 shall be allowed for stub setting.

2.9.2 Setting of stub at each location shall be approved by Owner.

2.9.3 However, in hilly region for towers with unequal leg extensions and for river crossing towers, props may be used with complete accuracy and high skilled supervision, subject to prior approval from Owner.

2.9.4 For all towers the Contractor shall submit for approval the proposed method for setting of stubs.

2.10.5 Stub Setting Templates / Props

2.10.5.1 Stub setting templates shall be arranged by the Contractor at his own cost for all heights of towers. Stub templates shall be of adjustable type. The Contractor shall also arrange for props for setting of stubs at specific locations where use of prop is approved by the Owner. Stub templates / props should be painted.
2.10.5.2 The Contractor shall deploy sufficient number of templates / props for timely completion of the line without any extra cost to Owner.

2.10.5.3 However following minimum number of stub setting templates may be deployed by the Contractor for every 100km of line length subject to minimum of 5 templates for suspension tower:

<table>
<thead>
<tr>
<th>Templates for tower type</th>
<th>Nos. to be deployed</th>
</tr>
</thead>
<tbody>
<tr>
<td>A/DA</td>
<td>10</td>
</tr>
<tr>
<td>For each type of B/DB, C/DC and D/DD type</td>
<td>3</td>
</tr>
<tr>
<td>For A/DA +18/25 M</td>
<td>1</td>
</tr>
<tr>
<td>for D/DD+18/25 M</td>
<td>1</td>
</tr>
</tbody>
</table>

However, if more templates are required for timely completion of the lines, the Contractor shall deploy the same without any extra cost to Owner.

The number of sets of prop (if permitted) to be supplied, will depend as per actual site condition and completion schedule of line.

2.10.5.4 One set of each type of stub setting template / props (if used) shall be supplied to the Owner, on completion of the project, at no extra cost to Owner.

2.10 Mixing, Placing and Compacting of Concrete

2.10.1 The concrete shall be mixed in the mechanical mixer. However, in case of difficult terrain, hand mixing may be permitted at the discretion of the Owner. The water for mixing concrete shall be fresh, clean and free from oil, acids and alkalis. Saltish or blackish water shall not be used.

2.10.2 Mixing shall be continued until there is uniform distribution of material and mix is uniform in colour and consistency, but in no case the mixing be carried out for less than two minutes. Normal mixing shall be done close to the foundation but exceptionally, in difficult terrain, the concrete may be mixed at the nearest convenient place. The concrete shall be transported from the place of mixing to the place of final deposit as rapidly as practicable by methods which shall prevent the segregation or loss of any ingredient. The concrete shall be placed and compacted before setting commences.

2.10.3 To avoid the possibility of reinforcement rods being exposed due to unevenness of the bottom of the excavated pit, a pad of lean concrete 50mm thick and corresponding to a 1:3:6 nominal mix shall be provided at the bottom of the pad.

2.10.4 Form boxes shall be used for casting all types of foundations except at an undercut interface for which the adjoining subsurface material shall provide adequate support.

2.10.5 The concrete shall be laid down in 150mm layers and consolidated well, so that the cement cream works, up to the top and no honey-combing occurs in the concrete. A mechanical vibrator shall be employed for compacting the concrete. However, in case of difficult, terrain, manual compaction may permitted at the discretion of the Owner. Monolithic casting of foundations must be carried out. However, in case of unavoidable circumstances, a key construction joint can be provided at the chimney-pad interface subject to approval of the Owner.
However nothing extra shall be paid to the Contractor for providing such construction joints. After concreting the chimney portion to the required height, the top surface should be finished smooth with a slight slope towards the outer edge for draining rain water.

2.10.6 Wet locations shall be kept completely dewatered, both during and 24 hours after placing the concrete, without disturbance of the concrete.

2.10.7 If minor defects in concrete surface is found after the form work has been removed, the damage shall be repaired with a rich cement sand mortar to the satisfaction of the Owner before the foundation is back filled.

2.11 Curing

The concrete shall be cured by maintaining the concrete wet for a period of at least 10 days after placing. Once the concrete has set for 24 hours the pit may be backfilled with selected moistened soil and well consolidated in layers not exceeding 200mm thickness and thereafter both the backfill earth and exposed chimney shall be kept wet for the remainder of the prescribed 10 days. The exposed concrete chimney shall also be kept wet by wrapping gunny bags around it and wetting the bags continuously during the critical 10 days period.

2.12 Backfilling and Removal of Stub Templates

2.12.1 After opening of formwork and removal of shoring, timbering, etc., backfilling shall be started after repairs, if any, to the foundation concrete. Backfilling shall normally be done with the excavated soil, unless it is a clay type or it consists of large boulders/stones, in which case the boulders shall be broken to a maximum size of 80-mm. At locations where borrowed earth is required for backfilling, Contractor shall bear the cost irrespective of leads & lift.

2.12.2 The backfilling materials shall be clean and free from organic or other foreign materials. A clay type soil with a grain size distribution of 50% or more passing the no. 200 sieve are unacceptable for backfilling. The earth shall be deposited in maximum 200mm layers, levelled, wetted if necessary and compacted properly before another layer is deposited. The moisture content for compaction shall be based on the Proctor compaction test results given in the Geo-technical Report, Clause 3.0 of section III. The density of the compacted backfill material may further be verified to the satisfaction of the Owner based on the sand-cone method described in the ASTM D1556-82 standard.

2.12.3 The backfilling and grading shall be carried to an elevation of about 75mm above the finished ground level to drain out water. After backfilling 50mm high, earthen embankment (band) will be made along the sides of excavation pits and sufficient water will be poured in the backfilling earth for at least 24 hours. After the pits have been backfilled to full depth the stub template can be removed.

2.13 Benching

When the line passes through hilly/undulated terrain, levelling the ground may be required for casting of tower footings. All such activities shall be termed benching and shall include cutting of excess earth and removing the same to a suitable point of disposal as required by Owner. Benching shall be resorted to only after approval from Owner. Volume of the earth to be cut shall be measured before cutting and approved by Owner for payment purposes. Further, to minimise benching, unequal leg extensions shall be considered and
provided if found economical. The proposal shall be submitted by the Contractor with detailed justification to the Owner.

2.14 Protection of Tower and Tower Footing

2.14.1 Tower shall be spotted such that the quantity of revetment are optimum. For tower locations in undulated terrain such as hill / mountain slopes, options like use of unequal leg extensions for towers, unequal chimney extensions etc. shall be explored by the contractor for optimizing the need for revetment & benching.

2.14.2 The work shall include all necessary stone revetments, concreting and earth filling above ground level, the clearing from site of all surplus excavated soil, special measures for protection of foundation close to or in nalis, river bank / bed, undulated terrain, protection of up hill / down hill slopes required for protection of tower etc., including suitable revetment or galvanised wire netting and meshing packed with boulders. The top cover of stone revetment shall be sealed with M-15 concrete (1:2:4 mix). Contractor shall recommend protection at such locations wherever required. Details of protection of tower/tower footing are given in drawing enclosed with these specifications for reference purpose only.

2.14.3 Tower footings shall generally be backfilled using soil excavated at site unless unsuitable for backfilling. In the latter case, backfilling shall be done with borrowed earth of suitable quality irrespective of leads and lift. The unit rate for backfilling quoted in BPS shall include the required lead and consolidation and leveling of earth after backfilling.

2.14.4 The provisional quantities for protection work of foundations are furnished in BPS. The unit rates shall also be applicable for any quantity variations during execution. The same unit rates shall hold good for protection work carried out on down hills or up hills slopes applicable for the tower locations.

2.14.5 The unit rates for random rubble masonry revetment quoted in price schedule shall also include excavation & (1:6) random masonry and unit rate for top sealing with M-15 concrete. For payment purposes the volume of random rubble masonry revetment shall be measured from bottom to top sealing coat and paid at the unit rates indicated in the Letter Of Award.

No extra payment shall be made for allied works such as excavation for revetment, packed stone at head of weep holes etc. However, no deduction shall be made for the volume enclosed by weep holes.

2.14.6 For some of the locations in nalis, river bed or undulated terrain etc., boulders of minimum. 150mm size bounded and packed in galvanised wire net/mesh of 8 SWG wire and 152 square (maxm.) mesh are to be provided. These stones shall be provided in crates size of 2.0mx2.0m or as deemed suitable for a particular location. Measurement shall be taken in cubic meters and 15% deduction will be made for void from cage/stack measurements.

3.0 Tower Erection, Stringing and Installation of Line Materials

3.1 General

3.1.1 The scope of erection work shall include the cost of all labour, tools and plant such as tension stringing equipment and all other incidental expenses in connection with erection and stringing work. The stringing equipment shall be of sufficient capacity to string the bundle conductors of specified size.
3.1.2 The Contractor shall be responsible for transportation to site of all the materials to be supplied by the Contractor as well as proper storage and preservation of the same at his own cost, till such time the erected line is taken over by the Owner. Similarly, the Contractor shall be responsible for transportation, proper storage, safe custody, and loss or damage of all Owner's supplied items for incorporation in the lines and shall maintain and render proper account of all such materials at all times. The Contractor shall reimburse the cost of any of the materials lost or damaged during storage and erection.

3.1.3 Contractor shall set up required number of stores along the line and the exact location of such stores shall be discussed and agreed upon with the Owner. Owner supplied items shall be dispatched to the railway stations situated nearest to the stores set up by the Contractor. From the railway stations, receipt, unloading and transportation to the stores shall be the entire responsibility of the Contractor.

3.1.4 Payment for stringing shall be done on the basis of per kilometer and irrespective of number of tension/suspension towers. However, stringing for river crossing spans have been given separately in the BPS. The units of measurement for tower erection and other line materials, like, earth wire, Hardware fittings and Accessories for conductor & earth wire are indicated in the BPS.

3.2 Treatment of Minor Galvanisation Damage

Minor defects in hot-dip galvanised members shall be repaired by applying zinc rich primer and two coats of enamel paint to the satisfaction of the Owner before erection.

3.3 Assembly

The Contractor shall give complete details of the erection procedures he proposes to follow.

3.3.1 The method for the erection of towers shall ensure the following:

a) Straining of the members shall not be permitted for positioning. It may, however, be necessary to match hole positions at joints using tommy bars not more than 450mm in length;

b) Prior to erection of an upper section, the lower sections shall be completely braced, and all bolts provided tightened adequately in accordance with approved drawings to prevent any mishap during tower erection;

c) All plan diagonals, oblique bracings etc for relevant section of tower shall be in place prior to assembly of an upper Section;

d) The bolt positions in assembled towers shall be as per IS-5613 (Part II/Section 2);

e) Tower shall be fitted with number, danger and phase plates as well as anti-climbing device, as described;

f) After complete erection of the tower, all blank holes, if any, are to be filled by bolts and nuts of correct size.
3.4 Tightening of Bolts and Nuts

3.4.1 All nuts shall be tightened properly using correct size spanner and torque wrench. Before tightening, it will be verified that filler washers and plates are placed in relevant gap between members, bolts of proper size and length are inserted, and one spring washer is inserted under each nut. In case of step bolts, spring washers shall be placed under the outer nuts. The tightening shall progressively be carried out from the top downwards, care being taken that all bolts at every level are tightened simultaneously. The threads of bolts projecting outside the nuts shall be punched at their position on the diameter to ensure that the nuts are not loosened in course of time. If, during tightening, a nut is found to be slipping or running over the bolt threads, the bolt together with the nut shall be replaced.

3.4.2 The threads of all the bolts except for Anti-theft bolts projected outside the nuts shall be welded at two diametrically opposite places, the circular length of each welding shall be at least 10mm. The welding shall be provided from ground level to waist level for single circuit towers and to bottom cross arm for double circuit towers. However, for towers, with +18 meter, +25 meter extensions and river crossing towers, the welding shall be provided from ground level to 30m height from stub level. After welding zinc-rich primer having approximately 90% zinc content shall be applied to the welded portion. At least two coats of the paint shall be applied. The surface coated with zinc rich primer shall be further applied with two finish coats of high build enamel of the grade recommended by the manufacturer of the zinc rich primer. The cost of welding and paint including application of paint shall be deemed to be included in the erection price.

3.5 Insulator Hoisting

Suspension insulator strings shall be used on Suspension towers (A/DA) and tension insulator strings on angle and dead end towers. These shall be fixed on all the towers just prior to the stringing. Damaged insulators and strings, if any, shall not be employed in the assemblies. Prior to hoisting, all insulators shall be cleaned in a manner that will not spoil, injure or scratch the surface of the insulator, but in no case shall any oil be used for that purpose. For checking the soundness of insulators, IR measurement using 10 kV (DC) Meager shall be carried out on 100% insulators. Corona control rings/arcing horn shall be fitted in an approved manner. Torque wrench shall be used for fixing various line materials and components, such as suspension clamp for conductor and earth wire, etc., whenever recommended by the manufacturer of the same.

3.6 Handling of Conductor and Earth wire

3.6.1 Running Out of the Conductors

3.6.1.1 The conductors shall be run out of the drums form the top in order to avoid damage. The Contractor shall be entirely responsible for any damage to tower or conductors during stringing.

3.6.1.2 A suitable braking device shall be provided to avoid damaging, loose running out and kinking of the conductors. Care shall be taken that the conductors do not touch and rub against the ground or objects which could scratch or damage the strands.

3.6.1.3 The sequence of running out shall be from the top down i.e. the earth wire shall be run out first followed in succession by the conductors. Unbalanced loads on
towers shall be avoided as far as possible. Inner phase of line conductors shall be strung before the stringing of the outer phases is taken up.

3.6.1.4 The Contractor shall take adequate steps to prevent clashing of sub conductors until installation of the spacers/spacer dampers. Care shall be taken that sub conductors of a bundle are from the same Contractor and preferably from the same batch so that creep behavior of sub conductors remains identical. During sagging, care shall be taken to eliminate differential sag in sub-conductors as far as possible. However, in no case shall sag mismatch be more than 25mm.

3.6.1.5 Towers not designed for one sided stringing shall be well guyed and steps taken by the Contractor to avoid damage. Guying proposal along with necessary calculations shall be submitted by the Contractor to Owner for approval. All expenditure related to this work is deemed to be included in the bid price and no extra payment shall be made for the same.

3.6.1.6 When the transmission lines runs parallel to existing energised power lines, the Contractor shall take adequate safety precautions to protect personnel; from the potentially dangerous voltage built up due to electromagnetic and electrostatic coupling in the pulling wire, conductors and earth wires during stringing operations.

3.6.1.7 The Contractor shall also take adequate safety precautions to protect personnel from potentially dangerous voltage build up due to distant electrical storms.

3.6.2 Running Blocks

3.6.2.1 The groove of the running blocks shall be of such a design that the seat is semicircular and larger than the diameter of the conductor/earth wire and it does not slip over or rub against the slides. The grooves shall be lined with hard rubber or neoprene to avoid damage to conductor and shall be mounted on properly lubricated bearings.

3.6.2.2 The running blocks shall be suspended in a manner to suit the design of the cross-arm. All running blocks, especially at the tensioning end will be fitted on the cross-arms with jute cloth wrapped over the steel work and under the slings to avoid damage to the slings as well as to the protective surface finish of the steel work.

3.6.3 Repairs to Conductors

3.6.3.1 The conductor shall be continuously observed for loose or broken strands or any other damage during the running out operations.

3.6.3.2 Repairs to conductor if accidentally damaged, shall be carried out with repair sleeve.

3.6.3.3 Repairing of the conductor surface shall be carried out only in case of minor damage, scuff marks, etc. The final conductor surface shall be clean, smooth and free from projections, sharp points, cuts, abrasions, etc.

3.6.3.4 The Contractor shall be entirely responsible for any damage to the towers during stringing.

3.6.4 Crossings

Derricks or other equivalent methods ensuring that normal services need not be interrupted nor damage caused to property shall be used during stringing.
operations where roads, channels, telecommunication lines, power lines and railway lines have to be crossed. However, shut down shall be obtained when working at crossings of overhead power lines. The Contractor shall be entirely responsible for the proper handling of the conductor, earth wire and accessories in the field.

3.7 Stringing of Conductor and Earth wire

3.7.1 The stringing of the conductor for 400kV shall be done by the control tension method. The equipment shall be capable of maintaining a continuous tension per bundle such that the sag for each conductor is about twenty percent greater than the sags specified in the stringing sag table.

3.7.2 The bidder shall give complete details of the stringing methods he proposes to follow. Prior to stringing the Contractor shall submit the stringing charts for the conductor and earth wire showing the initial and final sags and tension for various temperatures and spans along with equivalent spans in the lines for the approval of the Owner.

3.7.3 A controlled stringing method suitable for simultaneous stringing of the sub conductors shall be used. The two conductors making up one phase bundle shall be pulled in and paid out simultaneously. These conductors shall be of matched length. Conductors or earth wires shall not be allowed to hang in the stringing blocks for more than 96 hours before being pulled to the specified sag.

Conductor creep are to be compensated by over tensioning the conductor at a temperature of 26°C lower than the ambient temperature or by using the initial sag and tensions indicated in the tables.

3.8 Jointing

3.8.1 When approaching the end of a drum length at least three coils shall be left in place when the stringing operations are stopped. These coils are to be removed carefully, and if another length is required to be run out, a joint shall be made as per the specifications.

3.8.2 Conductor splices shall not crack or otherwise be susceptible to damage in the stringing operation. The Contractor shall use only such equipment/methods during conductor stringing which ensures complete compliance in this regard.

3.8.3 All the joints on the conductor and earth wire shall be of the compression type, in accordance with the recommendations of the manufacturer, for which all necessary tools and equipment like compressors, dies etc., shall be obtained by the Contractor. Each part of the joint shall be cleaned by wire brush till it is free of dust or dirt etc., and be properly greased with anti-corrosive compound. If required and as recommended by the manufacturer, before the final compression is carried out with the compressors.

3.8.4 All the joints of splices shall be made at least 30 meters away from the tower structures. No joints or splices shall be made in spans crossing over main roads, railways, power lines and small river spans up to 650m. Not more than one joint per sub conductor per span shall be allowed. The compression type fittings shall be of the self centering type or care shall be taken to mark the conductors to indicate when the fitting is centered properly. During compression or splicing operation; the conductor shall be handled in such a manner as to prevent lateral or vertical bearing against the dies. After compressing the joint the aluminium
3.8.5 During stringing of conductor to avoid any damage to the joint, the Contractor shall use a suitable protector for mid span compression joints in case they are to be passed over pulley blocks/aerial rollers. The pulley groove size shall be such that the joint along with protection can be passed over it smoothly.

3.9 Tensioning and Sagging Operations

3.9.1 The tensioning the sagging shall be done in accordance with the approved stringing charts or sag tables. The “initial” stringing chart shall be used for the conductor and final stringing chart for the earth wire. The conductors shall be pulled up to the desired sag and left in running blocks for at least one hour after which the sag shall be rechecked and adjusted, if necessary, before transferring the conductors from the running blocks to the suspension clamps. The conductor shall be clamped within 96 hours of sagging in.

3.9.2 The sag will be checked in the first and the last section span for sections up to eight spans, and in one additional intermediate span for sections with more than eight spans. The sag shall also be checked when the conductors have been drawn up and transferred from running blocks to the insulator clamps.

3.9.3 The running blocks, when suspended from the transmission structure for sagging, shall be so adjusted that the conductors on running blocks will be at the same height as the suspension clamp to which it is to be secured.

3.9.4 At sharp vertical angles, conductor and earth wire sags and tensions shall be checked for equality on both sides of the angle and running block. The suspension insulator assemblies will normally assume verticality when the conductor is clamped.

3.9.5 Tensioning and sagging operations shall be carried out in calm weather when rapid changes in temperature are not likely to occur.

3.10 Clipping In

3.10.1 Clipping of the conductors into position shall be done in accordance with the manufacturer’s recommendations.

3.10.2 Jumpers at section and angle towers shall be formed to parabolic shape to ensure maximum clearance requirements. Pilot suspension insulator strings shall be used, if found necessary, to restrict jumper swing to design values.

3.10.3 Fasteners in all fittings and accessories shall be secured in position. The security clip shall be properly opened and sprung into position.

3.11 Fixing of Conductors and Earth wire Accessories

Conductor and earth wire accessories including spacers, spacer dampers (for bundle conductor) and vibration dampers shall be installed by the Contractor as per the design requirements and manufacturer’s instruction within 24 hours of the conductor/earth wire clamping. While installing the conductor and earth wire accessories, proper care shall be taken to ensure that the surfaces are clean and smooth and that no damage occurs to any part of the accessories or of the conductors. Torque wrench shall be used for fixing the Dampers/Spacer Dampers, Suspension Clamps etc. and torque recommended by the manufacturer of the same shall be applied.
3.12 Replacement

If any replacement is to be effected after stringing and tensioning or during maintenance, leg member and bracing shall not be removed without first reducing the tension on the tower by proper guying techniques or releasing of the conductor. For replacement of cross arms, the conductor shall be suitably tied to the tower at tension points or transferred to suitable roller pulleys at suspension points.

3.13 Permitted Extra Consumption of Line materials

3.13.1 The quantity of conductor and earth wire to be incorporated in the line shall be worked as per the following norms.

Quantity of Conductor = Line length* as per detailed survey x 3 phases x Nos. of conductor per bundle (for Single Circuit Line)

= Line Length* as per detailed survey x 3 phases x Nos. of conductor per bundle x 2 (for Double Circuit Line)

Quantity of Earth wire = Line length* as per detailed survey x nos. of ground wires

* For calculation of conductor & Earth wire requirement in hilly stretches, inclined distance between the towers may be considered instead of horizontal distance (considered for line length).

3.13.2 The Contractor shall make every effort to minimise breakage, losses and wastage of the line materials during erection. However, the Contractor shall be permitted and extra consumption of line materials up to the limits specified in Table 5.1 and shall be permitted to dispose of the scrap, if any at the end.

Table 5.1: Permitted extra consumption of line materials

<table>
<thead>
<tr>
<th>Item</th>
<th>% of permitted extra consumption</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conductor &amp; earth wire</td>
<td>1</td>
</tr>
<tr>
<td>Insulators</td>
<td>1</td>
</tr>
</tbody>
</table>

3.13.3 In case of conductor and earth wire, the permitted extra consumption limit of one percent is inclusive of sag, jumpering, damage, loss and wastage etc.

3.13.4 The Contractor shall not be required to return to the Owner empty conductor and earth wire drums and shall dispose off the same at his cost.

3.13.5 Any conductor and earth wire drum which has been opened by the Contractor shall not be taken back by Owner and the unused conductor or earth wire in such drums may be treated as waste permissible within the overall limits specified in Table 5.1.

3.13.6 The Contractor shall return to the Owner all Owner supplied material not incorporated in the works, except those permitted by Owner as scrap in terms of Table 5.1. Otherwise, the Contractor shall pay in respect of such excess materials which he is unable to return at rates corresponding to the actual cost of procurement plus 15% for OSM procured under domestically funded
packages. The “cost of procurement” for the above purpose shall be F O R
destination site cost of OSM as per LOA of the respective packages plus taxes
& duties plus price variation (if positive) applicable as on the date of issuance of
TOC for Tower Package.

3.13.7 For calculation of conductor & earth wire consumption in hilly (mountainous)
stretches inclined distance between towers may be considered, instead of
horizontal distance between them.

3.13.8 The quantities of line materials to be supplied by the contractor (i.e. earth wire,
Hardware fittings & accessories) as indicated in the bill of quantities are
provisional and the actual quantity shall depend upon detailed survey.
Contractor shall be responsible for regulating the supplies of contractor supplied
materials in the basis of actual requirements. The Owner shall have right, not to
take any surplus contractor supplied line materials.

3.14 Final checking, Testing and Commissioning

After completion of the works, final checking of the line shall be carried out by
the Contractor to ensure that all foundation works, tower erection and stringing
have been done strictly according to the specifications and as approved by the
Owner. All the works shall be thoroughly inspected in order to ensure that:

a) Sufficient backfilled earth covers each foundation pit and is adequately
compacted;

b) Concrete chimneys and their copings are in good condition and finely
shaped.

c) All tower members are used strictly according to final approved drawing
and are free of any defect or damage whatsoever.

d) All bolts are properly tightened, punched, tack welded and painted with
zinc rich paint;

e) The stringing of the conductors and earth wire has been done as per the
approved sag and tension charts and desired clearances are clearly
available;

f) All conductor and earth wire accessories are properly installed;

g) All other requirements for completion of works such as fixing of danger
plate, phase plate, number plate, anti-climbing device, aviation signal have
been fulfilled.

h) Wherever required, that proper revetment (erosion protection) is provided;

i) The original tracings of profile and route alignment as well as tower
design, structural drawings, bill of material and shop drawings of all towers
are submitted to the Owner for reference and record.

j) The insulation of the line as a whole is tested by the Supplier through
provision of his own equipment, labour etc., to the satisfaction of the
Owner.

k) All towers are properly grounded.

l) The line is tested satisfactorily for commissioning purpose.
3.14.1 The contractor should also fulfill the requirements of pre-commissioning procedure as given in Appendix – I to this Specification

4.0 Field Quality Plan

All field activity shall be carried out in accordance with Standard Field Quality plan as given in Appendix – II to this Specification.
APPENDIX – I

PRE – COMMISSIONING SCHEDULE
INTRODUCTION

Over all procedure, safety rules, Statutory Requirements, dispatch procedures, switching sequences, observations, passing criteria and documentation of test results have been documented in this report.

The detailed inspection and handing over documents are required to be checked for the entire length of transmission line before energization.

The detailed inspection/test procedures for each activity has been elaborated in separate section of this documentation. The contents of this report are as following:

1. Definition
2. Overall Procedures
3. Safety procedures
4. Inspection
5. Statutory Requirements
6. Handing over
7. Protective system
8. Dispatch procedures
9. Switching procedures
10. Testing
11. Energization
12. De-energization
13. Observations and duration
14. Passing criteria
15. Documentation

1.0 DEFINITION

"Main Transmission Lines" means all high pressure cables and overhead lines (not being an essential part of the distribution system of a licensee) transmitting electricity from a generating station to another generating station or a sub-station, together with any step-up and step-down transformers, switch-gear and other works necessary to and used for the control of such cables or overhead lines, and such buildings or part thereof as may be required to accommodate such transformers, switch-gear and other works and the operating staff thereof;
"Power System" means a system under the control of the Government or any Board of Generating Company or other agency and having one or more-

i) generating station; or

ii) main transmission lines and sub-stations; or

iii) generating stations and main transmission lines and substations;

"Regional Electricity Board" means any of the Boards as constituted immediately before the commencement of the Electricity Laws (Amendment) Act, 1991, by resolution of the Central Government for ensuring integrated operation of constituent system in the region;

"Regional Load Dispatch Centre" means the Centre so designated where the operation of each of the Regional Electricity Grids constituting the country's power system is coordinated;

"Sub-Station" means a station for transforming or converting electricity for the transmission or distribution thereof and includes transformers, convertors, switch-gear, capacitors, synchronous condensers, structures cables and other appurtenant equipments and any buildings used for that purpose and the site thereof, a site intended to be used for any such purpose and any buildings used for housing the staff of the sub section;

"Tie-Line" means a line for the transfer of electricity between two power systems together with switchgear and other works necessary to, and used for the control of such line.

2.0 OVERALL PROCEDURE

First it is to be ascertained that the transmission line to be energized is ready for operation and has been properly handed over (released) in writing. This will include all safety aspects, Electrical inspector clearance, PTCC clearance, Statutory clearance, and final inspection, if any.

Instructions for the work and supervision is given by the test leader (Line in charge). However all switching and all operational activities will be executed by the regular operators.

Line charging instructions received from Corporate Engineering are clearly understood by the Line in charge and doubts, if any, are to be got clarified prior to the energisation of the line.

Once the line is handed over for charging no work shall be permitted without a valid WORKPERMIT.

When the whole system has been energized, including the AC line, it will be kept in this state for 8 hours or more for "soaking" with continuous inspection and monitoring. However recommendations of the Corporate Engg. may be checked. Otherwise it may be put into continuous operation.
3.0 SAFETY PROCEDURES

Energization implies an abrupt and serious change of the working conditions in the plant.

In order to avoid serious accidents, thorough information must be imparted to all personnel involved in the construction of transmission line. Incharge of the Transmission line (Group head OR Divisional head) must ensure that due publicity has been made to the public in all the villages/areas along the line route cautioning them against climbing the towers etc. and that the line is proposed to be charged on so and so date. It is also to be confirmed that the AGENCIES involved in the construction activities shall not carry out any job on the said line without a valid WORK PERMIT.

It shall be ensured before charging that all men, material, Tools and plants and any temporary earthing on any part of the entire length of line are removed.

It must be ensured that any power supply / low voltage charging used as anti-theft measure must be disconnected and isolated to avoid accidental connection.

All equipment tests and pre-commissioning tests must have been completed, reterminated (in case cables were isolated for testing purpose) and documented.

The system must be formally declared ready for energization and handed over for operation in writing.

4.0 INSPECTION

Before the line is scheduled to be handed over for the pre-commissioning/energization the same shall be inspected by representatives of UPCL and Construction Agency as follows :

Such an inspection shall include :

i) Right of way/way leave/electrical clearance
ii) Foundation and Revetments/Protection Work
iii) Tower and Tower accessories
iv) Hardware Fittings
v) Insulators
vi) Conductors and Earthwire
vii) Accessories for conductor and Earthwire
viii) Aviation Warning Signals (Lights/globules/painting)
4.1 RIGHT OF WAY/WAY LEAVE/ELECTRICAL CLEARANCE

4.1.1 Right of way/Way leave clearance

Ensure that no tree/tree branches are falling within the zone of minimum clearance specified as per Fig. 1.

Guidelines of forest/environmental rules shall be followed to avoid excessive tree cutting i.e. all the trees should be cut from ROUTE level in the 3 meter corridor below each line Conductor/Earthwires. In the balance corridor, Trees branches are only to be lopped to attain the specified clearance as per Table no 1.
TABLE NO. 1
CLEARANCE FOR RIGHT OF WAY

<table>
<thead>
<tr>
<th>TRANSMISSION VOLTAGE IN KV</th>
<th>MINIMUM RIGHT OF WAY (IN MTRS)</th>
</tr>
</thead>
<tbody>
<tr>
<td>132</td>
<td>27</td>
</tr>
<tr>
<td>220</td>
<td>35</td>
</tr>
<tr>
<td>400</td>
<td>52 (S/C)</td>
</tr>
<tr>
<td>400</td>
<td>46 (D/C)</td>
</tr>
</tbody>
</table>

4.1.2. Electrical Clearance

In case of line crossings, clearance between lowest conductor of line and top conductor of the other line shall be adequate as follows:

(Minimum clearances in mm between lines when crossing each other)

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Nominal System Voltage</th>
<th>132 kV</th>
<th>220 kV</th>
<th>400 kV</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>132 KV</td>
<td>3050</td>
<td>4580</td>
<td>5490</td>
</tr>
<tr>
<td>2</td>
<td>220 KV</td>
<td>4580</td>
<td>4580</td>
<td>5490</td>
</tr>
<tr>
<td>3</td>
<td>400 KV</td>
<td>5490</td>
<td>5490</td>
<td>5490</td>
</tr>
</tbody>
</table>

Jumpers in the tension tower are properly intact with conductor and form a parabolic shape in order to achieve adequate clearance from super steel structure.

4.1.2.1. Ground clearance

Normally at the time of construction adequate clearance is provided between lowest conductor and ground, but due to delay in charging/commissioning there are chances of dumping/heaping soil, earth and concrete etc. or staking bricks etc. which may cause reduction in ground clearance. In such cases the stored materials shall be removed.

Ensure that there is no temporary or permanent construction of houses or shades below the line. If the same has been constructed they shall be removed before charging.

The various clearances are given below as guidance however all the clearances indicated by Approved Drawings by Engg. Deptt./CC are to be referred.
The ground profile at the time of commissioning shall be checked with the profile approved at the time of check survey.

Ground clearance of lowest conductors at critical points/where ever the lowest conductor is touching the ground shall be checked in the field from any of the prevalent method and the values of ground clearance at these critical points shall be recorded in the prescribed format.

In case of hilly Terrain and for building clearance, the side clearance from conductors and jumpers at critical points shall also be checked and recorded for all phases of conductor/earthwire towards hill/ building side.

The permissible minimum ground clearances for different voltages are as given below.

<table>
<thead>
<tr>
<th>VOLTAGE (KV)</th>
<th>GROUND CLEARANCE (MM)</th>
</tr>
</thead>
<tbody>
<tr>
<td>132</td>
<td>6100</td>
</tr>
<tr>
<td>220</td>
<td>7015</td>
</tr>
<tr>
<td>400</td>
<td>8840</td>
</tr>
</tbody>
</table>

4.1.2.2. Clearance for Telephone line crossings

The minimum clearances between the conductors of the power line and telecommunication lines are specified as follows:

<table>
<thead>
<tr>
<th>VOLTAGE (KV)</th>
<th>CLEARANCE (MM)</th>
</tr>
</thead>
<tbody>
<tr>
<td>132</td>
<td>2745</td>
</tr>
<tr>
<td>220</td>
<td>3050</td>
</tr>
<tr>
<td>400</td>
<td>4880</td>
</tr>
</tbody>
</table>

The vertical clearances between conductors and between conductor and earth-wire shall be checked randomly say in any one span of all sections and 10 sections of hilly areas from single line diagram of the towers.
4.2. FOUNDATION AND REVETMENTS / PROTECTION WORK

FOUNDATION:
There shall not be any damage/uneven settlement of foundations. For this, tolerances in levels of all four stubs should not exceed the criteria provided in the Annexure-C of IS-5613 (Part-3/Section 2):1989.

It is to be ensured that back filling of foundation is properly done. Soil shall be filled over all legs up to ground level.

Extra surface earth after foundation back filling shall be removed from legs of the tower beyond a lead distance of 30 mtrs.

Any crack or break in chimney, if found, shall be repaired.

REVETMENTS / PROTECTION:
Cracks/damages to revetments shall be repaired.

Wherever revetments are provided, weep holes shall have slope such as to flush out the deposited water away from tower platform.

In case of hill terrain, the benching area should be leveled properly. The area around the tower shall have proper slope for drainage of rain water.

SPECIAL FOUNDATION

4.3 TOWER AND TOWER ACCESSORIES

4.3.1. Normal Tower
After completion of a transmission line, all the towers shall be thoroughly checked before charging the line. Special attention shall be given to the points as mentioned below:-

Deformed/Buckled/missing/Rusted Members and Nuts and Bolts

It is to be ensured that no members are bend, deformed or rusted have been used in towers and if so, the same shall be replaced.

If any members is found missing, a new member shall be Fixed as per erection drawing of Towers.

Nuts shall be sufficiently tightened for the required Torque specified by Engg. Deptt./Approved Drawing.*** Minimum 2/3 complete threads shall be projected outside the nut. All bolts shall have their nuts facing outside of the tower for Horizontal connection and Downwards for Vertical connections.

Nuts & bolts shall be properly tack welded/punched as per the specification and proper zinc rich paint shall be applied. It shall be ensured that the circular length of each welding shall be at least 10mm.
It shall also be ensured that all extra blank holes provided on tower members are filled with correct size of nuts & bolts.

4.3.2 Special Towers

In addition to the above checks for towers, ladders and platforms provided in special towers shall be properly tightened and no foreign material shall be left out on such platforms.

Earthing of Towers

Ensure that proper earthing of tower has been done and earthing strip is neither damaged or broken and is properly fixed to the stub.

In case of counter poise earthing, it is to be ensured that earthwire is sufficiently buried in the ground and no where it has drag out during cultivation. The length of counter-poise is normally 30 mtrs as per TS.

Before charging of the line, ensure that resistance is below 10 ohms. If the value (before stringing) has been recorded higher than 10 ohm earthing shall be changed to counterpoise type.

Earthing of special towers shall be verified as per approved drawings applicable for special towers/special foundation. (In case of anchor foundation bolt/anchor plate welded with last leg of special tower.)

4.3.3. Tower accessories

All the danger plates, number plates, circuit plates, and phase plates shall be in position & and as per the specification.

All plates shall be properly tightened.

It shall be ensured that phase plates are fixed in correct phase sequence. Specially at transposition towers, the phase plates in the correct phase sequence shall be provided at each towers or end tower as per the specification of the line.

It shall be ensured that the anti-climbing device (ACD) is provided, at the suit-able height of tower. In case of barbed wire ACD, barbed wire shall be tightly fixed. In case of spike type ACD, all spikes shall be properly fixed and oriented towards outer face of tower.

It shall be ensured that the step bolts (for normal towers) are provided upto the peak of tower. Any missing step bolts shall be replaced.

Fixing of birds guards (upto 220 kV/wherever applicable) shall be ensured.

4.4. HARDWARE FITTINGS

Tightening of all bolts and nuts are to be checked upto specified torque.

Check the fixing of all security clips (W/R type clips).
Surface condition of corona control rings and distance/alignment between Tower side arcing horn (wherever applicable) and line side arcing horn/corona control ring to be checked as per approved drawings.

Ensure that, no. of insulators per string is lesser by one number as compared to no. of discs in normal string (upto 220 kV) at approach spans to the terminal ends (approx last 1.5 KM).

To restrict the swing of jumpers, the provision of Pilot strings in case of Tension Towers shall be verified from the approved drawings.

4.5 **INSULATORS**

All the damaged/broken insulator discs shall be replaced.

Unusual deflection in suspension strings if observed shall be rectified.

The insulators shall be cleaned before charging.

IR value of individual disc of at least 5 insulators at random shall be checked by 5/10 kV Megger.

4.6. **CONDUCTORS and EARTHWIRES**

**Surface Condition**

Surface of the conductors shall be free from scratches/rubs

Ensure that conductor strands are not cut and opened up. Wherever strands are found cut/damaged/scratched, they must be repaired with repair sleeves/repair protective rods in case the nos. of damaged strands are within specified limits(normally upto 1/6th nos. of strands in the outer layer). ***

4.7. **ACCESSORIES FOR CONDUCTOR AND EARTHWIRES**

4.7.1. **Joints**

All joints on conductor/earthwircs shall be away from the tower at a distance of at least 30 metres or as provided in the Technical specification (TS).

Ensure that not more than one joint in a conductor is provided in one span or provided.

Ensure that no mid span joint is provided in major crossings for main roads, railway crossing and major rivers etc. or provided in TS.

Ensure that all mid span joints on conductors/earthwire and repair sleeves of compression type are free from sharp edges, rust and dust. Wherever grease are specified the same shall be applied in the joints.
4.7.2. **Clipping**
Ensure that conductor is not over tightened in the suspension clamps.

4.7.3 **Spacers, vibration dampers and copper bonds**
Placement and no. of spacers/dampers between two sub conductors on each phase shall be verified as per spacer/damper placement chart.

Damaged/missing spacers shall be replaced and loose/displaced spacers shall be tightened/relocated.

Spacing of Vibration dampers from the tower and spacing between damper to damper in case two Vibration Dampers (VD) were provided, shall be verified as per the damper placement chart. All loose/ displaced VD shall be properly tightened/relocated and missing VDs shall be provided.

To be ensured that no copper bond is loose/missing.

4.7.4 **Jumpers**
Verify Electrical clearance of jumpers to tower body as per design.

All the jumpers shall be checked properly. In case, jumpers (conductor/earthwire) is found loose, it shall be tightened sufficiently.

4.7.5 **Foreign material**
Ensure that all foreign materials viz dead bird, fallen tree branches, bird nests etc. on conductors, earthwires, Jumper, insulator string, cross arms are removed.

4.7.6 **Others**
It shall be ensured that all temporary/local earthing, guys, T & P (Tools and Plants), foreign material and other loose material which were used during stringing/tower erection have been removed.

In case there is any change in the ground profile before commissioning of line from the approved profile, the extra earth/obstruction /temporary sheds/any other construction shall be removed.

4.8 **AVIATION WARNING / OBSTRUCTION SIGNALS (LIGHTS/GLOBULES/PAINTING).**
It shall be ensured that following measures have been taken in the line/Towers falling within obstruction zone of civil aviation and defense establishments as per their requirement and our specification.

**Day markers**
Painting of Full/Top portion of Towers with Red/Orange and White Paints.
Globules on earthwires have been provided.
Night markers

It shall be ensured that proper aviation lights at the peak level/at specified heights of towers have been provided along with Solar panels/Battery banks/Control cubicles and other accessories as per specification. The functioning of lights with simulation to be checked/verified.

5.0 STATUTORY REQUIREMENT

5.1. The concerned authorities shall be informed before commissioning the lines and their approval obtained in accordance with Indian Electricity Act, 1910 and Indian Electricity Rule, 1956. and Electricity Supply Act 1948.

5.2 Before charging of the line PTCC approval from P&T Dept. shall be obtained.

6.0 HANDING OVER

The transmission line shall be inspected prior to energization and a formal handing over document to be jointly signed by the representative of SUPPLIER (if available), ERECTION AGENCY, POWERGRID ERECTION. However all contractual taking over has to be resolved separately as per the terms and conditions of the contract. The Handing over shall be limited to the completion of Erection and ready for Energization.

Any outstanding points or remaining activities are to be listed jointly by UPCL and ERECTION and signed jointly. This documents are also to be retained at Group Head Quarter with a copy to Regional Head Quarter. The remaining activities/outstanding points are classified in the following category.

Details of the SECTIONS :

A. List of outstanding activities remaining in any part of the line

B. A list of temporary arrangements introduced.

C. Check list records properly documented, completed and signed.

D. Original tracing of Profile, Route Alignment, Tower Design, Structural Drawings, Bill of Materials, Shop Drawings, Stringing charts (initial and final as applicable) etc. of all towers/line submitted to UPCL.

With the outstanding activities mentioned above are solved or with only minor points without influence on the charging remain (minor issues handing over of the transmission line shall be accepted by the pre-commissioning team. This handing over for energization with or without remaining activities shall be made by the group head to the commissioning in charge in writing.
Shortcomings noticed during the inspection, "List of outstanding activities" shall be recorded and a copy of the format is to be given to the responsible parties like SUPPLIER(s) and ERECTION AGENCY etc. for corrective action to be taken on a time schedule.

7.0 PROTECTIVE SYSTEM

Before energization it must be ascertained that all protective systems for the unit to be energized are operative.

This includes confirmation that the protections have been properly tested and that the tests have been documented.

It also includes verification by inspection or otherwise, if necessary by repetition of trip test, that the protections are actually functionally enabled. This verification serves to prevent that energization takes place of a unit where a protection has been disabled for test or other reason.

8.0 DISPATCH PROCEDURES

All operational activities (switching etc.) must be coordinated and communicated with the system dispatcher i.e. I0CC / CPCC / RLDC.

In this respect the general procedures already established by POWERGRID will be followed.

9.0 SWITCHING PROCEDURES

For each activity the instructions to the operators and the communications to the dispatchers will be made in writing or by confirmed telephone messages. The switching procedures first to be properly documented step by step and understood by everybody involved in the switching operation prior to the energization. Any clarification required in the procedures must be resolved. The format established by UPCL for switching orders and operational data logging shall be followed.

The implication of this is that each and every activity must be listed and described, so that complete information is available for detail investigation, if required in future.

10.0 TESTING AND MEASUREMENT PROCEDURES

10.1. Earth Resistance Measurement

Normally Earth tester is used for measuring

a) soil resistivity.

b) earth resistance

a. Prior to the testing of soil resistivity and earth resistance the operation manual of the testing instrument available at site may be referred and procedures to be adopted for measurement of soil resistivity and earth resistance.
A typical Earth tester has 4 terminals. C1, P1, C2, P2 and 4 similar electrodes are driven in the ground at equal distances and connected to the instruments in the order of C1 P1 and P2, C2. Then the handle is rotated or button is pressed and the reading of the resistance is read on the megger scale. If R is the resistance measured then the

Specific resistivity \( = 2 \pi aR \)

where a is the distance between the electrode and R is the resistance in ohms measured on the megger.

b) In order to measure earth resistance of electrode of the substation it could be connected to C1 and the value of R could be read in the scale with the rotation of the handle of the megger. This will give the earth resistance. The value as far as possible shall be below 10 Ohm. To improve the value, water shall be sprinkle at the earthing pit.

![Diagram of Test connection for a four terminal Megger](image)

**fig : 2 Test connection for a four terminal Megger**

10.2 Before commissioning of the lines following tests may be carried out.

10.2.1 Insulation Resistance Test

This test may be carried out with the help of a 10 OR 12 KV megger preferably power driven to ascertain the insulation condition of the line. In case 5 kV megger is used for insulation resistance measurement it shall be ensured that the induced voltage (CVT reading) is LESS than the instrument withstanding capacity otherwise it is likely that the instrument may be damaged.

This Test is to be carried out First prior to the continuity test.

**Measurement of Insulation Resistance**

One of the most common devices used for testing electrical insulation is the Megger Insulation Tester.

The DC test voltage is generated by a permanent magnet generator. This generator is turned either by hand or by an electric motor. In either case a slip
clutch maintains the generator speed at a constant value so long as the slipping speed is exceeded. A constant voltage is important when the insulation under test has a high capacitance. Common generator output voltage are 500, 1000, 2500 and 5000 volts.

Many Meggers have a “guard” terminal as well as “line” and “earth”. The guard terminal is useful shall one wish to exclude part of the insulation under test from the measurement. This is possible since current flowing to the generator via the guard circuit does not pass through the deflecting coil.

Another use of the guard circuit is to shield the “line” lead between the Megger and the apparatus under test. This prevents leakage to ground from the “line” lead which would invalidate the Megger reading.

Insulation resistance is the ratio VDC/IDC. VDC is applied across two conductors separately by the insulation under test.

IDC is the current flowing through/over the insulation. For a healthy and clean insulation the megger reading is in mega-Ohms to infinity. For dirty in, insulation and defective, moist insulation the meggers shows a very low insulation resistance value.

Megger test gives clear indication about the health, cleanliness and dryness of the line/equipment insulation.

5KV megger or 10KV megger or 12KV megger may be used for the Transmission line keeping all safety requirements, Permit to work, clearance from statutory bodies and other conditions prevailing at the Sub-station where charging of the line is being co-ordinated.

10.2.2 Conductor Continuity Test

10.2.2.1 The objective of this test is to verify that each conductor of the overhead line properly connected electrically (the value of electrical resistance of line does not vary abnormally from that of a continuous conductor of the same size and length). The electrical resistance of the conductor shall be measured with a Whetstone bridge or other suitable instrument, if available taking the safety aspects of Equipment as well as testing Engineer.

A simple method of continuity test is illustrated below:

Once the insulation test is completed and the results confirms no short circuit carry the following:

<table>
<thead>
<tr>
<th>Sending End</th>
<th>Receiving End</th>
<th>Results (Ohms)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CLOSE R-Ph GS</td>
<td>MEGGER R-Ph</td>
<td>ZERO/LOW</td>
</tr>
<tr>
<td>OPEN Y-Ph GS</td>
<td>MEGGER Y-Ph</td>
<td>HIGH</td>
</tr>
<tr>
<td>OPEN B-Ph GS</td>
<td>MEGGER B-Ph</td>
<td>HIGH</td>
</tr>
</tbody>
</table>
OPEN R-Ph GS       MEGGER R-Ph       HIGH
CLOSE Y – Ph GS   MEGGER Y-Ph       ZERO/LOW
OPEN B-Ph GS      MEGGER B-Ph       HIGH

OPEN R-Ph GS       MEGGER R-Ph       HIGH
OPEN Y–Ph GS       MEGGER Y-Ph       HIGH
CLOSE B-Ph GS      MEGGER B-Ph       ZERO/LOW

(ALL GS OPEN CONDITION)

GS means GROUND SWITCH

If the above test results are OK it confirms the continuity of the line.

10.2.2.2 The continuity Test of the line with proper phase indication or phase marking can be checked by continuity test as described below:

<table>
<thead>
<tr>
<th>SENDING END</th>
<th>RECEIVING END MEGGER BETWEEN</th>
<th>RESULTS (OHMS)</th>
</tr>
</thead>
</table>

If the test results are OK it confirm that marking of the phases are in order.

10.2.2.2 Phase Sequence

Once the line is charged from one end, without closing the Breaker at the other end the Phase sequence is to be checked from the CVT output by the help of Phase Sequence Meter. In case there is other feeders available Phase sequence is to be RECHECKED by the measurement of secondary voltage of both the Feeders (New line & available charged line).

Let the secondary Voltage of CVT is 110 volts (ph to ph) for both the Circuit.
In case of correct Phase Sequence the voltage reading shall be as follows:
In case the results are not matching the phase sequence in to be rechecked and reconfirmed before closing the breaker.

11.0 ENERGIZATION
Execution of the energization is simply the last event in the switching sequence, switching of the close control button for the relevant circuit breaker.

12.0 DE-ENERGIZATION
Instructions about de-energization will be given only if this is part of the test. Otherwise de-energization will be considered part of regular operation.

13.0 OBSERVATION AND DURATION
Visual and audible inspection (look and listen) of the relevant equipment and reading of permanent instrumentation will be made.

The system shall be charged at least for 8 hours. During this time continuous monitoring and inspection will be maintained in control room, auxiliary systems areas and switch yards.

This will include frequent, scheduled inspection of all equipment and reading of all permanent instruments and recorders, and surge arrester counters, especially system parameters as per standard procedures adopted by UPCL.

14.0 PASSING CRITERIA
Neither insulation breakdown nor protective system actions must occur. No irregular equipment behaviour noise, vibration, high temperature is permitted.

Corona discharges may not be “unreasonable”. Local discharges that may be attributable to sharp points shall be carefully located and recorded.

<table>
<thead>
<tr>
<th>NEW CIRCUIT</th>
<th>OLD CIRCUIT</th>
<th>VOLTAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>R-Phase</td>
<td>R-Phase</td>
<td>0</td>
</tr>
<tr>
<td>R-Phase</td>
<td>Y-Phase</td>
<td>110</td>
</tr>
<tr>
<td>R-Phase</td>
<td>B-Phase</td>
<td>110</td>
</tr>
<tr>
<td>Y-Phase</td>
<td>R-Phase</td>
<td>110</td>
</tr>
<tr>
<td>Y-Phase</td>
<td>Y-Phase</td>
<td>0</td>
</tr>
<tr>
<td>Y-Phase</td>
<td>B-Phase</td>
<td>110</td>
</tr>
<tr>
<td>B-Phase</td>
<td>R-Phase</td>
<td>110</td>
</tr>
<tr>
<td>B-Phase</td>
<td>Y-Phase</td>
<td>110</td>
</tr>
<tr>
<td>B-Phase</td>
<td>B-Phase</td>
<td>0</td>
</tr>
</tbody>
</table>
termination of the energization the equipment shall be closely inspected and the points rounded or covered.

No unscheduled changes of system nor of equipment is permitted during the 8 hour energized condition.

15.0 DOCUMENTATION

Switching and operational activities will be recorded in regular manner in the operators log. Likewise all readings of permanent instruments. Copies of this log, notes on special observations from inspections and other measurements will constitute the test records.
APPENDIX – II

STANDARD FIELD QUALITY PLAN
<table>
<thead>
<tr>
<th>S. No.</th>
<th>Description of Activity</th>
<th>Items to be Checked</th>
<th>Tests/Checks to be done</th>
<th>Ref. documents</th>
<th>Check/Testing</th>
<th>Counter Check/Test by TPGL</th>
<th>Accepting authority in TPGL</th>
</tr>
</thead>
</table>
b. Topographical map  
c. Tower spotting datas given by Engg. | Contractor | 100% at Field | 100% based on record documents | Project incharge |
2. Cold wt. Span  
3. Hot wt. Span  
4. Sum of Adj. Span (wind span)  
5. Angle of Devn. | a. Sag template  
b. Tower Spotting data  
c. Route alignment | Contractor  
- do-  
- do-  
- do-  
- do-  
- do- | 100% at Field  
- do-  
- do-  
- do-  
- do-  
- do- | 100% based on record documents |
| 2.    | Check Survey            | Tower Location & Final Length | i) Alignment  
i) Final Length | a. Route alignment  
b. Tower Schedule  
c. Profile | Contractor  
- do-  
- do-  
- do- | 100% at Field  
- do-  
- do-  
- do-  
- do-  
- do- | i) All angle towers in plains and 50% in hilly terrains.  
ii) Final length to be checked on 100% basis based on records/documents | Section Incharge |
2. SPT Test  
3. Collection of samples | As per TPGL Specification | Contractor | 100% at Field | To witness 20% at Field | Section Incharge |
<table>
<thead>
<tr>
<th>S. No.</th>
<th>Description of Activity</th>
<th>Items to be Checked</th>
<th>Tests/Checks to be done</th>
<th>Ref. documents</th>
<th>Check/Testing</th>
<th>Counter Check/Test by TPGL</th>
<th>Accepting authority in TPGL</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Agency</td>
<td>Extent</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Lab appd. By TPGL</td>
<td>100% by testing lab</td>
<td>Review of lab test results</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Lab appd. By TPGL</td>
<td>100% by testing lab</td>
<td>Review of lab test results</td>
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<tr>
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<td></td>
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<td>Review of lab test results</td>
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<tr>
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<td>Lab appd. By TPGL</td>
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<td>Review of lab test results</td>
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<td>Lab appd. By TPGL</td>
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<td>Review of lab test results</td>
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<td></td>
<td>Lab appd. By TPGL</td>
<td>100% by testing lab</td>
<td>Review of lab test results</td>
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<td></td>
<td></td>
<td>Lab appd. By TPGL</td>
<td>100% by testing lab</td>
<td>Review of lab test results</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Lab appd. By TPGL</td>
<td>100% by testing lab</td>
<td>Review of lab test results</td>
</tr>
</tbody>
</table>

4. Tower Foundation

**A. Materials**

1. **Cement**
   - 1. Source approval
     - Source meeting TPGL Specification/Approved vendor
     - Contractor
     - As proposed by Contractor
     - To verify the proposal based on the supply made and factory test results.
     - Line incharge
   - 2. Physical tests
     - As per document at Annexure-I of this FQP at Pg. 12, 13 & 14.
     - Samples to be taken jointly with TPGL and tested at TPGL approved lab
     - Review of all MTC’s and one sample for every 500 MT
     - 100% review of lab test results
     - Line incharge
   - 3. Chemical Tests
     - Chemical composition of Cement
     - Contractor to submit MTC
     - 100% review of MTC by Contractor
     - 100% review of MTC
     - Line Incharge

2. **Reinforcement Steel**
   - 1. Source approval
     - To be procured from main producers only.
     - Contractor
     - As proposed by Contractor
     - To review the proposal based on the documents.
     - Line incharge.
<table>
<thead>
<tr>
<th>S. No.</th>
<th>Description of Activity</th>
<th>Items to be Checked</th>
<th>Tests/Checks to be done</th>
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<td></td>
<td></td>
<td>Agency</td>
<td>Extent</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Contractor</td>
<td>Proposed by the Contractor, indicating the location of the quarry and based on the test results of Joint samples tested in TPGL approved lab</td>
<td>To review the proposal based on the documents</td>
</tr>
<tr>
<td>3</td>
<td>Coarse Aggregates</td>
<td>1. Source approval</td>
<td>Source meeting TPGL Specification</td>
<td>Contractor</td>
<td>Proposed by the Contractor, indicating the location of the quarry and based on the test results of Joint samples tested in TPGL approved lab</td>
<td>To review the proposal based on the documents</td>
<td>Line Incharge</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2. Physical tests</td>
<td>As per document at Annexure-3 of this FQP at page 16</td>
<td>Samples to be taken jointly and tested in TPGL approved lab</td>
<td>One sample per lot of 200 cum or part thereof</td>
<td>100% review of lab test results</td>
<td>Line Incharge</td>
</tr>
<tr>
<td>4</td>
<td>Fine aggregate</td>
<td>1. Source approval</td>
<td>Source meeting TPGL Specification</td>
<td>Contractor</td>
<td>Proposed by the Contractor, indicating the location of the quarry and based on the results of Joint samples tested in TPGL approved lab.</td>
<td>To review the proposal based on the documents</td>
<td>Line Incharge</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2. Physical test</td>
<td>As per Annexure-4 of this FQP at page 17</td>
<td>Samples to be taken jointly and tested in TPGL approved lab</td>
<td>One sample per lot of 200 cum or part thereof</td>
<td>100% review of lab test results</td>
<td>Line Incharge</td>
</tr>
<tr>
<td>5</td>
<td>Water</td>
<td>1. Cleaniness (Water shall be fresh and clean)</td>
<td>TPGL Specification</td>
<td>Contractor</td>
<td>100% visual check at Field Verification at random</td>
<td>Site Engineer</td>
<td></td>
</tr>
<tr>
<td>S. No.</td>
<td>Description of Activity</td>
<td>Items to be Checked</td>
<td>Tests/Checks to be done</td>
<td>Ref. documents</td>
<td>Check/Testing</td>
<td>Counter Check/Test by TPGL</td>
<td>Accepting authority in TPGL</td>
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<td></td>
<td>Agency</td>
<td>Extent</td>
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</tr>
<tr>
<td>2.</td>
<td>Suitability of water for concreting</td>
<td>TPGL Specification</td>
<td>Contractor</td>
<td>100% Visual Check at Field</td>
<td>Verification at random</td>
<td>Site Engineer</td>
<td></td>
</tr>
<tr>
<td>B. Classification</td>
<td>1. Visual observation of soil strata</td>
<td>TPGL Specification</td>
<td>Contractor</td>
<td>100% at Field</td>
<td>100% at Field</td>
<td>a. Section incharge</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2. Ground water level</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>b. In case of WBC/SFR/FS acceptance by Line Incharge</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3. History of water table in adj. area/surface water</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>c. For Spl. Fdns./pile fdns. Acceptance by Project In-charge</td>
<td></td>
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<td></td>
<td>4. Soil Investigation wherever required</td>
<td></td>
<td></td>
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<tr>
<td>C. Concrete Works</td>
<td>a. Before concreting</td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>1.</td>
<td>Bottom of excavated earth</td>
<td>Depth of foundation</td>
<td>Appd. Drgs.</td>
<td>Contractor</td>
<td>100% at Field</td>
<td>100% check by TPGL</td>
<td>Jr. Engr./Engr.</td>
</tr>
<tr>
<td></td>
<td>2. Stub setting</td>
<td>1) Centre Line</td>
<td>-do-</td>
<td>-do-</td>
<td>-do-</td>
<td>-do-</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>2) Diagonals</td>
<td>-do-</td>
<td>-do-</td>
<td>-do-</td>
<td>-do-</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>3) Level of stubs</td>
<td>Placement</td>
<td>Bar bending schedule</td>
<td>-do-</td>
<td>-do-</td>
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<td>b.</td>
<td>During concreting</td>
<td></td>
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<td>S. No.</td>
<td>Description of Activity</td>
<td>Items to be Checked</td>
<td>Tests/Checks to be done</td>
<td>Ref. documents</td>
<td>Check/Testing</td>
<td>Counter Check/Test by TPGL</td>
<td>Accepting authority in TPGL</td>
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<td>Agency</td>
<td>Extent</td>
<td></td>
</tr>
<tr>
<td>1.</td>
<td>Workability</td>
<td>Slump test</td>
<td>Range 25 mm to 55 mm refer document at Annexure-5 of this FQP at Pg. 18</td>
<td>Contractor</td>
<td>100% at field</td>
<td>20% check at random</td>
<td>Jr. Engr./Engr.</td>
</tr>
<tr>
<td>2.</td>
<td>Concrete Strength</td>
<td>Cubes Comp Strength</td>
<td>CPWD SPEC as referred in document at annexure-5 of this page at 18</td>
<td>Casting of cubes at site. Cubes to be tested at TPGL appd. Lab for 28 days strength</td>
<td>One sample of 3 cubes in each tower locations</td>
<td>100% review of lab test results. Cubes at 20% location are to be taken in presence of TPGL officials</td>
<td>Section Incharge</td>
</tr>
<tr>
<td>5.</td>
<td>Pile foundations</td>
<td>1. All materials like cement, steel Coarse/fine aggregate, water</td>
<td>To be tested as per procedure enumerated in the respective columns above</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td></td>
<td></td>
<td>2. Before concreting</td>
<td>1. Check for center line of each pile</td>
<td>Appd. Drawings</td>
<td>Contractor</td>
<td>100%</td>
<td>100%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>2. Check for dia/verticality of each pile</td>
<td>-do-</td>
<td>-do-</td>
<td>-do-</td>
<td>-do-</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>3. Check for depth of each pile</td>
<td>-do-</td>
<td>-do-</td>
<td>-do-</td>
<td>-do-</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3. During Concreting</td>
<td>a. Workability</td>
<td>1. Slump test</td>
<td>100-150 mm as per TPGL Specn.</td>
<td>Contractor</td>
<td>Every one hour. For each pile</td>
</tr>
<tr>
<td>S. No.</td>
<td>Description of Activity</td>
<td>Items to be Checked</td>
<td>Tests/Checks to be done</td>
<td>Ref. documents</td>
<td>Check/Testing</td>
<td>Counter Check/Test by TPGL</td>
<td>Accepting authority in TPGL</td>
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<td>Agency</td>
<td>Extent</td>
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<td></td>
<td></td>
<td>b. Concrete strength</td>
<td>2. Cubes compressive strength</td>
<td>As per TPGL Specn.</td>
<td>Contractor</td>
<td>One set for each pile. For Pile caps, beams, Chimney, one sample for every 20 Cu.m. or part thereof for each day of concreting.</td>
<td>100% cubes for piles, 20% Pile caps, beams, chimney etc. to be taken in presence of TPGL officials. 100% review of test results.</td>
</tr>
<tr>
<td>6.</td>
<td>Tower Erection</td>
<td>1. Materials</td>
<td>Visual checking for</td>
<td>Appd. Drgs./BOM</td>
<td>Contractor</td>
<td>100% at stores</td>
<td>100% verification of records</td>
</tr>
<tr>
<td></td>
<td></td>
<td>a. Tower member/bolts &amp; nuts/washers/accessories</td>
<td>1. Stacking</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>2. Cleanliness</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>3. Galvanizing</td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td>4. Damages</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>2. Erection of Super-structure</td>
<td>1. Sequence of erection</td>
<td>As per Appd. Drgs./TPGL specification</td>
<td>Contractor</td>
<td>100% at field</td>
<td>100% check</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>2. Check for completeness</td>
<td>-do-</td>
<td>-do-</td>
<td>-do-</td>
<td>-do-</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>3. Tightening of nuts and bolts</td>
<td>-do-</td>
<td>-do-</td>
<td>-do-</td>
<td>-do-</td>
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<td></td>
<td></td>
<td></td>
<td>4. Check for verticality</td>
<td>-do-</td>
<td>-do-</td>
<td>-do-</td>
<td>-do-</td>
</tr>
<tr>
<td>S. No.</td>
<td>Description of Activity</td>
<td>Items to be Checked</td>
<td>Tests/Checks to be done</td>
<td>Ref. documents</td>
<td>Check/Testing</td>
<td>Counter Check/Test by TPGL</td>
<td>Accepting authority in TPGL</td>
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<td>5. Tack welding for bolts &amp; nuts</td>
<td>TPGL Specification</td>
<td>Contractor</td>
<td>100% Check</td>
<td>Site Engineer</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>3. Tower footing resistance (TFR)</td>
<td>TFR at locations before and after earthing.</td>
<td>Contractor</td>
<td>100% Field</td>
<td>Line Incharge</td>
</tr>
<tr>
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<td>7. Stringing</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>1. Materials</td>
<td>a. Insulators</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>1. Visual check for cleanliness/glazing/cracks/and white spots.</td>
<td>TPGL Specification</td>
<td>Contractor</td>
<td>100% Field</td>
<td>Site Engineer</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>2. IR Value (min. 50M Ohms) -do-</td>
<td>-</td>
<td>-do-</td>
<td>One test per sample size of 20 for every lot of 10,000</td>
<td>-do-</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>3. E&amp;M test</td>
<td>-</td>
<td>Insulator supplier</td>
<td>a. 20 per 10,000 for discs b. 3 per 1500 for long rod</td>
<td>Collection of samples, sealing them and handing over by TPGL to Insulator supplier</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>4. Traceability (Make/batch No./Locations where installed)</td>
<td>Packing list/CIP</td>
<td>Contractor</td>
<td>100% Field</td>
<td>Site Engineer</td>
</tr>
<tr>
<td>S. No.</td>
<td>Description of Activity</td>
<td>Items to be Checked</td>
<td>Tests/Checks to be done</td>
<td>Ref. documents</td>
<td>Check/Testing</td>
<td>Counter Check/Test by TPGL</td>
<td>Accepting authority in TPGL</td>
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<tr>
<td></td>
<td>b. Conductor</td>
<td>On receipt,</td>
<td>Packing list</td>
<td>Contractor</td>
<td>100% at stores</td>
<td>20% check</td>
<td>Site Engineer</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1. Visual check of drum.</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>2. Check for seals at both ends, and TPGL sticker on outer end</td>
<td>-do-</td>
<td>-do-</td>
<td>-do-</td>
<td>-do-</td>
<td>-do-</td>
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<tr>
<td></td>
<td></td>
<td>3. Check depth from top of flange to the top of the outer most layer</td>
<td>-do-</td>
<td>-do-</td>
<td>-do-</td>
<td>-do-</td>
<td>-do-</td>
</tr>
<tr>
<td></td>
<td>c. Earthwire</td>
<td>Check for seals at both ends</td>
<td>Packing list</td>
<td>Contractor</td>
<td>100% at stores</td>
<td>20% check</td>
<td>-do-</td>
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<td></td>
<td>2. Field activity</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>a. Before Stringing</td>
<td>Readiness for stringing</td>
<td>Stringing procedures as per TPGL specification</td>
<td>Contractor</td>
<td>Readiness certificate to be submitted by the Contractor</td>
<td>Review of Certificate</td>
<td>Line Incharge</td>
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<tr>
<td></td>
<td>b. During stringing</td>
<td>(Conductor/Earth-wire)</td>
<td></td>
<td></td>
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<tr>
<td>S. No.</td>
<td>Description of Activity</td>
<td>Items to be Checked</td>
<td>Tests/Checks to be done</td>
<td>Ref. documents</td>
<td>Check/Testing</td>
<td>Counter Check/Test by TPGL</td>
<td>Accepting authority in TPGL</td>
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<td>Agency</td>
<td>Extent</td>
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</tr>
<tr>
<td>1.</td>
<td>Scratch/cut check (Visual)</td>
<td></td>
<td></td>
<td>Appd. Drawings/TPGL Specn.</td>
<td>Contractor</td>
<td>100% at Field</td>
<td>100% record &amp; Field check 20%</td>
</tr>
<tr>
<td>2.</td>
<td>Repair sleeve</td>
<td>-do-</td>
<td>-do-</td>
<td>-do-</td>
<td>-do-</td>
<td>-do-</td>
<td>-do-</td>
</tr>
<tr>
<td>3.</td>
<td>Mid span Joints</td>
<td>-do-</td>
<td>-do-</td>
<td>-do-</td>
<td>-do-</td>
<td>-do-</td>
<td>-do-</td>
</tr>
<tr>
<td>4.</td>
<td>Guying (in case of towers not designed for one side stringing)</td>
<td>-do-</td>
<td>-do-</td>
<td>-do-</td>
<td>-do-</td>
<td>100%</td>
<td>Section Incharge</td>
</tr>
<tr>
<td></td>
<td>c. After stringing</td>
<td>Check for,</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.</td>
<td>Sag/Tension</td>
<td>Sag tension chart/tower Spotting data</td>
<td>-do-</td>
<td>-do-</td>
<td>100% record &amp; Field check 20%</td>
<td>Site Engr.</td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td>Electrical clearances</td>
<td>As per appd. Drgs./TPGL specifications</td>
<td>-do-</td>
<td>-do-</td>
<td>-do-</td>
<td>-do-</td>
<td>-do-</td>
</tr>
<tr>
<td>i)</td>
<td>Ground clearance</td>
<td>-do-</td>
<td>-do-</td>
<td>-do-</td>
<td>-do-</td>
<td>-do-</td>
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<tr>
<td>ii)</td>
<td>Live metal clearance etc.</td>
<td>-do-</td>
<td>-do-</td>
<td>-do-</td>
<td>-do-</td>
<td>-do-</td>
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<tr>
<td>3.</td>
<td>Jumpering</td>
<td>-do-</td>
<td>-do-</td>
<td>-do-</td>
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<td>S. No.</td>
<td>Description of Activity</td>
<td>Items to be Checked</td>
<td>Tests/Checks to be done</td>
<td>Ref. documents</td>
<td>Check/Testing</td>
<td>Counter Check/Test by TPGL</td>
<td>Accepting authority in TPGL</td>
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<td>4.</td>
<td>Copper bond</td>
<td></td>
<td></td>
<td>As per Appd. Drgns./TPGL Specification</td>
<td>Contractor</td>
<td>100% at Field</td>
<td>100% record &amp; Field Check 20%</td>
</tr>
<tr>
<td>5.</td>
<td>Placement of spacer/damper</td>
<td></td>
<td></td>
<td>As per Specn./drgs/placement chart</td>
<td>-do-</td>
<td>-do-</td>
<td>-do-</td>
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<td>8.</td>
<td>Final Testing</td>
<td></td>
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<tr>
<td>a.</td>
<td>Pre-commissioning of lines</td>
<td>Readiness of lines for pre-commissioning</td>
<td>1. Completeness of line. 2. Meggar test of line</td>
<td>TPGL latest pre-commissioning procedures (Doc. No. D-2-01-70-01-00)</td>
<td>Contractor</td>
<td>100%</td>
<td>100% joint checking</td>
</tr>
<tr>
<td>b.</td>
<td>Commissioning of line</td>
<td>Readiness of lines for commissioning</td>
<td>2. Digital photograph of each tower to ascertain the completeness of tower. a. TPGL latest pre-commissioning procedures (Doc. No. D-2-01-70-01-00) b. Pre-commissioning Report c. CEA clearance</td>
<td>-do-</td>
<td>-do-</td>
<td>-do-</td>
<td>-do-</td>
</tr>
<tr>
<td>S. No.</td>
<td>Description of Activity</td>
<td>Items to be Checked</td>
<td>Tests/Checks to be done</td>
<td>Ref. documents</td>
<td>Check/Testing</td>
<td>Counter Check/Test by TPGL</td>
<td>Accepting authority in TPGL</td>
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</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Agency</td>
<td>Extent</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>-do-</td>
<td>-do-</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3. Electrical Inspectors clearance from CEA.</td>
<td></td>
<td></td>
<td></td>
<td>-do-</td>
<td>-do-</td>
<td></td>
</tr>
</tbody>
</table>

Section-IV Appendix-2, Volume - I
ACCEPTANCE CRITERIA AND PERMISSIBLE LIMITS FOR CEMENT

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Name of the test</th>
<th>Ordinary Portland Cement 33 grade as per IS 269</th>
<th>Ordinary Portland Cement 43 grade as per IS 8112</th>
<th>Ordinary Portland Cement 53 grade as per IS 12269</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>a)</td>
<td>Physical tests</td>
<td></td>
<td></td>
<td></td>
<td>To be conducted in apprd. Lab</td>
</tr>
<tr>
<td>(i)</td>
<td>Fineness</td>
<td>Specific surface area shall not be less than 225 sq.m. per Kg or 2250 Cm²/gm.</td>
<td>Specific surface area shall not be less than 225 sq.m. per Kg or 2250 Cm²/gm.</td>
<td>Specific surface area shall not be less than 225 sq.m. per Kg or 2250 Cm²/gm.</td>
<td>Blaine’s air permeability method as per IS 4031 (Part-2)</td>
</tr>
<tr>
<td>(ii)</td>
<td>Compressive strength</td>
<td>72+/- 1 hour : Not less than 16 Mpa (16 N/mm²)</td>
<td>72+/- 1 hour : Not less than 23 Mpa (23 N/mm²)</td>
<td>72+/- 1 hour : Not less than 27 Mpa (27 N/mm²)</td>
<td>As per IS 4031 (Part-6)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>168+/-2 hour : Not less than 22 Mpa (22 N/mm²)</td>
<td>168+/-1 hour : Not less than 33 Mpa (33 N/mm²)</td>
<td>168+/-2 hour : Not less than 37 Mpa (37 N/mm²)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>672+/-4 hour : Not less than 33 Mpa (33 N/mm²)</td>
<td>672+/-1 hour : Not less than 43 Mpa (43 N/mm²)</td>
<td>672+/-4 hour : Not less than 53 Mpa (53 N/mm²)</td>
<td></td>
</tr>
<tr>
<td>(iii)</td>
<td>Initial &amp; Final setting time</td>
<td>Initial setting time : Not less than 30 minutes</td>
<td>Initial setting time : Not less than 30 minutes</td>
<td>Initial setting time : Not less than 30 minutes</td>
<td>As per IS 4031 (Part-5)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Final setting time : Not more than 600 minutes</td>
<td>Final setting time : Not more than 600 minutes</td>
<td>Final setting time : Not more than 600 minutes</td>
<td>-do-</td>
</tr>
<tr>
<td>(iv)</td>
<td>Soundness</td>
<td>Unaerated cement shall not have an expansion of more than 10mm when tested by Le chatlier and 0.8% Autoclave test.</td>
<td>Unaerated cement shall not have an expansion of more than 10mm when tested by Le chatlier and 0.8% Autoclave test.</td>
<td>Unaerated cement shall not have an expansion of more than 10mm when tested by Le chatlier and 0.8% Autoclave test.</td>
<td>Le chatlier and Autoclave test as per IS 4031 (Part-3)</td>
</tr>
<tr>
<td>No.</td>
<td>Name of the test</td>
<td>Ordinary Portland Cement 33 grade as per IS 269</td>
<td>Ordinary Portland Cement 43 grade as per IS 8112</td>
<td>Ordinary Portland Cement 53 grade as per IS 12269</td>
<td>Remarks</td>
</tr>
<tr>
<td>-----</td>
<td>------------------</td>
<td>-----------------------------------------------</td>
<td>-----------------------------------------------</td>
<td>-----------------------------------------------</td>
<td>---------</td>
</tr>
<tr>
<td>b)</td>
<td>Chemical composition tests</td>
<td></td>
<td></td>
<td></td>
<td>Review of MTCC only</td>
</tr>
<tr>
<td>a)</td>
<td>Ratio of percentage of lime to percentage of silica, alumina &amp; iron oxide 0.66 to 1.02</td>
<td>a) Ratio of percentage of lime to percentage of silica, alumina % iron oxide 0.66 to 1.02</td>
<td>a) Ratio of percentage of lime to percentage of silica, alumina % iron oxide 0.66 to 1.02</td>
<td></td>
<td></td>
</tr>
<tr>
<td>b)</td>
<td>Ratio of percentage of alumina to that of iron oxide Minimum 0.66%</td>
<td>a) Ratio of percentage of alumina to that of iron oxide Minimum 0.66%</td>
<td>a) Ratio of percentage of alumina to that of iron oxide Minimum 0.66%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>c)</td>
<td>Insoluble residue, percentage by mass Max. 4.00%</td>
<td>c) Insoluble residue, percentage by mass Max. 4.00%</td>
<td>c) Insoluble residue, percentage by mass Max. 4.00%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>d)</td>
<td>Magnesia percentage by mass Max. 6%</td>
<td>d) Magnesia percentage by mass Max. 6%</td>
<td>d) Magnesia percentage by mass Max. 6%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>e)</td>
<td>Total sulphur content calculated as sulphuric anhydride (SO3), percentage by mass Not more than 2.5 and 3.0 when tri-calcium aluminate percent by mass is 5 or less and greater than 5 respectively.</td>
<td>e) Total sulphur content calculated as sulphuric anhydride (SO3), percentage by mass Not more than 2.5 and 3.0 when tri-calcium aluminate percent by mass is 5 or less and greater than 5 respectively.</td>
<td>e) Total sulphur content calculated as sulphuric anhydride (SO3), percentage by mass Not more than 2.5 and 3.0 when tri-calcium aluminate percent by mass is 5 or less and greater than 5 respectively.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>c)</td>
<td>Total loss on Ignition</td>
<td>Not more than 5 percent</td>
<td>Not more than 5 percent</td>
<td>Not more than 5 percent</td>
<td></td>
</tr>
<tr>
<td>S. No.</td>
<td>Name of the test</td>
<td>Remarks</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-------</td>
<td>----------------------------------</td>
<td>-------------------------------------------------------------------------</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td>POZZOLANA PORTLAND CEMENT AS PER IS 1489</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>a)</td>
<td>Physical tests</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>i)</td>
<td>Fineness</td>
<td>Specific surface area shall not be less than 300 sq.m. per Kg. or 3000 Cm2/gm</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
| ii)   | Compressive strength             | 168+/- 2 hour : Not less than 22 Mpa (22 N/mm²)  
672+/- 2 hour : Not less than 33 Mpa (33 N/mm²) |
| iii)  | Initial & Final setting time     | Initial setting time : Not less than 30 minutes  
Final setting time : Not more than 600 minutes |
| iv)   | Soundness                        | Unaerated cement shall not have an expansion of more than 10mm          |
| b)    | Chemical composition tests       |                                                                         |
| a)    | Magnesia percentage by mass      | Max. 6%                                                                 |
| b)    | Insoluble material, percentage by mass | x + 2 (100-x)/100 where x is the declared % of pozzolana in the PPC |
| c)    | Total sulphur content calculated as sulphur anhydride (SO₃), percentage by mass | Not more than 2.75 and 3.0 when tri-calcium aluminate percent by mass is 7 or less and greater than 7 respectively. |
| c)    | Total loss on Ignition           | Not more than 5 percent                                                 |
# ACCEPTANCE CRITERIA AND PERMISSIBLE LIMITS FOR REINFORCEMENT STEEL

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Name of the test</th>
<th>Mild and medium tensile steel as per IS 432</th>
<th>Cold twisted Deformed bars Fe 415 as per IS 1786</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>i)</td>
<td>Chemical analysis test</td>
<td>Carbon (For 20 mm dia and below) 0.23% Max.</td>
<td>Carbon</td>
<td>0.30% Max</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Carbon (For over 20 mm dia) 0.25%</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Sulphur</td>
<td>0.055%</td>
<td>Sulphur</td>
<td>0.060%</td>
</tr>
<tr>
<td></td>
<td>Phosphorus</td>
<td>0.055%</td>
<td>Phosphorus</td>
<td>0.060%</td>
</tr>
<tr>
<td>ii)</td>
<td>Physical tests</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>a) Ultimate Tensile stress</td>
<td></td>
<td>a) Ultimate Tensile stress</td>
<td></td>
</tr>
<tr>
<td></td>
<td>For all dia bars</td>
<td>410 N/Sq.mm. (min.)</td>
<td>10% more than actual 0.2% proof stress but not less than 485</td>
<td></td>
</tr>
<tr>
<td></td>
<td>b) Yield stress (N/Sq.mm) min.</td>
<td></td>
<td>N/Sq.mm.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>For bars upto 20 mm dia</td>
<td>250</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>For bars above 20 mm dia</td>
<td>240</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>c) Percentage of elongation</td>
<td>23%</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>b) 0.2% of proof stress/Yield stress</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>For bars upto 20 mm dia</td>
<td>415</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>c) Percentage of elongation</td>
<td>14.5%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>iii)</td>
<td>Bend &amp; Rebend tests</td>
<td>Pass</td>
<td>Pass</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Testing in approved lab
### Annex-3

**ACCEPTANCE CRITERIA AND PERMISSIBLE LIMITS FOR COARSE AGGREGATES AS PER IS 383**

#### 3. Coarse Aggregates

**i) Physical Tests**

<table>
<thead>
<tr>
<th>a) Determination of particles size</th>
<th>a. IS Sieve Designation</th>
<th>Percentage Passing for grades Aggregate of nominal size</th>
</tr>
</thead>
<tbody>
<tr>
<td>63 mm</td>
<td>100</td>
<td>-</td>
</tr>
<tr>
<td>40 mm</td>
<td>85 to 100</td>
<td>100</td>
</tr>
<tr>
<td>20 mm</td>
<td>0 to 20</td>
<td>85 to 100</td>
</tr>
<tr>
<td>16 mm</td>
<td>-</td>
<td>85 to 100</td>
</tr>
<tr>
<td>12.5 mm</td>
<td>-</td>
<td>85 to 100</td>
</tr>
<tr>
<td>10 mm</td>
<td>0 to 5</td>
<td>0 to 20</td>
</tr>
<tr>
<td>4.75 mm</td>
<td>-</td>
<td>0 to 5</td>
</tr>
<tr>
<td>2.36 mm</td>
<td>-</td>
<td>0 to 5</td>
</tr>
</tbody>
</table>

#### Flakiness index
- Not to exceed 25%

#### Crushing Value
- Not to exceed 45%

#### Presence of deleterious material
- Total presence of deleterious materials not to exceed 5%

#### Soundness test (for concrete work subject to frost action)
- 12% when tested with sodium sulphate and 18% when tested with magnesium sulphate

---

Section-IV Appendix-2, Volume - I  Page 16 of 19
### ACCEPTANCE CRITERIA AND PERMISSIBLE LIMITS FOR FINE AGGREGATES AS PER IS 383

#### 4. Fine aggregates

**i) Physical Tests**

<table>
<thead>
<tr>
<th>IS Sieve Designation</th>
<th>Percentage passing for graded aggregate of nominal size</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>F.A. Zone I</td>
</tr>
<tr>
<td>10 mm</td>
<td>100</td>
</tr>
<tr>
<td>4.75 mm</td>
<td>90-100</td>
</tr>
<tr>
<td>2.36 mm</td>
<td>60-95</td>
</tr>
<tr>
<td>1.18 mm</td>
<td>30-70</td>
</tr>
<tr>
<td>600 microns 12.5 mm</td>
<td>15-34</td>
</tr>
<tr>
<td>300 microns</td>
<td>5 to 20</td>
</tr>
<tr>
<td>150 microns</td>
<td>0-10</td>
</tr>
</tbody>
</table>

**b) Silt content**

Not to exceed 8%

**c) Presence of deleterious material**

Total presence of deleterious materials shall not exceed 5%

**d) Soundness Applicable to concrete work subject to frost action**

12% when tested with sodium sulphate and 15% when tested with magnesium sulphate
ACCEPTANCE CRITERIA AND PERMISSIBLE LIMITS FOR CONCRETE WORK

1) Concrete
   a) Workability
      Slump shall be recorded by slump cone method and it shall be between 25-55 mm.

   b) Compressive strength
      Three samples of 15 cm cube for 28 days compressive strength for all concrete works except pile foundation work shall be taken. For pile foundation works, six cubes, three for 7 days testing and balance three for 28 days testing shall be taken.

Notes:

1) For nominal (volumetric) concrete mixes, compressive strength for 1:1.5:3 (Sand : Fine aggregates : Coarse aggregates) concrete shall be 265 kg/Sq.cm. for 28 days and for 1:2:4 nominal mix, it shall be 210 kg/Sq.cm.

2) ACCEPTANCE CRITERIA BASED ON 28 DAYS COMPRESSIVE STRENGTHS FOR NOMINAL MIX CONCRETE:
   a) the average of the strength of three specimen be accepted as the compressive strength of the concrete, provided the strength of any individual cube shall neither be less than 70% nor higher than 130% of the specified strength.
   b) If the actual average strength of accepted sample exceeds specified strength by more than 30%, the Engineer-in-charge, if he so desires, may further investigate the matter. However, if the strength of any individual cube exceeds more than 30% of the specified strength, it will be restricted to 30% only for computation of strength.
   c) If the actual average strength of accepted sample is equal to or higher than specified upto 30%, the strength of the concrete shall be considered in order and the concrete shall be accepted at full rates.
   d) If the actual average strength of accepted sample is less than specified strength but not less than 70% of the specified strength, the concrete may be accepted at reduced rate at the discretion of Engineer-in-charge.
   e) If the actual average strength of accepted sample is less than 70% of specified strength, the Engineer-in-charge shall reject the defective portion of work represent by sample and nothing shall be paid for the rejected work. Remedial measures necessary to retain the structure shall taken at the risk and cost of contractor. If, however, the Engineer-in-charge so desires, he may order...
additional tests to be carried out to ascertain if the structure can be retained. All the charges in connection with these additional tests shall be borne by the Contractor.

**General Notes:**

1) This standard Field Quality Plan is not to limit the supervisory checks which are otherwise required to be carried out during execution of work as per drawings/Technical specifications etc.

2) All materials should have Cat-A CIP before they are erected.

3) Contractor shall be responsible for implementing/documenting the SFQP. Documents shall be handed over by the contractor to TPGL after the completion of the work.

4) Project incharge means over all incharge of work. Line Incharge means incharge of the line. Section in-charge means incharge of the section.

5) In case of deviation the approving authority will be one step above the officer designated for acceptance in this quality plan subject to minimum level of Line incharge.

6) Acceptance criteria and permissible limits for tests are indicated in the Annexures. However for further details/tests TPGL specification and relevant Indian standards shall be referred.

7) Tests as mentioned in this FQP shall generally be followed. However E.I.C. reserves the right to order additional tests wherever required necessary at the cost of the agency.

8) All counter checks/tests by TPGL shall be carried out by TPGL’s officials atleast at the level of Jr. Engr.
SECTION – V

Pile
### SECTION-V

### CONTENTS

<table>
<thead>
<tr>
<th>Clause</th>
<th>Description</th>
<th>Page No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0</td>
<td>Bored Cast in Situ RCC Vertical Pile Foundation</td>
<td>1</td>
</tr>
<tr>
<td>2.0</td>
<td>Construction of Bored Cast in Situ RCC Vertical Pile Foundation</td>
<td>5</td>
</tr>
<tr>
<td>3.0</td>
<td>Pile Installation</td>
<td>28</td>
</tr>
<tr>
<td>4.0</td>
<td>Structural Steel M.S. Liner for RCC Vertical Piles and Painting of Liners</td>
<td>49</td>
</tr>
<tr>
<td>5.0</td>
<td>Standards and Codes</td>
<td>60</td>
</tr>
<tr>
<td></td>
<td>Annexure-A</td>
<td>63</td>
</tr>
<tr>
<td></td>
<td>Annexure-B</td>
<td>64</td>
</tr>
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<td></td>
<td>Annexure-C</td>
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</tr>
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<td>Annexure-D</td>
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<td>Annexure-E</td>
<td>68</td>
</tr>
<tr>
<td></td>
<td>Annexure-F</td>
<td>74</td>
</tr>
</tbody>
</table>
1.0 BORED CAST- IN – SITU R.C.C. VERTICAL PILE FOUNDATION

1.1 General Scope

1.1.1 The work to be performed under this specification consists of boring, driving and installation of cast-in-situ vertical bored piles providing all labour, supervision, dewatering, materials, scaffolding, platform, cranes, staging, power, fuel, construction equipments, tools, tackles and plants, supplies, transportation on land and water, all incidental items not shown or specified but reasonably implied or necessary for successful completion of work including Contractor’s supervision in strict accordance with IS Codes, approved drawings and specifications. The nature of work shall generally involve construction/installation of cast-in-situ vertical bored piles of specified size, pile caps, pedestals, tie beam (if required) etc as per Owner’s construction drawing. The bidder shall furnish in their bid complete data regarding the method of installation of the pile foundations, complete list of equipments, tools and tackles, rigs, men, materials to be deployed for the work etc.

1.1.2 The Bidder’s offer should be based on the mobilisation of at least one no. of piling rig for each tower location together with all associated working gangs, tool & tackles etc.(including at least 1 no. of rotary drilling rig capable of boring minimum 1200 mm diameter and upto 25 m depth below ground level with necessary tool/accessories for boring). However, if extra rigs are required to be deployed by the Contractor to match with the project construction schedule, in that case the same shall be deployed without any additional cost to the Owner.

1.1.3 The work shall include mobilization of all necessary equipments, providing necessary engineering supervision through qualified and technical personnel, skilled and unskilled labour, etc. as required to carry out the complete piling work. The minimum capacities of some key equipment are listed below. However, bidder has to furnish informations regarding the equipments they intend to deploy for the project as per Performa stipulated in the relevant schedules of the BPS.
<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Description</th>
<th>Capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Tripod height</td>
<td>6m. to 10m. (clear drop)</td>
</tr>
<tr>
<td>2.</td>
<td>Rig (winch) capacity</td>
<td>3T to 5T</td>
</tr>
<tr>
<td>3.</td>
<td>Weight of chisel</td>
<td>2T to 3T</td>
</tr>
<tr>
<td>4.</td>
<td>Mud pump capacity</td>
<td>15 HP to 25 HP</td>
</tr>
<tr>
<td>5.</td>
<td>Dia. of outlet pipe for bentonite</td>
<td>2.5 inch</td>
</tr>
<tr>
<td>6.</td>
<td>Rotary drilling rig (Hydraulic) along with all accessories</td>
<td>Minimum torque 12T</td>
</tr>
</tbody>
</table>

Note: Bidder may have to provide higher capacity equipments than mentioned above, as per the actual requirement for the execution of the job, without any additional financial implication to TPGL.

1.1.4 The Contractor shall be responsible for the soundness of the above pile foundations attributable to the installation/construction of these foundations.

1.1.5 After completion of installation / construction of piles, pile integrity test shall be conducted for each pile by the contractor, in presence of Owner’s representative, to establish its soundness. The procedure for conducting of pile integrity test is given briefly at clause 3.31 of this section. The tentative quantity of tests to be carried out are given in BPS. Bidder has to quote the price accordingly.

1.1.6 The setting of stub/fixing of foundation anchor bolts, as the case may be, shall be the responsibility of the Contractor.

1.1.7 In order to familiarize with the site condition and the work involved, the Bidders are advised to visit the site for on the spot study of the location before quoting their rates.

1.1.8 The Bidder has to quote based on the BOQ furnished in the schedule of Prices of B.P.S. No deviation in this respect will be acceptable and any bid quoted based on different Bill of Quantities shall be liable for rejection. However, the payment will be made as per actual quantity executed based on the unit rates quoted.

1.2 Qualifying requirement for Pile foundation

The bidder should have experience of its own or should engage the services of an agency (ies) meeting the following experience, for carrying out pile foundations covered under the scope of the work of the package. In case the
bidder intend to engage services of an agency (ies) for pile foundations meeting the stipulated experience, an undertaking as per Format enclosed at Annexure-F shall be submitted from the agency (ies) along with the bid.

A) Technical Experience

The bidder/agency shall have successfully carried out as a prime contractor or as a sub-contractor or as a member in a Joint Venture and in which each one of them has been responsible for 100% execution of at least two works of a nature and complexity comparable to the work covered in the proposed contract(s) within the last ten years. The bidder’s/ agency (ies) experience should include the following:

(i) The bidder/agency should have installed cast-in-situ vertical bored pile foundation having 1200 mm minimum diameter and having minimum depth of 25 metres below ground level.

(ii) a) The monthly rate of pile boring achieved by the bidder / agency should be 270 m for Package in any calendar month during last 5 years.

b) The monthly average rate of pile boring achieved by the bidder / agency should be 135 m for Package in any financial year during last 5 years.

(iii) The monthly average rate of Concreting for pile cap, pedestal, tie beams etc. achieved by the bidder / agency should be 69 Cum for Package in any financial year during last 5 years.

B) Equipment capabilities

The bidder/ agency should own or have access to atleast 1 (one) no. Rotary drilling machine capable of boring 1200 mm diameter and up to 40 m depth below ground level with necessary tools/accessories for boring in all kinds of soil including bed rock.

In case bidder/agency is proposing above facilities from other agencies, they shall furnish the details of such agencies along with their consent letters.
1.3 Design and Drawing Requirements

The detailed soil investigation is to be carried out by the Contractor. Owner will develop the pile foundation design based on the soil investigation report for the particular location. The construction drawing required for execution of pile foundation shall be given to the contractor after finalising the agency for execution of pile foundation.

1.4 Criteria For Terminating The Piles

1.4.1 The piles can be terminated at a depth based on design developed by the Owner, where loads bear by the piles can be transmitted to the soil in a proper manner or the depth where specified ‘N’ value is achieved, whichever occurs later. However, in no case piles should be terminated at a higher level than that indicated in the drawing.

1.4.2 Standard penetration test (SPT) shall be carried out starting from 1.0 M above the specified pile termination depth and there after @ 1m. upto the pile termination depth.

1.4.3 The Standard Penetration Test (SPT) shall be carried out based on the following test procedures:

The test shall be conducted by driving a standard split spoon sampler in the bore hole by means of a 60 N hammer having a free fall of 0.75 M. The sampler shall be driven for 450 mm using the hammer and the number of blow shall be recorded for every 150mm penetration. The number of blows for the last 300 mm drive shall be reported as N value. The test shall be discontinued when the blow count is equal to 100 or the penetration is less than 25mm for 50 blows, whichever is earlier.

At the location where the test discontinued, the penetration and the number of blows shall be reported. Sufficient quantity of disturbed sample shall be collected from the split spoon sampler for identification/classification of soil. The sample shall be visually classified and recorded at the site.

The specification for the equipments and other accessories, procedure for conducting the test and collection of the disturbed soil sample shall conform to IS:2131 latest edition.

2.0 Construction of Bored Cast-in-Situ Pile Foundation

2.1 General Requirement

2.1.1 The specification along with specific requirements under Annexure-A covers the technical requirements for piling work, general description of
work, quality and workmanship. In every case, work shall be carried out to the satisfaction of the Owner and conform to location, lines, grades and cross sections shown on the construction drawing or as directed by the Owner. The specifications are not, however, intended to cover minute details and the work shall be executed according to the relevant latest Indian Codes. In absence of the IS Codes, work shall be executed according to the best prevailing local Public Works Department practice or to the recommendations of the relevant American / British Standards or to the instructions of the Owner. This specification shall have precedence in case anything contrary to this is stated anywhere in this Bid Document. All the latest Editions of IS Codes are to be followed. In case of conflict between the Specification and Codes, the former shall prevail.

2.1.2 The work shall include mobilization of all necessary equipments (Annexure-B), providing necessary engineering supervision through qualified and technical personnel, skilled and unskilled labour, etc. as required to carry out the complete piling work, and submission of records as per schedule. The bidder shall furnish complete data of their equipments required for installation of piles.

2.2 Layout and Levels

Layout and levels of structures etc. shall be made by the Contractor, at his own cost, from the general grid of the plot and the bench marks given by the Owner. The Contractor shall make his own arrangements, at his own cost, for locating the co-ordinates and position of piles as per approved drawings and for determining the Reduced Level (R.L.) of the locations with respect to the single bench mark indicated by the Owner. Two established reference lines in mutually perpendicular direction shall be indicated to the Contractor. The Contractor shall provide at site all the required survey instruments, materials and men to Owner for checking the detailed layout and correctness of the layout and levels to the satisfaction of the Owner so that the work can be carried out accurately according to specifications and drawings. The contractor shall be solely responsible for the correctness of layout and levels.

2.3 Properties, Storage & Handling of Construction Materials

This section specifies the properties, storage & handling of common building materials unless otherwise mentioned in the drawings or schedule of items.

2.3.1 Properties of Materials

All materials viz., cement, steel, aggregates, water etc. which are to be used
for pile construction are detailed below. However, aggregates more than 20mm shall not be used.

2.3.1.1 Stone

All stones shall be from approved quarries, hard, tough, durable, 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. Stone with round surface shall not be used. Stones showing mottled colours shall not be used for face work. A stone shall not absorb more than 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 Owner. Samples shall be submitted by the Contractor and approved samples shall be retained by the Owner for comparison of bulk supply.

2.3.1.2 Cement

Cement used shall be ordinary Portland Cement, unless mentioned otherwise, conforming to the latest Indian Standard Code IS:269 or IS:8112 or IS:12269. Any variety of cement other than ordinary Portland Cement such as Portland Pozzolana Cement conforming to IS:1489 (latest edition) or Portland Slag Cement conforming to IS:455 (Latest edition) shall be used only after the written permission of the Owner. The Contractor shall submit the manufacturers certificate, for each consignment of cement procured, to the Owner. However Owner reserves the right to direct the Contractor to conduct tests for each batch/lot of cement used by the Contractor and Contractor will conduct those tests free of cost at the laboratory so directed by the Owner. The Contractor shall also have no claim towards suspension of work due to time taken in conducting tests in the laboratory. Changing of brand or type of cement within the same structure shall not be permitted without the prior approval of the Owner. Sulphate resistant cement shall be used if sulphate content is more than the limit specified in IS : 456, as per Geotechnical Investigation report.

2.3.1.3 Coarse aggregates

a) Coarse aggregates shall be as per IS:383 (Latest Edition) consisting of hard, strong and durable pieces 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.

b) Aggregate other than crushed stone conforming to the provisions of specifications may be used if permitted by the Owner.

c) Sieving and washing of aggregates by approved method shall be carried out, if desired by the Owner.

d) Grading of coarse aggregate 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.

e) The maximum size of aggregate shall be as follows unless specified otherwise:
   i) Reinforced concrete with very narrow space - 10mm.
   ii) Reinforced concrete & Plain Concrete - 20mm.
   iii) Lean Concrete 1:3:6 or 1:4:8-40mm.

2.3.1.4 Sand

Sand shall be hard, durable, clean and free from any adherent coatings or organic matter and shall not contain clay balls or pellets. The sand shall be free from impurities such as iron pyrites, alkalies, salts, 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 corosions to any metal in contact with such mortar, plaster or concrete. In no case the cumulative percentage of impurities in sand shall be more than 5% by weight. All sand shall be properly graded. Unless otherwise directed by the Owner all sand shall pass through IS Sieve no. 240 and 15% to 35% of sand for masonry mortar and 5% of sand for plaster shall pass through Sieve No. 30. Sand for concrete shall conform to IS:383.

2.3.1.5 Water

Water shall be clean, fresh and free from organic matters, acids or soluble salts and other deleterious substances which may cause corrosion, discolouration, efflorescence etc. Potable water is generally considered fit for use. Water to be used shall comply with the requirements of IS:456.

Average 28 days compressive strength of atleast 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 of water shall generally be not less than 6.
2.3.1.6 Reinforcement

Reinforcement steel shall be clean and free from loose mill scales, dust, loose rust, oil and grease or other coatings which may impair proper bond. Structural steel and medium tensile steel bars and hard drawn steel wire for concrete reinforcement shall conform to IS:432 (Part-I). Cold twisted steel bars shall conform to IS:1786. Thermo mechanically Treated (TMT) bars (equivalent grade) in place of Cold twisted deformed steel bars are also acceptable. Hard drawn steel wire fabric shall conform to IS:1566 (Latest Edition). All steel bars including and above 6mm diameter shall be of tested quality. All wire netting shall be galvanised. Substitution of reinforcement shall not be permitted without the prior approval of the Owner.

2.3.2 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 Owner. Storage of materials shall be as described in IS:4032.

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 Owner shall not be used for concrete, and shall be removed from site immediately, failing which, the Owner will get the materials removed and the cost thereof shall be recovered from contract price. The Contractor shall maintain upto date accounts of receipt, issue and balance (stockwise) of all materials.

2.3.2.1 Stones

Stones shall be stored at site in manner approved by the Owner. Dressed stone for wall facing paving etc. shall be stored with special care to avoid defacement of faces and edges or damp and rust stains.

2.3.2.2 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 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 as soon as it is detected. Cement stored for period beyond 90 days shall be tested before use.

2.3.2.3 Coarse and Fine Aggregate

Aggregates shall be stored on bricks soling or an 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 Owner, aggregates from different sources shall be stacked separately with proper care to prevent intermixing.

2.3.2.4 Reinforcement

Reinforcement steel shall be stored consignment wise and size wise, off the ground and under cover, if desired by the Owner. It shall be protected from rusting, oil grease and distortions. If directed by the Owner, the reinforcement steel may have to be coated with cement wash before stacking, to prevent scale and rust at no extra cost to the Owner. The stacks shall be easily measurable. Only steel needed for immediate use shall be removed from storage. Fabricated reinforcement shall be carefully stored to prevent damage, distortion, corrosion & deterioration.

2.4 Owner’s Authority to Reject Materials

Any material considered to be Sub-standard or not up to the specifications declared/certified by the Owner shall not be used by the Contractor and shall be removed from the site immediately at no extra cost to the Owner.

2.5 Site Preparation

This section of the specification covers site preparation of the areas as indicated in the drawings.

2.5.1 Reference Points and Bench Marks

2.5.1.1 Permanent reference pillars have been established and under no circumstances shall the Contractor remove or disturb any permanent mark without the approval of the Owner. The Contractor shall carefully maintain and protect all bench marks and reference points and shall layout all his work by accurate reference thereto. The Contractor shall remove all vegetation, excluding trees, from the site areas as directed by the Owner.
2.5.1.2 The area shall be stripped to remove roots of grass, rubbish and slush, shrubs or other organic materials. Spoiled materials shall be burnt or removed to approved disposal areas on or near the job site as directed by the Owner.

2.6 **Excavation (applicable for construction of pile cap)**

2.6.1 The Contractor shall furnish all labour, equipment and materials required for complete execution of the work in accordance with the drawings and as described herein.

2.6.2 The Contractor shall control the grading in the vicinity of all excavation so that the surface of the ground will be properly slopped or diked to prevent surface water from running into the excavated areas during construction.

2.6.3 Excavation shall include the removal of all materials required to execute the work properly and shall be made with sufficient clearance to permit the placing, inspection and setting of forms and completion of all works for which the excavation was done.

2.6.4 Side and bottoms of excavation shall be cut sharp and true, undercutting shall not be permitted. Each sides of excavation shall be used in lieu of formwork for placement of concrete unless authorised, in special cases, by the Owner, where limitation of space for larger excavation necessitate such decision.

2.6.5 When machines are used for excavation, the last 300mm before reaching the required level shall be excavated by hand or by such equipment that will leave the soil at the required final level, in its natural conditions.

2.6.6 Suitability for bearing of the bottoms of excavations shall be determined by the Owner.

2.6.7 The bottom of excavation shall be trimmed to the required level and when carried below such levels, by error, shall be brought to level by filing with lean concrete 1:4:8 mix, with aggregate of 40mm maximum nominal size at the Contractor’s cost.

2.6.8 The Contractor shall be responsible for assumptions and conclusions regarding the nature of materials to be excavated and the difficulty of making and maintaining the required excavations and performing the work required as shown on the drawing and in accordance with these specifications. Cofferdams, sheet piling, sheeting, shoring, bracing, draining,
dewatering etc, shall be furnished and installed as required and the cost there of shall be included in the unit rate quoted for the item of excavation. The Contractor shall be responsible for any damage to any part of the work and property caused by collapse of sides of excavations. Materials may be salvaged if it can be done with safety for the work and structure, as approved by the Owner.

However, no extra claim shall be entertained for materials not salvaged or any other damage to Contractor’s property as a result of the collapse. He shall not be entitled to any claim for redoing the excavation as a result of the same.

2.6.9 Excavations for foundations specified shall be carried at least 100mm or as specified in relevant drawings below the bottom of structural concrete and then be brought to the required level by placing lean concrete of 1:4:8 mix or as specified in drawings with aggregate of 40mm maximum nominal size.

2.6.10 When excavation requires sheet piling, bracing, sheeting or shoring etc. the Contractor shall submit to Owner, drawings showing arrangement and details of proposed installation and shall not be proceed until he has received approval from the Owner.

2.6.11 The Contractor shall have to constantly pump out the water collected in pits due to rain water, springs etc. and maintain dry working conditions at no extra cost to the Owner.

2.6.12 **Classifications**

For the purpose of excavation in earthwork, all types of soil including kankar, morum, shingle and boulders upto 150mm size without binding matrix are included and no separate payment shall be made for different type of soils.

2.6.13 **Measurement of Excavation**

Measurement for payment will be based on volume calculations determined by the existing grade, the bottom elevation of structural/lean concrete with lateral dimension (vertical sides) 0.3m outside concrete outline of lowest footing for depths upto 1.0m below existing grade, and 1.0m outside concrete outline of lowest footing for depths more than 1m below existing grade (Concrete dimensions determined from drawings). The unit of measurement shall be cu.m.
Nothing extra would be payable for slope, shoring, shuttering, sheeting, sheet piling etc. irrespective of whatever is provided. If directed by Owner the excavation shall be done on slopes for slope stability point of view at no extra cost to the Owner. The Contractor shall arrange to transport the excavated soil to a distance as directed by Owner and the rates quoted for excavation in Price schedule shall include all lead, lift, carriage etc.

2.7 Cement Concrete

2.7.1 This section of the specification deals with cement concrete, plain or reinforced, and covers the requirement for concrete mix design, strength and quality, pouring at all levels, forming, protection, curing finishing, admixtures, inserts and other miscellaneous works.

2.7.2 The provisions of the latest revision of IS:456 shall be complied with unless permitted otherwise. Any other Indian Standard Code (Latest Revision) shall form the part of the specification to the extent it has been referred to or applicable within this specification.

2.7.3 The Contractor shall furnish all labour, material and equipment to form, place and finish all structural concrete, concrete works and miscellaneous items complete, as described herein.

2.7.4 Admixtures

The admixtures in concrete for promoting workability, improving strength, entertaining air or for any other purpose shall be used only after the written permission from the Owner is obtained. Addition of admixtures should not reduce the specified strength of concrete in any case. The admixtures shall conform to IS:9103 (Latest Edition). In case plasticisers are used in the concrete for any structure, fresh mix design be done considering the admixture with the specific approval from Owner. Nothing extra shall be payable to the Contractor on this account.

2.7.5 Grades of Concrete

The minimum grade of concrete to be used for piling shall be M-25 and minimum cement content shall be 400 kg/m³ in all condition. Concrete shall conform to the controlled design mix as specified in IS:456 (latest edition). In addition, nominal mixes of 1:3:6 and 1:4:8 (with aggregates of nominal size 40mm maximum or as indicated on drawings), by volume or any other mix shall be used as per field quality plan or where specified. The concrete in aggressive surroundings due to presence of sulphate, etc., shall confirm to
IS:456 (latest edition). The slump of concrete shall be maintained between 150 to 200 mm.

2.7.6 Workmanship

2.7.6.1 General

All workmanship shall be according to the latest and best possible standards.

Before starting a pour the Contractor shall obtain the approval of the Owner in a “Pour Card” maintained for this purpose. He shall obtain complete instructions about the material and proportions to be used. Slump, workability, Quantity of water per unit weight of cement, number of test cubes to be taken type of finishing to be done, any admixture to be added, any limitation on size of pour and stopping of concrete in case of premature stopping of pours.

2.7.7 Mixing of Concrete

All control/design mix concrete shall be mixed at a single central batching plant situated within the area allocated for the Contractor’s particular use as shown on the drawings. The plant shall have mechanically operated mixer of an approved size and type capable of ensuring a uniform distribution on the materials through the mass.

The proportions of fine and coarse aggregate, cement and water shall be as determined by the mix design or according to fixed proportions in case of nominal mix concrete and shall always be approved by the Owner. The quantities of the cement, final and coarse aggregates shall be determined by weight. The water shall be measured accurately after giving proper allowance for surface water present in the aggregate for which regular check shall be made by the Contractor.

The water shall not be added to the mix until all the cement and aggregates consisting the batch are already in the drum and dry mixed for atleast one minute. Mixing of each batch shall be continued until there is a uniformity in colour and consistency but in no case shall mixing be done for less than two (2) minutes and at least forty (40) revolutions after all the materials and water are in the drum. When absorbent aggregates are used or when the mix is very dry, the mixing time shall be extended as may be directed by the Owner. Mixers shall not be loaded above their rated capacity as it prevents through mixing. If there is segregation after
unloading from the mixer the concrete should be remixed.

The entire contents of the drum shall be discharged before the ingredients for the next batch are fed into the drum. No partly set or remixed or excessively wet concrete shall be used and it shall be immediately removed from site. Each time the work stops, the mixer shall be thoroughly cleaned and when the next mixing commences, the first batch shall have 10% additional cement at no extra cost to the Owner to allow for loss in the drum.

When hand mixing is permitted by the Owner for concrete to be used in unimportant locations it shall be carried out on a water tight platform and care shall be taken to ensure that mixing is continued until the mass is uniform in colour and consistency. In case of hand mixing, an extra 10% of cement shall be added to each batch at no extra cost to Owner.

2.7.8 Conveying Concrete

Concrete shall be handled and conveyed from the place of mixing to the place of final laying as rapidly as practicable, by approved means, before the initial setting of the cement starts. Concrete should be conveyed in such a way as will prevent segregation of Concrete which may occur during transportation of concrete. In case of any such segregation during transport, the concrete shall be re-mixed. During very hot or cold weather, if directed by the Owner, concrete shall be transported in deep containers, mortar leak proof, which will reduce the rate or water loss by evaporation and loss of heat. Conveying equipments for concrete shall be well maintained and thoroughly cleaned before commencement of concrete mixing. Such equipment shall be kept free from set concrete.

2.7.9 Placing of Concrete

a) Formwork and reinforcement shall be approved in writing by the Owner before concrete is placed. The forms shall be well wetted and all shavings, dirt and water that may have collected at the bottom shall be removed before concrete is placed. Concrete shall be deposited in its final position without segregation, rehandling or flowing. The interval between adding the water to the dry materials in the mixer and the completion of the final placing inclusive of compaction of the concrete shall be well within the initial setting time for the particular cement in use or as directed by the Owner. As far as possible, concrete shall be placed in the formwork by means approved by the Owner and shall not be dropped from a height or
handled in a manner which may cause segregation. Any drop over 180cm shall have to be approved by the Owner. Once the concrete is deposited in its final position, it shall not be disturbed. Care should be taken to avoid displacement of reinforcement or movement of formwork.

b) The placing of concrete shall be a continuous operation with no interruption in excess of 30 minutes between the placing of continuous portions of concrete.

c) After the concrete has been placed it shall be spreaded and thoroughly compacted by approved mechanical vibration to a maximum subsidence without segregation and thoroughly worked around reinforcement or other embedded fixtures into the correct form and shape. Vibrators shall not be used for pushing and shoveling concrete into adjoining areas. Vibrators must be operated by experienced men and over-vibration shall not be permitted. Head tamping in some cases may be allowed subject to the approval of the Owner. Care must be taken to ensure that the inserts, fixtures, reinforcement and form work are not displaced or disturbed during placing of concrete. No concrete shall be placed in open while it rains. If there has been any sign of washing of cement and sand, the concrete shall be entirely removed immediately. Suitable precautions shall be taken in advance to guard against rains before leaving the fresh concrete unattended. No accumulation of water shall be permitted on or around freshly laid concrete. Slabs, beams, pile caps, footings and the similar members shall be poured in one operation normally, in special circumstances with the approval of the Owner these can be poured in horizontal layers not exceeding fifty (50) cm in depth. When poured in layers, it must be ensured that the under layer, is not already hardened. Blending of under layer if any, shall be effectively removed.

d) Wherever vibration has to be applied externally the design of formwork and the disposition of vibrators shall receive special consideration to ensure efficient compaction and to avoid surface blemishes.

2.7.10 Construction Joints (for pedestal, pile cap, tie beam etc.)

a) When the work is to be interrupted, the concrete shall be rebated at the joint to such shape and size as may be required by the Owner or as shown on the drawings. All vertical construction joints shall be
made with stone boards, which are rigidly fixed and slotted to allow for the passage of the reinforcing steel. If desired by the Owner, keys and/or dowel bars shall be provided at the construction joints. Construction joints shall be provided in positions as shown or described on the drawing. Where it is not described, the joints shall be in accordance with the following:

i) In a column, the joint shall be formed about 75mm below the lowest soft of the beams framing into it.

ii) Concrete in a beam shall be placed throughout without a joint, but if the provision or a joint is unavoidable, the joint shall be vertical and at the middle of the span.

iii) In forming a joint, concrete shall not be allowed to slope away to thin edge. The locations of construction joints shall be planned by the Contractor well in advance of pouring and have to be approved by the Owner.

b) Before the fresh concrete is placed, the cement skin of the partially hardened concrete shall be thoroughly removed and surface made rough by hacking, sand blasting, water jetting, air jetting or any other method as directed by the Owner. The rough surface shall be thoroughly wetted for about two hours and shall be dried and coated with 1:1 freshly mixed cement sand slurry immediately before placing the new concrete. The new concrete shall be worked against the prepared surface before the slurry sets. Special care shall be taken to see that the first layer of concrete placed after a construction joint is thoroughly rammed against the existing layer. Old joints during pour shall be treated with 1:1 freshly made cement sand slurry only after removing all loose materials.

c) The unit rate of concrete work shall include the cost of preparation of construction joints as mentioned above and no extra payment shall be admissible on this account.

2.7.11 Inserts

All anchors, anchor bolts, inserts, stubs, etc. and any other items those are required to be embedded in the concrete shall be placed in correct position before pouring. Extra care shall be taken during pouring operation to maintain their locating Blockouts and openings shall be kept as indicated in the drawings. These inserts shall be welded to the nearest reinforcement to
keep them in position and all such welding shall be deemed to be included in the unit rate quoted and nothing extra shall be payable on this account.

2.7.12 Blockouts

Blockouts in concrete as indicated in the drawing and as directed by the Owner shall be provided wherever required. Nothing extra shall be payable to the Contractor on this account.

2.7.13 Repairs and Finishes of Concrete

All concrete surfaces either cast-in-situ or pre-cast shall have even, clean finish, free from honey combs, air bubbles, fins or other blemishes. The formwork joints marks for concrete work exposed to view shall be rubbed with carborandum stone and defects patched up with a paste of 1 part sand and 1 part cement and cured. The finish shall be made to the satisfaction of the Owner.

Concrete surfaces to be subsequently plastered or where brickwork shall be built against it shall be adequately hacked as soon as the form is stripped off so that proper bond can develop. The unit rate of concrete work shall be inclusive of the cost of cleaning and finishing exposed surface as mentioned above.

2.7.14 Curing and Protection of Concrete (for pile cap, pedestal & tie beam)

Newly placed concrete shall be protected by approved means from rain, sun & wind. Concrete placed below ground level shall be protected from failing earth during the after placing. Concrete placed in ground containing deleterious substances shall be kept free from contact with such ground or with water leaking from such ground during placing of concrete and for a period of at least three days or as otherwise instructed by the Owner. The ground water around newly poured concrete shall be kept to an approved level by pumping or other approved means of drainage. Adequate steps shall be taken to prevent floatation or flooding. Steps, as approved by the Owner, shall also be taken to protect immature concrete from damage by debris, excessive loading, vibration etc. which may impair the strength or durability of the concrete.

All fresh concrete shall be covered with a layer of hessain or similar absorbant material and kept constantly wet for a period of seven days or more from the date of placing of concrete as per directions of the Owner. Curing can also be made by ponding. Concrete shall be cured by flooding
with water of minimum 25mm depth for the period mentioned above. Step shall also be taken to protect immature concrete from damage debris by excessive loading, vibrations, abrasions, deleterious ground water, mixing with earth or foreign materials, floatations etc. that may impair the strength and durability of the concrete. Approved curing compound may be used in view of moist curing with the permission of the Owner. Such compound shall be applied to all exposed surfaces of the concrete as soon as possible after the concrete has set.

2.7.15 Testing and Acceptance Criteria

The Contractor shall carry all sampling and testing in accordance with Standard Field Quality Plan at his own cost in a laboratory approved by the Owner and submit to the Owner the test results in triplicate within 3 (Three) days after completion of the test.

2.7.16 Acceptance Criteria for Concrete

a) The acceptance criteria of concrete shall be in accordance with Standard Field Quality Plan (SFQP). However, in exceptional circumstances, the Owner may at his discretion accept a concrete of lower strength than specified and which is otherwise unacceptable according to SFQP.

b) Payment for concrete which is normally unacceptable as per the SFQP, but has been accepted by the Owner shall be made at a reduced rate proportionate to the strength obtained.

c) Concrete work found unsuitable for acceptances shall have to be dismantled and replacement is to be done as per specification by the Contractor. No payment for the dismantled concrete, the relevant form work and reinforcement, embedded fixtures, etc. wasted in the dismantling shall be made to the Contractor. If any damage is done to the embedded items of adjacent structures, the same shall be made good free of charge by the Contractor, to the satisfaction of Owner.

d) The dimensions of concrete as cast, when compared with the drawing, shall be within the tolerances given below. Steps in surface alignment shall not exceed 2mm. No reduction will be permitted in the cover to reinforcement because of a specified negative tolerance in a concrete section.
<table>
<thead>
<tr>
<th>Structural Element Detail</th>
<th>Permissible Deviation in mm.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Faces of concrete in foundations and structural members against which backfill is placed</td>
<td>+25 -5</td>
</tr>
<tr>
<td>Exposed concrete foundations</td>
<td>+10 -5</td>
</tr>
<tr>
<td>Top surfaces of slabs and for concrete to received grouted plant or structural steel work</td>
<td>+5 -5</td>
</tr>
<tr>
<td>Alignment of beams, columns walls slabs and similar items</td>
<td>+5 0</td>
</tr>
<tr>
<td>Cross sectional dimensions of beams, columns, walls, slabs and similar items</td>
<td>+5 -5</td>
</tr>
<tr>
<td>Level and alignment of holding down bolts</td>
<td>+5 -5</td>
</tr>
<tr>
<td>Level of holding down bolt assemblies</td>
<td>+10 -5</td>
</tr>
<tr>
<td>Alignment of holding down bolts assemblies</td>
<td>+5 -5</td>
</tr>
<tr>
<td>Centres of pockets or holes with greatest lateral dimensions not exceeding 150mm</td>
<td>+5 -5</td>
</tr>
<tr>
<td>Centres of pockets or holes with greatest lateral dimension exceeding 150mm.</td>
<td>+10 -5</td>
</tr>
</tbody>
</table>
2.7.17  Method of Measurement

2.7.17.1  Actual volume of work as executed or as per drawing issued, whichever is less, shall be measured in cubic metre correct upto second place of decimal. Deductions for openings, conduits, pipes, ducts, pockets, chases etc. shall be made provided they are larger than 0.1 sq.m. in area (for each opening upto and less than 0.1 sq.m. in area the form work shall not be paid for separately).

2.7.17.2  No deduction shall be made for embedded fixtures including reinforcement, sleeves, anchor bolts and similar items.

2.7.17.3  Separate items are measured for the various grades of concrete.

2.8  Reinforcement Steel

2.8.1  This section of the specification shall cover furnishing of working drawings with bar-bending schedule and the furnishing, cleaning, bending, binding, placing with arrangements for chairs, supports and suitable covers for all reinforced concrete works, below and above ground level as per drawings and specifications.

2.8.2  General Requirements

2.8.2.1  The Contractor shall prepare and furnish to the Owner bar-bending schedule with working drawings for all RCC works for review and approval by the Owner. Reinforcement steel of same type & grade shall be used for structural reinforcement. No work shall be commenced without the approval of the bar-bending schedule by the Owner.

2.8.2.2  Contractor shall supply, fabricate and place reinforcement to shapes and dimensions as indicated or required to carry out the intent of drawings and specifications. The reinforcement shall be either plain or deformed steel bars or welded wire fabric conforming to relevant IS specifications.

2.8.2.3  Any adjustment in reinforcement to suit feels conditions and construction joints other than shown on drawings shall be subjected to the approval of Owner.

2.8.3  Bending

2.8.3.1  Unless otherwise specified, reinforcing steel shall be bent in accordance with procedure specified in IS:2502 and or as approved by the Owner. Bends and shapes shall comply strictly with the dimensions in the approved Bar Bending Schedule. Contractor shall be entirely responsible for its
correctness. Bars correctly bend shall only be used.

2.8.3.2 No reinforcement shall be bent when in position in the work without approval of the Owner, whether or not it is partially embedded in concrete. Bars shall not be straightened in a manner that will injure the material. Rebending can be done only if approved by the Owner. Reinforcement bars shall be bent by machine or other approved means producing a gradual and even motion. All the bars shall be cold bent unless otherwise approved.

2.8.4 Placing in position

2.8.4.1 All reinforcement shall be accurately fixed and maintained in position as shown on the drawings by such approved means as mild steel chairs, and/or concrete spacer blocks. Bars intended to be in contract, at crossing points, shall be securely bond together at all such points by two number No.20G annealed soft-iron wire.

Binders shall tightly embrace the bars with which they are intended to be in contract and shall be securely held. The vertical distance between successive layers of bars shall be maintained by provision of mild steel spacer bars. They should be so spaced that the main bars do not sag preceptibly between adjacent spacers.

2.8.4.2 The placing of reinforcements shall be completed well in advance of concrete pouring. Immediately before pouring, the reinforcement shall be checked by the Owner for accuracy of placement and cleanliness and necessary correction as directed by him shall be carried out. The cover for concrete over the reinforcements shall be as shown on the approved drawings unless otherwise directed by the Owner. Care should be taken to ensure that projecting ends of ties and other embedded metal do not encroach into the concrete cover. Where concrete blocks are used for ensuring the cover and positioning reinforcement, they shall be made of mortar 1:2 (one part cement: two parts sand) by volume and cured for atleast (7) days. The sizes and locations of the concrete blocks shall be approved by the Owner.

2.8.4.3 Longitudinal reinforcement in pile shall be high yield strength deformed steel bars conforming to IS:1786 unless specified otherwise. Thermo mechanically Treated (TMT) bars (equivalent grade) in place of Cold twisted deformed steel bars are also acceptable. Lateral reinforcement in pile shall be of for steel or mild steel conforming to IS:432 Part-I.

2.8.4.4 The longitudinal reinforcement in pile shall be provided considering the combination of vertical (compression and tension) and horizontal loads. However, the minimum longitudinal reinforcement shall be 0.4 percent of
the sectional area calculated on the basis of outside area of casing or the pile shaft where casing is not used, whichever is more. The minimum number of longitudinal reinforcement shall be six and its minimum diameter shall be 12mm. The stipulated minimum reinforcement shall be provided for the full length of pile.

2.8.4.5 The longitudinal reinforcement shall project 52 times its diameter above cut-off level unless otherwise indicated.

2.8.4.6 The minimum diameter of the links or spirals bar shall be 6mm and the spacing of the links or spiral shall not be less than 150mm and in no case more than 250mm. The laterals shall be tied to the longitudinal reinforcement to maintain its shape and spacing.

2.8.4.7 Reinforcement cage shall be sufficiently rigid to withstand handling and installation without any deformation and damage. As far as possible number of joints (laps) in longitudinal reinforcement shall be minimum. In case the reinforcement cage is made up of more than one segment, these shall preferably be assembled before lowering into casing tube/pile bore by providing necessary laps as per IS:456.

2.8.4.8 The minimum clear distance between the two adjacent main reinforcement bars shall normally be 100mm for the full depth of cage, unless otherwise specified.

2.8.4.9 The laps in the reinforcement shall be such that the full strength of the bar is effective across the joint and the reinforcement cage is of sound construction. Laps and anchorage lengths of reinforcing bars shall be in accordance with IS:456, unless otherwise specified. If the bars in a lap are not of the same diameter, the smaller will guide the lap length.

2.8.4.10 Laps shall be staggered as far as practicable and as directed by the Owner. Not more than 50% bars shall be lapped at a particular section. Lap joints shall be staggered by at least 1.3 times the lapped length (Centre to Centre).

2.8.4.11 Proper cover and central placement of the reinforcement cage in the pile bore shall be ensured by use of suitable concrete spacers or rollers, cast specifically for the purpose without any additional cost to the Owner.

2.8.4.12 Minimum clear cover to the reinforcement shall be 75mm unless otherwise mentioned.

2.8.4.13 Unless otherwise specified by the Owner reinforcement shall be placed within the following tolerance as specified in Clause 11.3 of IS:456.

a) For effective depth 200mm or less +10mm.
b) For effective depth more than 200mm +15mm.

The cover shall in no case be reduced by more than one-third of specified cover or 5mm whichever is less.

2.8.4.14 Welding of reinforcement bars shall be avoided. However, welding may be done in specific case subject to prior permission from the Owner.

2.8.5 Acceptance Criteria

Reinforcement shall be checked for cleanliness, proper bending, binding, placing and securing in position with provision for proper cover.

2.8.6 Method of Measurement

2.8.6.1 Bar or any other type of reinforcement used like hard drawn steel wire fabric etc. for reinforced concrete shall be measured by weight in Tonnes. The weight shall be arrived at by multiplying the actual or theoretical length measured along standard hooks, cranks, bends, authorised laps, etc. whichever is less by the sectional weights. Claims for payment for this items shall be submitted with supporting documents giving the schedule of Bars with sketches. The sectional weight to be adopted shall be IS Sectional weight.

2.8.6.2 Standard hooks, cranks, bends, authorised laps, etc. shall be measured.

2.8.6.3 Separator pieces between two or more layers of steel shall not be measured.

2.8.6.4 No payment shall be made for supports, spacers, chairs, hangers, etc. of height/length 300mm and less, required for keeping the steel in position unless otherwise specified in the contract. For supporting horizontal reinforcement at heights larger than 300mm support drawings shall be prepared by the Contractor and payment shall be made for the supports as provided by the Owner, or as actually placed, whichever is less, at the same rate as for reinforcement.

2.8.6.5 No extra will be paid for modification of already embedded reinforcement, if required due to faulty fabrication of placement.

2.8.6.6 Dowels neither shown in the drawings nor instructed by the Owner, but required for construction facilities and/or sequences, shall not be measured.
2.9 Form work (applicable for pile cap, pedestal & tie beam)

2.9.1 General

2.9.1.1 If it is so desired by the Owner, the Contractor shall prepare, before commencement of the actual work, design and drawings for form work and centering and get them approved by the Owner. The form work shall conform to the shape, lines and dimensions as shown on the drawings.

Form work shall be composed of steel and/or best quality shuttering wood of non-absorbant 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. Plywood or equivalent shall be used where specified to obtain smooth surfaces for exposed concrete work. Sturts shall generally be mild steel tubes, and strong sal ballis of 150mm in diameter or above. Bamboos, small diameter ballis, etc. shall not be used unless approved by the Owner in specified cases.

Supports or props should not be supported on an unpropped lower suspended floor or beam unless calculations are submitted to the Owner to confirm the strength of the lower floor or beam and no propping shall be taken out until the Owner approval has been given.

2.9.1.2 The concreting 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 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, building, distortion or loosening off 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 Owner 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 Owner shall be used but they must in no way impair the strength of concrete or leave stains or marks on the finished 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.

2.9.1.3 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 in plumb and true and throughout cross braced to keep them so. All floors and beams centering shall be crowned not less than 8mm in all directions for every 5 metres span. Unless described on the drawing or elsewhere bevelled strips 25mm shall be provided without any extra charge to form angles and 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 as may be directed by the Owner. The temporary openings shall be so formed that they can be conveniently closed when required and must not leave any mark on the concrete.

2.9.2 Cleaning and Treatment of Forms

2.9.2.1 All forms shall be thoroughly cleaned of old concrete wood shavings, saw dust, dirt and dust sticking to them before they are fixed in position. All rubbish loose concrete, chippings, shavings saw dust etc. shall be scrupulously removed from the interior of the forms before the concrete is poured. Alongwith wire brushes, brooms, etc. compressed air jet and/or water jet shall be kept handy for cleaning, if directed by the Owner.

2.9.2.2 Before shuttering is placed in position the form surface in contact with concrete shall be treated with approved non-standing oil or composition. Care shall be taken that the oil or composition does not come in contact with reinforcing steel or existing concrete surface. They shall not be allowed to accumulate at the bottom of the shuttering.

2.9.2.3 Formwork 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. Repropping of beams shall not be done except with the approval of Owner and props can be reinstated in anticipation of abnormal conditions. If formwork for column is erected for the full height of the section, as placing of concrete proceeds, 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.

2.9.3 Removal of Forms

2.9.3.1 The Contractor shall begin the removal of formwork only after approval of Owner. He shall place on record the date on which the concrete is placed in
different parts of the work and the date of the removal of formwork therefrom. This record shall be checked and countersigned by the Owner. The Contractor shall be responsible for the safe removal of formwork but the Owner may delay the time of removal if he considers it necessary. Any work showing signs of damage through premature removal of form-work or loading shall be entirely reconstructed without any extra cost to Owner.

2.9.3.2 Forms for various types of structural components shall not be removed before the minimum periods specified below which shall also be subject to the approval of the Owner.

2.9.3.3 No supporting forms shall be removed suddenly in such manner as to create shock loading. Forms for sides shall not be removed before 2 days. Bottom forms shall not be removed before 28 days unless this period is reduced with specified concurrence of the Owner.

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 forms.

2.9.4 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 Owner.

2.9.5 Acceptance of Formwork and Finished Concrete

2.9.5.1 Finished concrete shall be true to shape, lines, levels plumb and dimensions as shown on drawings.

2.9.5.2 All embedded fixtures shall be of correct type and in correct position as shown in drawings.

2.9.5.3 Finished concrete surface shall be free from blemishes like honey-combs, air bubbles, fins, etc.

2.9.5.4 Exposed 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 Owner.
2.9.5.5 The finished concrete shall be of a standard quality and equal to the accepted sample.

3.0 **Pile Installation**

Installation of piles shall be carried out as per pile layout drawings, installation criteria and the directions of the Owner.

3.1 **Equipment and Accessories**

3.1.1 The equipment and accessories for installation of bored cast-in-situ piles shall be selected giving due consideration to the sub soil conditions, ground water conditions and the method of casting, etc. These shall be of standard type and shall have the approval of the Owner.

3.1.2 List and details of equipment and accessories proposed to be used for the job shall be submitted along with the bid.

3.1.3 The capacity of the rig shall be adequate so as to reach the specified founding level.

3.1.4 Provision shall be kept for chiseling within the pile bore, as specified elsewhere in this specification. Chiseling shall be carried out only with the approval of Owner.

3.2 **Installation Criteria**

3.2.1 The Contractor while boring the pile bores, shall constantly collect the bore spoils and these shall be compared with the layerwise soil classifications reported in the bore-log details of the location, reported in the soil investigation report. Should there be any variation between the two soil classification, these shall be immediately reported to the Owner/Owner.

3.2.2 Whenever the rock strata is encountered in the pile bore, the Contractor shall immediately report the matter to the Owner and shall take up the work of rock chiselling only after the certification/approval of the Owner. Since the piles are required to be terminated in the firm/hard strata the Contractor shall demonstrate such founding strata and seek approval of the Owner before terminating the piles.

3.2.3 In order to verify the terminating depth, where rock strata is met with, the rock samples obtained from the bore spoils obtained from the chiselling of pile bores shall be tested for point load strength index and these shall then be compared/correlated to the values of uniaxial compression strength test shown in the soil investigation report. Accordingly, the termination of piles in the socketing horizon shall be done with prior approval of the Owner.

3.2.4 Approval of foundation level by the Owner shall in no way absolve the
Contractor of his responsibility to guarantee the sound installation of piles true to the requirement of the specifications.

3.3 Control of position and alignment

3.3.1 Piles shall be installed as accurately vertical as possible, the permissible limits for deviation with respect to position and inclination/alignment shall conform to IS-2911 Part I/Sec.2, which is reproduced below for ready reference.

a) The maximum deviation of vertical piles shall not exceed 1.5 per cent in alignment.

b) Piles should not deviate more than 75mm or D/10 whichever is less from their designed position at cut off level.

3.4 Boring

3.4.1 Boring operations shall be done by rotary or percussion type drilling rigs using direct or reverse mud circulation (DMC or RMC) methods or grab method. In soft clays and loose sands bailer method, if used, shall be used with caution to avoid the effect of suction. In cohesive soils, use of water for boring shall be restricted to a minimum, while boring in cohesionless deposits water level in the bore hole shall be maintained at or slightly above the standing water table.

Boring operations by any of the above methods shall be done using drilling mud. The bidder shall be required to furnish alongwith their bid, complete details regarding the installation of piles and the method by which they wish to install the piles.

3.4.2 The Contractor shall satisfy himself about the suitability of the method to be adopted for site. If DMC or RMC is used, bentonite slurry shall be pumped through drill rods by means of high pressure pumps. The cutting tools shall have suitable pores for the bentonite slurry to flow out at high pressure. If the Contractor fails to make proper bore for any reason, the Contractor has to modify the boring technique and switchover to other boring methods as approved by the Owner at no extra cost to the Owner.

3.4.3 Working level shall be above the pile cut off level. After the initial boring of about 1.0 to 2.0m temporary guide casing shall be lowered in the pile bore. The diameter of guide casing shall be of such diameter to give the necessary finished diameter of the concrete pile. The centre line of guide casing shall be checked before continuing further boring. Guide casing shall be minimum 2.0m length. Additional length of casing may be used depending on the conditions of the strata, ground water level etc.

3.4.4 Use of drilling mud (bentonite slurry) for stabilising the sides of the pile
bore is necessary wherever subsoil is likely to collapse in the pile bore. Drilling mud to be used shall meet the requirement as given in Annexure-C.

3.4.5 The bentonite slurry and the cuttings, which are carried to the surface by the rising flow of the slurry shall pass through settling tanks of adequate size to remove the sand and spoils from the slurry before the slurry is recirculated back to the boring. The bentonite slurry mixing and recirculation plant shall be suitably designed and installed.

3.4.6 The bentonite slurry shall be maintained at 1.5m above the ground water level during boring operations and till the pile is concreted. When DMC or RMC method is used the bentonite slurry shall be under constant circulation till start of concreting.

3.4.7 The size of cutting tools shall not be less than the diameter of the pile by more than 75mm. However, the pile bore shall be of the specified size.

3.5 Chiseling

3.5.1 Chiseling, if required, may be resorted to with the permission of the Owner below the socketing horizon. The chiseling tool or bit shall be of adequate size and weight so as to reach the desired depth.

3.6 Cleaning of Pile bore

3.6.1 After completion the pile bore upto the required depth, the bottom of the pile bore shall be thoroughly cleaned. Cleaning shall ensure that the pile bore is completely free from sludge/bored material, debris of rock/boulder etc. Necessary checks shall be made as given in this Section to confirm the thorough cleaning of the pile bore.

3.6.2 Pile bore shall be cleaned by fresh drilling mud through tremie pipe before start of concreting and after placing reinforcement.

3.6.3 Pile bore spoil along with used drilling mud shall be disposed off from site upto 2 Km. or as directed by the Owner.

3.7 Adjacent Structures

3.7.1 When working near existing structures care shall be taken to avoid any damage to such structures.

3.8 Concreting

3.8.1 The Contractor shall carry out concrete mix design in accordance with IS:10262 and submit mix design calculations and get them approved from the Owner well in advance of installation of piles. The Contractor shall carry out adequate number of tests in accordance with IS:456 to ensure concrete of
the minimum specified strength at requisite workability (slump).

3.8.2 Concreting shall not be done until the Owner is satisfied that the bearing strata (soil/rock) met with the termination level of pile, satisfied the installation criteria/approved founding depth.

3.8.3 The time between the completion of boring and placing of concrete shall not exceed 6 hrs. In case the time interval exceed 6 hrs the pile bore shall be abandoned. However, the Owner may allow concreting, provided the Contractor extends the pile bore by 0.5 m beyond the proposed depth, and clean the pile bore properly. The entire cost of all operation and materials for this extra length shall be borne by the Contractor.

3.8.4 Pile bore bottom shall be thoroughly cleaned to make it free from sludge or any foreign matter before and after placing the reinforcement cage.

3.8.5 Proper placement of the reinforcement cage to its full length shall be ensured before concerting.

3.8.6 Entire concreting shall be done by tremie method. The operation of tremie concreting shall be governed by IS:2911 Part I/Sec.2. Drilling mud shall be maintained sufficiently above the ground water level.

3.8.7 Concreting operations shall not proceed if the contaminated drilling mud at the bottom of the pile bore posses density more than 1.25 T/Cu.m. or sand content more than 7%. The drilling mud sample shall be collected from the bottom of pile bore. This shall be checked at regular intervals, as decided by the Owner thereafter.

3.8.8 Consistency of the drilling mud suspension shall be controlled throughout concreting operations in order to keep the bore stablised as well as to prevent concrete getting mixed up with the thicker suspension of the mud.

3.8.9 It shall be ensured that volume of concrete poured is at least equal to the theoretically computed volume of pile shaft being cast.

3.8.10 The temporary guide casing shall be entirely withdrawn cautiously, after concreting is done upto the required level. While withdrawing the casing concrete shall not be disturbed.

3.8.11 Tests on concrete cubes shall be carried out as specified in this section of the Specifications.
3.9 Cut-off-level (COL)

3.9.1 Cut-off-level of piles shall be as indicated in approved construction drawings or as directed by the Engineer-in-Charge.

3.9.2 The top of concrete in pile shall be brought above the COL to remove all laittance and weak concrete and to ensure good concrete at COL for proper embedments into pile cap.

3.9.3 When the pile cut off level is less than 1.0 metre below the working level, concrete shall be cast upto the piling platform level to permit overflow of concrete for visual inspection. In case COL of pile is more than 1.0 metre below working level then concrete shall be cast to minimum of one metre above COL.

3.9.4 In the circumstances where COL is below ground water level, the need to maintain a pressure on the unset concrete equal to or greater than water pressure shall be observed and accordingly length of extra concrete above COL shall be determined by the Contractor with prior approval of Owner.

3.10 Sequence of Piling

3.10.1 Each pile shall be identified with a reference number and date wise proper record of construction shall be maintained by the Contractor.

3.10.2 The convenience of installation may be taken into account while scheduling the sequence of piling in a group. This scheduling shall avoid piles being bored close to other recently constructed piles.

3.11 Building up of Piles

3.11.1 If any pile, already cast as per construction drawing, requires any extra casting due to any change in cut off level or the cast pile top level is less than the specified level or for any other reason, then the pile shall be built up by using M-25 grade concrete, ensuring proper continuity with the existing concrete and to the satisfaction of the Owner. Necessary reinforcement as per design requirement and suitable shuttering shall be provided before casting the concrete. Surrounding soil shall also be built up to the required level by proper compaction to ensure lateral capacity of the pile.
3.12 **Breaking off of Piles**

3.12.1 If any pile already cast requires breaking due to lowering in cut off level or for any other reason, then the same shall be carried out, (not before seven days of casting of concrete in the piles) without affecting the quality of existing pile such as loosening, cracking etc. to the satisfaction of the Owner.

3.13 **Preparation of Pile head**

3.13.1 The soil surrounding the piles shall be excavated upto the bottom of the ear concrete below the pile cap with provision for working space sufficient enough to place shuttering reinforcement concreting and any other related operations.

3.13.2 The exposed part of concrete above the COL, shall be removed/chipped off and made square at COL not before seven days of casting of pile.

3.13.3 The projected reinforcement above COL shall be properly cleaned and bent to the required shape and level to be anchored into the pile cap.

3.13.4 The pile top shall be embedded into the pile cap by minimum 50mm or clear cover to reinforcement, whichever is higher.

3.13.5 All loose material on the top of pile head after chipping to the desired level shall be removed and disposed off upto a lead of 2km or as directed by the Owner.

3.14 **Rejection and Replacement of Defective Piles**

3.14.1 The Owner reserve the right to reject any pile which in his opinion is defective on account of load capacity, structural integrity, position, alignment, concrete quality etc. Piles that are judged defective shall be pulled out or left in place as decided by the Owner without affecting the performance of adjacent piles. The Contractor shall install additional piles to substitute the defective piles as per the directions of the Owner at no extra cost to the Owner.

3.15 **Recording of Piling Data**

3.15.1 The Contractor shall record all the information during installation of piles. Typical data sheet for recording pile data as shown in Appendix D of IS:2911 Part I/Sec.2 shall be maintained by the contractor. The pile data shall also include all the details as in Annexure-D. On completion of each pile
installation, pile record in triplicate shall be submitted to Owner within two
days of completion of concreting of the pile.

3.16 Sampling, Testing and Quality Assurance

3.16.1 Facilities required for sampling and testing materials, concrete, etc. in field
and in laboratory shall be provided by the Contractor. The Contractor shall
carry out all sampling and testing in accordance with the relevant Indian
Standards and this Specification. Where no specific testing procedure is
mentioned the tests shall be carried out as per the prevalent accepted
engineering practice to the directions of the Owner. Tests shall be done in
the presence of the Owner or his authorised representative. In case the
Owner requires additional test, the Contractor shall arrange to get these
tests done and submit to the Owner the test results in triplicate within three
days after completion of any test.

3.16.2 The Contractor shall maintain records of all inspection and testing, which
shall be made available to the Owner. The Owner at his discretion, may
waive some of the stipulations for small and unimportant concreting
operations and other works.

3.16.3 Materials found unsuitable for acceptance shall be removed and replaced by
the Contractor. The work shall be redone as per specification requirements
and to the satisfaction of the Owner at no extra cost to the Owner.

3.17 Quality Assurance Programme

a) The standard field quality plan (SFQP) enclosed in this specification is
to be adhered to by the contractor while executing the pile foundation
work in conjunction with the various testing procedures described in
the specification. Wherever the procedures for testing and quality
described in this specification is in variance to the standard field
quality plan, the testing and quality assurance procedures described
herein will prevail. The testing apparatus/equipment installed in the
filed laboratory shall be calibrated/corrected by the qualified person as frequently as possible
to give accurate testing results.

b) Frequency of sampling and testing, etc. and Acceptance Criteria are
given in SFQP. The testing shall be done at field laboratory or any
other laboratory approved by the Owner. However, the testing
frequencies set forth are the desirable minimum and the Owner shall
have the full authority to call for tests as frequently as he may deem
necessary to satisfy himself that the materials and works comply with the Specifications. The materials shall be tested to meet all the specified requirements before acceptance at manufacturers premises or at independent government approved laboratory. Tests indicated in the table are for cross checking at site the conformity of the materials to the Specifications.

3.18 Testing Concrete

3.18.1 Concrete and other materials shall be tested for qualify and strength and other properties. Details of testing shall be specified elsewhere in the technical specification for concrete and allied works.

3.18.2 One sample consisting of six test cubes shall be made from the concrete used in each test pile, three to be tested after 7 days and three after 28 days.

3.18.3 For working piles, minimum one sample consisting of six test cubes shall be made from the concrete for each pile, three to be tested after 7 days and three after 28 days.

3.18.4 In preparation of test cubes/specimens vibrators shall not be used.

3.18.5 Concrete shall be tested for slump at every 1 hour interval.

3.18.6 Other properties of concrete and materials shall be tested for frequency of sampling and testing pertaining to concrete and allied works.

3.19 Testing for position and alignment

3.19.1 Each pile shall be checked for its position with respect to specified location. Each pile bore shall be checked for its alignment.

3.19.2 Permissible limits for deviation shall be as specified under clause of this Section of the Specification.

3.20 Properties of drilling mud

3.20.1 Properties of drilling mud shall be checked as per requirements indicated in Annexure ‘C’. Prior to the commencement of piling work and thereafter minimum once in a week or as found necessary by the Owner, one sample consisting of 3 specimens shall be tested.
3.20.2 Density and sand content of the drilling mud shall be checked in each pile.

3.21 Check for Pile bore

3.21.1 On completion of boring and cleaning the bottom of each pile bore shall be checked by the methods as approved by the Owner, to ensure that it is free from pile bore spoil/debris and any other loose material, before concreting. Concreting shall be done only after the approval of the Owner.

3.21.2 For sampling of drilling mud from the pile bore the following method or any other suitable method shall be adopted.

A solid cone shall be lowered by a string to the bottom of pile bore. A sampler tube closed at top with a central hole (hollow cylinder) is lowered over the cone, then a top cover shall be lowered over the cylinder. Care shall be taken for proper fittings of assembly to minimise the leakage while lifting the cone assembly to the ground surface. The slurry collected in the sampler tube shall be tested for density and sand content.

3.22 Rates and Measurements

3.22.1 Rates

3.22.1.1 The items of work in the schedule of items, describe the work in brief. The various items in schedule of items shall be read in conjunction with the corresponding sections in the Technical Specifications, including amendments, and additions, if any. For each item in schedule of items, the unit rate shall include for the activities covered in the description of the item as well as for all necessary operations described in the specification and specific requirements.

3.22.1.2 The unit rates shall include for minor details which are obviously and fairly intended, and which may not have been included in the description in these documents, but are essential for the satisfactory completion of the work. Unit rates shall also include for all safety measures as required by codal provisions, local regulations, acts, bye-laws, etc. and for execution of work to the satisfaction of the Owner.

3.22.1.3 Unit rate for each item shall be inclusive of mobilisation all plant, equipment, scaffolding, labour, materials, skilled and unskilled labour, and demobilisation after completion of work, supervision, establishing level and coordinates at each work.

3.22.1.4 Unit rate per metre length basis for a particular diameter and capacity of pile shall remain valid for the actual lengths provided/to be provided irrespective of the minimum length specified elsewhere in this specification.

3.22.1.5 The unit rate for pile boring through soil including weathered rock/laterite
shall be inclusive of boring with RMC method only and providing all plant equipment, labour, materials, skilled and unskilled labour, making observations, establishing the ground level and coordinates at each location of pile by carrying levels from one established bench mark and distances from one set of grid lines furnished by the Owner.

3.22.1.6 Unit rate for pile boring through soil, including weathered rocks shall be inclusive of bailing out all the pile bore spoils from the pile bore, keeping the bore hole free from bored material/debris etc. and disposing the bored/chiseled material along with the drilling mud upto a distance of 2 Kms., flushing the pile bore by fresh bentonite before concreting, collection of samples from bottom of pile bore, transporting to laboratory, testing and reporting of results.

3.22.1.7 Unit rate quoted for pile boring through soil including weathered rocks and chiseling through rock shall include shifting of plant and equipment from one pile location to another providing temporary casing pile and removal of the same after completing, concreting, supply of necessary materials, equipment and manpower, cost of boring by approved method as specified, etc. The quoted unit rate for boring/installation of pile shall also be inclusive of the empty boring and extra concreting required above the pile cut off level.

3.22.1.8 Unit rate for pile boring through soil including weathered rock / laterite shall also include chiseling, if any required, the chiseling through rock in the pile below socketing horizon up to the specified level shall be inclusive of bailing out the pile bore debris/spoils from the pile bore and disposing off the chiseled materials/debris along with the sludge/mud upto 2 kms., flushing the pile bore by fresh bentonite before concreting, collection of samples from bottom of the pile bore, transporting to laboratory, testing and reporting of results.

3.22.1.9 Unit rate of concreting shall include concreting in piles by tremie method, cost of preparation of pile head and disposal of debris etc., resulting from breaking off of pile upto COL, upto a distance of 2 km.

3.22.1.10 Unit rate of reinforcement shall include cleaning, straightening, cutting, bending, binding with annealed wire, welding, tack welding, providing concrete cover blocks, spacers, chairs, placing of reinforcement cage in pile shaft and all other cost for tools and plants, materials, labour, transportation of steel to the piling site by all means as required.

3.22.1.11 Unit rate shall include for all quality assurance requirements, but not limited to providing for technical inspection, transportation of samples to laboratory, testing samples, maintaining and submitting all test records, etc.
3.22.12 The rate quoted for boring and installation shall be inclusive of performing point load test on the rock samples obtained from bore spoils during the chiselling operations, and shall be inclusive of transportation to laboratory, testing and reporting of the results.

3.22.2 Measurement

3.22.2.1 Measurement for the item of boring through soil including weathered rock shall be done by linear measurement for the length bored from the pile cut off level through soil/weathered rock up to approved termination/founding level of the pile in metres, upto second place of decimal, separately for a pile of given diameter and capacity.

3.23 Pile Caps, Pedestals, Tie Beams etc.

3.23.1 The Concrete work in pile caps, pedestals/chimneys, tie Beams etc. including reinforcement and formwork shall have to be done by the Contractor as shown in the construction drawings and as per Specification for concrete, formwork and reinforcement given in this Specification.

3.23.2 The payment for the various items for pile caps, pedestals/chimneys, tie-beams etc. shall be governed by the rates quoted against the relevant items of the schedule of items. The volume of piles below and within the pile cap shall be deducted while calculating the quantity of P.C.C. below pile cap and R.C.C. of pile cap.

3.23.3 The use of admixtures in concrete for promoting workability, improving strength, eliminating formation of entraining air or for any other purposes may be used only with the written approval of the Owner. Addition of admixture should not reduce the specified strength of concrete in any case. The admixtures shall conform to IS:6103 (Latest Edition). In case, plasticisers are used in the concrete for any structure, fresh mix design shall be done considering the admixture and mix design shall be approved by the Owner. Nothing extra shall be payable to the Contractor on this account.

3.24 Back Filling

3.24.1 General Requirement

3.24.1.1 After completion of foundation footings, pile caps, pedestals, tie beams and other constructions below the elevation of the grades, and prior to back filling, all forms of temporary shoring, timber etc. shall be removed and the excavation cleaned of all trash, debris and perishable materials, back filling shall begin only with the approval of the Owner.

3.24.1.2 The soil to be used for back filling purpose shall be inorganic material and shall be free from any foreign substance which can harm or impair the strength of footing in any manner. In any case the soil to be used for back
filling purpose shall have the prior approval of the Owner.

3.24.1.3 The soil to be used for back filling purpose shall be either from the excavated earth or from the borrow pits, as directed by the Owner. The soil may have to be brought from a distance upto 2 km. By the shortest haulage route as approved by the Owner. If directed by the Owner, the excavated earth from the adjoining areas (which is to be disposed off upto a distance of 500 metres by manual labour) shall be used as for back filling purpose. In such case the Contractor shall be paid only for the operations involving back filling. The lead for this purpose shall not be paid as this shall be paid under the excavation item.

3.24.1.4 Back filling shall not be dropped directly upon or against any structure where there is danger of displacement or damage.

3.24.1.5 Back filling shall be placed in horizontal layers not to exceed 200mm in thickness. Each layer shall be compacted with proper moisture content and with such equipment as may be required to obtain a density equal to or greater than 95% of maximum dry density as determined by the relevant Indian Standard. The method of compaction shall be subject to the approval of the Owner. Pushing of earth for back filling shall not be adopted under any circumstances.

3.24.1.6 On completion of structures, the earth surrounding them shall be accurately finished to line and grade as shown on the drawings or as per the instruction of the Owner. Finished surface shall be free of irregularities and depressions and shall be within 50mm of the specified level.

3.24.1.7 Any additional quantity of back filling, if required, beyond the excavation payment line shall be done by the contractor at his own expense.

3.24.2 Measurements

Measurements shall be based on the volume between the structure near line and the payment line. Measurement shall be in cubic metre rounded off upto 2\textsuperscript{nd} place of decimal and the rate shall include all the necessary operations required to complete the work as per drawing, Specifications and satisfaction of the Owner.

3.25 Erection of Steel Embedded Parts

3.25.1 This covers the technical requirements for the supply and fabrication and/or erection of all embedded steel parts by the Contractor. The extent and type of embedded steel parts to be erected shall be as per detailed
3.25.2 The supply of embedded steel parts is in the scope of the Contractor.

3.25.3 Embedded steel parts shall include items such as foundation grillages anchor bolts, slabs anchor bolt, pipe sleeves, hoist structures, ladders, steel pieces set in concrete inserts, expansion bolts, auxiliary framing for equipment supports, dowel bars for concrete work, miscellaneous frames, etc. shown on the drawing or as material shall include setting in forms for connecting in place and grouting as required. The grouting operations shall be performed as per the direction of Owner.

3.25.4 The Contractor shall erect all embedded steel parts in accordance with the drawings and these specification including setting materials in concrete or grouting pieces in place, furnishing all labour, materials, scaffolding, tools and services necessary for and incidental to the work to its transporting, unloading, storing, handling and erection. Contractor shall furnish welding rods and arrange for field welding as required in accordance with IS Code 816 (Latest Edition).

3.25.5 Exposed surface of embedded material are to be painted with one coat of approved anticorrosive and/or bituminous paint without any extra cost to the Owner. The threads of holding down bolts shall be greased and protected with water proof tape.

3.25.6 Installation

3.25.6.1 During erection, the Contractor shall provide necessary temporary bracing or supports to ensure proper installation of the materials. All materials shall be erected in the true locations as shown in the drawings, plumb and level. Extreme care shall be taken to ensure that the threads of holding down bolts and comparable items are protected from damage.

3.25.6.2 The Contractor shall set holding down bolts, anchor and tubes using the templates. He shall fabricate templates from the drawings supplied. Where no drawings are supplied he shall produce his own fabricated drawings for approval by the Owner and shall fabricate the templates accordingly.

3.25.6.3 Groups of holding down bolts shall be set to a tolerance such that the whole group is not more than 3mm from its true position in plan at the top of the bolt tubes and not more than 3mm from the required level. The top ends of all bolt shanks shall be in one plane to the tolerance stated above.
Holding down bolt assemblies shall be set vertically to a tolerance of not less than 1:500.

3.25.7 Protection Against Damage in Transit

3.25.7.1 All steel work shall be efficiently and sufficiently protected against damage in transit to site from any cause whatsoever. All protecting plates or bars and all ends of members at joints shall be stiffened, all straight bars and plates shall be bundled, all screwed ends and machined surface shall be suitably packed and all bolts, nuts, washers and small loose parts shall be packed separately in cases so as to prevent damage or distortion during transit. Should there be any distortion of fabricated members, the Contractor shall immediately report the matter to the Owner. Distorted steel received from stores or distorted during transport from stores to the fabrication yard shall not be used in fabrication unless the distortions are minor which in the opinion of the Owner can be removed by acceptable methods. The cost of all such straightening shall be borne by the Contractor within his unit rates.

These distortions shall be rectified by the Contractor by cold bending. If heating is necessary to rectify the defects, the details of the procedure shall be intimated to the Owner whose approval shall be taken before such rectification. The temperature of heat treatment shall not exceed the limits beyond which the original properties of steel are likely to be impaired.

3.26 Foundations Bolts

3.26.1 Foundation bolts for the structures and elsewhere may require to be supplied through this contract, these shall be embedded in first stage concrete while the foundation is cast. The Contractor shall ensure the proper alignment of these bolts to match the holes in the base plate. The final adjustment of these bolts and their grouting are included in the scope of this contract. Grouting of block outs and the gap between the base plate and top of concrete shall be done by the Contractor after finalisation of alignments. The unit rate of concreting quoted for pedestal shall include the cost of above adjustments, grouting, templates and skins etc. required for this purpose.

3.26.2 The Contractor shall be responsible for the correct alignment and levelling of all steel work on site to ensure that the towers are in plumb.

3.26.3 Before erection of columns/towers 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 materials and shall be chipped with a chisel to ensure proper bond between the grout and the foundation concrete. The Contractor shall also be responsible for bringing down the top of concrete to the desired level by chipping. In case the foundation as cast is lower than the desired level, the Contractor shall make up the difference by providing additional pack plates without extra payment for any such work or material. No steel structures shall be erected on their foundations unless such foundations have been certified fit for erection steel by the Owner. Adequate number of air release holes and inspection holes shall be provided in the base plate.

3.26.4 Stability of Structure

3.26.4.1 The Contractor shall be responsible for the stability of the structure at all stages of its erection at site and shall take all necessary measures by the additions of temporary bracings and guying to ensure adequate resistance to wind and also to loads due to erection equipment and their operations. Guying and bracing shall be done due to erection equipment and their operations. Guying and bracing shall be done in such a way that it does not interface with the movement or working of other agencies working in the area. For the purpose of guying the Contractor shall not use other structures in the vicinity which are likely to be damaged by the guy.

3.26.4.2 Such temporary bracings shall neither be included in the measurement nor extra rate shall be payable. Such temporary bracings used shall be the property of the Contractor and may be removed by him at the end of the job from the site of work.

3.27 Grouting and under Pinning

3.27.1 Furnishing of all labour materials and equipment and performance of all operations necessary to complete the work of grouting of blockouts and foundation bolt holes and under pinning of base plates is in the scope of the Contractor. The cost of the above shall be included in the unit concreting rate for pedestal.

3.27.2 Materials

3.27.2.1 Cement shall conform to the stipulations contained in IS:383 (Latest Edition) and shall have a fineness modulus not exceeding 3 and less than 2.5.
3.27.2.2 Sand shall conform to the stipulations contained in IS:383 (Latest Edition) and shall have a fineness modules not exceeding 3 and less than 2.5.

3.27.2.3 Water shall be clean and fresh and shall be of potable quality.

3.27.2.4 Aluminium powder or anti-shrinkage admixture like ‘Groutex’ CRS-NS grout (by Cement Research Institute of India) or its equivalent shall be of standard brand from reputed manufacturer and shall be approved by the Owner prior to its use for work.

3.27.3 General Requirements

3.27.3.1 The blockout and bolt holes which have to be grouted shall be cleaned thoroughly by use of compressed air immediately before taking up the grouting operations.

3.27.4 Grouting

Grouting shall be adopted for filling the blockouts, pockets below foundation bolt holes. Cement and aluminium powder or anti-shrinkage admixture of approved quality shall be first blended thoroughly in the required proportions as per manufacturer’s specification. The mix of grouting shall contain one part of cement and two parts of coarse sand. The quantity of aluminium powder shall usually be of the order of 0.005% by weight of cement. Any grout which has been mixed for a period longer than half an hour shall not be used on the work. Immediately after preparation the grout shall be poured into the blockouts, pockets and foundation bolt holes either from the sides or through the holes provided for this purpose in the base plate, by using special equipment for pressure grouting. It shall be ensured by rodding and by tapping of bolts that the blockout is completely filled without leaving any voids. The pouring shall cease as soon as each hole is filled and any excess grout found on the surface of the concrete foundation shall be completely removed and the surface dried.

3.27.5 Under Pinning

a) It shall be resorted to for filling the space between the underside of base plate and the top of foundation concrete. After grouting has been completed as specified above, space between the top surface of the foundation concrete and the underside of the base plate shall be filled with mortar or concrete depending upon thickness to be filled as follows:
Less than 40mm  Dry packed mortar  
Over 40mm  Dry packed fine concrete  

Mortar, fine concrete shall be blended with aluminium powder about 0.005% by weight of cement or with anti-shrinkage admixture in a suitable proportion to the cement mortar in accordance with the recommendations of the manufacturer and subject to the approval of the Owner. Mortar shall comprise cement, sand and water in proportion of approx. 1:3:0.4 by weight. Concrete shall comprise cement, sand, 10mm max. sized coarse aggregate and water in proportion of 1:1.25:2:0.4 weight. In all cases minimum 28 days cube strength should not be less than 25N/mm².

Shims provided for the alignment of plant bases shall be positioned at the edges of the base to permit subsequent removal which shall take place not less than 7 days after the underpinning has been executed. The resulting cavities shall be made good with the same grade of mortar or concrete as has been used for the underpinning of the rest of the base plate.

b) Cement, sand and aluminium powder or approved anti-shrinkage admixture, shall first be blended thoroughly in the required proportion. The mortar shall then be prepared by mixing with quantity of water which will produce a sufficiently workable mix to enable complete and proper compaction of the mortar.

c) The mortar shall then be placed below the base plate and rammed in a horizontal direction for each edge until the mortar oozes out through the grout holes provided in the base plate.

d) When it is clear that the centre of base has been properly filled, the mortar outside the base plate shall be briefly rammed to ensure compaction below the edges.

e) Any mortar which has been mixed for a period longer than half an hour, shall not be used in the work.

3.276 Curing

The work shall be cured for a period of 7 days commencing 24 hours after the completion of the grouting and underpinning operations. The curing shall be done by covering the surfaces with wet gunny bags.
3.28  **Water Proofing Cement Additive**

3.28.1 This covers the technical requirements for furnishing, placing and mixing waterproofing cement additive in all kinds of cement concrete, plain or reinforced and cement mortar for all kinds of steel structures at all levels, including encasement of steel sections, as shown in drawing or otherwise specified.

3.28.2 The Contractor shall furnish all labour and equipment to place and mix waterproofing cement additive in concrete of any grade and cement mortar, thereafter carry out the work as specified earlier, for concrete and then complete the work as indicated on the drawing and described herein.

3.28.3 **Material**

3.28.3.1 The waterproofing cement additive shall conform to Indian Standard Specifications IS:2645 (Latest Edition).

3.28.3.2 Waterproofing 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. and Pre-stressed concrete work.

3.28.3.3 The Contractor shall arrange the service of the manufacturer’s supervision at no extra cost to the Owner to supervise the work, if desired by the Owner.

3.28.4 **Mixing**

Waterproofing additive shall be based at the rate specified by the manufacturer or as indicated in the drawing and shall be mixed as required by the Owner.

3.28.5 **Test of Samples**

Samples of concrete in which waterproofing cement is added shall be tested for waterproofness, compressive strength, water absorption, density etc. The results shall conform to relevant IS Specifications.

3.29  **Water Proofing of Concrete Structures**

3.29.1 Water proofing of concrete structures shall be done by either suitable extraneous treatments like applying Bituminous paints, applying waterproof plaster, etc. or internally by suitable design of the concrete mix, addition of suitable admixture in the concrete or mortar at the time of
mixing and/or installing water bars at the joints. Addition of admixtures shall not reduce the specified strength of concrete in any case.

3.29.2 Materials and Application

3.29.2.1 The materials shall conform to the respective I.S. Codes whenever applicable. The Owner’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 Owner, test certificates for the materials shall be submitted by the Contractor and samples for the testing by the Contractor shall be supplied free. The materials shall be of best quality available, fresh and thoroughly cleaned.

3.29.3 Water Proofing Admixtures in Concrete

i) In Concrete works

This shall be described under clause specified elsewhere in the specification for water proofing cement additive.

ii) In Plastering

The Concrete surface, to be plastered, shall be packed to Owner’s satisfaction, cleaned thoroughly and kept wetted for 24 hours. The admixture shall be of approved manufacturer and be of best quality available subject to approval of the Owner. The plasters shall be in cement sand mortar mixed in proportion varying from 1:1 to 1:4 by volume alongwith the approved water proofing admixture and laid in appropriate thickness in layers not exceeding 15mm layer or as per Manufacturer’s specification. The additive shall be of quality and type approved by the Owner. If desired by the Owner, the Contractor shall have the work supervised by the Manufacturer’s supervisor at no extra cost to the Owner. On completion, the plastered surface shall be cured continuously for a minimum period of 14 days.

3.29.4 Bituminus Painting

Surface to be waterproofed shall be absolutely dry clean and dust free. The surface shall be sand prepared completely coated with hot coal tar pitch as per IS:216 (not heated above 375 deg.F) using not less than 3 Kg. per sq.m. or with hot asphaltic bitumen according to IS:73 (not heated above 400 deg.F)
using not less than 1.25 Kg. in case of coal tar and 1 Kg. per sq.m. in case of asphalt. Immediately after application of the second coat and before it has dried up, sand shall be spread on the surface to cover it completely. Sufficient time shall be allowed after spreading of sand, before back filling is done, in order to allow the final coat to dry up completely. Coal tar or asphalt to be used shall be of approved manufacturer and of the best quality available subject to approval by the Owner.

3.30 Bar Grips

3.30.1 This covers the technical requirement for furnishing and installation of bar grips complete including all labour materials, equipments, staging, etc.

3.30.2 The Contractor shall furnish and install the bar grips for various dia of deformed bars as indicated in drawings and as required by these specifications.

The bar grip splicing system shall be of approved manufacturer and of the best quality available subject to approval of the Owner.

3.30.3 Splicing

3.30.3.1 a) The reinforcement bars are to be joined end to end without any gap and the sleeve placed in position.

b) Pressure is applied by means of a hydraulic press which swages the sleeve down on the bar ends in a series of bites which are applied at high pressure.

c) The job can also be done in two stages. The 1st stage is to press the half sleeve on the loose bar at the reinforcement yard. The 2nd stage work is to be done at the actual site after the loose bar is inserted through the unpresented end of the sleeve and pressed insitu.

3.30.3.2 The joints shall be staggered as far as possible. Necessary staging arrangements are to be made by the Contractor.

3.30.3.3 It may be necessary to fix the sleeve to the reinforcement bars at one end in the open yard for the facility of working. All these working details are to be furnished earlier subject to the approval of the Owner.

3.30.3.4 The length of the sleeve should be adequate, that it is safe under the pull
out loading conditions.

3.30.3.5 One percent representative samples of each dia, bars shall be sent for laboratory testing at the cost of the Contractor to check the efficiency of the joints under ideal condition. These samples of sleeves will be sent in the Laboratory for pull out tests.

3.30.4 Inspection

All bar grips installation shall be subject to inspection and approval by the Owner before concreting operation are performed. In case of any defect or joint being not upto mark, the same shall be replaced by the Contractor at no extra cost.

3.31 Pile Integrity Test

3.31.1 Pile Integrity test is used to assess the as-installed pile characteristics as well quality achieved during the construction of pile. The parameters to be evaluated through the Pile Integrity Test (also known as dynamic pile testing) should generally cover True static capacity of the pile at the time of testing, total skin friction and end bearing of the pile, skin friction variation along the length of the pile, compressive and tensile stress, displacement of pile, changes in cross-section if any etc.

3.31.2 The equipments consist of an electronic control unit, a hand-held instrumented hammer and an accelerometer and computer.

3.31.3 The pile top is prepared to make a plane surface (by placing a thin cement mortar in an area of 200mm x 200mm) after removal of weak lattaince. The accelerometer is fixed to the top of the pile and the instrumented hammer is struck firmly on the pile top. This generates a wave form that travels down the pile and gets reflected from the bottom as well as from any discontinuities in the pile.

3.31.4 The results to be stored in a compact control unit and transferred to computer and detail analysis to be carried out.

3.31.5 The contractor is to submit a detailed report for the data specified in cl. 7.1 above and as required by the Owner.
4.0 Structural Steel MS Liner for R.C.C. Vertical Piles and Painting of Liner

4.1 General Requirements

This specification covers general requirements for supply, fabrication, shop painting (if required), and delivery at site mild steel liners of specified diameters and lengths for piles.

4.2 M.S. liner shall be provided to piles at locations, as directed by the Owner. The extent upto which the MS liners for piles required to be provided shall be as shown in the approved drawings and as per direction and written approval of the Owner.

4.3 Drawings

4.3.1 Contractor shall submit calculations and fabrication details for connection/splice/joint for fabrication of liners and get these approved by the Owner before starting any fabrication works. The approval of fabrication drawings prepared by the Contractor shall not relieve the Contractor of the responsibility for the liners in place.

Fabrication drawing (drawn to large enough scale) to convey all information clearly shall include the following:

i) Reference of the design drawings based on which fabrication had been prepared. The reference should include and indicate the latest revision of design drawing.

ii) Layout, elevations and sections with erection marking of all members.

iii) Quality of Structural Steel, Welding electrodes, and standards to which these conform to.

iv) Detailing of structural joints and shop/field splices.

v) Details of shop and field joints/connections.

vi) Bill of material indicating size and weight of members/component.

vii) Erection assemblies and sub-assemblies identifying all transportable parts.

viii) Method of erection, special erection instructions, and special precautions to be taken during erection, as required.

4.3.2 Owner reserves the right to make changes in the fabrication drawings. Revisions to drawings may be made to reflect more updated requirements. Revisions to drawings and any new drawings made to include additional work by Contractor shall be considered as a part of this specification and the Owner shall entertain no extra claim on this account. All revisions in the
drawings should be highlighted in the drawing distinctly.

4.3.3 Unless otherwise specified, the drawings and specifications are intended to include everything obviously requisite and necessary for the proper and entire completion of the work and the job shall be carried out accordingly for the completeness as required.

4.3.4 In the case of variations in drawings and specifications, the decision of the Owner shall be final. In case Contractor in the execution of his work, find discrepancies in the information furnished by Owner, he shall refer such discrepancies to the Owner before proceeding with such work.

4.4 Fabrication

4.4.1 General

The fabrication work shall be carried out generally in accordance with IS:800 as well as the stipulation contained in these specifications. All materials shall be completely shop fabricated and finished with proper connection materials for ready assembly in the field. All the workmanship and finish shall be of the best quality and shall conform to the best approved method of fabrication. All materials shall be finished straight and shall be machined true and square where so specified. All edges shall be free of burrs, shearing and chipping shall be neatly and accurately done. Material at the shop shall be kept clean and protected from weather, Checklist format, inspection certificate for fabrication and protocol for handing over of structural steel shall be submitted by the Contractor in the form as agreed to by the Owner.

4.5 Straightening

All material shall be straight and free from bends or twists. If necessary, before being worked, the materials shall be straightened, unless otherwise required/specified. In case plates are distorted or twisted, straightening or flattening shall be done by methods that will not injure the plates. Long plates shall be straightened by passing through mangle of leveling rolls. Heating or forging shall not be resorted to without the prior approval of Owner in writing.

4.6 Welding

4.6.1 Welding shall be in accordance with IS:816, IS:819, IS:1024, IS:1261, IS:1323, IS:4353 and IS:9595, as appropriate.
4.6.2 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:1393, IS:7307 (Part I), as relevant and as per the checklists given in the Annexure to this section of the specification.

4.6.3 The works shall be done as per approved fabrication drawings which would clearly indicate various details of joints to be welded, type of weld, length and size of weld, whether shop or site weld. Symbols for welding on shop drawings shall be according to IS:813. Efforts shall be made to reduce site welding so as to avoid improper welding due to constructional difficulties.

4.6.4 Welding of Structural Steel shall be done by an electric arc process. The procedure to be followed, materials, plant and equipment to be applied shall be subject to the approval of the Owner and shall conform generally to relevant acceptable standards viz. IS:816, IS:9595, IS:814, and Indian Standard Hand Book for metal arc welding, and other standard codes of practice internationally accepted.

4.6.5 “Open-Arc-Welding” process employing coated electrodes shall be employed for fabrication of other welded connections and field welding.

4.6.6 Wherever welding is done for assembling the components of liner, the job shall be so positioned that downhand welding is possible. In cases where such positioning of job is not possible other manual welding positions could be resorted to.

4.6.7 Any structural joints shall be welded only by those welders who are qualified for all welding procedures and positions required in such joint that is welded. The entire weld of any liner joint shall be made by one welder.

4.6.8 All welds shall be free from defects like blow holes, slag inclusions, lack of penetration, undercutting, cracks and show uniform Sections, smoothness of Weld metal, feather edge without overlap and freedom from porosity.

4.6.9 Proper edge preparation shall be made for jointing of materials before welding. Suitable edge preparation shall be done for all processes of welding except for square butt welds. Type of edge preparation shall depend on the thickness of parent materials that are to be joined. The edge forms shall be chosen to suit the design, technology and production conditions and shall be subject to the approval of the Owner. The edge form of weldments shall be prepared either by machines or by automatic gas cutting with surface roughner of the welding area not exceeding 50sq.mm.
All edge cut by flame shall be ground before they are welded.

4.6.10 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 e.g. normal penetration welds or deep penetration welds.

4.6.11 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 AWSA-5-17-69 and IS:3613 (Latest). The electrodes shall be sorted properly and the flux shall be baked before use in an oven in accordance with the manufacturer’s requirements as stipulated.

4.6.12 Specific approval of the Owner shall be taken by the Contractor for the various electrodes proposed to be used on the work before any welding is started.

4.6.13 Electrodes larger than 5mm diameter shall not be used for root-runs in butt-welds.

4.6.14 Welding plant and accessories shall have capacity adequate for the welding procedure laid down and shall satisfy appropriate standards and be of approved make and quality. All the electrical plant in connection with the welding operation shall be properly and adequately earthed and adequate means of measuring the current shall be provided.

4.6.15 Voltage and current (and polarity if direct current is used) shall be set according to the recommendations of the manufacturer of the electrode being used and suitability to thickness of material, joint form etc.

4.6.16 Pre-qualified welding procedures recommended by appropriate welding standards and known to provide satisfactory welds shall be followed. For non-standard procedures, qualification tests as prescribed in IS:9595 (latest) shall be made to verify the adequacy of the procedures. A welding procedure shall be prepared by Contractor and submitted to the Owner for approval before start of welding. This shall include all details of welding procedures with references to provisions of IS:9595 (Latest) and IS:4353. Approval of the welding procedure by Owner shall not relieve Contractor of his responsibility for correct and sound welding without undue distortion in the finished structure.

4.6.17 No welding shall be done, when the surface of the members is wet, during
periods of high wind, unless the welding operator and the work are properly protected.

4.6.18 In joints connected by fillet welds, the minimum sizes of single run fillet welds for first run and minimum full sizes of fillet welds shall conform to requirements of IS:816.

4.7 Pre-Heating Inter-run Temperature and Post Weld Heat Treatment.

i) Welding of mild steel shall not be undertaken when the plate temperature is 0°C or below.

ii) Mild steel plates conforming to IS:226 and thicker than 20 mm and plates conforming to IS:2062 and thicker than 25 mm may require preheating of the parent plate prior to welding. In welding materials of unequal thickness the thicker part shall be taken for this purpose.

Minimum Preheat and Interpass Temperature

<table>
<thead>
<tr>
<th>Thickness of Thicker part at point of welding</th>
<th>Other than low hydrogen welding electrodes</th>
<th>Low hydrogen welding electrodes</th>
</tr>
</thead>
<tbody>
<tr>
<td>IS:226 steel or IS:2062 steel</td>
<td>IS:8500 steel</td>
<td>IS:8500 steel or steel IS:2062</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Thickness</th>
<th>Preheat/Interpass Temperature</th>
</tr>
</thead>
<tbody>
<tr>
<td>Upto 20mm incl.</td>
<td>None</td>
</tr>
<tr>
<td>Over 20mm to 40mm incl.</td>
<td>65 deg.C not allowed</td>
</tr>
<tr>
<td>Over 40mm to 63mm incl.</td>
<td>110 deg.C</td>
</tr>
<tr>
<td>Over 63mm</td>
<td>150 deg.C</td>
</tr>
</tbody>
</table>

None  

10 deg.C  

65 deg.C  

110 deg.C  

150 deg.C
iii) Base metal shall be preheated, as required to the temperature given in table above prior to welding or tack welding. When base metal not otherwise required to be preheated is at a temperature below 0 deg. C, it shall be preheated, prior to tack welding or welding. Preheating shall bring the surface of the base metal to the specified preheat temperature and this temperature shall be maintained as minimum interpass temperature while welding is in progress.

iv) Pre-heating may be applied by external flame heating equipment, by electric resistance or electric induction process such that uniform heating of the surface extending up to a distance or four times the thickness of the plate on either side of the welding joint is obtained.

v) Thermo-Chalk or other approved methods shall be used for measuring the plate temperature.

4.8 Sequence of Welding

i) 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 of by counter distortion. The direction of welding should be away from the point of restraint and towards the point of maximum freedom.

ii) Each case shall be carefully studied before finally following a particular sequence of welding.

4.8.1 Approval of welding sequence and procedure shall not relieve the Contractor of the responsibility for the correct welding and for minimising the distortion in the finished structure which in no case shall exceed that laid down in Indian Standards.

4.8.2 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.

4.8.3 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 so as to leave the edges unmelted.

4.8.4 Pudding shall be sufficient to enable the gases to escape from the molten
metal before it solidifies.

4.8.5 Non-uniform heating and cooling should be avoided to ensure the excessive stresses are not locked up resulting ultimately in cracks.

4.8.6 The fusion faces shall be carefully aligned. Angle shrinkage shall be controlled by presenting. Correct gap and alignment shall be maintained during the welding operation.

4.8.7 All main butt welds shall have complete penetration and except where it is impracticable they shall be welded from both sides, back surface of the weld being gouged out clean before first run of the weld is given from the back.

4.8.8 Intermittent welds shall not be permitted without the approval of the Owner. These shall be permitted only when specifically approved in the fabrication drawings.

4.9.9 Inspection of Welds: All Welds shall be inspected for flaws by any of the methods described under Clause “Inspection”. The choice of the method adopted shall be determined by Owner.

4.8.10 The Contractor shall carry out tests which establish soundness of welds. In case the tests uncover defective work, the Contractor shall correct such defects at his own cost and prove the soundness of rectified work at his own cost.

4.8.11 The 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 particles inspection or any other equally positive means as prescribed by Owner shall be used to ensure that the whole of the crack and material upto 25 mm beyond each end of the crack has been removed. Cost of all such test and operations incidental to correction shall be to Contractor’s account.

4.9 Inspection and Rectification

4.9.1 Visual Inspection

100 percent of the welds shall be inspected visually for external defects. Dimensions of welds shall be checked. The length and size of weld shall be as per approved fabrication drawing. It may be slightly over sized but should not be under sized. The profile of weld is affected by the position of the joint but it should be uniform. In case of butt and corner welds the
profile shall be convey and in case of submerged are fillet weld, it shall be slightly concave. The welds should have regular height and width of beads. The height and spacing or ripples shall be uniform. The joints in the weld run where welding has been recommended shall as far as possible be smooth and should not show any humps or craters in the weld surface. Welds shall be free from the unfilled craters on the surface, under cuts slags on the surface visible cracks. Such inspection shall be done after clearing the welds surface with steel wire brushes and chisel to remove the sputter metal, scales, slag, etc. If external defects mentioned above are noticed the work shall be dismantled and redone duly replacing the defective materials including the base members.

4.9.2 Rectification of Defective Welding Work

Wherever defects like improper penetration, extensive presence of blow holes, undercuts cracking, slag inclusion etc. are noticed by visual inspection/other tests, the welds at such locations 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 rewelded. The gouging as far as possible, be done using gouging electrodes. Flame gouging shall be resorted to only in special cases with specific permission of the Owner.

4.9.3 Acceptance of the Welded Structures

The acceptance of the welded work shall depend upon correct dimensions and alignment, absence of distortion in the structure, satisfactory results from the examination and testing of the joints and the test specimens as per I.S. soundness of the welds and upon general workmanship being good.

4.9.3.1 Random die penetration tests shall be conducted after welding of M.S. liner plates.

4.10 Erection marks

4.10.1 Before any steel work leaves the Contractor’s fabrication shop, it shall be suitably marked in accordance with the approved fabrication drawing and according to an approved marking plan. Copies of all drawing showing such erection marks on the various steel works to be furnished to the Owner well in advance of the erection.

4.10.2 The erection marks assigned to various components of the structural steel
work shall also contain an erection sequence number indicating the sequence in which the various components are to be erected.

4.10.3 Erection marks shall be clearly painted on the work, each piece being marked in at least two places. Each piece shall also have its weight marked thereon. In order to help identification, each piece shall bear the erection marks and erection sequence number. Erection marks shall be painted on the structures, during the process of fabrication to facilitate their identification during inspection. Where a number of components are identical and bear the same erection marks, these components shall be further identified by assigning numberals in addition to the common erection mark.

4.11 Errors

Any error in shop work prevents proper assembling and fitting up of parts in the field, Moderate use of drift pins or moderate amount of reaming will be classified by Owner as defective workmanship. All charges incurred by Owner either directly or indirectly because of workmanship will be deducted from the amount due to Contractor before payment is made. The amount of such deduction will consist of the sum total of the costs of labour direct or indirect, material, plants, transportation, equipment, rental and overhead expense. In case Owner chooses to reject the material because of poor workmanship the cost of all handling and returning the material Contractor, if he so desires, shall entirely be to Contractor’s account and in such cases, the cost of handling transport and delivery to site shall be borne by Contractor.

4.12 Protection Against Damage in Transit

All steel work shall be efficiently and sufficiently protected against damage in transit to site from any cause whatsoever to prevent damage or distortion during transit. Should there be any distortion of fabricated members the Contractor shall immediately report the matter to the Owner. Distorted steel shall not be used in fabrication unless the distortion are minor which in the opinion of the Owner can be removed by acceptable methods. These distortions shall be rectified by the Contractor by cold-bending. If heating is necessary to rectify the defects the details of the procedure shall be intimated to the Owner whose approval shall be taken before such rectification. The temperature of heat treatment shall not exceed the limits beyond which the original properties of steel are likely to be impaired.

4.13 Anti Corrosive Treatment for Mild Steel Liners and Permanent
Form Box

4.13.1 After inspection and issue of test and acceptance certificate, all steel surfaces shall be coated with a coat of direct to rust primer i.e. Densotrol or equivalent and thereafter these shall be provided with a final coat of minimum 200 microns of high built epoxy coal tar, as specified below. The fabricated mild steel liners to be used for the piling work shall be cleaned from grease or any other contaminant, by mechanical/manual cleaning. The primer shall be applied with a brush or spray to develop a dry film thickness or minimum 25 microns. The primer surface shall be left for curing for at least 24 hours before it is coated with the final coat. The final coat shall consist of high built epoxy coal tar with a thickness of minimum 200 microns. The physical properties of primer and top coat shall be as given below.

4.13.2 Technical data of Priming material

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Binder content</td>
<td>45%</td>
</tr>
<tr>
<td>Total Solids</td>
<td>45%</td>
</tr>
<tr>
<td>Solvent</td>
<td>55%</td>
</tr>
<tr>
<td>Viscosity</td>
<td>16 (Ford Cup No.4)</td>
</tr>
<tr>
<td>Density</td>
<td>0.88</td>
</tr>
<tr>
<td>Flash point</td>
<td>+40°C</td>
</tr>
<tr>
<td>Anti-porosity</td>
<td>80/99 in one and two layers, respectively.</td>
</tr>
<tr>
<td>Heat-resistance</td>
<td>170/220 continuously &amp; short period strain.</td>
</tr>
<tr>
<td>Contact angle</td>
<td>5º (Lorentzon &amp; Westtress)</td>
</tr>
<tr>
<td>Covering Capacity</td>
<td>12-20 Sq.m./litre</td>
</tr>
<tr>
<td>Layer thickness</td>
<td>12/25 on glossy/coarse surface</td>
</tr>
<tr>
<td>Homogeneity</td>
<td>No sediment</td>
</tr>
</tbody>
</table>
Thinning

Normally, no thinner shall be used.

Drying time

Dust-free in 2 hrs, Solid in 4/5 hrs.
Between layers from wet-in-wet to 2 hrs. for continuous penetration between layers.

Lustre

Semi-glossy

Colour

Lightly yellowish

YSAM group

2

Injurious to health

No

Physiological condition when welding

No dangerous gas generation

Application

Airless spray equipment or conventional painting with roll/brush.

Cleaning of equipment

White spirit

4.13.3 Technical particulars of final coat

System

Two Components
Component A : Base Part
Component B : Accelerator Part

Colour

Black

Mixing Ratio

1:1 by Weight

% Solid by Weight

More than 95%

Pot Lift (Temp.27°C
Relative humidity 65%)

2 hours

Setting Time (At 22°C
Relative humidity 65%)

4-5 hours

Fully cured

7 days
Density of cured mass 1.35

Flash Pt. of blended product 40°C (104°F)

Hardness 75 Shore D

Finish Semi glossy

Water absorption after 6 mths. Negligible

Covering Capacity 1.5 sq.m./Kg (400 Microns thk.)

Storage Life 1 year in sealed condition.

4.14 Shop Connections

Surfaces to be permanently in contact shall receive a priming coat immediately at the works except where jointed by welding.

5.0 Standards and Codes

The construction work of pile foundation shall conform to the following Indian/International Standards, which shall mean latest revisions, amendments/changes adopted and published, unless otherwise specified hereinbefore. Some of the important relevant applicable codes for this section are as follows:

IS : 226 Structural Steel (Standard Quality)
IS : 432 Specification for mild steel and high tensile steel bars and hard drawn steel wire for concrete reinforcement.
IS : 456 Code of practice for plain and reinforcement concrete
IS : 516 Methods of test for strength of concrete
IS : 800 Code of Practice for General Construction in Steel
IS : 813 Scheme of symbols for Welding
IS : 814 Specification for Covered Electrodes for Metal Arc Welding of Structural Steels
IS : 816 Code of Practice for use of Metal Arc Welding for General Construction in Mild Steel.
IS : 817   Code of Practice for Liquid Penetrant Flaw Detection.
IS : 1199  Methods of sampling and analysis of concrete.
IS : 1200  Method of measurement of Building and civil Engineering work — arthwork.
IS : 1200  Method of measurement of Building and civil Engineering work — Piling
IS : 1786  Cold worked steel high strength deformed bars for concrete reinforcement.
IS : 1838  Performed fillers for expansion joints in concrete non-extruding and resilient type (bitumen impregnated filler).
IS : 2062  Weldable structural steel
IS : 2074  Ready Mixed Paint, air drying, Red Oxide Zinc Chrome, Priming.
IS : 2386  Specific gravity, density, voids absorption and bulking.
IS : 2502  Code of Practice for bending and fixing of bars for concrete reinforcement.
IS : 2505  General requirements for concrete vibrators immersion type.
IS : 2506  Screed board concrete vibrators.
IS : 2514  Concrete vibrating tables.
IS : 3025  Methods of sampling and test (Physical and chemical) for water used in Industry.
IS : 3350  Methods of tests for routine control for water used in Industry.
IS : 3370  Code of Practice for concrete structure for the storage of liquids.
IS : 3613  Acceptance Tests for Wire Flux Combinations for submerged Arc welding of structural steels.
IS : 3658  Recommended Practice for Radiographic Examination of Fusion Welded Butt Joints in Steel Plates.
IS : 3764  Safety codes for Excavation work.
IS : 4353  Recommendations for Submerged Arc Welding of Mild Steel and Low Alloy Steels.

IS : 4656  Form vibrators for concrete.

IS : 4701  Code of practice for earth work on canals.

IS : 8500  Specification for weldable structural steel (medium and high strength qualities)

IS : 9103  Admixtures for concrete.

IS : 10262 Recommended guidelines for concrete mix design.
ANNEXURE - A

BIDDER TO FURNISH INFORMATION ALONGWITH THE BIDS

A1.0 Installation criteria/Technique to be adopted for boring of piles in all types of soils: (Refer Clause No.2.1.1).

NOTE:

1. The above mentioned details/informations are required to be furnished by the bidder alongwith their bid.

2. The installation criteria/technique required to be adopted for actual installation/execution of work shall be submitted by the Contractor.
ANNEXURE - B

BIDDER TO FURNISH INFORMATION ALONGWITH THE BIDS

List of Equipments

<table>
<thead>
<tr>
<th>Sl.No.</th>
<th>Description</th>
<th>Make/Size</th>
<th>Capacity</th>
<th>Nos.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Piling Rigs</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td>High pressure Mud Pumps</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.</td>
<td>Bentonite mixing plants</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

NOTE:

1. The bidder shall furnish a complete list of equipments, tools and tackles which they intend to use for the work.

2. In order to complete the work successfully, if the bidder would have required additional mobilisation of the equipment specified above, these shall be done at no extra cost to the Owner.
C1.0 Bentonite suspension used for piling work shall satisfy the following requirements:

a) Liquid limit of bentonite when tested in accordance with IS:2720 (Part V) shall be more than 300 percent and less than 450 percent.

b) Sand content of the bentonite powder shall not be greater than 7 percent.

c) Bentonite solution should be made by mixing it with fresh water using pump for circulation. The density of the freshly prepared bentonite suspension shall be between 1.024 and 1.10 gm/ml depending upon the pile dimensions and type of soil in which the pile is to be met. However, the density of bentonite suspension after mixing with deleterious materials in the pile bore may be upto a maximum of 1.25 gm/ml.

d) The Marsh viscosity when tested by a Marsh cone shall be between 30 to 60 seconds.

e) The differential free swell shall be more than 540 percent.

f) The pH value of the bentonite suspension shall be between 9 and 11.5.
ANNEXURE - D

ONLY FOR REFERENCE OF THE BIDDER. TO BE UTILISED/USED.

PILE DATA

1. Reference No. Location (Co-ordinates) of area.

2. Sequence of Piling

3. Pile diameter & Type

4. Working level (Platform level)

5. Cut off level (COL)

6. Actual length below COL

7. Pile termination level

8. Top of finished concrete level

9. Date and time of start and completion of boring

10. Depth of Ground water table in the vicinity

11. Type of strata at pile tip

12. Method of boring operation

13. Details of drilling mud as used:
   i) Freshly supplied mud
      liquid limit
      sand content
      density
      marsh viscosity
      Swelling index
      pH value
   ii) Contaminated mud
density
sand content

14. SPT, N values in soil (from the nearest bore hole). UCS value in rock (from the nearest bore hole).

15. Chiseling if any, from....m to.....m.

16. Date and time of start and completion of concreting

17. Method of placing concrete

18. Concrete quantity :

    Actual
    Theoretical

19. Ref. Number of test cubes

20. Grade and slump of concrete

21. Results of test cubes

22. Reinforcement details :

    Main Reinforcement                     Stirrups : Type
    No._______________                      No._______________
    Dia_______________                     Dia_______________
    Depth_____________                     Spacing_____________

23. Any other information regarding constructions, delay and other interruption to the sequence of work.

NOTE : The above details are required to be furnished by the Contractor before starting the installation work.
ANNEXURE - E

A. INSPECTION & TESTING (STANDARDS) FOR STRUCTURAL STEEL WORKS

Title: An indicative programme of inspection/testing

1.0 INSPECTION & TESTING

Contractor shall carry out a comprehensive inspections and testing programme during fabrication and erection. An indicative programme of inspection/testing envisaged by Owner is given below. This is however not intended to form a comprehensive programme as it is the Contractor’s responsibility to draw up and carry out such a programme duly approved by the Owner. Such approval shall not relieve the Contractor of the responsibility about the correctness and adequacy of workmanship, materials etc.

1.1 Raw Materials Inspection

1.1.1 Steel

i) Specifications

Check the specification of steel and availability of the relevant Test Certificates.

ii) Physical Conditions

a) Steel shall not be pitted and should be free from scales and rust.

b) If the plates are bent or distorted, bent to distortion shall normally be removed by the cold treatment etc.

c) Straightening under hot stage shall be resorted to only under specific permission from the Owner.

d) If any rolling defect viz, laminations, cracks etc. are discovered in the steel during processing is shall be rejected.

iii) Storage

a) Steel plates of different specifications shall be stacked separately.

b) Steel of IS:2062 quality shall be given a distinctive identification mark.
Steel sections shall be stacked over spacers supported on posts of about 50 cm height above round. Passage and space between the stacks shall be sufficient for rigging operations.

1.1.2 Electrodes

i) Electrodes for manual metal arc welding shall be procured envisaged in the welding procedure sheet predetermined before actual welding operation starts.

ii) Electrodes shall be properly stored dry as required by the IS Code or by the manufacturer.

iii) Electrodes shall bear the I.S.I or equivalent Certification mark.

iv) The approval for all the consumables for welding shall be specifically obtained before hand.

1.1.3 Paints/Primers

i) The relevant I.S or equivalent mark on sealed tins shall be checked.

ii) A few tins shall be opened at random to check the condition of the paints. Paint from old stock and showing signs of solidification shall not be accepted.

1.2 Welding Procedure Qualification.

As per ASME section (ix) or equivalent Indian Standards, Welding procedures, Specification shall be submitted by the Contractor for review and approval of Owner.

1.3 Welders Qualification Test

As per ASME section (ix) or equivalent Indian Standard.

1.4.0 Inspection for Tack Assembly set up for:

i) Level

ii) Gap

iii) Offsetting

iv) Shrinkage allowance

v) Fitment sequence

vi) Principal overall size.
1.5 **Preheating**

Temperature control by thermochalk or suitable equivalent method.

1.6 **Inspection of Main welds**

a) Fillet welds for
   i) Size
   ii) Dye Check
   iii) Visual examination
   iv) Dye penetration test/MPI shall be carried out.

b) Buttwelds for
   i) Dye check for root after back gauging shall be carried out.
   ii) Mechanical testing of welds (Destructive Tests)
       Minimum on joint per liner length/piece.
   iii) Non-destructive - as per FCL: SS:4
       - 100% visual examination.

B. **FABRICATION CHECK LIST (STANDARD)**

**Title:** Welding Tests on welds and Weld Defects

Mechanical testing of welds (Destructive test) Butt welds having one or more of the following defects are not acceptable.

i) Bend test : No crack on root/face on being bent through 180 deg. with mandrel of 4t where t is the thickness of plate.

ii) Tensile test : Weld strength not to be less than part metal’s strength.

**VISUAL EXAMINATION**

Following defects are not allowed:

1) Unsatisfactory appearance
2) Incomplete weld
3) Molten metal flow
4) Pits
5) Surface crack, lack of penetration
6) Insufficient length
7) Surface defects exceeding 5% of weld seam area

DYE PENETRATION TEST

All surfaces to be examined shall be free from:

a) Relevant linear indications
b) Four or more rounded defects in a line separated by 1/16" or less (edge to edge) except where the specification for the material establishes requirements for acceptance so far as defects are concerned.

C. TYPICAL WELDING PROCEDURE DATA SHEET

Contractor.................................................................Address..................

Quality of weld metal..........................Specification...............................

Inspection and Test Schedule ............ Specification..............................

Material Specification..................Thickness.............Batch/Cast No........

Joint Preparation (Fig.).........................Gap........................................

Location of Specimens.................................................................

Weather Conditions...........Time of day.......Wind brake used.............

Electrode Group No........ Make..................Specimen........................

Pre and Post-Heating............................................................

Welding Position.................................................................

Size of Reinforcement...........Whether removed..........................

Welding Sequence..........................Welding Process...........................

Backing Strip use..................Type........................................

Welding Process.................................................................

Current Conditions-Polarity........................................

Size of Electrode.................................................................
<table>
<thead>
<tr>
<th>Engineer-in-Charge</th>
<th>Signature</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power-Grid</td>
<td>For and on behalf of Contractor</td>
</tr>
<tr>
<td>(Inspecting Authority)</td>
<td>Date :</td>
</tr>
</tbody>
</table>
D. **FABRICATION CHECK LIST : ACCEPTANCE PROFORMA**

No. ______________________

Dt. ______________________

---

**Project**

---

**Work**

---

**Sub-Assy**

---

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Characteristic</th>
<th>Asper DRG/FCL</th>
<th>Actual</th>
<th>Accept/Reject</th>
<th>Remarks</th>
</tr>
</thead>
</table>

---

Power Grid Representative

---

Contractor’s Representative

---
ANNEXURE-F

PROFORMA OF UNDERTAKING BY THE PROPOSED AGENCY FOR PILE FOUNDATION

(On Non-Judicial Stamp Paper of appropriate value, wherever applicable)

To,

Power Grid Corporation of India Ltd.
B-9, Qutab Institutional Area
Katwaria Sarai
New Delhi - 110016

Dear Sir,

Whereas Power Grid Corporation of India Ltd., with its Registered Office at B-9, Qutab Institutional Area, Katwaria Sarai, New Delhi – 110016 (hereinafter referred to be as the ‘Owner’), having invited bids for ______________________ (Name of the package & Specification No.)__________________, in response to which M/s._____________(Name of the Bidder), with its Registered office at _______________________________(Full Address _______________________________) are submitting the bid vide ref_________________ date___________________(hereinafter called the ‘Bid’).

We,__________________(Name of the Agency) with its Registered Office at___________________(Full Address____________________(hereinafter referred to as the ‘Agency’, which expression shall unless repugnant to the context and meaning therefore include its successor, administrator, executor and permitted assigns) do hereby undertake in the event of award of the Contract to execute the pile foundation work covered under the scope of the Contract, fulfilling all the requirements and construction schedule agreed under the Contract.

Signed on this day of _________2005 at________________

(Signature)___________________
Authorised signatory on behalf of
M/s______________
(Name)______________
(Designation)______________

Note: Separate undertaking to be provided in case of more than one agency proposed.
<table>
<thead>
<tr>
<th>Clause No.</th>
<th>Description</th>
<th>Page No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0</td>
<td>Galvanised Steel Earth wire</td>
<td>1</td>
</tr>
<tr>
<td>2.0</td>
<td>Tests and Standards</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Annexure – A</td>
<td>12</td>
</tr>
</tbody>
</table>
1.0 Galvanised Steel Earth wire

1.1 Details of Earth wire

1.1.1 The galvanised steel earth wire shall generally conform to the specification of ACSR core wire as mentioned in IS: 398 (Part-II)-1976 except where otherwise specified herein.

1.1.2 The basic details of the earth wire for 400 kV and 220 kV are tabulated below:

<table>
<thead>
<tr>
<th>Sl.No.</th>
<th>Description</th>
<th>Unit</th>
<th>400 kV</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Stranding &amp; Wire diameter</td>
<td>mm</td>
<td>7/3.66 (steel)</td>
</tr>
<tr>
<td>2.</td>
<td>Strands</td>
<td>No.</td>
<td>1 (one)</td>
</tr>
<tr>
<td>a)</td>
<td>Steel Core</td>
<td>No.</td>
<td>6 (six)</td>
</tr>
<tr>
<td>b)</td>
<td>Outer layer</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.</td>
<td>Total sectional area</td>
<td>Sq.mm.</td>
<td>73.65</td>
</tr>
</tbody>
</table>

Other technical details are furnished in the section – I of this Specification.

1.2 Workmanship

1.2.1 All steel strands shall be smooth, uniform and free from all imperfections, such as spills and splits, die marks, scratches, abrasions and kinks after drawing and also after stranding.

1.2.2 The finished material shall have minimum brittleness as it will be subjected to appreciable vibration while in use.

1.2.3 The steel strands shall be hot dip galvanised and shall have minimum Zinc coating after stranding, as stipulated in Cl. 1.7, Table 1 of this section of the Specification. The zinc coating shall be smooth, continuous, of uniform thickness, free from imperfections. The steel wire rod shall be of such quality and purity that, when drawn to the size of the strands specified and coated with zinc, the finished strands shall be of uniform quality and have the same properties and characteristics as prescribed in ASTM designation B498-M.

1.2.4 The steel strands shall be preformed and post formed in order to prevent spreading of strands while cutting of composite earth wire. Care shall be taken to avoid damage to galvanisation during preforming and postforming operation.
1.2.5 To avoid susceptibility towards wet storage stains (white rust), the finished material shall be provided with a protective coating of boiled linseed oil.

1.3 Joints in Wires

There shall be no joint of any kind in the finished steel wire strand entering into the manufacture of the earth wire. There shall be no strand joints or strand splices in any length of the completed stranded earth wire.

1.4 Tolerances

The manufacturing tolerance to the extent of the limits as stipulated in Cl. 1.7, Table 1 of this section of the Specification only shall be permitted in the diameter of the individual steel strands and lay length of the earth wire:

1.5 Materials

1.5.1 Steel

The steel wire strands shall be drawn from high carbon steel rods and the chemical composition shall conform to the requirements as stipulated in Cl. 1.7, Table 1 of this section of the Specification.

1.5.2 Zinc

The zinc used for galvanising shall be electrolytic High Grade Zinc and shall conform to the requirements of IS:209.

1.6 Standard Length

1.6.1 The standard length of the earth wire shall be as stipulated in Cl. 1.7, Table 1 with the specified tolerance on standard length.

1.6.2 Random length will be accepted provided no length is less than 70% of standard length and the total quantity of random lengths is not more than ten (10) percent of the total quantity in each shipment.
1.7 Guaranteed technical particulars

1.7.1 The guaranteed technical particulars to be adhered by the contractor / manufacturer are furnished in below:

**TABLE – 1 (7/3.66mm Galvanised Steel Earth wire)**

<table>
<thead>
<tr>
<th>Sl.no.</th>
<th>Description</th>
<th>Unit</th>
<th>Guaranteed Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0</td>
<td>Raw Materials</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.1</td>
<td>Steel wires / rods</td>
<td></td>
<td></td>
</tr>
<tr>
<td>a)</td>
<td>Carbon</td>
<td>%</td>
<td>Not more than 0.55</td>
</tr>
<tr>
<td>b)</td>
<td>Manganese</td>
<td>%</td>
<td>0.40 to 0.90</td>
</tr>
<tr>
<td>c)</td>
<td>Phosphorous</td>
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<tr>
<td>d)</td>
<td>Sulphur</td>
<td>%</td>
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<td>Silicon</td>
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<td>Maximum</td>
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<td>c)</td>
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<td>Minimum breaking load of strand</td>
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<td>Minimum weight of zinc coating per sq.m. after stranding</td>
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<td>Minimum number of dips that the galvanized strand can withstand in the standard preece test</td>
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<td>c)</td>
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</table>
2.0 Tests and Standards

2.1 Type Tests on Earth wire

The following tests shall be conducted once on sample/samples of earth wire for every 500 Kms of production from each manufacturing facility:

(a) UTS test ) Annexure - A
(b) DC resistance test )

2.2 Acceptance Tests on Earth wire

(a) Visual and dimensional check on drum )
(b) Visual check for joints scratches etc. and lengths of earth wire )
(c) Dimensional check )
(d) Lay length check ) Annexure - A
(e) Galvanising test )
(f) Torsion test )
(g) Elongation test ) IS:398 (Part-II)
(h) Wrap test )
(i) DC resistance test )
(j) Breaking load test ) IS:398 (Part-II)
(k) Chemical Analysis of steel ) Annexure-A

2.3 Routine Tests on Earth wire

(a) Check for correctness of stranding
(b) Check that there are no cuts, fins etc. on the strands.
(c) Check that drums are as per Specification.

2.4 Tests During Manufacture

(a) Chemical analysis of zinc used for galvanising ) Annexure - A
(b) Chemical analysis of steel )

2.5 Testing Expenses

2.5.1 The break-up of the testing charges for the type tests specified shall be indicated separately.
2.5.2 Bidders shall indicate the laboratories in which they propose to conduct the type tests. They shall ensure that the tests can be completed in these laboratories within the time schedule guaranteed by them.

2.5.3 In case of failure in any type test the Contractor is either required to manufacture fresh sample lot and repeat all the test successfully once or repeat that particular type test three times successfully on the sample selected from the already manufactured lot at his own expenses. In case fresh lot is manufactured for testing then the lot already manufactured shall be rejected. The decision of the Purchaser in this regard shall be final and binding on Contractor.

2.5.4 The entire cost of testing for the acceptance and routine tests and tests during manufacture specified herein shall be treated as included in the quoted unit price except for the expenses of the inspector/Owner’s representative.

2.5.5 In case of failure in any type test, repeat type tests are required to be conducted, then all the expenses for deputation of Inspector/Owner’s representative shall be deducted from the contract price. Also if on receipt of the Contract's notice of testing the Owner's representative/Inspector does not find ‘materials and facilities’ to be ready for testing, the expenses incurred by the Owner for re-deputation shall be deducted from the contract price.

2.6 Additional Tests

2.6.1 The Owner reserves the right of having at his own expenses any other test(s) of reasonable nature carried out at Contractor’s premises, at site, or in any other place in addition to the aforesaid type, acceptance and routine tests to satisfy himself that the materials comply with the Specifications.

2.6.2 The Owner also reserves the right to conduct all the tests mentioned in this specification at his own expense on the samples drawn from the site at Contractor's premises or at any other test center. In case of evidence of non compliance, it shall be binding on the part of Contractor to prove the compliance of the items to the technical specifications by repeat tests, or correction of deficiencies, or replacement of defective item all without any extra cost to the Owner.

2.7 Sample Batch For Type Testing

2.7.1 The Contractor shall offer material for selection of samples for type testing only after getting Quality Assurance Plan approved from Owner’s Quality Assurance Deptt. The sample shall be manufactured strictly in accordance with the Quality Assurance Plan approved by Owner.

2.7.2 The Contractor shall offer at least three drums for selection of sample required for conducting all the type test.

2.7.3 The Contractor is required to carry out all the Acceptance tests successfully in presence of Owner’s representative before sample selection.

2.8 Test Reports
2.8.1 Copies of type test reports shall be furnished in at least six copies along with one original. One copy will be returned duly certified by the Owner only after which the commercial production of the material shall start.

2.8.2 Record of routine test reports shall be maintained by the Contractor at his works for periodic inspection by the Owner’s representative.

2.8.3 Test Certificates of tests during manufacture shall be maintained by the Contractor. These shall be produced for verification as and when desired by the Owner.

2.9 Inspection

2.9.1 The Owner’s representative shall at all times be entitled to have access to the works and all places of manufacture, where earth wire shall be manufactured and representative shall have full facilities for unrestricted inspection of the Contractor’s works, raw materials and process of manufacture for conducting necessary tests as detailed herein.

2.9.2 The Contractor shall keep the Owner informed in advance of the time of starting and of the progress of manufacture of earth wire in its various stages so that arrangements can be made for inspection.

2.9.3 No material shall be despatched from its point of manufacture before it has been satisfactorily inspected and tested, unless the inspection is waived off by the Owner in writing. In the latter case also the earth wire shall be despatched only after satisfactory testing for all tests specified herein have been completed.

2.9.4 The acceptance of any quantity of material shall in no way relieve the Contractor of any of his responsibilities for meeting all requirements of the Specification, and shall not prevent subsequent rejection if such material is later found to be defective.

2.10 Test Facilities

2.10.1 The following additional test facilities shall be available at the Contractor’s works:

a) Calibration of various testing and measuring equipment including tensile testing machine, resistance measurement facilities, burette, thermometer, barometer etc.

b) Standard resistance for calibration of resistance bridges.

c) Finished Earth wire shall be checked for length verification and surface finish on separate rewinding machine at reduced speed (variable from 8 to 16 meters per minute). The rewinding facilities shall have appropriate clutch system and free of vibrations, jerks etc., with traverse laying facilities.

2.11 Packing for Earth wire

2.11.1 The Earth wire shall be supplied in non-returnable, strong, wooden drums and provided with lagging of adequate strength, constructed to protect the Earth wire against all damage and displacement during transit, storage and subsequent handling and stringing operations in the field. The
Contractor shall be responsible for any loss or damage during transportation handling and storage due to improper packing. The drums shall generally conform to IS:1778-1980, except as otherwise specified hereinafter.

2.11.2 The drums shall be suitable for wheel mounting and for letting off the earth wire under a minimum controlled tension of the order of 5 kN.

2.11.3 The general outline of the drum for Earth wire shall be as per annexed drawing. The Contractor should submit their proposed drum drawings along with the bid.

2.11.4 For Earth wire, two standard length shall be wound on each drum.

2.11.5 For Earth wire, each strand shall be individually welded to prevent parting of two lengths at a tension less than 15 kN. The two ends where the first length finishes and the second length starts, shall be clearly marked with adhesive tape and no weld should be present outside these marks. The length between the two marks shall be treated as scrap and will not be taken into account for measurement purposes.

2.11.6 All wooden components shall be manufactured out of seasoned softwood free from defects that may materially weaken the component parts of the drums. Preservative treatment shall be applied to the entire drum with preservatives of a quality which is not harmful to the earth wire.

2.11.7 The flanges shall be of two ply construction with each ply at right angles to the adjacent ply and nailed together. The nails shall be driven from the inside face flange, punched and then clenched on the outer face. The thickness of each ply shall not vary by more than 3 mm from that indicated in the figure. There shall be at least 3 nails per plank of ply with maximum nail spacing of 75 mm. Where a slot is cut in the flange to receive the inner end of the earth wire the entrance shall be in line with the periphery of the barrel.

2.11.8 The wooden battens used for making the barrel of the earth wire shall be of segmental type. These shall be nailed to the barrel supports with at least two nails. The battens shall be closely butted and shall provide a round barrel with smooth external surface. The edges of the battens shall be rounded or chamfered to avoid damage to the earth wire.

2.11.9 Barrel studs shall be used for the construction of drums. The flanges shall be holed and the barrel studs shaft be threaded over a length on either end, sufficient to accommodate washers, spindle plates and nuts for fixing flanges at the required spacing.

2.11.10 Normally, the nuts on the studs shall stand protruded of the flanges. All the nails used on the inner surface of the flanges and the drum barrel shall be counter sunk. The ends of barrel shall generally be flushed with the top of the nuts.

2.11.11 The inner cheek of the flanges and drum barrel surface shall be painted with a bitumen based paint.

2.11.12 Before reeling, cardboard or double corrugated or thick bituminous waterproof bamboo paper shall be secured to the drum barrel and inside...
of flanges of the drum by means of a suitable commercial adhesive material. After reeling the earth wire, the exposed surface of the outer layer of earth wire shall be wrapped with waterproof thick bituminous bamboo paper to preserve the earth wire from dirt, grit and damage during transport and handling.

Medium grade craft/crepe/polythene paper shall be used in between the layers.

2.11.13 A minimum space of 50 mm for earth wire shall be provided between the inner surface of the external protective lagging and outer layer of the earth wire.

2.11.14 Each batten shall be securely nailed across grains as far as possible to the flange, edges with at least 2 nails per end. The length of the nails shall not be less than twice the thickness of the battens. The nails shall not protrude above the general surface and shall not have exposed sharp edges or allow the battens to be released due to corrosion.

2.11.15 The nuts on the barrel studs shall be tack welded on the one side in order to fully secure them. On the second end, a spring washer shall be used.

2.11.16 Outside the protective lagging there shall be minimum of two binder consisting of hoop iron/galvanised steel wire. Each protective lagging shall have two recesses to accommodate the binders.

2.11.17 The earth wire ends shall be properly sealed and secured on the side of one of the flanges to avoid loosening of the earth wire layers during transit and handling.

2.12 Marking

Each drum shall have the following information stenciled on it in indelible ink along with other essential data

(a) Contract/Award letter number.
(b) Name and address of consignee.
(c) Manufacturer’s name and address.
(d) Drum number
(e) Size of earth wire
(f) Length of earth wire in meters
(g) Gross weight of drum with earth wire & lagging
(h) Weight of empty drum with lagging
(i) Arrow marking for unwinding
(j) Position of the earth wire ends
(k) Number of turns in the outer most layer
(l) Distance between outer most layer of Earth wire and the inner surface of lagging
(n) Barrel diameter at three locations and an arrow marking at the location of measurement

2.13 Verification of Earth wire Length

The Owner reserves the right to verify the length of earth wire after unreeling at least ten (10) percent of the drums in a lot offered for inspection.

2.14 Standards

The earth wire shall conform to the following Indian/ International Standards, which shall mean latest revisions, amendments/changes adopted and published, unless otherwise in the Specification.

In the event of the supply of earth wire conforming to standards other than specified, the Contractor shall confirm in his bid that these standards are equivalent to those specified. In case of award salient features of comparison between the standards proposed by the Contractor and those specified in this documents will be provided by the Contractor to establish their equivalence.

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<th>Indian Standards</th>
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<td>6.</td>
<td>IS 1778-1997</td>
<td>Reels and Drums for Bare Conductors</td>
<td>BS:1559-1949</td>
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<td>7.</td>
<td>IS 1521-1991</td>
<td>Method of Tensile Testing of Steel Wire</td>
<td>IS06892-1984</td>
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<td>2629-1997</td>
<td>Recommended Practice for Hot Dip Galvanising of Iron and Steel</td>
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<td>9.</td>
<td>2633-1990</td>
<td>Method of Testing Uniformity of Coating on Zinc Coated Articles</td>
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<td>Hard drawn aluminium wire for overhead line conductors</td>
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<td>British Standards,</td>
<td>British Standards Institution</td>
</tr>
<tr>
<td></td>
<td>101, Pentonville Road,</td>
<td>N - 19-ND, UK</td>
</tr>
<tr>
<td>IEC/CISPR</td>
<td>International Electro technical Commission, Bureau Central de la Commission, Electro Technique International, 1 Rue de verembe, Geneva SWITZERLAND</td>
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<tr>
<td>BIS</td>
<td>Bureau Of Indian Standards, Manak Bhavan, 9, Bahadur Shah Zafar Marg, New Delhi - 1 1 0001, INDIA</td>
<td></td>
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<tr>
<td>ISO</td>
<td>International Organisation for Standardization, Danish Board of Standardization Danish Standardising Sraat, Aurehoegvej-1 2 DENMARK.</td>
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<tr>
<td>NEMA</td>
<td>National Electric Manufacture Association, 1 55, East 44th Street, New York, NY 10017, U.S.A.</td>
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ANNEXURE-A

1.0 Tests on Earth wire

1.1 UTS Test

Circles perpendicular to the axis of the earth wire shall be marked at two places on a sample of earth wire of minimum 5 m length suitably compressed with dead end clamps at either end. The load shall be increased at a steady rate up to 50% of UTS and held for one minute. The circles drawn shall not be distorted due to relative movement of strands. Thereafter the load shall be increased at steady rate to 100% of UTS and held for one minute. The earth wire sample shall not fail during this period. The applied load shall then be increased until the failing load is reached and the value recorded.

1.2 D.C. Resistance Test

On a earth wire sample of minimum 5m length two contact clamps shall be fixed with a predetermined bolt torque. The resistance shall be measured by a Kelvin double bridge by placing the clamps initially at zero meter and subsequently one meter apart. The test shall be repeated at least five times and the average value recorded. The value obtained shall be corrected to the value at 20ºC. The resistance corrected at 20ºC shall conform to the requirements of this Specification.

1.3 Chemical Analysis of Zinc

Samples taken from the zinc ingots shall be chemically/ spectrographically analysed. The same shall be in conformity to the requirements stated in the Specification.

1.4 Chemical Analysis of Steel

Samples taken from the steel ingots/coils/strands shall be chemically/spectrographically analysed. The same shall be in conformity to the requirements stated in this Specification.

1.5 Visual and Dimensional Check on Drums and its barrel strength test.

The drums shall be visually and dimensionally checked to ensure that they conform to the requirements of this Specification. The details regarding barrel strength test will be discussed and mutually agreed to by Contractor and Owner in the quality assurance programme.

1.6 Visual Check for Joints, Scratches etc. and Length of Earth wire

Ten percent drums from each lot shall be rewound in the presence of the Owner. The Owner shall visually check for scratches, joints etc. and see that the earth wire generally conforms to the requirements of this Specification. The length of earth wire wound on the drum shall be measured with the help of counter meter during rewinding.
1.7 Dimensional Check

The individual strands shall be dimensionally checked to ensure that they conform to the requirement of this Specification.

1.8 Lay Length Check

The lay length shall be checked to ensure that they conform to the requirements of this Specification.

1.9 Galvanising Test

The test procedure shall be as specified in IS:4826-1979. The material shall conform to the requirements of this Specification. The adherence of zinc shall be checked by wrapping around a mandrel four times the diameter of steel wire.

1.10 Torsion Test

The minimum number of twists which a single steel strand shall withstand during torsion test shall be eighteen for a length equal to 100 times the standard diameter of the strand. In case test sample length is less or more than 100 times the stranded diameter of the strand the minimum number of twists will be proportioned to the length and if number comes in the fraction then it will be rounded off to next higher whole number.
### SECTION – VII

**CONTENTS**

<table>
<thead>
<tr>
<th>Clause No.</th>
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</tr>
</thead>
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<tr>
<td>1.0</td>
<td>Technical Description of Hardware Fittings</td>
<td>01</td>
</tr>
<tr>
<td>2.0</td>
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</tr>
<tr>
<td></td>
<td>Annexure – A</td>
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<td>Annexure – B</td>
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1.0 Technical Description of Hardware Fittings

1.1 Details of Hardware Fittings

1.1.1 The hardware fittings shall be suitable for use with Disc insulators and/or porcelain long rod insulators having ball and socket fittings. The hardware fittings shall be as per the specification drawings enclosed with Section-VIII of the specification. Each hardware fitting shall be supplied complete in all respects and shall include the following hardware parts:

1.1.2 Suitable arcing horn as specified in clause 1.8 hereinafter.
1.1.3 Suitable yoke plates complying with the specifications given hereinafter.
1.1.4 Corona control rings/grading ring with fittings for attachment to line side yoke plate.
1.1.5 Sag adjustment plate for *Double tension hardware fittings and turn buckle for single tension hardware fittings.
1.1.6 Suspension and dead end assembly to suit conductor size as detailed in clause 1.13, 1.14 and 1.15 hereinafter.
1.1.7 Provisions for attaching balancing weights on the line side yoke plate of single suspension pilot hardware fittings.
1.1.8 Other necessary fittings viz D-shackles, eye links, extension links, ball clevis, socket clevis, clevis eye, U clevis and chain link etc. to make the hardware fittings complete.
1.1.9 2.5% extra fasteners.

1.2 Dimensions of Insulator String Along with Hardware Fitting

The various limiting dimensions of the insulator strings along with hardware fittings shall be as per the specification drawings enclosed with Section-VII of this specification.

1.3 Interchangeability

1.3.1 The hardware for insulator strings with disc insulators / porcelain long rod insulators together with ball and socket fittings shall be of standard design, so that these hardware are inter-changeable with each other and suitable for use with insulators of any make conforming to relevant Indian/International Standard.

1.4 Corona And RI Performance

Sharp edges and scratches on all the hardware fittings shall be avoided. All surfaces must be clean, smooth, without cuts and abrasions or projections. The Contractor must give suitable assurance about the satisfactory corona and radio interference performance of the materials offered by him.

1.5 Maintenance

1.5.1 The hardware fittings offered shall be suitable for employment of hot line maintenance technique so that usual hot line operations can be carried out with ease, speed and safety. The technique adopted for hot line maintenance shall be
generally bare hand method & hot stick method. The Bidder should clearly establish in the bid, the suitability of his fittings for hot line maintenance.

1.5.2 The line side yoke plate shall have a notch & a working hole of suitable size. The design of corona control rings/grading ring shall be such that it can be easily replaced by employing hot line maintenance technique.

1.6 Designation

1.6.1 Ball and Socket Designation

The dimensions of the ball and socket are furnished in section – I of this Specification. The designation should be in accordance with the standard dimensions stated in IS:2486-(Part-II)/IEC:120. The dimensions shall be checked by the appropriate gauge after galvanising only.

1.7 Security Clips and Split Pins

1.7.1 Security clips for use with ball and socket coupling shall be R-shaped, hump type which provides positive locking of the coupling as per IS:2486-(Part-III)/IEC : 372. The legs of the security clips shall be spread after assembly in the works to prevent complete withdrawal from the socket. The locking device should be resilient, corrosion resistant and of suitable mechanical strength. There shall be no risk of the locking device being displaced accidentally or being rotated when in position. Under no circumstances shall the locking devices allow, separation of fittings.

1.7.2 The hole for the security clip shall be countersunk and the clip should be of such design that the eye of clip may be engaged by a hot line clip puller to provide for disengagement under energised conditions. The force required to pull the security clip into its unlocked position shall not be less than 50 N (5 kg) or more than 500 N (50 kg).

1.7.3 Split pins shall be used with bolts & nuts.

1.8 Arcing Horn/Intermediate Arcing Horn

1.8.1 The arcing horn / Intermediate Arcing Horn shall be either ball ended rod type or tubular type.

1.8.2 The arcing horn shall be provided as shown on the drawing of the hardware fittings, in this specification.

1.8.3 The air gap shall be so adjusted to ensure effective operation under actual field conditions.

1.9 Yoke Plates

The strength of yoke plates shall be adequate to withstand the minimum ultimate tensile strength as specified in the bid drawings.

The plates shall be either triangular or rectangular in shape as may be necessary. The design of yoke plate shall take into account the most unfavorable loading conditions likely to be experienced as a result of dimensional tolerances for disc insulators as well as components of hardware fittings within the specified range. The plates shall have suitable holes for fixing corona control rings/grading ring/arcing horn. All the corners and edges should be rounded off with a radius of atleast 3 mm. Design calculations i.e. for bearing & tensile strength, for deciding the dimensions of yoke plate shall be furnished by the bidder. The holes provided for bolts in the yoke plate should satisfy shear edge condition as per Clause No. 8.10 of IS:800-1984.
1.10 **Corona Control Rings/Grading Ring**

1.10.1 The Corona control rings/grading ring shall be provided with hardware fittings and shall be of such design that it should cover at least one disc insulator in disc insulator strings so that they will reduce the voltage across the insulator units. It shall also improve corona and radio interference performance of the complete insulator string along with hardware fittings.

1.10.2 The corona control rings/grading ring shall be made of high strength heat treated aluminium alloy tube of minimum 2.5 mm wall thickness. If mild steel brackets are used then the brackets shall not be welded to the pipe but shall be fixed by means of bolts and nuts on a small aluminium plate attachment welded to the pipe. The welded center of the corona control ring/grading ring shall be ground before buffing. Alternately, Aluminium tube/flats of suitable dimensions welded to the corona control ringsgrading rings may be used for connection to yoke plate.

1.10.3 The Corona control rings/grading ring should have a brushed satin finish and not a bright glossy surface. No blemish should be seen or felt when rubbing a hand over the metal.

1.10.4 The limiting dimensions of corona control ring shall be as per the specification drawings.

1.10.5 Bidder may quote for grading ring with armour grip suspension assembly. The grading ring shall be of open type design with a gap of 125 mm. The open ends shall be suitably terminated. The outside diameter of the tube shall be 60 mm. The ends of grading ring tube shall be sealed with welded aluminium cap duly buffered.

1.11 **Sag Adjustment Plate**

1.11.1 The sag-adjustment plate to be provided with the double tension hardware fitting shall be of three plate type. The sag adjustment plate shall be provided with a safety locking arrangement. The device shall be of such design that the adjustment is done with ease, speed and safety.

1.11.2 The maximum length of the sag adjustment plate from the connecting part of the rest of the hardware fittings shall be 520 mm. The details of the minimum and maximum adjustment possible and the steps of adjustment shall be clearly indicated in the drawing. An adjustment of 150 mm minimum at the interval of 6 mm shall be possible with the sag adjustment plate.

1.11.3 Design calculations for deciding the dimensions of sag adjustment plate shall be furnished by bidder. The hole provided for bolts should satisfy shear edge condition as per Clause No.8.10 of IS:800-1984.

1.12 **Turn Buckle**

1.12.1 The turn buckle is to be provided with single tension hardware fitting. The threads shall be of sufficient strength to remain unaffected under the specified tensile load.

1.12.2 The maximum length of the turn buckle from the connecting part of the rest of the hardware fittings shall be 520 mm. The details of the minimum and maximum adjustment possible shall be clearly indicated in the drawing. An adjustment of 150 mm minimum shall be possible with turn buckle.

1.13 **Suspension Assembly**

1.13.1 The suspension assembly shall be suitable for the specific Conductor as given in Section I of this Specification.
1.13.2 The suspension assembly shall include free center type suspension clamp along with standard preformed armour rods or armour grip suspension clamp; except for Pilot insulator string for which only suitable Envelope type suspension clamp shall be used.

1.13.3 The suspension clamp along with standard preformed armour rods set shall be designed to have maximum mobility in any direction and minimum moment of inertia so as to have minimum stress on the conductor in the case of oscillation of the same.

1.13.4 The suspension clamp along with standard preformed armour rods/armour grip suspension clamp set shall have the slip strength not less than that specified in the Standard Technical Particulars.

1.13.5 The suspension assembly shall be designed, manufactured and finished to give it a suitable shape, so as to avoid any possibility of hammering between suspension assembly and conductor due to vibration. The suspension assembly shall be smooth without any cuts, grooves, abrasions, projections, ridges or excrescence, which might damage the conductor.

1.13.6 The suspension assembly/clamp shall be designed so that it shall minimise the static & dynamic stress developed in the conductor under various loading conditions as well as during wind induced conductor vibrations. It shall also withstand power arcs & have required level of Corona/RIV performance.

1.13.7 The magnetic power loss shall not be more than that stipulated in the Standard Technical Particulars.

1.13.8 Free Center Type Suspension Clamp

For the Free Center Suspension Clamp seat shall be smoothly rounded and curved into a bell mouth at the ends. The lip edges shall have rounded bead. There shall be at least two U-bolts for tightening of clamp body and keeper pieces together.

1.13.10 Standard Preformed Armour Rod Set

1.13.10.1 The Preformed Armour Rods Set, suitable for specific Conductor, shall be used to minimise the stress developed in the sub-conductor due to different static and dynamic loads because of vibration due to wind, slipping of conductor from the suspension clamp as a result of unbalanced conductor tension in adjacent spans and broken wire condition. It shall also withstand power arcs, chafing and abrasion from suspension clamp and localised heating effect due to magnetic power losses from suspension clamps as well as resistance losses of the conductor.

1.13.10.2 The preformed armour rods set shall have right hand lay and the inside diameter of the helics shall be less than the outside diameter of the conductor to have gentle but permanent grip on the conductor. The surface of the armour rod when fitted on the conductor shall be smooth and free from projections, cuts and abrasions etc.

1.13.10.3 The pitch length of the rods shall be determined by the Bidder but shall be less than that of the outer layer of conductor and the same shall be accurately controlled to maintain uniformity and consistently reproducible characteristic wholly independent of the skill of linemen.

1.13.10.4 The length of each rod along with permissible tolerances shall be as stipulated in the Standard Technical Particulars. The end of armour rod shall be parrot billed.
1.13.10.5 The number of armour rods in each set shall as stipulated in the Standard Technical Particulars. Each rod shall be marked in the middle with paint for easy application on the line.

1.13.10.6 The armour rod shall not loose their resilience even after five applications.

1.13.10.7 The conductivity of each rod of the set shall not be less than 40% of the conductivity of the International Annealed Copper Standard (IACS).

1.13.11 Armour Grip Suspension Clamp

1.13.11.1 The armour grip suspension clamp shall comprise of retaining strap, support housing, elastomer inserts with aluminium reinforcements and AGS preformed rod set.

1.13.11.2 Elastomer insert shall be resistant to the effects of temperature up to 95°C, Ozone, ultraviolet radiations and other atmospheric contaminants likely to be encountered in service. The physical properties of the elastomer shall be of approved standard. It shall be electrically shielded by a cage of AGS performed rod set. The elastomer insert shall be so designed that the curvature of the AGS rod shall follow the contour of the neoprene insert.

1.13.11.3 The AGS preformed rod set shall be as detailed in clause 1.13.10.4 to 1.13.10.7 in general except for the following.

1.13.11.4 The length of the AGS preformed rods shall be such that it shall ensure sufficient slipping strength as detailed under clause 1.13.4 and shall not introduce unfavorable stress on the conductor under all operating conditions. However the length of AGS preformed rods shall not be less than that stipulated in the Standard Technical Particulars.

1.14 Envelope Type Suspension Clamp

1.14.1 The seat of the envelope type suspension clamp shall be smoothly rounded & suitably curved at the ends. The lip edges shall have rounded bead. There shall be at least two U-bolts for tightening of clamp body and keeper pieces together. Hexagonal bolts and nuts with split-pins shall be used for attachment of the clamp.

1.15 Dead end Assembly

1.15.1 The dead end assembly shall be suitable for specific Conductor.

1.15.2 The dead end assembly shall be compression type with provision for comprising jumper terminal at one end. The angle of jumper terminal to be mounted should be 30° with respect to the vertical line. The area of bearing surface on all the connections shall be sufficient to ensure positive electrical and mechanical contact and avoid local heating due to I²R losses. The resistance of the clamp when compressed on Conductor shall not be more than 75% of the resistance of equivalent length of Conductor.

1.15.3 Die compression areas shall be clearly marked on each dead-end assembly designed for continuous die compressions and shall bear the words ‘COMPRESSION FIRST’ suitably inscribed near the point on each assembly where the compression begins. If the dead end assembly is designed for intermittent die compressions it shall bear identification marks ‘COMPRESSION ZONE’ AND ‘NON-COMPRESSION ZONE’ distinctly with arrow marks showing the direction of compressions and knurling marks showing the end of the zones. The letters, number and other markings on the finished clamp shall be distinct and legible. The dimensional tolerances of the cross section of aluminium and steel dead end; for
dead end assembly for the specific conductor shall be as stipulated in the Standard Technical Particulars.

1.15.4 The assembly shall not permit slipping of, damage to, or failure of the complete conductor or any part thereof at a load less than 95% of the ultimate tensile strength of the conductor.

1.16 Fasteners : Bolts, Nuts and Washers

1.16.1 All bolts and nuts shall conform to IS:6639. All bolts and nuts shall be galvanised as per IS-1367 - (Part 13)/IS-2629. All bolts and nuts shall have hexagonal heads, the heads being forged out of solid truly concentric, and square with the shank, which must be perfectly straight.

1.16.2 Bolts up to M16 and having length up to 10 times the diameter of the bolt should be manufactured by cold forging and thread rolling process to obtain good and reliable mechanical properties and effective dimensional control. The shear strength of bolt for 5.6 grade should be 310 MPa minimum as per IS-.12427. Bolts should be provided with washer face in accordance with IS:1363 Part-1 to ensure proper bearing.

1.16.3 Nuts should be double chamfered as per the requirement of IS:1363 Part-III. It should be ensured by the manufacturer that nuts should not be over tapped beyond 0.4 mm oversize on effective diameter for size up to M16.

1.16.4 Fully threaded bolts shall not be used. The length of the bolt shall be such that the threaded portion shall not extend into the place of contact of the component parts.

1.16.5 All bolts shall be threaded to take the full depth of the nuts and threaded enough to permit the firm gripping of the component parts but no further. It shall be ensured that the threaded portion of the bolt protrudes not less than 3 mm and not more than 8 mm when fully tightened. All nuts shall fit and tight to the point where shank of the bolt connects to the head.

1.16.6 Flat washers and spring washers shall be provided wherever necessary and shall be of positive lock type. Spring washers shall be electro-galvanised. The thickness of washers shall conform to IS:2016-1967.

1.16.7 The Bidder shall furnish bolt schedules giving thickness of components connected. The nut and the washer and the length of shank and the threaded portion of bolts and size of holes and any other special details of this nature.

1.16.8 To obviate bending stress in bolt, it shall not connect aggregate thickness more than three time its diameter.

1.16.9 Bolts at the joints shall be so staggered that nuts may be tightened with spanners without fouling.

1.16.10 To ensure effective in-process Quality control it is essential that the manufacturer should have all the testing facilities for tests like weight of zinc coating, shear strength, other testing facilities etc, in-house. The manufacturer should also have proper Quality Assurance system, which should be in line with the requirement of this specification and IS-.14000 services Quality System standard.

1.16.11 Fasteners of grade higher than 8.8 are not to be used.

1.17 Materials

The materials of the various components shall be as specified hereunder. The Bidder shall indicate the material proposed to be used for each and every...
component of hardware fittings stating clearly the class, grade or alloy designation of the material, manufacturing process & heat treatment details and the reference standards.

1.17.1 The details of materials for different component are listed as in Table-I

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Name of Item</th>
<th>Material Treatment</th>
<th>Process of Reference</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Security Clips</td>
<td>Stainless Steel/Phos/pher Bronze</td>
<td>-</td>
<td>AISI 302 or 304-L/ IS-1385</td>
</tr>
<tr>
<td>2.</td>
<td>Arcing Horn</td>
<td>Mild Steel Rod/Tube Type</td>
<td>Hot dip galvanised</td>
<td>As per IS-226-or IS-2062</td>
</tr>
<tr>
<td>3.</td>
<td>Ball Fittings, Socket, All shackles, links, clevis,</td>
<td>Class-IV Steel</td>
<td>Drop forged &amp; normalised Hot dip galvanised</td>
<td>As per IS: 2004</td>
</tr>
<tr>
<td>4.</td>
<td>Yoke Plate</td>
<td>Mild Steel</td>
<td>Hot dip galvanised</td>
<td>As per IS: 226/IS-2062</td>
</tr>
<tr>
<td>5.</td>
<td>Sag Adjustment plate</td>
<td>Mild Steel</td>
<td>Hot dip galvanised</td>
<td>As per IS: 226/IS-2062</td>
</tr>
<tr>
<td>6.</td>
<td>(a) Corona Control ring/Grading ring (400 kV)</td>
<td>High Strength Al. Alloy tube (6061/6063/1100 type or 65032/63400 Type)</td>
<td>Heat treated</td>
<td>ASTM-B429 or as per IS Mech. strength of weld-ed joint shall not be less than 20 KN</td>
</tr>
<tr>
<td></td>
<td>(b) Supporting Brackets &amp; Mounting Bolts</td>
<td>High Strength Al. alloy 6061/6063 65032/63400 Type) or Mild Steel</td>
<td>Heat treated</td>
<td>ASTM-B429 or as per IS:226</td>
</tr>
<tr>
<td>7.</td>
<td>Turn Buckle</td>
<td>Class II Steel</td>
<td>Forged Hot dip galvanised</td>
<td>As per IS:2004</td>
</tr>
</tbody>
</table>
8. Free Center clamp/Envelope type Clamp

(a) Clamp Body/ Keeper Piece
High Stren-
gh Al. Alloy 4600/ LM-6 or 6061/65032 Casted or forged & Heat treated IS:617 or ASTM-B429

(b) Cotter bolts, Hangers, Shackles, Brackets
Mild Steel Hot dip galvanised IS-226/IS-2062

(c) U Bolts
Stainless Steel or High Stren-
gh Al. alloy 6061/6063 or 65032/63400 Forged & heat treated AISI 302 or 304-L ASTM-B429

9. P.A. Rod
High Stren-
gh Al. alloy type 6061/ 65032 Heat treatment during manufacturing ASTM-B429 Min tensile strength of 35 kg/ mm²

10. AGS Clamp
(a) Supporting House
High Stren-
gh Corros -ion resistant AL. Alloy LM6, 4600 or 6061/65032 Cast/ forged Heat treated IS:617 or ASTM-B429

(b) Al. Insert & Retaining strap
High Stren-
gth Al. Alloy of type 6061/ 65032 forged & Heat treated ASTM-B429 or as per IS

(c) Elastomer Cushion
Moulded on Al. reinforcement

11. Dead End Assembly
(a) Outer Sleeve
EC grade Al of purity not less than 99.50%

(c) Steel Sleeve
Mild Steel Hot Dip Galvanised As per IS:226/IS-2062

12. Balancing Weights
Cast Iron /MCi/Mach-
ined Mild Steel Hot dip galvanised
Note: Alternate materials conforming to other national standards of other countries also may be offered provided the properties and compositions of these are close to the properties and compositions of material specified. Bidder should furnish the details of comparison of material offered vis-à-vis specified in the bid or else the bids are liable to be rejected.

1.18 Workmanship

1.18.1 All the equipment shall be of the latest design and conform to the best modern practices adopted in the Extra High Voltage field. The Bidder shall offer only such equipment as guaranteed by him to be satisfactory and suitable for the rated transmission lines and will give continued good performance.

1.18.2 The design, manufacturing process and quality control of all the materials shall be such as to give the specified mechanical rating, highest mobility, elimination of sharp edges and corners to limit corona and radio-interference, best resistance to corrosion and a good finish.

1.18.3 All ferrous parts including fasteners shall be hot dip galvanised, after all machining has been completed. Nuts may, however, be tapped (threaded) after galvanising and the threads oiled. Spring washers shall be electro galvanised. The bolt threads shall be undercut to take care of the increase in diameter due to galvanising. Galvanising shall be done in accordance with IS:2629-1985 / IS-1367 (Part 13) and shall satisfy the tests mentioned in IS:2633-1986.

1.18.4 Before ball fittings are galvanised, all die flashing on the shank and on the bearing surface of the ball shall be carefully removed without reducing the dimensions below the design requirements.

1.18.5 The zinc coating shall be perfectly adherent, of uniform thickness, smooth, reasonably bright, continuous and free from imperfections such as flux, ash rust, stains, bulky white deposits and blisters. The zinc used for galvanising shall be Zinc of any grade in IS: 209:1992 ingot (fourth revision) or IS:13229:1991.

1.18.6 Pin balls shall be checked with the applicable “GO” gauges in at least two directions, one of which shall be across the line of die flashing, and the other 90° to this line. "NO GO" gauges shall not pass in any direction.

1.18.7 Socket ends, before galvanising, shall be of uniform contour. The bearing surface of socket ends shall be uniform about the entire circumference without depressions of high spots. The internal contours of socket ends shall be concentric with the axis of the fittings as per IS:2486/IEC : 120.

The axis of the bearing surfaces of socket ends shall be coaxial with the axis of the fittings. There shall be no noticeable tilting of the bearing surfaces with the axis of the fittings.

1.18.8 In case of casting, the same shall be free from all internal defects like shrinkage, inclusion, blow holes, cracks etc. Pressure die casting shall not be used for casting of components with thickness more than 5 mm.

1.18.9 All current carrying parts shall be so designed and manufactured that contact resistance is reduced to minimum.

1.18.10 No equipment shall have sharp ends or edges, abrasions or projections and cause any damage to the conductor in any way during erection or during continuous operation which would produce high electrical and mechanical stresses in normal working. The design of adjacent metal parts and mating surfaces shall be such as to prevent corrosion of the contact surface and to maintain good electrical contact under service conditions.
1.18.11 All the holes shall be cylindrical, clean cut and perpendicular to the plane of the material. The periphery of the holes shall be free from burrs.

1.18.12 All fasteners shall have suitable corona free locking arrangement to guard against vibration loosening.

1.18.13 Welding of aluminium shall be by inert gas shielded tungsten arc or inert gas shielded metal arc process. Welds shall be clean, sound, smooth, uniform without overlaps, properly fused and completely sealed. There shall be no cracks, voids incomplete penetration, incomplete fusion, under-cutting or inclusions. Porosity shall be minimised so that mechanical properties of the aluminium alloys are not affected. All welds shall be properly finished as per good engineering practices.

1.19 Bid Drawings

1.19.1 The Bidder shall furnish full description and illustrations of materials offered.

1.19.2 Fully dimensioned drawings of the complete insulator string hard wares and their component parts showing clearly the following arrangements shall be furnished along with the bid. Weight, material and fabrication details of all the components should be included in the drawings.

(i) Attachment of the hanger or strain plate.
(ii) Suspension or dead end assembly.
(iii) Arcing horn attachment to the string as specified in clause 1.8 of this technical Specification.
(iv) Yoke plates
(v) Hardware fittings of ball and socket type for inter connecting units to the top and bottom Yoke plates.
(vi) Corona control rings/grading ring attachment to conductor and other small accessories.
(vii) Links with suitable fittings.
(viii) Details of balancing weights and arrangements for their attachment in the single suspension pilot insulator string.

1.19.3 All drawings shall be identified by a drawing number and contract number. All drawings shall be neatly arranged. All drafting & lettering shall be legible. The minimum size of lettering shall be 3 mm. All dimensions & dimensional tolerances shall be mentioned in mm.

The drawings shall include:

(i) Dimensions and dimensional tolerance.
(ii) Material, fabrication details including any weld details & any specified finishes & coatings. Regarding material designation & reference of standards are to be indicated.
(iii) Catalogue No.
(iv) Marking
(v) Weight of assembly
(vi) Installation instructions
Design installation torque for the bolt or cap screw.

Withstand torque that may be applied to the bolt or cap screw without failure of component parts.

The compression die number with recommended compression pressure.

All other relevant terminal details.

1.19.4 After placement of award, the Contractor shall submit fully dimensioned drawing including all the components in four (4) copies to the Owner for approval. After getting approval from the Owner and successful completion of all the type tests, the Contractor shall submit thirty (30) more copies of the same drawings to the Owner for further distribution and field use at Owner’s end.

2.0 Accessories For Conductor

2.1 General

2.1.1 This portion (under clause 2.0) details the technical particulars of the accessories for Conductor.

2.1.2 2.5% extra fasteners and retaining rods shall be provided.

2.2 Mid Span Compression Joint

2.2.1 Mid Span Compression Joint shall be used for joining two lengths of conductor. The joint shall have a resistivity less than 75% of the resistivity of equivalent length of conductor. The joint shall not permit slipping off, damage to or failure of the complete conductor or any part there of at a load less than 95% of the ultimate tensile strength of the conductor.

2.2.2 The joint shall be made of steel and aluminium sleeves for jointing the steel core and aluminium wires respectively. The steel sleeve should not crack or fail during compression. The steel sleeve shall be hot dip galvanised. The aluminium sleeve shall have aluminium of purity not less than 99.5%. The dimensions and dimensional tolerances of mid span compression joint shall be as per Standard Technical Particulars.

2.3 T-Connector

T-Connector of compression type shall be used for jumper connection at transposition tower. It shall be manufactured out of 99.5% pure aluminium and shall be strong enough to withstand normal working loads. The T-connector shall have a resistivity across jumper less than 75% resistivity of equivalent length of conductor. The T-connector shall not permit slipping off, damage or failure of complete conductor. The welded portions shall be designed for 30 kN axial tensile load. Leg sleeve of T-connector should be kept at an angle of 15 deg. from vertical and horizontal plane of the conductor in order to minimise jumper pull at the welded portion. The dimensions and dimensional tolerances of T-connector shall be as per Standard Technical Particulars.

2.4 Repair Sleeve

Repair Sleeve of compression type shall be used to repair conductor with not more than two strands broken in the outer layer. The sleeve shall be manufactured from 99.5% pure aluminium and shall have a smooth surface. The repair sleeve shall comprise of two pieces with a provision of seat for sliding of the keeper piece. The edges of the seat as well as the keeper piece shall be so rounded that the conductor
strands are not damaged during installation. The dimensions and dimensional
tolerances of repair sleeve shall be as per Standard Technical Particulars.

2.5 Vibration Damper

2.5.1 Vibration dampers of 4R-stockbridge type with four (4) different resonances spread
within the specified aeolian frequency band width corresponding to wind speed of 1
m/s to 7 m/s shall be used at suspension and tension points on each conductor in
each span along with bundle spacers to damp out aeolian vibration as mentioned
herein after.

2.5.2 Alternate damping systems or “Dogbone” dampers offering equivalent or better
performance also shall be accepted provided the manufacturer meets the qualifying
requirements stipulated in the Specifications. Relevant technical documents to
establish the technical suitability of alternate systems shall be furnished by the
Bidder along with the bid.

2.5.3 One damper minimum on each side per Conductor/Sub-conductor for suspension
points and two dampers minimum on each side per conductor/sub-conductor for
tension points shall be used for ruling design span of 400 meters for 400 kV.

2.5.4 The Bidder may offer damping system involving more number of dampers per ruling
design span than the specified. However suitable price compensation shall be
considered for evaluation. For the purpose of price compensation 80% of the towers
as suspension locations and 20% of the towers as tension locations and all the
spans shall be assumed to be ruling design spans.

2.5.5 The clamp of the vibration damper shall be made of high strength aluminium alloy
of type LM-6. It shall be capable of supporting the damper and prevent damage or
chaffing of the conductor during erection or continued operation. The clamp shall
have smooth and permanent grip to keep the damper in position on the conductor
without damaging the strands or causing premature fatigue failure of the conductor
under the clamp. The clamp groove shall be in uniform contact with the conductor
over the entire clamping surface except for the rounded edges. The groove of the
clamp body and clamp cap shall be smooth, free from projections, grit or other
materials which could cause damage to the conductor when the clamp is installed.
Clamping bolts shall be provided with self locking nuts and designed to prevent
corrosion of threads or loosening in service.

2.5.6 The messenger cable shall be made of high strength galvanised steel/stainless
steel. It shall be of preformed and post formed quality in order to prevent
subsequent droop of weight and to maintain consistent flexural stiffness of the cable
in service. The messenger cable other than stainless steel shall be hot dip
galvanised in accordance with the recommendations of IS:4826 for heavily coated
wires.

2.5.7 The damper mass shall be made of hot dip galvanised mild steel/cast iron or a
permanent mould cast zinc alloy. All castings shall be free from defects such as
cracks, shrinkage, inclusions and blow holes etc. The surface of the damper masses
shall be smooth.

2.5.8 The damper clamp shall be casted over the messenger cable and offer sufficient
and permanent grip on it. The messenger cable shall not slip out of the grip at a
load less than the mass pull-off value of the damper. The damper masses made of
material other-than zinc alloy shall be fixed to the messenger cable in a suitable
manner in order to avoid excessive stress concentration on the messenger cables
which shall cause premature fatigue failure of the same. The messenger cable ends
shall be suitably and effectively sealed to prevent corrosion. The damper mass
made of zinc alloy shall be casted over the messenger cable and have sufficient and permanent grip on the messenger cable under all service conditions.

2.5.9 The damper assembly shall be so designed that it shall not introduce radio interference beyond acceptable limits.

2.5.10 The vibration damper shall be capable of being installed and removed from energised line by means of hot line technique. In addition, the clamp shall be capable of being removed and reinstalled on the conductor at the designated torque without shearing or damaging of fasteners.

2.5.11 The contractor must indicate the clamp bolt tightening torque to ensure that the slip strength of the clamp is maintained between 2.5 kN and 5 kN. The clamp when installed on the conductor shall not cause excessive stress concentration on the conductor leading to permanent deformation of the conductor strands and premature fatigue failure in operation.

2.5.12 The magnetic power loss of vibration damper shall not exceed the limit as stipulated in the Standard Technical Particulars.

2.5.13 The vibration analysis of the system, with and without damper and dynamic characteristics of the damper as detailed under Annexure-A, shall have to be submitted. The technical particulars for vibration analysis and damping design of the system are as follows:

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Description</th>
<th>Technical Particulars</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Span length in meters</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(i) Ruling design span :</td>
<td>400 meters</td>
</tr>
<tr>
<td></td>
<td>(ii) Maximum span :</td>
<td>1100 meters</td>
</tr>
<tr>
<td></td>
<td>(iii) Minimum span :</td>
<td>100 meters</td>
</tr>
<tr>
<td>2.</td>
<td>Configuration :</td>
<td>As per Section – I of this Specifications</td>
</tr>
<tr>
<td>3.</td>
<td>Tensile load in each sub-conductor At temperature of 0 deg.C and still air</td>
<td>As per sag tension calculations</td>
</tr>
<tr>
<td>4.</td>
<td>Armour rods used :</td>
<td>Standard preformed armour rods/AGS</td>
</tr>
<tr>
<td>5.</td>
<td>Maximum permissible dynamic strain :</td>
<td>+/- 150 micro strains</td>
</tr>
</tbody>
</table>

2.5.14 The damper placement chart for spans ranging from 100m to 1100m shall be submitted by the Bidder. Placement charts should be duly supported with relevant technical documents and sample calculations.

2.5.15 The damper placement charts shall include the following

(1) Location of the dampers for various combinations of spans and line tensions clearly indicating the number of dampers to be installed per conductor per span.
(2) Placement distances clearly identifying the extremities between which the distances are to be measured.

(3) Placement recommendation depending upon type of suspension clamps (viz Free center type/Armour grip type etc.)

(4) The influence of mid span compression joints, repair sleeves and armour rods (standard and AGS) in the placement of dampers.

2.6 Bundle Spacer

2.6.1 Armour grip bundle spacers shall be used to maintain the spacing of 450 mm between the two sub-conductors of each bundle under all normal working conditions.

2.6.2 Spacers offering equivalent or better performance shall also be accepted provided offer meets the qualifying requirements stipulated in the Specification.

2.6.3 The offer shall include placement charts recommending the number of spacers per phase per span and the sub span lengths to be maintained between the spacers while installing on the twin bundle conductors.

2.6.3.1 The placement of spacers shall be in such a way that adjacent sub spans are sufficiently detuned and the critical wind velocity of each sub span shall be kept more than 30 km/hr and to avoid clashing of sub conductors. The placement shall ensure bundle stability under all operating conditions.

2.6.3.2 The placement chart shall be provided for spans ranging from 100 m to 1100m. The number of spacers recommended for a ruling design span of 400m shall however be seven with no sub-span greater than 70m and no end sub-span longer than 40m.

2.6.3.3 The Bidder may offer more number of spacers per ruling design span than the specified. However, in such case, suitable price compensation shall be considered for evaluation. For the purpose of price compensation, all the spans shall be assumed to be ruling design spans.

2.6.3.4 The Bidder shall also furnish all the relevant technical documents in support of their placement charts along with the bid.

2.6.4 Jumpers at tension points shall also be fitted with spacers so as to limit the length of free conductor to 3.65 m and to maintain the sub conductor spacing of 450 mm. Bidder shall quote for rigid spacer for jumper. It shall meet all the requirements of spacer used in line except for its vibration performance. Spacers requiring retaining rods shall not be quoted for jumpers.

2.6.5 The spacer offered by the Bidder shall satisfy the following requirements.

2.6.5.1 Spacer shall restore normal spacing of the sub conductors after displacement by wind, electromagnetic and the electrostatic forces under all operating conditions including the specified short circuit level without permanent deformation damage either to conductor or to the assembly itself. They shall have uniform grip on the conductor.

2.6.5.2 For spacer requiring retaining rods, the retaining rods shall be designed for the specified conductor size. The preformed rods shall be made of high strength, special aluminium alloy of type 6061/65032 and shall have minimum tensile strength of 35 kg/sq.mm. The ends of retaining rods should be ball ended. The rods shall be heat-treated to achieve specified mechanical properties and give proper resilience and retain the same during service.
2.6.5.3 Four number of rods shall be applied on each clamps to hold the clamp in position. The minimum diameter of the rods shall be $7.87 \pm 0.1$ mm and the length of the rods shall not be less than 1100 mm.

2.6.5.4 Where elastomer surfaced clamp grooves are used, the elastomer shall be firmly fixed to the clamp. The insert should be forged from aluminium alloy of type 6061/65032. The insert shall be duly heat treated and aged to retain its consistent characteristics during service.

2.6.5.5 Any nut used shall be locked in an approved manner to prevent vibration loosening. The ends of bolts and nuts shall be properly rounded for specified corona performance or suitably shielded.

2.6.5.6 Clamp with cap shall be designed to prevent its cap from slipping out of position when being tightened.

2.6.5.7 The clamp grooves shall be in uniform contact with the conductor over the entire surface, except for rounded edges. The groove of the clamp body and clamp cap shall be smooth and free of projections, grit or other material which cause damage to the conductor when the clamp is installed.

2.6.5.8 For the spacer involving bolted clamps, the manufacturer must indicate the clamp bolt tightening torque to ensure that the slip strength of the clamp is maintained between 2.5 kN and 5 kN. The clamp when installed on the conductor shall not cause excessive stress concentration on the conductor leading to permanent deformation of the conductor strands and premature fatigue failure in operation.

2.6.5.9 Universal type bolted clamps, covering a range of conductor sizes, will not be permitted.

2.6.5.10 No rubbing, other than that of the conductor clamp hinges or clamp swing bolts, shall take place between any parts of the spacer. Joint incorporating a flexible medium shall be such that there is no relative slip between them.

2.6.5.11 The spacer shall be suitably designed to avoid distortion or damage to the conductor or to themselves during service.

2.6.5.12 Rigid spacers shall be acceptable only for jumpers.

2.6.5.13 The spacer shall not damage or chafe the conductor in any way which might affect its mechanical and fatigue strength or corona performance.

2.6.5.14 The clamping system shall be designed to compensate for any reduction in diameter of conductor due to creep.

2.6.5.15 The spacer assembly shall not have any projections, cuts, abrasions etc. or chattering parts which might cause corona or RIV.

2.6.5.16 The spacer tube shall be made of aluminium alloy of type 6061/65032. If fasteners of ferrous material are used, they shall conform to and be galvanised conforming to relevant Indian Standards. The spacer involving ferrous fasteners shall not have magnetic power loss more than one watt at 600 Amps 50 Hz alternating current per sub conductor.

2.6.5.17 Elastomer, if used, shall be resistant to the effects of temperature up to 95 deg.C, ultraviolet radiation and other atmospheric contaminants likely to be encountered in service. It shall have good fatigue characteristics. The physical properties of the elastomer shall be of approved standard.
2.6.5.18 The spacer assembly shall have electrical continuity. The electrical resistance between the sub-conductor across the assembly in case of spacer having elastomer clamp grooves shall be suitably selected by the manufacturers to ensure satisfactory electrical performance and to avoid deterioration of elastomer under all service conditions.

2.6.5.19 The spacer assembly shall have complete ease of installation and shall be capable of removal/reinstallation without any damage.

2.6.5.20 The spacer assembly shall be capable of being installed and removed from the energised line by means of hot line technique.

2.7 Material and Workmanship

2.7.1 All the equipment shall be of the latest proven design and conform to the best modern practice adopted in the extra high voltage field. The Bidder shall offer only such equipment as guaranteed by him to be satisfactory and suitable for 400kV transmission line application with bundle conductors and will give continued good performance.

2.7.2 The design, manufacturing process and quality control of all the materials shall be such as to achieve requisite factor of safety for maximum working load, highest mobility, elimination of sharp edges and corners, best resistance to corrosion and a good finish.

2.7.3 All ferrous parts shall be hot dip galvanised, after all machining has been completed. Nuts may, however, be tapped (threaded) after galvanising and the threads oiled. Spring washers shall be electro galvanised as per grade 4 of IS-1573-1970. The bolt threads shall be undercut to take care of increase in diameter due to galvanising. Galvanising shall be done in accordance with IS:2629/IS-1367 (Part-13) and satisfy the tests mentioned in IS-2633. Fasteners shall withstand four dips while spring washers shall withstand three dips. Other galvanised materials shall have a minimum overall coating of Zinc equivalent to 600 gm/sq.m and shall be guaranteed to withstand at least six dips each lasting one minute under the standard Preece test for galvanising unless otherwise specified.

2.7.4 The zinc coating shall be perfectly adherent, of uniform thickness, smooth, reasonably bright, continuous and free from imperfections such as flux, ash, rust stains, bulky white deposits and blisters. The zinc used for galvanising shall be of grade Zn.99.95 as per IS:209.

2.7.5 In case of castings, the same shall be free from all internal defects like shrinkage, inclusion, blow holes, cracks etc.

2.7.6 All current carrying parts shall be so designed and manufactured that contact resistance is reduced to minimum and localised heating phenomenon is averted.

2.7.7 No equipment shall have sharp ends or edges, abrasions or projections and shall not cause any damage to the conductor in any way during erection or during continuous operation which would produce high electrical and mechanical stresses in normal working. The design of adjacent metal parts and mating surfaces shall be such as to prevent corrosion of the contact surface and to maintain good electrical contact under all service conditions.

2.7.8 Particular care shall be taken during manufacture and subsequent handling to ensure smooth surface free from abrasion or cuts.

2.7.9 The fasteners shall conform to the requirements of IS:6639. All fasteners and clamps shall have corona free locking arrangement to guard against vibration loosening.

2.8 Compression Markings

Die compression areas shall be clearly marked on each equipment designed for continuous die compressions and shall bear the words ‘COMPRESS FIRST’ suitably inscribed on each
equipment where the compression begins. If the equipment is designed for intermittent die compressions, it shall bear the identification marks ‘COMPRESSION ZONE’ and ‘NON-COMPRESSION ZONE’ distinctly with arrow marks showing the direction of compression and knurling marks showing the end of the zones. The letters, number and other markings on finished equipment shall be distinct and legible.

2.9 **Bid Drawings**

2.9.1 The Bidder shall furnish detailed dimensioned drawings of the equipments and all component parts. Each drawing shall be identified by a drawing number and Contract number. All drawings shall be neatly arranged. All drafting and lettering shall be legible. The minimum size of lettering shall be 3 mm. All dimensions and dimensional tolerances shall be mentioned in mm.

2.9.2 The drawings shall include

(i) Dimensions and dimensional tolerances
(ii) Material fabrication details including any weld details and any specified finishes and coatings. Regarding material, designations and reference of standards are to be indicated.
(iii) Catalogue No.
(iv) Marking
(v) Weight of assembly
(vi) Installation instructions
(vii) Design installation torque for the bolt or cap screw
(viii) Withstand torque that may be applied to the bolt or cap screw without failure of component parts
(ix) The compression die number with recommended compression pressure.
(x) All other relevant technical details

2.9.3 Placement charts for spacer and damper

2.9.4 The above drawings shall be submitted with all the details as stated above along with the bid document. After the placement of award, the Contractor shall again submit the drawings in four copies to the Purchaser for approval. After Purchaser’s approval and successful completion of all type tests, 10 (ten) more sets of drawings shall be submitted to Purchaser for further distribution and field use at Purchaser’s end.

3.0 **G.S. Earth wire Accessories**

3.1 **General**

3.1.1 This portion Specify the details of the technical particulars of the accessories for Galvanised Steel Earth wire.

3.1.2 2.5% extra fasteners shall be supplied.

3.2 **Mid Span Compression Joint**

Mid Span Compression Joint shall be used for joining two lengths of earth wire. The joint shall be made of mild steel with aluminium encasing. The steel sleeve should not crack or fail during compression. The Brinnel Hardness of steel should not
3.3 Vibration Damper

3.3.1 Vibration dampers of 4R-Stockbridge type with four (4) different frequencies spread within the specified aeolian frequency band-width corresponding to wind speed of 5m/s to 7 m/s shall be used for suspension and tension points on each earth wire in each span to damp out aeolian vibrations as mentioned herein after.

3.3.2 Alternate damping systems or "Dogbone" dampers offering equivalent or better performance also shall be acceptable provided the manufacturer meets the qualifying requirements stipulated in the Specifications. Relevant technical documents to establish the technical suitability of alternate systems shall be furnished by the Bidder along with the bid.

3.3.3 One damper minimum on each side per earth wire at suspension points and two dampers on each side per earth wire at tension points shall be used for ruling design span of 400 meters for 400 kV line.

3.3.4 The Bidder may offer damping system involving more number of dampers per ruling design span than the specified. However suitable price compensation shall be considered for evaluation. For the purpose of price compensation 80% of towers as suspension locations and 20% of the towers as tension locations and all the spans assumed to be ruling design spans.

3.3.5 The clamp of the vibration damper shall be made of aluminium alloy. It shall be capable of supporting the damper during installation and prevent damage or chaffing of the earth wire during erection or continued operation. The clamp shall have smooth and permanent grip to keep the damper in position on the earth wire without damaging the strands or causing premature fatigue failure of the earth wire under the clamp. The clamp groove shall be in uniform contact with the earth wire over the entire clamping surface except for the rounded edges. The groove of the clamp body and clamp cap shall be smooth, free from projections, grit or materials which could cause damage to the earth wire when the clamp is installed. Clamping bolts shall be provided with self locking nuts designed to prevent corrosion of the threads or loosening during service.

3.3.6 The messenger cable shall be made of high strength galvanised steel/stainless steel with a minimum strength of 135 Kg/sq.mm. It shall be of preformed and post formed quality in order to prevent subsequent droop of weights and to maintain consistent flexural stiffness of the cable in service. The number of standards in the messenger cable shall be 19. The messenger cable ends shall be suitably and effectively sealed to prevent corrosion.

3.3.7 The damper mass shall be made of hot dip galvanised mild steel/cast iron or a permanent mould cast zinc alloy. All castings shall be free from defects such as cracks, shrinkages, inclusions and blow holes etc. The inside and outside surfaces of the damper masses shall be smooth.
3.3.8 The vibration analysis of the system, with and without damper, dynamic characteristic of the damper as detailed under Annexure-A, shall have to be submitted by the Bidder along with his bid. The technical particulars for vibration analysis and damping design of the system are as follows

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Description</th>
<th>Technical Particulars</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Span length in meters</td>
<td></td>
</tr>
<tr>
<td>(i)</td>
<td>Ruling design span</td>
<td>400 meters</td>
</tr>
<tr>
<td>(ii')</td>
<td>Maximum span</td>
<td>1100 meters</td>
</tr>
<tr>
<td>(iii)</td>
<td>Minimum span</td>
<td>100 meters</td>
</tr>
<tr>
<td>2.</td>
<td>Tensile load in each earth wire at temperature of 0° C and still air</td>
<td>As per sag tension calculations</td>
</tr>
<tr>
<td>3.</td>
<td>Maximum permissible dynamic strain</td>
<td>±150 micro strains</td>
</tr>
</tbody>
</table>

3.3.9 The damper placement chart for spans ranging from 100 m to 1100 m shall be submitted by the Bidder. All the placement charts should be duly supported by relevant technical documents.

3.3.10 The damper placement charts shall include the following:

1. Location of the dampers for various combinations of spans and line tensions clearly indicating number of dampers to be installed per earth wire per span.

2. Placement distances clearly identifying the extremities between which the distances are to be measured.

3. Placement recommendation depending upon type of suspension clamps (viz, free center type/trunion type etc.)

4. The influence of mid span compression joints in the placement of dampers.

3.4 Flexible Copper Bond

The flexible copper bond shall be circular in cross-section of minimum 34 sq.mm equivalent copper area and not less than 500 mm in length. It shall consist of 259 wires of 0.417 mm dia. tinned copper conductor. It shall be laid up as 7 stranded ropes, each of 37 bunched wires. The tinning shall be as per relevant Indian Standard. Two tinned copper connecting lugs shall be press jointed to either ends of the flexible copper cable. One lug shall be suitable for 12 mm, dia. bolt and the other for 16 mm dia bolt. The complete assembly shall also include one 16 mm dia., 40 mm long HRH MS Bolt hot dip galvanised with nut and lock washer.

3.5 Suspension Clamp

3.5.1 Standard anchor shackle/twisted shackle for earth wire suspension clamp shall be supplied for attaching to the hanger plate of tower.
3.5.2 At all suspension towers, suitable suspension clamps shall be used to support the required earth wire. The clamps shall be of either free center type or trunion type and shall provide adequate area of support to the earth wire. The groove of the clamp shall be smooth, finished in an uniform circular or oval shape and shall slope downwards in a smooth curve to avoid edge support and hence to reduce the intensity of bending moment on earth wire.

3.5.3 There shall be no sharp point in the clamps coming in contact with earth wire. There shall not be any displacement in the configuration of the earth wire strands nor shall the strands be unduly stressed in final assembly during working conditions.

3.5.4 The clamping piece and the clamp body shall be clamped by at least two U-bolts of size not less than 10 mm diameter having one nut and one 3 mm thick lock nut with washer on each of its limbs. Suspension clamps shall be provided with inverted type U-bolts. One limb of the U-bolt shall be long enough to accommodate the lug of the flexible copper bond.

3.5.5 The Contractor shall supply all the components of the suspension assembly including shackles, bolts, nuts, washers, split pin etc. The total drop of the suspension assembly from the center point of the attachment to the center point of the earth wire shall not exceed 150 mm. The design of the assembly shall be such that the direction of run of the earth wire shall be same as that of the conductor.

3.5.6 The complete assembly shall be guaranteed for slip strength of not less than 12 kN and not more than 17 kN. The breaking strength of the assembly shall not be less than 25 kN.

3.6 Tension Clamp

3.6.1 At all tension towers suitable compression type tension clamps shall be used to hold the required galvanised steel earth wire. Anchor shackle shall be supplied which shall be suitable for attaching the tension clamp to strain plates.

3.6.2 The clamps shall have adequate area of bearing surface to ensure positive electrical and mechanical contact and shall not permit any slip to the earth wire under working tension and vibration conditions. The angle of jumper terminal to be mounted should be 30 deg. with respect to the vertical line.

3.6.3 The clamps shall be made of mild steel with aluminium encasing. The steel should not crack or fail during compression. The Brinnel hardness of steel sleeve shall not exceed 200. The steel sleeve shall be hot dip galvanised. The aluminium encasing shall have aluminium of purity not less than 99.5%. Filler aluminium sleeve shall also be provided at the end.

3.6.4 The complete assembly shall be so designed as to avoid undue bending in any part of the clamp and shall not produce any hindrance to the movements of the clamps in horizontal or vertical directions.

3.6.5 The slip strength of the assembly shall not be less than 95% of the ultimate strength of the earth wire.

3.6.6 The clamps shall be complete with all the components including anchor shackle, bolts, nuts, washers, split pin, jumper arrangement etc.

3.7 Flexible Copper Bond

The flexible copper bond shall be circular in cross-section of minimum 34 sq.mm equivalent copper area not less than 500mm length. It shall consist of 259 wires of 0.417mm dia. Tinned copper conductor. It shall be laid up as 7 stranded ropes, each
of 37 bunched wires. The tinning shall be as per relevant Indian standard. Two tinned copper connecting lugs shall be press jointed to either ends of the flexible copper cable. One lug shall be suitable for 12mm dia. bolt and the other for 16mm dia. Bolt. The complete assembly shall also include one 16mm dia. 40mm long HRM MS bolt, hot dip galvanized with nut and lock washer.

3.8 Material and Workmanship
Same as Clause 2.7 of this section

3.9 Compression Marking
Same as Clause 2.8 of this section

3.10 Bid Drawings
Same as Clause 2.9 of this section

4.0 Standard Technical particulars
4.1 The Standard technical particulars to adhered by the contractor / manufacturer are furnished below:
Standardised Technical Particulars of Hardware Fittings and Accessories for Twin ACSR Moose Conductor

1. Suspension hardware fittings for twin ACSR MOOSE Conductor

<table>
<thead>
<tr>
<th>Sl.</th>
<th>Description</th>
<th>Unit</th>
<th>Single “I” Suspension Fittings with AGS clamp</th>
<th>Double “V” Suspension Fittings with AGS clamp</th>
<th>Single suspension Pilot Fitting with Free Centre clamp</th>
<th>Envelope clamp</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>AGS clamp</td>
<td>Free Centre clamp</td>
<td>AGS clamp</td>
<td>Free Centre clamp</td>
</tr>
<tr>
<td>1.</td>
<td>Maximum magnetic power loss of one suspension assembly at sub-conductor current of 600 amperes</td>
<td>Watt</td>
<td>4</td>
<td>4</td>
<td>8</td>
<td>NA</td>
</tr>
<tr>
<td>2.</td>
<td>Slipping strength of suspension assembly</td>
<td>KN</td>
<td>20-29</td>
<td>20-29</td>
<td>20-29</td>
<td>20-29</td>
</tr>
<tr>
<td>3.</td>
<td>Particulars of standard/AGS preformed armour rod set for suspension assembly</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>a) No. of rods per set</td>
<td>No.</td>
<td>12</td>
<td>12</td>
<td>12</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td>b) Direction of lay</td>
<td></td>
<td>Right hand</td>
<td>Right hand</td>
<td>Right hand</td>
<td>Right hand</td>
</tr>
<tr>
<td></td>
<td>c) Overall length after fitting on conductor</td>
<td>mm</td>
<td>2235</td>
<td>2540</td>
<td>2235</td>
<td>2540</td>
</tr>
<tr>
<td></td>
<td>d) Diameter of each rod</td>
<td>mm</td>
<td>9.27</td>
<td>9.27</td>
<td>9.27</td>
<td>9.27</td>
</tr>
<tr>
<td></td>
<td>e) Tolerance</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>i) Diameter of each rod</td>
<td>±mm</td>
<td>0.10</td>
<td>0.10</td>
<td>0.10</td>
<td>0.10</td>
</tr>
<tr>
<td></td>
<td>ii) Length of each rod</td>
<td>±mm</td>
<td>25</td>
<td>25</td>
<td>25</td>
<td>25</td>
</tr>
<tr>
<td></td>
<td>iii) Difference of length between the longest and shortest rod in a set</td>
<td>±mm</td>
<td>13</td>
<td>13</td>
<td>13</td>
<td>13</td>
</tr>
<tr>
<td></td>
<td>f) Type of Aluminium alloy used for manufacture of PA rod set</td>
<td></td>
<td>6061/65032</td>
<td>6061/65032</td>
<td>6061/65032</td>
<td>6061/65032</td>
</tr>
<tr>
<td></td>
<td>g) Minimum UTS of each rod</td>
<td>Kg/mm²</td>
<td>35</td>
<td>35</td>
<td>35</td>
<td>35</td>
</tr>
</tbody>
</table>

4. Particulars of Elastomer (For AGS Clamp only)

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th>Chioroprene/Neoprene Rubber</th>
<th>Chioroprene/Neoprene Rubber</th>
<th>Chioroprene/Neoprene Rubber</th>
<th>Chioroprene/Neoprene Rubber</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>a) Type of elastomer</td>
<td></td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td></td>
<td>b) Shore hardness of elastomer</td>
<td></td>
<td>65 to 85</td>
<td>NA</td>
<td>65 to 85</td>
<td>NA</td>
</tr>
</tbody>
</table>

SECTION – VI , Volume-II of TECHNICAL SPECIFICATION    Page 22 of 55
<table>
<thead>
<tr>
<th>Sl.</th>
<th>Description</th>
<th>Unit</th>
<th>Single Tension</th>
<th>Double Tension</th>
<th>Triple Tension</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Mechanical strength of Tension fitting(excluding dead end clamp)</td>
<td>KN</td>
<td>120</td>
<td>2x160</td>
<td>3x160</td>
</tr>
<tr>
<td>2.</td>
<td>Type of dead end assembly</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.</td>
<td>Compression pressure</td>
<td>MT</td>
<td>100</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4.</td>
<td>Maximum electrical resistance of dead end assembly as a percentage of equivalent length of Conductor</td>
<td>%</td>
<td>75</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5.</td>
<td>Slip strength of dead end assembly</td>
<td>KN</td>
<td>153.2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6.</td>
<td>Purity of Zinc used for galvanising</td>
<td>%</td>
<td>99.95</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7.</td>
<td>Min. No. of dips in standard preece test the ferrous parts can withstand</td>
<td>Nos.</td>
<td>a) Fasteners: 4 dips of 1 minute b) Spring washers: 3 dips of 1 minute c) all others: 6 dips of 1 minute</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### 3. Mid span compression Joint for ACSR MOOSE Conductor

<table>
<thead>
<tr>
<th>Sl.</th>
<th>Description</th>
<th>Unit</th>
<th>Aluminium Sleeve</th>
<th>Steel Sleeve</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Material of Joint</td>
<td></td>
<td>Aluminium of purity 99.5%</td>
<td>Mild Steel(Fe-410, IS:2062)</td>
</tr>
<tr>
<td>2.</td>
<td>Range of Hardness of the steel sleeve (Brinnel hardness)</td>
<td>BHN</td>
<td>From 100 to 200</td>
<td></td>
</tr>
<tr>
<td>3.</td>
<td>Weight of Zinc coating for steel sleeve</td>
<td>gm/m²</td>
<td>610</td>
<td></td>
</tr>
<tr>
<td>4.</td>
<td>Dimension of sleeve Before compression</td>
<td></td>
<td>Aluminium sleeve</td>
<td>Steel sleeve</td>
</tr>
<tr>
<td></td>
<td>i) Inside diameter</td>
<td>mm</td>
<td>34.00 ± 0.5</td>
<td>11.50 ± 0.2</td>
</tr>
<tr>
<td></td>
<td>ii) Outside diameter</td>
<td>mm</td>
<td>54.00 ± 1.0</td>
<td>21.00 ± 0.5</td>
</tr>
<tr>
<td></td>
<td>iii) Length</td>
<td>mm</td>
<td>735 ± 5</td>
<td>250 ± 5</td>
</tr>
<tr>
<td>5.</td>
<td>Dimensions of Sleeve after compression</td>
<td></td>
<td>Aluminium sleeve</td>
<td>Steel sleeve</td>
</tr>
</tbody>
</table>

SECTION – VI , Volume-II of TECHNICAL SPECIFICATION
### Mid span compression Joint for 7/3.66 mm GS Earthwire

<table>
<thead>
<tr>
<th>Sl.</th>
<th>Description</th>
<th>Unit</th>
<th>Particulars/ Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Material of Joint</td>
<td></td>
<td>Aluminium / Filler Sleeve</td>
</tr>
<tr>
<td></td>
<td>Range of Hardness of the steel sleeve (Brinell hardness)</td>
<td>BHN</td>
<td>Aluminium of minimum purity 99.5%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Mild Steel(Fe-410, IS:2062)</td>
</tr>
<tr>
<td>2.</td>
<td>Weight of Zinc coating</td>
<td>gm/m²</td>
<td>610</td>
</tr>
<tr>
<td>3.</td>
<td>Dimension of sleeve Before compression</td>
<td></td>
<td>Alumini / Steel Sleeve</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Steel Sleeve</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Alu filler sleeve</td>
</tr>
<tr>
<td>i)</td>
<td>Inside diameter</td>
<td>mm</td>
<td>22.00 ± 0.5</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>11.05 ± 0.2</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>11.50 ± 0.2</td>
</tr>
<tr>
<td>ii)</td>
<td>Outside diameter</td>
<td>mm</td>
<td>30.00 ± 0.5</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>21.00 ± 0.5</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>21.00 ± 0.5</td>
</tr>
<tr>
<td>iii)</td>
<td>Length</td>
<td>mm</td>
<td>400 ± 5</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>230 ± 5</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>60 ± 5</td>
</tr>
<tr>
<td>4.</td>
<td>Dimensions of Sleeve after compression</td>
<td></td>
<td>Alumini / Steel Sleeve</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Steel Sleeve</td>
</tr>
<tr>
<td>i)</td>
<td>Outside dimension(Corner to Corner)</td>
<td>mm</td>
<td>29.40 ± 0.5</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>20.20 ± 0.5</td>
</tr>
<tr>
<td>ii)</td>
<td>Outside dimension (face to face)</td>
<td>mm</td>
<td>25.00 ± 0.5</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>17.50 ± 0.5</td>
</tr>
<tr>
<td>iii)</td>
<td>Length</td>
<td>mm</td>
<td>430 (approx)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>265 (approx)</td>
</tr>
<tr>
<td>5.</td>
<td></td>
<td></td>
<td>Slip strength</td>
</tr>
<tr>
<td></td>
<td></td>
<td>KN</td>
<td>65</td>
</tr>
<tr>
<td>6.</td>
<td></td>
<td></td>
<td>Maximum resistance of the compressed unit expressed, as percentage of the resistance of equivalent length of bare Earthwire</td>
</tr>
</tbody>
</table>
### 5. Repair sleeve for ACSR MOOSE Conductor

<table>
<thead>
<tr>
<th>Sl.</th>
<th>Description</th>
<th>Unit</th>
<th>Particulars/ Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Material</td>
<td></td>
<td>Aluminium of minimum purity 99.5%</td>
</tr>
<tr>
<td>2.</td>
<td>Dimension of Aluminum sleeve Before compression</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>i) Inside diameter</td>
<td>mm</td>
<td>34.00 ± 0.5</td>
</tr>
<tr>
<td></td>
<td>ii) Outside diameter</td>
<td>mm</td>
<td>54.00 ± 1.0</td>
</tr>
<tr>
<td></td>
<td>iii) Length</td>
<td>mm</td>
<td>300.00 ± 5.0</td>
</tr>
<tr>
<td>3.</td>
<td>Dimensions of Aluminum Sleeve after compression</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>i) Outside dimension (Corner to corner)</td>
<td>mm</td>
<td>53.00 ± 0.5</td>
</tr>
<tr>
<td></td>
<td>ii) Outside dimension (face to face)</td>
<td>mm</td>
<td>46.00 ± 0.5</td>
</tr>
<tr>
<td></td>
<td>iii) Length</td>
<td>mm</td>
<td>330.00(Approx.)</td>
</tr>
<tr>
<td>4.</td>
<td>Minimum corona Extinction voltage kV (rms) under dry condition</td>
<td>kV</td>
<td>320</td>
</tr>
<tr>
<td>5.</td>
<td>Maximum Radio Interference Voltage at 1 MHz for phase to earth voltage of 305 kV (rms) under dry condition</td>
<td>Micro Volts</td>
<td>1000</td>
</tr>
</tbody>
</table>

### 6. Flexible Copper Bond for 7/3.66 mm GS Earthwire

<table>
<thead>
<tr>
<th>Sl.</th>
<th>Description</th>
<th>Unit</th>
<th>Particulars/ Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Stranding</td>
<td></td>
<td>37/7/0.417</td>
</tr>
<tr>
<td>2.</td>
<td>Cross sectional area</td>
<td>Sq.mm</td>
<td>35.4</td>
</tr>
<tr>
<td>3.</td>
<td>Minimum copper equivalent area</td>
<td>Sq.mm</td>
<td>34</td>
</tr>
<tr>
<td>4.</td>
<td>Length of copper cable</td>
<td>mm</td>
<td>500 ± 5</td>
</tr>
<tr>
<td>5.</td>
<td>Material of lugs</td>
<td></td>
<td>Tinned copper</td>
</tr>
<tr>
<td>6.</td>
<td>Bolt Size</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>i) Diameter</td>
<td>mm</td>
<td>16</td>
</tr>
<tr>
<td></td>
<td>ii) Length</td>
<td>mm</td>
<td>40</td>
</tr>
</tbody>
</table>

### 7. Vibration Damper for ACSR MOOSE conductor (for twin bundle conductor only)

<table>
<thead>
<tr>
<th>Sl.</th>
<th>Description</th>
<th>Unit</th>
<th>Particulars/ Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Type of Damper</td>
<td></td>
<td>4R-Stockbridge type</td>
</tr>
<tr>
<td>2.</td>
<td>Materials of components</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>a) Damper masses</td>
<td></td>
<td>Cast iron/mild steel/Zinc alloy</td>
</tr>
<tr>
<td></td>
<td>b) Clamp</td>
<td></td>
<td>Aluminum alloy 4600</td>
</tr>
<tr>
<td></td>
<td>c) Messenger cable</td>
<td></td>
<td>High tensile strength galvanized steel</td>
</tr>
<tr>
<td>3.</td>
<td>Number of strands in stranded messenger cable</td>
<td>Nos.</td>
<td>19</td>
</tr>
<tr>
<td>4.</td>
<td>Minimum ultimate tensile strength of stranded messenger cable</td>
<td>Kg/mm²</td>
<td>135</td>
</tr>
<tr>
<td>5.</td>
<td>Slip strength of stranded messenger cable (mass pull off)</td>
<td>KN</td>
<td>5</td>
</tr>
<tr>
<td>6.</td>
<td>Slipping strength of damper clamp</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(a) Before fatigue test</td>
<td>KN</td>
<td>2.5</td>
</tr>
<tr>
<td></td>
<td>(b) After fatigue test</td>
<td>KN</td>
<td>2</td>
</tr>
<tr>
<td>---</td>
<td>------------------------</td>
<td>-----</td>
<td>---</td>
</tr>
<tr>
<td>7.</td>
<td>Resonance frequencies range</td>
<td>Hz</td>
<td>5 to 40</td>
</tr>
<tr>
<td>8.</td>
<td>Maximum magnetic power loss per vibration damper watts for 600 amps, 50 Hz Alternating Current</td>
<td>Watts</td>
<td>1</td>
</tr>
<tr>
<td>9.</td>
<td>Minimum corona Extinction voltage kV (rms) under dry condition</td>
<td>kV</td>
<td>320</td>
</tr>
<tr>
<td>10.</td>
<td>Maximum Radio Interference Voltage (RIV) at 1 MHz for phase to earth voltage of 305 kV (rms) under dry condition</td>
<td>Micro Volts</td>
<td>1000</td>
</tr>
<tr>
<td>11.</td>
<td>Percentage variation in reactance after fatigue test in comparison with that before fatigue test</td>
<td>%</td>
<td>+/-40 (Maximum)</td>
</tr>
<tr>
<td>12.</td>
<td>Percentage variation in power dissipation after fatigue test in comparison with that before fatigue test</td>
<td>%</td>
<td>+/-40 (Maximum)</td>
</tr>
</tbody>
</table>

8. Vibration Damper for 7/3.66 mm GS Earthwire

<table>
<thead>
<tr>
<th>Sl.</th>
<th>Description</th>
<th>Unit</th>
<th>Particulars/ Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Type of Damper</td>
<td></td>
<td>4R-Stockbridge type</td>
</tr>
<tr>
<td>2.</td>
<td>Materials of components</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>a) Damper masses</td>
<td></td>
<td>Cast iron/mild steel/Zinc alloy duly hop dip galvanised</td>
</tr>
<tr>
<td></td>
<td>b) Clamp</td>
<td></td>
<td>Aluminum alloy 4600</td>
</tr>
<tr>
<td></td>
<td>c) Messenger cable</td>
<td></td>
<td>High tensile strength galvanized steel</td>
</tr>
<tr>
<td>3.</td>
<td>Number of strands in stranded messenger cable</td>
<td>Nos.</td>
<td>19</td>
</tr>
<tr>
<td>4.</td>
<td>Minimum ultimate tensile strength of stranded messenger cable</td>
<td>Kg/mm²</td>
<td>135</td>
</tr>
<tr>
<td>5.</td>
<td>Slip strength of stranded messenger cable (mass pull off)</td>
<td>kN</td>
<td>2.5</td>
</tr>
<tr>
<td>6.</td>
<td>Slipping strength of damper clamp</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(a) Before fatigue test</td>
<td>kN</td>
<td>2.5</td>
</tr>
<tr>
<td></td>
<td>(b) After fatigue test</td>
<td>kN</td>
<td>2</td>
</tr>
<tr>
<td>7.</td>
<td>Resonance frequencies range</td>
<td>Hz</td>
<td>10 to 60</td>
</tr>
<tr>
<td>8.</td>
<td>Percentage variation in reactance after fatigue test in comparison with that before fatigue test</td>
<td>%</td>
<td>+/-40 (Maximum)</td>
</tr>
<tr>
<td>9.</td>
<td>Percentage variation in power dissipation after fatigue test in comparison with that before fatigue test</td>
<td>%</td>
<td>+/-40 (Maximum)</td>
</tr>
</tbody>
</table>
### 9. Bundle spacer for line for ACSR MOOSE Conductor (for twin bundle conductor only)

<table>
<thead>
<tr>
<th>Sl.</th>
<th>Description</th>
<th>Unit</th>
<th>Particulars/ Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td><strong>Type of Bundle Spacer</strong></td>
<td>Armour grip type</td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td><strong>Materials of components</strong></td>
<td>Insert</td>
<td>Main body</td>
</tr>
<tr>
<td>(i)</td>
<td><strong>Insert</strong></td>
<td></td>
<td>Retaining rods (if any)</td>
</tr>
<tr>
<td></td>
<td><strong>Main body</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Heat treatment during manufacturing</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.</td>
<td><strong>Retaining rods (if used)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(a)</td>
<td>Number of retaining rods used for each spacer</td>
<td>no.</td>
<td>8</td>
</tr>
<tr>
<td>(b)</td>
<td>Diameter</td>
<td>mm</td>
<td>7.87 ± 0.1</td>
</tr>
<tr>
<td>(c)</td>
<td>Length</td>
<td>mm</td>
<td>1100±15</td>
</tr>
<tr>
<td>4.</td>
<td><strong>Elastomer</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(a)</td>
<td>Type</td>
<td></td>
<td>Chloroprene/Neoprene</td>
</tr>
<tr>
<td>(c)</td>
<td>Moulded on insert</td>
<td></td>
<td>Yes</td>
</tr>
<tr>
<td>(d)</td>
<td>Shore hardness</td>
<td></td>
<td>65 to 80</td>
</tr>
<tr>
<td>(e)</td>
<td>Thickness on insert</td>
<td>mm</td>
<td>5(Average)</td>
</tr>
<tr>
<td>(f)</td>
<td>Temp. range for which designed</td>
<td>°C</td>
<td>95</td>
</tr>
<tr>
<td>5.</td>
<td><strong>Minimum ultimate tensile strength of spacer</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(a)</td>
<td>Compressive load</td>
<td>kN</td>
<td>14</td>
</tr>
<tr>
<td>(b)</td>
<td>Tensile load</td>
<td>kN</td>
<td>7</td>
</tr>
<tr>
<td>6.</td>
<td><strong>Slipping strength of spacer clamp</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>a)</td>
<td>Before vibration test</td>
<td>KN</td>
<td>2.5</td>
</tr>
<tr>
<td>b)</td>
<td>After vibration test</td>
<td>KN</td>
<td>2</td>
</tr>
<tr>
<td>7.</td>
<td><strong>Minimum corona Extinction voltage kV (rms) under dry condition</strong></td>
<td>kV</td>
<td>320</td>
</tr>
<tr>
<td>8.</td>
<td><strong>Maximum Radio Interference Voltage (RIV) at 1 MHz for phase to earth voltage of 305 kV (rms) under dry condition</strong></td>
<td>Micro volts</td>
<td>1000</td>
</tr>
</tbody>
</table>

### 10. Rigid spacer for jumper for ACSR MOOSE Conductor (for Twin bundle conductor)

<table>
<thead>
<tr>
<th>Sl.</th>
<th>Description</th>
<th>Unit</th>
<th>Particulars/ Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td><strong>Type of Spacer</strong></td>
<td></td>
<td>Rigid type without retaining rods</td>
</tr>
<tr>
<td>2.</td>
<td><strong>Material of component parts</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(a)</td>
<td>Clamp</td>
<td>Aluminum alloy (4600)</td>
<td></td>
</tr>
<tr>
<td>(b)</td>
<td>Main body</td>
<td>Aluminum alloy 6063/63400</td>
<td></td>
</tr>
</tbody>
</table>
3. **Manufacturing process of component parts**

<table>
<thead>
<tr>
<th>Description</th>
<th>Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a) Clamp</td>
<td>Die-casting</td>
</tr>
<tr>
<td>(b) Main body</td>
<td>Aluminum extrusion</td>
</tr>
</tbody>
</table>

4. **Minimum ultimate tensile strength of spacer**

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a) Compressive load</td>
<td>14 kN</td>
</tr>
<tr>
<td>(b) Tensile load</td>
<td>7.0 kN</td>
</tr>
</tbody>
</table>

5. **Slipping strength of spacer clamp**

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2.5 kN</td>
</tr>
</tbody>
</table>

6. **Maximum Magnetic power loss per spacer for 600 Amps, 50 Hz Alternating Current**

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1 Watts</td>
</tr>
</tbody>
</table>

7. **Minimum corona Extinction voltage kV (rms) under dry condition**

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>320 kV</td>
</tr>
</tbody>
</table>

8. **Maximum Radio Interference Voltage (RIV) at 1 MHz for phase to earth voltage of 305 kV (rms) under dry condition**

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1000 Micro Volts</td>
</tr>
</tbody>
</table>

9. **T-connector for ACSR MOOSE Conductor**

<table>
<thead>
<tr>
<th>Sl.</th>
<th>Description</th>
<th>Unit</th>
<th>Particulars/ Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Material</td>
<td></td>
<td>Aluminium of purity 99.5%</td>
</tr>
<tr>
<td>2.</td>
<td>Dimension of Aluminum sleeve Before compression</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>i) Inside diameter</td>
<td>mm</td>
<td>34.00 ± 0.5</td>
</tr>
<tr>
<td></td>
<td>ii) Outside diameter</td>
<td>mm</td>
<td>54.00 ± 1.0</td>
</tr>
<tr>
<td></td>
<td>iii) Length</td>
<td>mm</td>
<td>400.00 ± 5.0</td>
</tr>
<tr>
<td>3.</td>
<td>Dimensions of Aluminum Sleeve after compression</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>i) Outside dimension(Corner to corner)</td>
<td>mm</td>
<td>53.00 ± 0.5</td>
</tr>
<tr>
<td></td>
<td>ii) Outside dimension ( face to face)</td>
<td>mm</td>
<td>46.00 ± 0.5</td>
</tr>
<tr>
<td>4.</td>
<td>Axial tensile strength of welded portion of T-connector</td>
<td>KN</td>
<td>30</td>
</tr>
<tr>
<td>5.</td>
<td>Maximum resistance of the compressed unit expressed, as percentage of the resistance of equivalent length of bare conductor.</td>
<td>%</td>
<td>75</td>
</tr>
<tr>
<td>6.</td>
<td>Minimum corona Extinction voltage kV (rms) under dry condition</td>
<td>kV</td>
<td>320</td>
</tr>
<tr>
<td>7.</td>
<td>Maximum Radio Interference Voltage at 1 MHz for phase to earth voltage of 305 kV (rms) under dry condition</td>
<td>Micro Volts</td>
<td>1000</td>
</tr>
</tbody>
</table>

10. **Suspension Clamp for 7/3.66 mm GS Earthwire**

<table>
<thead>
<tr>
<th>Sl.</th>
<th>Description</th>
<th>Unit</th>
<th>Particulars/ Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Material of components</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(a) Shackle</td>
<td></td>
<td>Forged Steel</td>
</tr>
<tr>
<td></td>
<td>(b) Clamp Body &amp; Keeper</td>
<td></td>
<td>Malleable cast iron / SGI</td>
</tr>
<tr>
<td></td>
<td>(c) U- Bolt</td>
<td></td>
<td>Mild Steel</td>
</tr>
<tr>
<td>2.</td>
<td>Total Drop (Maximum)</td>
<td>mm</td>
<td>150</td>
</tr>
<tr>
<td>3.</td>
<td>Breaking Strength (Minimum)</td>
<td>kN</td>
<td>25</td>
</tr>
<tr>
<td>4.</td>
<td>Slipping Strength</td>
<td>kN</td>
<td>12 to 17</td>
</tr>
</tbody>
</table>
### 13. Tension Clamp for 7/3.66 mm GS Earthwire

<table>
<thead>
<tr>
<th>Sl.</th>
<th>Description</th>
<th>Unit</th>
<th>Particulars/Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Material of components</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(i) Anchor Shackle</td>
<td></td>
<td>Forged Steel</td>
</tr>
<tr>
<td></td>
<td>(ii) Compression Clamp</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>a) Steel Sleeve</td>
<td></td>
<td>Mild Steel</td>
</tr>
<tr>
<td></td>
<td>b) Aluminium sleeve</td>
<td></td>
<td>Aluminium of purity 99.5%</td>
</tr>
<tr>
<td></td>
<td>c) Aluminium Filler sleeve</td>
<td></td>
<td>Aluminium of purity 99.5%</td>
</tr>
<tr>
<td>3.</td>
<td>Range of Hardness of the steel sleeve (Brinnel hardness)</td>
<td>BHN</td>
<td>120-200</td>
</tr>
<tr>
<td>4.</td>
<td><strong>Dimension of sleeve Before compression</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>i) Inside diameter</td>
<td>mm</td>
<td>22.00 ± 0.5</td>
</tr>
<tr>
<td></td>
<td>ii) Outside diameter</td>
<td>mm</td>
<td>30.00 ± 0.5</td>
</tr>
<tr>
<td></td>
<td>iii) Length</td>
<td>mm</td>
<td>245 ± 5</td>
</tr>
<tr>
<td>5.</td>
<td><strong>Dimensions of Sleeve after compression</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>i) Outside dimension (Corner to Corner)</td>
<td>mm</td>
<td>29.40 ± 0.5</td>
</tr>
<tr>
<td></td>
<td>ii) Outside dimension (face to face)</td>
<td>mm</td>
<td>25.00 ± 0.5</td>
</tr>
<tr>
<td>6.</td>
<td>Slip strength</td>
<td>KN</td>
<td>65</td>
</tr>
<tr>
<td>7.</td>
<td>Minimum Breaking strength of assembly (excluding clamp)</td>
<td>KN</td>
<td>70</td>
</tr>
<tr>
<td>8.</td>
<td>Compression Pressure</td>
<td>Ton</td>
<td>100</td>
</tr>
</tbody>
</table>
5.0 Tests and Standards

5.1 Type Tests

5.1.1 On the complete Insulator String with Hardware Fittings

(a) Power frequency voltage withstand test with corona control rings/grading ring and arcing horns under wet condition ) IEC:60383

(b) Switching surge voltage withstand test under wet condition ) IEC:60383

(c) Impulse voltage with-stand test under dry condition ) IEC:60383

(d) Impulse voltage flash-over test under dry condition ) IEC:60383

(e) Voltage distribution test (for disc insulators only) 

(f) Corona and RIV test under dry condition 

(g) Mechanical Strength test 

(h) Vibration test 

(i) Power Arc Test

5.1.2 On Suspension Hardware Fittings only

(a) Magnetic power loss test for suspension assembly 

(b) Clamp slip strength Vs torque test for suspension clamp Annexure-A

(c) Mechanical strength Test 

(d) OZONE Test on elastomer 

5.1.3 On Tension Hardware fittings only

(a) Electrical resistance test for dead end Assembly IS:2486-(Part-I), Clause 5.4&5.6

(b) Heating cycle test for dead end Assembly 

(c) Slip strength test for dead-end assembly
5.1.4 **Mid Span Compression Joint for Conductor and Earth wire**

(a) Chemical analysis of materials  
(b) Electrical resistance test  
(c) Heating cycle test  
(d) Slip strength test  
(e) Corona extinction voltage test (dry)  
(f) Radio interference voltage test (dry)  

Note: Tests mentioned at (c), (e) & (f) are not applicable to mid span compression joints for earth wire.

5.1.5 **T-Connector for Conductor**

(a) Chemical analysis of materials  
(b) Electrical resistance test  
(c) Heating cycle test  
(d) Axial tensile load test for welded portion  
(e) Corona extinction voltage test (dry)  
(f) Radio interference voltage test (dry)  

5.1.6 **Repair Sleeve for Conductor**

(a) Chemical analysis of materials  
(b) Corona extinction voltage test (dry)  
(c) Radio interference voltage test (dry)
5.1.7 **Flexible Copper Bond**

(a) Slip, Strength Test  
Annexure-A

5.1.8 **Vibration Damper for Conductor and Earth wire**

(a) Chemical analysis of materials
(b) Dynamic characteristics test
(c) Vibration analysis
(d) Clamp slip test
(e) Fatigue tests  
Annexure-A
(f) Magnetic power loss test
(g) Corona extinction voltage test (dry)
(h) Radio interference voltage test (dry)
(i) Damper efficiency test  
IS:9708

Note: Tests mentioned at (f), (g) & (h) are not applicable to dampers for earth wire.

5.1.9 **Spacer for Line - For Twin ACSR 'MOOSE'**

(a) Chemical analysis of materials
(b) Clamp slip test
(c) Vibration test
   (i) Vertical vibration
   (ii) Longitudinal vibration
   (iii) Sub span oscillation  
Annexure - A
(d) Magnetic power loss test (if applicable)
(e) Tension – Compression test
(f) Corona extinction voltage test (dry)
(g) Radio interference voltage test (dry)
5.1.10 **Rigid Spacer for Jumper (For Twin ACSR 'MOOSE')**

(a) Chemical analysis of materials
(b) Clamp slip test
(c) Magnetic power loss test (if applicable)
(d) Tension compression test
(e) Corona extinction voltage test (dry)
(f) Radio interference voltage test (dry)

5.1.11 **Earth wire Suspension Clamp Assembly**

(a) Chemical analysis of materials
(b) Mechanical strength test
(c) Clamp slip strength Vs Torque test for suspension assembly

5.1.12 **Earth wire Tension Clamp Assembly**

(a) Chemical analysis of materials
(b) Mechanical strength test (excluding clamp)
(c) Slip strength test on tension assembly
(d) Electrical resistance test on tension clamp

5.1.13 All the type tests given under clause no. 5.1.1 above shall be conducted on Single suspension and Double tension insulator string along with hardware fittings.

5.1.14 The tests specified under Clause No. 5.1.1 (a) to (g) shall be conducted on single suspension pilot, Double suspension and single tension Insulator string along with hardware fittings.

5.1.15 The magnetic power loss test specified under clause no. 5.1.2 (a) shall be conducted on Single suspensions, Double suspension and Single suspension pilot assembly.

5.1.16 Heating cycle test on dead end assembly, mid span compression joint for Conductor and T – connector shall not be required to be carried out if a valid test certificate is available for a similar design, i.e., test conducted earlier should have been conducted in accredited laboratory (accredited based on ISO/IEC guide 25/17025 or EN 45001 by the National Accreditation body of the country where laboratory is located).
located) or witnessed by the representative(s) of TPGL or Utility. The test reports submitted shall be for the tests conducted within the last 5 (five) years prior to the date of Bid opening.

5.1.17 In case the tests have been conducted earlier than the above stipulated period or in the event of any discrepancy in the test report (i.e., any test report not applicable due to any design / manufacturing change including substitution of components or due to non compliance with the requirement stipulated in the Technical Specification) the tests shall be conducted by the Contractor at no extra cost to the Owner.

5.1.18 Type tests specified under Clause 5.1.1 (a) to (d) shall not be required to be carried out if a valid test certificate is available for a similar design, i.e., tests conducted earlier should have been conducted in accredited laboratory (accredited based on ISO/IEC guide 25/17025 or EN 45001 by the National Accreditation body of the country where laboratory is located) or witnessed by the representative(s) of TPGL or Utility. The test reports submitted shall be for the tests conducted within the last 5 (five) years prior to the date of Bid opening.

In case the tests have been conducted earlier than the above stipulated period or in the event of any discrepancy in the test report (i.e., any test report not applicable due to any design / manufacturing change including substitution of components or due to non compliance with the requirement stipulated in the Technical Specification) the tests shall be conducted by the Contractor at no extra cost to the Owner.

5.2 Acceptance Tests

5.2.1 On Both Suspension and Tension Hardware Fittings

(a) Visual Examination ) IS:2486-(Part-I), Clause 5.8 & 5.9
(b) Verification of dimensions 
(c) Galvanising/Electroplating test 
(d) Mechanical strength test of each component (excluding corona control rings grading ring and arcing horn) 
(e) Mechanical Strength test of welded joint 
(f) Mechanical strength test for corona control rings, grading ring and arcing horn 
(g) Test on locking device for ball and socket coupling 
(h) Chemical analysis, hardness tests, grain size, inclusion rating & magnetic particle inspection for forgings/castings

5.2.2 On Suspension Hardware Fitting only
5.2.3 On Tension Hardware Fittings Only
(a) Slip strength test for dead end assembly ) IS:2486 (Part-I) Clause 5.4

5.2.4 Mid Span Compression Joint for Conductor and Earth wire
(a) Visual examination and dimensional verification ) IS:2121 -(Part-II)-Clause 6.2, 6.3 and 6.7
(b) Galvanising test ) Annexure - B
(c) Hardness test )

5.2.5 T-Connector for Conductor
(a) Visual examination and dimensional verification ) IS:2121 -(Part-II)-Clause 6.2, 6.3
(b) Axial tensile load test for welded portion ) As per Specification

5.2.6 Repair Sleeve for Conductor
(a) Visual examination and dimensional verification ) IS:2121 -(Part-II)-Clause 6.2, 6.3

5.2.7 Flexible Copper Bond
(a) Visual examination and dimensional verification ) IS:2121 -(Part-II)-Clause 6.2, 6.3
(b) Slip strength test ) Annexure - B

5.2.8 Vibration Damper for Conductor and Earthier
(a) Visual examination and dimensional verification ) IS:2121-(Part- II)-Clause 6.2, 6.3
(b) Galvanising test ) and 6.7
(i) On damper masses
(ii) On messenger cable
(c) Verification of resonance frequencies
(d) Clamp slip
(e) Clamp bolt torque test
(f) Strength of the messenger cable Annexeure - B
(g) Mass pull off test
(h) Dynamic characteristics test

5.2.9 Earth wire Suspension Clamp Assembly
(a) Visual examination and dimensional verification IS:2121-(Part-II)
(b) Galvanising test
(c) Clamp slip strength test Annexure - A
(d) Mechanical strength test on each component

5.2.10 Earth wire Tension Clamp Assembly
(a) Visual examination and dimensional verification IS:2121-(Part-II)
(b) Galvanising test
(c) Slip strength test for tension clamp
(d) Mechanical strength test on each component (excluding clamp) Annexure - A
(e) Hardness test

5.3 Routine Tests
5.3.1 For Hardware Fittings
(a) Visual examination IS:2486-(Part-I)
(b) Proof Load Test Annexure - A

5.3.2 For Conductor and Earth wire Accessories
(a) Visual examination and dimensional verification IS:2121-(Part-II) Clause 6.2 & 6.3

5.4 Tests During Manufacture
On all components as applicable
(a) Chemical analysis of Zinc used for galvanising

(b) Chemical analysis mechanical metallographic test and magnetic particle inspection for malleable castings. Annexure-A

(c) Chemical analysis, hardness tests and magnetic particle inspection for forgings

5.5 Testing Expenses

5.5.1 Testing charges for the type test specified shall be indicated separately in the prescribed schedule.

5.5.2 Bidder shall indicate charges for all type tests covered under Clause No. 5.1.2 to 5.1.12 separately. The charges for each type test shall be separately indicated.

5.5.3 Testing charges for all type tests specified under clause no. 5.1.1 shall be indicated only by insulator Supplier's as the charges for these tests shall be paid to them duly by the Owner to avoid duplication and shall not be indicated by the hardware Supplier's.

5.5.4 For type tests which involve the tests on the complete insulator string with hardware fittings, the Contractor of hardware fittings shall supply the necessary number of sets of hardware fittings at the place of testing free of cost.

5.5.5 In case of failure in any type test, the Bidder whose material has failed is either required to modify the design of the material & successfully carryout all the type tests as has been detailed out in Clause 5.1 of this specification or to repeat that particular type test at least three times successfully at his own expenses. In case of failure of the complete string in any type test, the manufacturer whose product has failed in the test shall get the test repeated at his cost. The Supplier whose material has not failed in the test shall be required to supply the requisite quantity of material (that is, insulator discs or hardware fittings as the case may be) required for repeat testing at the place of testing and the cost of supply shall be borne by the Contractor whose material has failed in testing.

5.5.6 Bidder shall indicate the laboratories in which they propose to conduct the type tests. They shall ensure that adequate facilities for conducting the tests are available in the laboratory and the tests can be completed in these laboratories within the time schedule guaranteed by them in the appropriate schedule.

5.5.7 The entire cost of testing for acceptance and routine tests and tests during manufacture specified herein shall be treated as included in the quoted Ex-works/CIF Price.

5.5.8 In case of failure in any type test, repeat type tests are required to be conducted, then, all the expenses for deputation of Inspector/Owner's representative shall be deducted from the contract price. Also if on receipt of the Contractor's notice of testing, the Owner's representative/Inspector does not find 'plant' to be ready for testing the expenses incurred by the Owner for re-deputation shall be deducted from contract price.

5.5.9 The Contractor shall intimate the Owner about carrying out of the type tests along with detailed testing programme at least 3 weeks in advance (in case of Domestic Contractor and at least 6 weeks advance in case of Foreign Contractor) of the
scheduled date of testing during which the Owner will arrange to depute his representative to be present at the time of carrying out the tests.

5.6 **Sample Batch For Type Testing**

5.6.1 The Contractor shall offer material for sample selection for type testing only after getting Quality Assurance Programme approved by the Owner. The Contractor shall offer at least three times the quantity of materials required for conducting all the type tests for sample selection. The sample for type testing will be manufactured strictly in accordance with the Quality Assurance Programme approved by the Owner.

5.6.2 Before sample selection for type testing the Contractor shall be required to conduct all the acceptance tests successfully in presence of Owner’s representative.

5.7 **Schedule of Testing and Additional Tests**

5.7.1 The Bidder has to indicate the schedule of following activities in their bids

(a) Submission of drawing for approval.

(b) Submission of Quality Assurance programme for approval.

(c) Offering of material for sample selection for type tests.

(d) Type testing.

5.7.2 The Owner reserves the right of having at his own expense any other test(s) of reasonable nature carried out at Contractor’s premises, at site, or in any other place in addition to the aforesaid type, acceptance and routine tests to satisfy himself that the material comply with the specifications.

5.7.3 The Owner also reserves the right to conduct all the tests mentioned in this specification at his own expense on the samples drawn from the site at Contractor’s premises or at any other test center. In case of evidence of non compliance, it shall be binding on the part of Contractor to prove the compliance of the items to the technical specifications by repeat tests, or correction of deficiencies, or replacement of defective items, all without any extra cost to the Owner.

5.8 **Co-ordination for testing**

The Contractors shall have to co-ordinate testing of their hardware fittings with insulators to be supplied by other Supplier to the Owner and shall have to also guarantee overall satisfactory performance of the hardware fittings with the insulators.

5.9 **Test Reports**

5.9.1 Copies of type test reports shall be furnished in at least six copies along with one original. One copy shall be returned duly certified by the Owner, only after which the commercial production of the concerned material shall start.

5.9.2 Copies of acceptance test report shall be furnished in at least six copies. One copy shall be returned, duly certified by the Owner, only after which the materials will be despatched.

5.9.3 Record of routine test report shall be maintained by the Contractor at his works for periodic inspection by the Owner’s representative.

5.9.4 Test certificates of tests during manufacture shall be maintained by the Contractor. These shall be produced for verification as and when desired by the Owner.
5.10 Inspection

5.10.1 The Owner's representative shall at all times be entitled to have access to the works and all places of manufacture, where the material and/or its component parts shall be manufactured and the representatives shall have full facilities for unrestricted inspection of the Contractor's, sub-Contractor's works raw materials, manufacturer's of all the material and for conducting necessary tests as detailed herein.

5.10.2 The material for final inspection shall be offered by the Contractor only under packed condition as detailed in clause 5.11 of this part of the Specification. The engineer shall select samples at random from the packed lot for carrying out acceptance tests.

5.10.3 The Contractor shall keep the Owner informed in advance of the time of starting and of the progress of manufacture of material in its various stages so that arrangements could be made for inspection.

5.10.4 Material shall not be despatched from its point of manufacture before it has been satisfactorily inspected and tested unless the inspection is waived off by the Owner in writing. In the latter case also the material shall be despatched only after all tests specified herein have been satisfactorily completed.

5.10.5 The acceptance of any quantity of material shall in no way relieve the Contractor of his responsibility for meeting all the requirements of the Specification, and shall not prevent subsequent rejection, if such material are later found to be defective.

5.11 Packing and Marking

5.11.1 All material shall be packed in strong and weather resistant wooden cases/crates. The gross weight of the packing shall not normally exceed 200 Kg to avoid handling problems.

5.11.2 The packing shall be of sufficient strength to withstand rough handling during transit, storage at site and subsequent handling in the field.

5.11.3 Suitable cushioning, protective padding, dunnage or spacers shall be provided to prevent damage or deformation during transit and handling.

5.11.4 Bolts, nuts, washers, cotter pins, security clips and split pins etc. shall be packed duly installed and assembled with the respective parts and suitable measures shall be used to prevent their loss.

5.11.5 Each component part shall be legibly and indelibly marked with trade mark of the manufacturer.

5.11.6 All the packing cases shall be marked legibly and correctly so as to ensure safe arrival at their destination and to avoid the possibility of goods being lost or wrongly despatched on account of faulty packing and faulty or illegible markings. Each wooden case/crate shall have all the markings stenciled on it in indelible ink.

5.12 Standards

5.12.1 The Hardware fittings; conductor and earth wire accessories shall conform to the following Indian/International Standards which shall mean latest revisions, with amendments / changes adopted and published, unless specifically stated otherwise in the Specification.

5.12.2 In the event of the supply of hardware fittings; conductor and earth wire accessories conforming to standards other than specified, the Bidder shall confirm in his bid that these standards are equivalent to those specified. In case of award, salient features
of comparison between the Standards proposed by the Contractor and those specified in this document will be provided by the Contractor to establish their equivalence.

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Indian Standard</th>
<th>Title</th>
<th>International Standards</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>IS : 209</td>
<td>Specification for Zinc</td>
<td>BS:3436-1986</td>
</tr>
<tr>
<td>2.</td>
<td>IS : 398 - Part-V</td>
<td>Aluminium Conductor Galvanised Steel-Reinforced for Extra High Voltage (400 KV) and above</td>
<td>IEC:1089-1991</td>
</tr>
<tr>
<td>3.</td>
<td>IS 1573</td>
<td>Electroplated Coating of Zinc on iron and Steel</td>
<td></td>
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<tr>
<td>4.</td>
<td>IS : 2121</td>
<td>Specification for Conductor and Earthwire Accessories for Overhead Power lines Part-I</td>
<td>Mid-span Joints and Repair Sleeves for Conductors</td>
</tr>
<tr>
<td>5.</td>
<td>IS:2486</td>
<td>Specification for Insulator Fittings for Overhead power Lines with Nominal Voltage greater than 1000 V Part-I</td>
<td>General Requirements and Tests</td>
</tr>
<tr>
<td>6.</td>
<td>IS:2629</td>
<td>Recommended Practice for Hot Dip Galvanising of Iron and Steel</td>
<td></td>
</tr>
<tr>
<td>7.</td>
<td>IS:2633</td>
<td>Method of Testing Uniformity of Coating on Zinc Coated Articles</td>
<td></td>
</tr>
<tr>
<td>8.</td>
<td></td>
<td>Ozone test on Elastomer</td>
<td>ASTM-D1171</td>
</tr>
<tr>
<td>9.</td>
<td></td>
<td>Tests on insulators of Ceramic material or glass for overhead lines with a nominal voltage greater than 1000V</td>
<td>IEC:383-1993</td>
</tr>
<tr>
<td>10.</td>
<td>IS:4826</td>
<td>Galvanised Coating on Round Steel Wires</td>
<td>ASTMA472-729</td>
</tr>
<tr>
<td>11.</td>
<td>IS:6745</td>
<td>Methods of Deter</td>
<td>BS:433-1969</td>
</tr>
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<td>Reference</td>
<td>Name and Address</td>
<td></td>
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<td></td>
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</tr>
<tr>
<td>BS</td>
<td>British Standards, British Standards Institution 101 Pentonvile Road. N 19-ND UK</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BIS/IS</td>
<td>Bureau Of Indian Standards, Manak Bhavan, 9, Bahadur Shah Zafar Marg, New Delhi - 110001. INDIA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ISO</td>
<td>International Organisation for Standardization. Danish Board of Standardization Danish Standardising Sraat. Aurehoegvej-12 DK-2900. Heeleprup. DENMARK.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>NEMA</td>
<td>National Electric Manufacture</td>
<td></td>
<td></td>
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</table>
1.0 Tests on Complete Strings with Hardware Fittings

1.1 Voltage Distribution Test (For Insulator String with Disc Insulators)

The voltage across each insulator unit shall be measured by sphere gap method. The result obtained shall be converted into percentage. The voltage across any disc shall not exceed 9% for suspension insulator strings and 10% for tension insulator strings for 400 kV insulator strings.

1.2 Corona Extinction Voltage Test (Dry)

The sample assembly when subjected to power frequency voltage shall have a corona Extinction voltage of not less than 320 kV (rms) line to ground under dry condition. There shall be no evidence of corona on any part of the sample. The atmospheric condition during testing shall be recorded and the test results shall be accordingly corrected with suitable correction factor as stipulated in IEC:60383.

1.3 RIV Test (Dry)

Under the conditions as specified under (1.2) above, the insulator string along with complete hardware fittings shall have a radio interference voltage level below 1000 micro volts at one MHz when subjected to 50 Hz AC voltage of 305 kV line to ground under dry condition. The test procedure shall be in accordance with IS:8263/IEC:437.

1.4 Mechanical Strength Test

The complete insulator string along with its hardware fitting excluding arcing horn, corona control ring, grading ring and suspension assembly/dead end assembly shall be subjected to a load equal to 50% of the specified minimum ultimate tensile strength (UTS) which shall be increased at a steady rate to 67% of the minimum UTS specified. The load shall be held for five minutes and then removed. After removal of the load, the string components shall not show any visual deformation and it shall be possible to disassemble them by hand. Hand tools may be used to remove cotter pins and loosen the nuts initially. The string shall then be reassembled and loaded to 50% of UTS and the load shall be further increased at a steady rate till the specified minimum UTS and held for one minute. No fracture should occur during this period. The applied load shall then be increased until the failing load is reached and the value recorded.

1.5 Vibration Test

The suspension string shall be tested in suspension mode, and tension string in tension mode itself in laboratory span of minimum 30 meters. In the case of suspension string a load equal to 600 kg shall be applied along the axis of the suspension string by means of turn buckle. The insulator string along with hardware fittings and two sub conductors each tensioned at 43 KN shall be secured with clamps. The system shall be suitable to maintain constant tension on each sub-conductors throughout the duration of the test. Vibration dampers shall not be used on the test span. Both the sub-conductors shall be vertically vibrated simultaneously at one of the resonance frequencies of the insulators string (more than 10 Hz) by means of vibration inducing equipment. The peak to peak displacement in mm of vibration at the antinode point nearest to the string shall be measured and the same shall not be less than 1000/$f^{1.8}$ where $f$ is the frequency of vibration in cycles/sec. The insulator string shall be vibrated for not less than 10 million cycles without any failure. After the test the disc insulators shall be examined for looseness of pins and cap or any crack in the cement. The hardware shall be examined for looseness,
fatigue failure and mechanical strength test. There shall be no deterioration of properties of hardware components and disc insulators after the vibration test. The disc insulators shall be subjected to the following, tests as per relevant standards:

<table>
<thead>
<tr>
<th>Test</th>
<th>Percentage of insulator units to be tested</th>
</tr>
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<tbody>
<tr>
<td>(a) Temperature cycle test followed by</td>
<td>60</td>
</tr>
<tr>
<td>mechanical performance test</td>
<td></td>
</tr>
<tr>
<td>(b) Puncture test/steep wave front test</td>
<td>40</td>
</tr>
</tbody>
</table>

### 1.6 Power Arc test

This test shall be performed on the complete string in accordance with IEC Technical Report IEC : 61467-1997 with the following test series:

<table>
<thead>
<tr>
<th>Test circuit</th>
<th>Short circuit current duration of test</th>
<th>Number and duration test</th>
</tr>
</thead>
<tbody>
<tr>
<td>B</td>
<td>I_n = I_{sys} = 40 KA</td>
<td>Two of t_n = 0.2s and</td>
</tr>
<tr>
<td></td>
<td></td>
<td>one of t_n = 0.5s</td>
</tr>
</tbody>
</table>

The acceptance criteria after the completion of test series shall be following.

1. Insulator separation not permitted.
2. Burning/melting of metal components, breaking of insulator sheds, glaze removal are permitted.
3. The complete insulator string along with its hardware fittings including arcing horn, corona control ring/grading ring shall withstand 80% of UTS.

### 1.7 Assembly Test

This test shall be carried out to ensure that the cotter pins, bolts, clamps etc., fit freely and properly.

### 2.0 Tests on Hardware Fittings

#### 2.1 Magnetic Power Loss Test for Suspension Assembly

Two hollow aluminium tubes of 32 mm diameter shall be placed 450 mm apart. An alternating current over the range of 400 to 800 Amps for Twin "MOOSE" Conductor, shall be passed through each tube. The reading of the wattmeter with and without two suspension assemblies along with line side yoke plate, clevis eye shall be recorded. Not less than three suspension assemblies shall be tested. The average power loss for suspension assembly shall be plotted for each value of current. The value of the loss corresponding to 600 amperes for 400 kV line, shall be read off from the graph.

#### 2.2 Galvanising/Electroplating Test

The test shall be carried out as per Clause no. 5.9 of IS:2486-(Part-1) - 1972 except that both uniformity of zinc coating and standard preecce test shall be carried out and the results obtained shall satisfy the requirements of this specification.
2.3 **Mechanical Strength Test of Each Component**

Each component shall be subjected to a load equal to the specified minimum ultimate tensile strength (UTS) which shall be increased at a steady rate to 67% of the minimum UTS specified. The load shall be held for five minutes and then removed. The component shall then again be loaded to 50% of UTS and the load shall be further increased at a steady rate till the specified UTS and held for one minute. No fracture should occur. The applied load shall then be increased until the failing load is reached and the value recorded.

2.4 **Mechanical Strength Test of Welded Joint**

The welded portion of the component shall be subjected to a Load of 2000 kgs for one minute. Thereafter, it shall be subjected to die-penetration/ultrasonic test. There shall not be any crack at the welded portion.

2.5 **Clamp Slip Strength Vs Torque Test for Suspension Clamp**

The suspension assembly shall be vertically suspended by means of a flexible attachment. A suitable length of ACSR conductor shall be fixed in the clamp. The clamp slip strength at various tightening torques (for Pilot strings) shall be obtained by gradually applying the load at one end of the conductor. The Clamp slip strength vs. torque curve shall be drawn. The above procedure is applicable only for free center type suspension clamp. For AG suspension clamp only clamp slip strength after assembly shall be found out.

2.6 **Shore Hardness Test for Elastomer Cushion for AG Suspension Assembly**

The shore hardness at various points on the surface of the elastomer cushion shall be measured by a shore hardness meter and the shore hardness number shall be between 65 to 80.

2.7 **Proof Load Test**

Each component shall be subjected to a load equal to 50% of the specified minimum ultimate tensile strength which shall be increased at a steady rate to 67% of the UTS specified. The load shall be held for one minute and then removed. After removal of the load the component shall not show any visual deformation.

2.8 **Tests for Forging Casting and Fabricated Hardware**

The chemical analysis, hardness test, grain size, inclusion rating and magnetic particle inspection for forging, castings and chemical analysis and proof load test for fabricated hardware shall be as per the internationally recognised procedures for these tests. The sampling will be based on heat number and heat treatment batch. The details regarding test will be as in the Quality Assurance programme.

2.9 **Mechanical Strength Test for Suspension/Tension Hardware Fittings**

2.9.1 **Suspension/Tension Hardware Fittings**

The complete string without insulators excluding arcing horn, corona control rings/grading ring and suspension assembly/dead end assembly shall be subjected to a load equal to 50% of the specified minimum ultimate tensile strength (UTS) which shall be increased at a steady rate to 67% of the minimum UTS specified. This load shall be held for five minutes and then removed. After removal of the load, the string component shall not show any visual deformation and it shall be possible to disassemble them by hand. Hand tools may be used to remove cotter pins and loosen the nuts initially. The string shall then be reassembled and loaded to 50% of UTS and the load shall be further increased at a steady rate till the specified minimum UTS is reached and held for the one minute. No fracture should occur.
during this period. The applied load shall then be increased until the failing load is reached and the value recorded.

2.10 **Ozone Test for Elastomer**

This test shall be performed in accordance with ASTM D-1171 by the Ozone chamber exposure method (method B). The test duration shall be 500 hours and the ozone concentration 50 PPHM. At the test completion, there shall be no visible crack under a 2 x magnification.

3.0 **Tests on Conductor and Earth wire Accessories**

3.1 **Mid Span Compression Joint for Conductor and Earth wire**

(a) **Slip Strength Test**

The fitting compressed on conductor/earth wire shall not be less than one meter in length. The test shall be carried out as per IS:2121 (Part-II) clause 6.4 except that the load shall be steadily increased to 95% of minimum ultimate tensile strength of conductor/earth wire and retained for one minute at this load. There shall be no movement of the conductor/earth wire relative to the fittings and no failure of the fittings during this one minute period.

3.2 **T-Connector for Conductor**

Axial Tensile Load Test for Welded Portion

The sleeve portion of the T-Connector shall be compressed on conductor. The compressed portion shall be held rigidly on some fixtures and axial load shall be applied along with the jumper terminal. The load shall be increased gradually till breaking of welded joint occurs. The breaking load should be above 30 kN.

3.3 **Flexible Copper Bond**

Slip Strength Test

On applying a load of 3 kN between the two ends, stranded flexible copper cable shall not come out of the connecting lugs and none of its strands shall be damaged. After the test, the lugs shall be cut open to ascertain that the gripping of cable has not been affected.

3.4 **Vibration Damper for Conductor and Earth wire**

(a) **Dynamic Characteristics, Test**

The damper shall be mounted with its clamp tightened with torque recommended by the manufacturer on shaker table capable of simulating sinusoidal vibrations for aeolian vibration frequency band ranging from 5 to 40 Hz for damper for 'MOOSE' conductor and 10 to 60 Hz for damper for earth wire. The damper assembly shall be vibrated vertically with a ± 1 mm amplitude from 5 to 15 Hz frequency and beyond 15 Hz at ± 0.5mm to determine following characteristics with the help of suitable recording instruments:

(i) Force Vs frequency

(ii) Phase angle Vs frequency

(iii) Power dissipation Vs frequency
The Force Vs frequency curve shall not show steep peaks at resonance frequencies and deep troughs between the resonance frequencies. The resonance frequencies shall be suitably spread within the aeolian vibration frequency-band between the lower and upper dangerous frequency, limits determined by the vibration analysis of conductor/earth wire without dampers.

Acceptance criteria for vibration damper.

(i) The above dynamic characteristics test on five damper shall be conducted.

(ii) The mean reactance and phase angle Vs frequency curves shall be drawn with the criteria of best fit method.

(iii) The above mean reactance response curve should lie within following limits:

V.D. for "MOOSE" - 0.191 f to 0.762 f kgf/mm
V.D. for "7/3.66" Earth wire - 0.060 f to 0.357 f kgf/mm

Where f is frequency in Hz.

(iv) The above mean phase angle response curve shall be between 25° to 130° within the frequency range of interest.

(v) If the above curve lies within the envelope, the damper design shall be considered to have successfully met the requirement.

(vi) Visual resonance frequencies of each mass of damper is to be recorded and to be compared with the guaranteed values.

(b) Vibration Analysis

The vibration analysis of the conductor/earthwire shall be done with and without damper installed on the span. The vibration analysis shall be done on a digital computer using energy balance approach. The following parameters shall be taken into account for the purpose of analysis:

(i) The analysis shall be borne for single conductor/earthwire without armour rods as per the parameters given under clause 2.5.13 and 3.3.8 of this part of the Specification. The tension shall be taken as 43 kN for ACSR ‘MOOSE’ conductor and 14 kN for 7/3.66 mm earth wire respectively for a span ranging from 100 m to 1100 m.

(ii) The self damping factor and flexural stiffness (EI) for conductor and earthwire shall be calculated on the basis of experimental results. The details of experimental analysis with these data should be furnished.

(iii) The power dissipation curve obtained from Dynamic Characteristics Test shall be used for analysis with damper.

(iv) Examine the aeolian vibration level of the conductor/earthwire with and without vibration damper installed at the recommended location or wind velocity ranging from 0 to 30 Km per hour, predicting amplitude, frequency and vibration energy input.

(v) From vibration analysis of conductor/earthwire without damper, antinode vibration amplitude and dynamic strain levels at
clamped span extremities as well as antinodes shall be examined and thus lower and upper dangerous frequency limits between which the aeolian vibration levels exceed the specified limits shall be determined.

(vi) From vibration analysis of conductor/earthwire with damper/dampers installed at the recommended location, the dynamic strain level, at the clamped span extremities, damper attachment point and the antinodes on the conductor/earthwire shall be determined. In addition to above damper clamp vibration amplitude and antinode vibration amplitudes shall also be examined.

The dynamic strain levels at damper attachment points, clamped span extremities and antinodes shall not exceed the specified limits. The damper vibration amplitude shall not be more than that of the specified fatigue limits.

c) Clamp Slip and Fatigue Tests

(i) Test Set Up

The clamp slip and fatigue tests shall be conducted on a laboratory set up with a minimum effective span length of 30 m. The ACSR 'MOOSE' conductor shall be tensioned at 43 KN and 7/3.66 mm earth wire at 14 kN and shall not be equipped with protective armour rods at any point. Constant tension shall be maintained within the span by means of lever arm arrangement. After the conductor/earthwire has been tensioned, clamps shall be installed to support the conductor/earthwire at both ends and thus influence of connecting hardware fittings are eliminated from the free span. The clamps shall not be used for holding the tension on the conductor/earthwire. There shall be no loose parts, such as suspension clamps, U bolts on the test span supported between clamps mentioned above. The span shall be equipped with vibration inducing equipment suitable for producing steady standing vibration. The inducing equipment shall have facilities for stepless speed control as well as stepless amplitude arrangement. Equipment shall be available for measuring the frequency, cumulative number of cycles and amplitude of vibration at any point along the span.

(ii) Clamp Slip test

The vibration damper shall be installed on the test span. The damper clamp, after lightning with the manufacturer's specified tightening torque, when subjected to a longitudinal pull of 2.5 kN parallel to the axis of conductor/earthwire for a minimum duration of one minute shall not slip i.e. the permanent displacement between conductor/earthwire and clamp measured after removal of the load shall not exceed 1.0 mm. The load shall be further increased till the clamp starts slipping. The load at which the clamp slips shall not be more than 5 kN.

(iii) Fatigue Test

The vibration damper shall be installed on the test span with the manufacturer’s specified tightening torque. It shall be ensured that
the damper shall be kept minimum three loops away from the shaker to eliminate stray signals influencing damper movement.

The damper shall then be vibrated at the highest resonant frequency of each damper mass. For dampers involving torsional resonant frequencies, tests shall be done at torsional modes also in addition to the highest resonant frequencies at vertical modes. The resonance frequency shall be identified as the frequency at which each damper mass vibrates with the maximum amplitude on itself. The amplitude of vibration of the damper clamp shall be maintained not less than ± 25/f mm, where f is the frequency in Hz.

The test shall be conducted for minimum ten million cycles at each resonant frequency mentioned above. During the test if resonance shift is observed the test frequency shall be tuned to the new resonant frequency.

The clamp slip test as mentioned hereinabove shall be repeated after fatigue test without retorquing or adjusting the damper clamp, and the clamp shall withstand a minimum load equal to 80% of the slip strength for a minimum duration of one minute.

After the above tests, the damper shall be removed from conductor / earthwire and subjected to dynamic characteristics test. There shall not be any major deterioration in the characteristic of the damper. The damper then shall be cut open and inspected. There shall not be any broken, loose, or damaged part. There shall not be significant deterioration or wear of the damper. The conductor/earthwire under clamp shall also be free from any damage.

For the purpose of acceptance, the following criteria shall be applied.

(1) There shall not be any frequency shift by more than ±2 Hz for frequencies lower than 15 Hz and ± 3 Hz for frequencies higher than 15 Hz.

(2) The force response curve shall generally lie within guaranteed % variation in reactance after fatigue test in comparison with that before fatigue test by the Contractor.

(3) The power dissipation of the damper shall not be less than guaranteed % variation in power dissipation before fatigue test by the Contractor. However, it shall not be less than minimum power dissipation which shall be governed by lower limits of reactance and phase angle indicated in the envelope.

3.5 Spacer (for twin bundle)

(a) Vibration Tests

The test set up shall be as per Clause No.3.4(c) (i) of Annexure - A. The spacer assembly shall be clamped to conductor. During the vibration tests the axis of the clamp of sample shall be maintained parallel to its initial static position by applying a tension of 43 kN on the ACSR ‘MOOSE’ conductor. The spacer assembly shall be free to vibrate and shall not be retorqued or adjusted between the tests.
All the vibration tests mentioned hereunder shall be conducted on the same sample on the same test span. The samples shall withstand the vibration tests without slipping on the conductor, loosening, damage or failure of component parts. After each vibration test, clamp slip test shall be carried out as per the procedure given in Clause No3.5 (b) below

(i) Longitudinal Vibration Test

The stationary conductor and the vibrating conductor/equivalent diameter of aluminium alloy tube shall be restrained by fixed clamps. The displacement of the vibrating conductor shall be 25mm minimum on either side. The longitudinal movement shall be parallel to the conductor at frequency not less than 2 Hz for minimum one million cycles.

(ii) Vertical Vibration Test

The spacer/spacer damper shall be installed in the middle of the test span and the frequency chosen so as to get an odd number of loops. The shaker shall be positioned at least two loops away from the test specimen to allow free movement of the conductor close to the test specimen. One conductor shall be connected to the shaker and vibrated to an amplitude such that.

\[
f^{1.8} Y_{\text{max}} > 1000 \text{ mm/sec.}
\]

Where \( Y_{\text{max}} \) being the antinode displacement (mm) and \( f \) is the test frequency (Hz). The test frequency shall be greater than 24 Hz and the total number of cycles shall be more than 10 millions.

(iii) Sub-span Oscillation Test

The test shall be conducted for oscillation in horizontal plane at frequency higher than 3 Hz for minimum one million cycles. The amplitude for oscillation shall be kept equivalent to an amplitude of 150 mm for a full sub-span of 80m. Both the conductor shall be vibrated 180 deg. out of phase with the above minimum amplitude.

(b) Clamp Slip Test

The spacer assembly shall be installed on test span of twin ACSR ‘MOOSE’ conductor bundle string at a tension of 43 kN. In case of spacer for jumper, the clamp of sample shall be tightened with a specified tightening torque. One of the clamp of the sample when subjected to a longitudinal pull of 2.5 kN parallel to the axis of conductor for a minimum duration of one minute shall not slip on the conductor i.e. the permanent displacement between the conductor and the clamp of sample measured after removal of the load, shall not exceed 1.0 mm. Similar test shall be performed on the other clamp of the same sample. Such clamp slip tests shall also be conducted after each of the vibration test mentioned in clause 3.5(a). Each clamp shall withstand a minimum longitudinal load of 2 kN for a minimum duration of one minute after the vibration test without any adjustment of sample.

3.6 Magnetic Power Loss Test for Damper/Spacer

The sample involving ferrous parts shall be tested in a manner to simulate service conditions for 50 Hz pure sine-wave. The test should be carried out at various currents ranging from 300 amperes to 900 amperes for ACSR “MOOSE” Conductor and the magnetic power loss at various currents should be specified in tabulated
The difference between the power losses without and with sample at room temperature shall be limited to 1 watt for 600 amperes current (rms) for 'MOOSE' conductor. The losses shall be determined by averaging the observations obtained from at least four samples.

3.7 Mechanical Strength Test for Earthwire Suspension/Tension Clamp

(a) The suspension assembly/tension assembly (excluding tension clamp) shall be subjected to a load equal to 50% of the specified minimum ultimate tensile strength (UTS) which shall be increased at a steady rate to 67% of the minimum UTS specified. This load shall be held for five minutes and then removed. After removal of the load, the components shall not show any visual deformation and it shall be possible to disassemble them by hand. Hand tools may be used to loosen the nuts initially. The assembly shall then be reassembled and loaded to 50% of UTS and the load shall be further increased at a steady rate till the specified minimum UTS is reached and held for one minute. No fracture should occur during this period. The applied load shall then be increased until the failing load is reached and the value recorded.

(b) Clamp Slip Strength Vs Torque Test for Suspension Assembly

The suspension assembly shall be vertically suspended by means of a flexible attachment. A suitable length of Earthwire shall be fixed in the clamps. The clamp slip strength at various tightening torques shall be obtained by gradually applying the load at one end of the earthwire. The clamp slip strength Vs torque curve shall be drawn. The clamp slip strength at the recommended tightening torque shall be more than 12 kN but less than 17 kN for 7/3.66 mm earthwire.

(c) Slip Strength Test of Tension Clamp

Tension clamps shall be compressed on a 5 m length of earthwire on both ends. The assembly shall be mounted on a tensile testing machine and anchored in a manner similar to the arrangement to be used in service. A tensile load of 50% of the specified breaking load of the earthwire shall be applied & the sample shall be marked in such a way that movement relative to the fitting can easily be detected. Without any subsequent adjustment of the fitting, the load shall be steadily increased to 95% of the specified breaking load and maintained for one minute. There shall be no movement of the earthwire relative to the fitting during this one minute period and no failure of the fitting also.

(d) Electrical Resistance Test of Tension Clamp

The tension clamp and the jumper shall be compressed on two suitable lengths of earthwire. The electrical resistance shall be measured between points on earthwire near the clamp and near the jumper mouth keeping 25 mm clearance of the fitting and should not exceed 75% of the measured resistance of equivalent length of earthwire. The test shall be conducted with direct current. The current connections shall be at a distance not less than 50 times the diameter of earthwire from the fitting and shall be made so that effective contact is ensured with all those strands of the earth wire which would be taken into account in calculating its equivalent resistance. The test shall be repeated with the polarity reversed and the average of the two results considered as the measured value.

3.8 Corona Extinction Voltage Test (Dry)
The sample when subjected to power frequency voltage shall have a corona extinction voltage of not less 320 kV rms line to ground under dry condition for 400 kV line. There shall be no evidence of corona on any part of the sample. The atmospheric condition during testing shall be recorded and the test results shall be accordingly corrected with suitable correction factor as stipulated in IS:731.

### 3.9 Radio Interference Voltage Test (Dry)

Under the conditions as specified under (3.8) above, the sample shall have a radio interference voltage level below 1000 micro volts at one MHz when subjected to 50 Hz AC voltage of 305 kV rms line to ground under dry condition for 400 kV line. The test procedure shall be in accordance with IS:8263.

### 3.11 Chemical Analysis Test

Chemical analysis of the material used for manufacture of items shall be conducted to check the conformity of the same with Technical Specification and approved drawing.

### 4.0 Tests on All components (As applicable)

#### 4.1 Chemical Analysis of Zinc used for Galvanizing

Samples taken from the zinc ingot shall be chemically analysed as per IS-209-1979. The purity of zinc shall not be less than 99.95%.

#### 4.2 Tests for Forgings

The chemical analysis hardness tests and magnetic particle inspection for forgings, will be as per the internationally recognised procedures for these tests. The sampling will be based on heat number and heat treatment batch. The details regarding test will be as discussed and mutually agreed to by the Contractor and Purchaser in Quality Assurance Programme.

#### 4.3 Tests on Castings

The chemical analysis, mechanical and metallographic tests and magnetic particle inspection for castings will be as per the internationally recognised procedures for these tests. The samplings will be based on heat number and heat treatment batch. The details regarding test will be as discussed and mutually agreed to by the Contractor and Purchaser in Quality Assurance Programme.
Acceptance Tests

1. Mid Span Compression Joint for Conductor and Earthwire
   (a) Hardness Test
   The Brinnel hardness at various points on the steel sleeve of conductor core and of the earthwire compression joint and tension clamp shall be measured.

2. T-Connector for Conductor
   (a) Axial Tensile Load Test for Welded Portion
   Same as clause 3.2 of Annexure - A.

3. Flexible Copper Bond
   (a) Slip Strength Test
   Same as clause 3.3 of Annexure - A.

4. Vibration Damper for Conductor and Earthwire
   (a) Verification of Resonance Frequencies
   The damper shall be mounted on a shaker table and vibrate at damper clamp displacement of +/-0.5 mm to determine the resonance frequencies. The resonance shall be visually identified as the frequency at which damper mass vibrates with maximum displacement on itself. The resonance frequency thus identified shall be compared with the guaranteed value. A tolerance of ± 1 Hz at a frequency lower than 15 Hz and ± 2 Hz at a frequency higher than 15 Hz only shall be allowed.
   (b) Clamp Slip Test
   Same as Clause 3.5 (b) of Annexure - A.
   (c) Clamp Bolt Torque Test
   The clamp shall be attached to a section of the conductor/earthwire. A torque of 150 percent of the manufacturer's specified torque shall be applied to the bolt. There shall be no failure of component parts. The test set up is as described in Clause 3.4 (c) (i), Annexure-A.
   (d) Strength of the Messenger Cable
   The messenger cable shall be fixed in a suitable tensile testing machine and the tensile load shall be gradually applied until yield point is reached. Alternatively, each strand of message caste may be fixed in a suitable tensile testing machine and the tensile load shall be gradually applied until yield point is reached. In such a case, the 95% of yield strength of each wire shall be added to get the total strength of the caste. The load shall be not less than the value guaranteed by the Contractor.
   (e) Mass Pull off Test
Each mass shall be pulled off in turn by fixing the mass in one jaw and the clamp in the other of a suitable tensile testing machine. The longitudinal pull shall be applied gradually until the mass begins to pull out of the messenger cable. The pull off loads shall not be less than the value guaranteed by the Contractor.

(f) Dynamic Characteristics Test

The test will be performed as acceptance test with the procedure mentioned for type test with sampling mentioned below:

<table>
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<tr>
<th>Vibration Damper of-Conductor</th>
<th>1 Sample for 1000 Nos. &amp; below</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>3 Samples for lot above 1000 &amp; up to 5000 nos.</td>
</tr>
<tr>
<td></td>
<td>Additional 1 sample for every additional 1500 pieces above 5000.</td>
</tr>
</tbody>
</table>

The acceptance criteria will be as follows:

(i) The above dynamic characteristics curve for reactance & phase angle will be done for frequency range of 5 Hz to 40 Hz for vibration damper for 'MOOSE' conductor and 10 Hz to 60 Hz for vibration damper for 7/3.66 mm earth wire.

(ii) If all the individual curve for dampers are within the envelope as already mentioned for type test for reactance & phase angle, the lot passes the test.

(iii) If individual results do not fall within the envelope, averaging of characteristics shall be done.

(a) Force of each damper corresponding to particular frequency shall be taken & average force of three dampers at the frequency calculated.

(b) Similar averaging shall be done for phase angle.

(c) Average force Vs frequency and average phase Vs frequency curves shall be plotted on graph paper. Curves of best fit shall be drawn for the entire frequency range.

(d) The above curves shall be within the envelope specified.

5. Spacer

(a) Test Set up

The test set up for the test described hereunder shall be as per clause 3.4 (c) (i) Annexure-A.

(b) Movement Test

The spacer assembly shall be capable of the following movements without damaging the conductor, assuming one conductor is fixed and the other moving:

(i) Longitudinal movement ± 50 mm
parallel to the conductor

(ii) Vertical movement in a vertical direction at right angle to the conductor ± 25 mm

(iii) Torsional movement/angular movement in a vertical plane parallel to the conductor ± 5 deg.

(c) Compressive and Tensile Test

The spacer assembly shall withstand ultimate compressive load of 14 kN and tensile load of 7.0 kN applied between sub conductor bundle and held for one minute without failure. Line distance between clamps shall be recorded during each of the compression and tension test. Measurement shall be recorded at (i) no load (ii) with load (iii) after release of load. The center line distance under load shall be within ± 100 mm of the nominal design spacing. After release of load it shall be possible to retain the clamps at their original position using only slight hand pressure. There shall be no deformation or damage to the spacer assembly which would impair its function of maintaining the normal spacing.

(d) Clamp Slip Test

Same as clause 3.5(b) of Annexure-A.

(e) Clamp Bolt Torque Test

The spacer assembly shall be attached to conductor. A torque of 150 per cent of the manufacturer's specified tightening torque shall be applied to the clamp bolts or cap screws. There shall be no failure of the component parts.

(f) Assembly Torque Test

The spacer assembly shall be installed on conductor. The same shall not rotate on either clamp on applying a torque of 0.04 kN in clockwise or anti-clockwise direction.

(g) Hardness test for Elastomer

The shore hardness at different points on the elastomer surface of cushion grip clamp shall be measured by shore hardness meter. They shall lie between 65 to 80.

(h) UTS of Retaining Rods

The ultimate tensile strength of the retaining rods shall be measured. The value shall not be less than 35 kg/sq.mm.
Section – VIII

DRAWINGS
### Table:

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<tr>
<th>S.NO.</th>
<th>DESCRIPTION</th>
<th>QTY.</th>
<th>MATERIAL</th>
<th>MIN. ULTIMATE TENSILE STRENGTH</th>
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<td>SUSPENSION LAMP</td>
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### NOTES:

1. SPRING WASHERS ELECTRO GALVANISED
2. OTHER FERROUS PARTS HOT DIP GALVANISED.
3. BALL & SOCKET SIZE 20 MM. OF DESIGNATION.
4. THE OVERALL MIN. & MAX. DIMENSIONS INDICATED ARE INCLUSIVE OF MAX. VARIATION IN LENGTH DUE TO:
   a) INSULATOR DISC TOLERANCE OF +/- 4MM
   b) TOLERANCE ON TOTAL LENGTH OF HARDWARE FITTING OF +/- 2%
5. THE TYPES OF THE VARIOUS FITTING & MODE OF ATTACHMENT AS SHOWN ARE INDICATIVE ONLY & NOT MANDATORY.
6. ALL DIMENSIONS ARE IN MM.

---

Torrent Power Grid Ltd.

**PROJECT:**

400 KV TRANSMISSION SYSTEM

**TITLE:**

OUT LINE DSRG.OF 400 K.V. 23 UNIT SINGLE SUSPENSION INSULATOR STRING (TWIN MOOSE)

**DRAW NO.**

TL/400KV/TWIN/DISC/018

**REV.**

0
# SPECIAL NOTES

Intermediate Arcing Horns and Intermediate Double Ball Pins are in the scope of Long Rod Insulator Supplier.
NOTES:-
1. SPRING WASHERS ELECTRO GALVANISED
2. OTHER FERRUS PARTS HOT DIP GALVANISED
3. BALLA SOCKET SIZE 20MM. OF DESIGNATION
4. THE OVERALL MIN. & MAX. DIMENSIONS INDICATED ARE INCLUSIVE OF MAX. VARIATION IN LENGTH OUT TO:
   A) INSULATOR DISC TOLERANCE OF + 4MM
   B) TOLERANCE ON TOTAL LENGTH OF HARDWARE FITTING OF + 2%
5. THE TYPES OF THE VARIOUS FITTING & MODE OF ATTACHMENT AS SHOWN ARE INDICATIVE ONLY & NOT MANATORY
6. ALL DIMENSIONS ARE IN MM.

THIS DRAWING IS FOR 400KV TRANSMISSION LINES
IN WIND ZONE - 1,2,3 & 4 OF IS:875:1987

FOR BID PURPOSE ONLY

Torrent Power Grid Ltd.

PROJECT
400 - K.V. TRANSMISSION LINE

TITLE
OUT LINE DRG. OF 24 UNIT SINGLE TENSION INSULATOR STRING (TWIN MOOSE)

DATE

DRAWN

SHEET

PGCIL/400KV-016

REV.
### NOTES:

1. SPRING WASHERS ELECTRO GALVANISED
2. OTHER FERROUS PARTS HOT DIP GALVANISED.
3. BALL SOCKET SIZE 20MM. OF DESIGNATION AS PER IEC 120
4. THE OVERALL MIN. & MAX. DIMENSIONS INDICATED ARE INCLUSIVE OF MAX. VARIATION IN LENGTH OUT TO:
   A) INSULATOR LENGTH
   B) TOLERANCE ON TOTAL LENGTH OF HARDWARE FITING OF ± 2.5%
5. THE TYPES OF THE VARIOUS FITTINGS & MODE OF ATTACHMENT AS SHOWN ARE INDICATIVE ONLY & NOT MANDATORY.
6. ALL DIMENSIONS ARE IN MM.

### SPECIAL NOTES

INTERMEDIATE ARCS HORN AND INTERMEDIATE DOUBLE BALL PIN
ARE IN THE SCOPE OF LONG ROD INSULATOR SUPPLIER.

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<tr>
<td>5</td>
<td>BALL CLEVIS</td>
<td>2</td>
<td>FORGED STEEL</td>
<td>160KN</td>
</tr>
<tr>
<td>6</td>
<td>ARCING HORN</td>
<td>1</td>
<td>MILD STEEL</td>
<td>N.A.</td>
</tr>
<tr>
<td>7</td>
<td>SOCKET CLEVIS</td>
<td>2</td>
<td>FORGED STEEL</td>
<td>160KN</td>
</tr>
<tr>
<td>8</td>
<td>YOKE</td>
<td>1</td>
<td>MILD STEEL</td>
<td>320KN</td>
</tr>
<tr>
<td>9</td>
<td>CORONA CONTROL RING SET</td>
<td>1</td>
<td>AL ALOY PIPE</td>
<td>N.A.</td>
</tr>
<tr>
<td>10</td>
<td>CLEVIS EYE</td>
<td>2</td>
<td>FORGED STEEL</td>
<td>160KN</td>
</tr>
<tr>
<td>11</td>
<td>SAG ADJUSTING PLATE</td>
<td>2</td>
<td>MILD STEEL</td>
<td>160KN</td>
</tr>
<tr>
<td>12</td>
<td>ANCHOR SHACKLE</td>
<td>2</td>
<td>FORGED STEEL</td>
<td>160KN</td>
</tr>
<tr>
<td>13</td>
<td>TENSION CLAMP</td>
<td>2</td>
<td>E.C. GRADE</td>
<td>153KN SLIP STRENGTH</td>
</tr>
</tbody>
</table>

**NOTES:-**

1. SPRING WASHERS ELECTRO GALVANISED.
2. OTHER FERROUS PARTS HOT DIP GALVANISED.
3. BALL & SOCKET SIZE 0" 20MM. DESIGNATION.
4. THE OVERALL MIN. & MAX. DIMENSIONS INDICATED ARE INCLUSIVE OF MAX. VARIATION IN LENGTH DUE TO -
   a) INSULATOR DISC TOLERANCE OF + 5MM
   b) TOLERANCE ON TOTAL LENGTH OF HARDWARE FITING OF + 2%
   c) ADJUSTMENT OF SAG ADJUSTMENT DEVICE
5. THE TYPES OF THE VARIOUS FITTING & MODE OF ATTACHMENT
   AS SHOWN ARE INDICATIVE ONLY & NOT MANDATORY.
6. ALL DIMENSIONS ARE IN MM.

 Torrent Power Grid Ltd.

**PROJECT**
400 KV TRANSMISSION SYSTEM

**TITLE**
OUTLINE DRAWING OF 2 X 23 UNIT DOUBLE TENSION INSULATOR STRING (TWIN MOOSE)

**ORIG. NO:**

**REV:**

TL/400KV/TWIN/DISC/014
SPECIAL NOTE:-

INTERMEDIATE ARCING HORNS AND INTERMEDIATE DOUBLE BALL PINS ARE IN THE SCOPE OF LONG ROD INSULATOR SUPPLIER.
TECHNICAL DETAILS:

1. ALL DIMENSIONS ARE IN mm.
2. ALL FERROUS PARTS HOT DIP GALVANISED AS PER POWER GRID SPECIFICATIONS.
3. BALL & SOCKET SIZE 20 mm AS PER IS:2488 (PART-1).
4. MIN. CORONA EXTINCTION VOLTAGE (DRY) 320 KV (R.M.S.)
5. R.I.V. AT 305 KV. (R.M.S.) (DRY) BELOW 1000 MICROVOLT.
6. SLIPPING STRENGTH OF CLAMP 20 TO 29 KN.
7. GENERAL TOLERANCES:±3%.
8. TOLERANCE ON TOTAL LENGTH OF HARDWARE FITTING, ±2%.
9. SPRING WASHERS ARE ELECTRO GALVANIZED.

TENDER PURPOSE ONLY

TITLE:
400 KV. DOUBLE"V" SUSPENSION STRING
FOR "MOOSE ACSR" CONDUCTOR.
UTS : 412 KN.

Torrent Power Grid Ltd.

PROJECT:
400kV Transmission System

TITLE:
Drg for Double Suspension String
Drg No.
400kV/TWIN/DISC/DVS
12 COMPRESSION DEADEND  
11 CLEVIS CLEVIS  
10 SAG ADJUSTING PLATE  
9 CLEVIS EYE  
8 CORONA CONTROL RING  
7 YOKE PLATE (LINE SIDE)  
6 SOCKET CLEVIS  
5 ARCING IRON (TOWER SIDE)  
4 HORSE HOLDER BALL CLEVIS  
3 YOKE PLATE (TOWER SIDE)  
2 CHAIN LINK  
1 ANCHOR SHACKLE

**TECHNICAL DETAILS:**

1) ALL DIMENSIONS ARE IN mm.
2) SPRING WASHER ELECTRO GALVANIZED.
3) SLIPPING STRENGTH OF CLAMP : 214 KN (Min.)
4) BALL & SOCKET SIZE 20 mm. IS:2488 (PART-II)
5) ALL FERROUS PARTS HOT DIP GALVANIZED PER POWER GRID SPECIFICATION
6) MIN CORONA EXTINCTION VOLTAGE (DRY): 320 KV (RMS).
7) RIV AT 305 KV (RMS) (DRY) BELOW 1000 MICROVOLTS.
8) GENERAL TOLERANCE ± 3% UNLESS OTHERWISE SPECIFIED.
9) HARDWARE TOLERANCES ON LENGTH ± 2%.
10) TOLERANCES ON INSULATOR DISC ± 150.

**TENDER PURPOSE ONLY**

**TITLE:**

400 KV. TRIPLE TENSION STRING
FOR "MOOSE" ACSR TWIN CONDUCTOR.
UTS : 480 KN.

Torrent Power Grid Ltd.

**PROJECT:**

400kV Transmission System

**TITLE:**

Drg for Triple Tension String

Drg No.
400kV/TWIN/DISC/TT
GATE DETAIL PLAN AT A-A

NOTES

1: ALL DIMENSIONS ARE IN MILIMETERS
2: ALL HOLES ARE 17.5MM Ø TO SUIT 16mm Ø BOLTS
3: BLANK HOLES AT GATES ARE TO RECEIVE BARBED WIRE
4: ONE 3 MM SPRING WASHER TO BE PROVIDED UNDER EACH NUT
5: BARBED WIRE SHALL CONFORM TO IS 278 (SIZE DESIGNATION A1)

FOR BID PURPOSE ONLY

Torrent Power Grid Ltd.
PROJECT
400KV TRANSMISSION SYSTEM
TITLE
DETAIL OF ANTI CLIMBING DEVICE
ORG. NO.
TL/400KV/007
REV. 0
NOTES
1. ALL DIMENSIONS ARE IN MM.
2. MATERIAL - BOLTS CONFIRMING TO ISO:898 / ISO 4016
   WITH MECHANICAL PROPERTIES OF CLASS 5.6.
3. TO BE GALVANISED AFTER MANUFACTURE AS PER IS:1367 PART-XIII
4. NUT TO BE TAPPED OVER SIZE FOR GALVANIZED BOLT
5. ANTI-THEFT BOLTS TO BE ADOPTED FOR REDUNDANT MEMBERS CONNECTIONS UPTO TWO BOTTOM MOST PANELS.

FOR BID PURPOSE ONLY

Torrent Power Grid Ltd.

PROJECT: 400KV TRANSMISSION SYSTEM
TITLE: ANTI THEFT FASTNERS
DRG. NO. TL/400KV/ATB
16 Ø BOLTS 45 LG WITH SPRING WASHER AND NUT

GS LUG COMPRESSED TYPE

X IS NOT LESS THAN 1000MM

LUG FITTING (TYPICAL)
FOR THREE LEGS

STUB ANGLE

16 Ø BOLTS 35LG

GS LUG
10.97 GLVD. WIRE

LUG FITTING ON FOURTH LEG

BASE OF TOWER

REQUIRED LENGTH OF COUNTER SIDE
WIRE SUBJECT TO MIN. 25MM LENGTH

COMPRSSED JOINTS TO BE FORGED
17.5 Ø BOLT

1097 MM GLVD. WIRE

DETAIIL OF LUG

LIST OF BOLTS & NUTS/TOWER

<table>
<thead>
<tr>
<th>S. No</th>
<th>SIZE</th>
<th>QTY.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>M16 X 45LG</td>
<td>3</td>
</tr>
<tr>
<td>2</td>
<td>M16 X 35LG</td>
<td>1</td>
</tr>
<tr>
<td>3</td>
<td>3.5 THK. SPG WASHER</td>
<td>4</td>
</tr>
</tbody>
</table>

NOTES

1: ALL DIM. ARE IN MM
2: 10.97mm GALVINISED WIRE WITH GS LUG FORGED AT ONE END
   OTHER END FREE FOR A REQUIRED LENGTH OF COUNTERPOISE WIRE
3: FOUR GS. LUG WILL BE REQUIRED PER TOWER. THREE LUGS WILL BE
   CONNECTED ON 3 LEGS & FOURTH LUG WILL BE CONNECTED WITH FLAT
   TYPE ‘C’ PROVIDED FOR PIPE TYPE EARTHING.
4: 10.97 MM WIRE SHALL BE OUTSIDE COPPING.
5: ONE SET COMPRISING OF FOUR NUMBERS OF REQUIRED LENGTH OF
   COUNTERPOISE WIRE

FOR BID PURPOSE ONLY

Torrent Power Grid Ltd.

PROJECT
400KV TRANSMISSION SYSTEM

TITLE
COUNTERPOISE EARTHING ARRANGEMENT

DRG. NO.
TL/400KV/006 (SHEET 2/3)

REV. 0
DETAIL OF FLAT TYPE 'C'

DETAIL OF FLAT TYPE 'D'

NOTES

1: ALL DIM. ARE IN MM
2: AFTER FABRICATION, BOTH FLATES ARE TO BE HOT DIP GALVINISED AS PER IS - 2629.
3: 'FLAT TYPE 'C' IS TO BE PROVIDED ON ONE LEG OF EACH TOWER
4: FLAT TYPE 'D' IS TO BE PROVIDED WITH PIPE EARTH ARRANGEMENT AND TO BE CONNECTED WITH FLAT 'C' FOR THE LOCATION WHERE TOWER FOOTING RESISTANCE IS MORE THAN 10 OHMS

LIST OF BOLTS & NUTS WITH SP. WASHER

<table>
<thead>
<tr>
<th>S.NO.</th>
<th>SIZE</th>
<th>QTY.</th>
<th>REMARKS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>M 16Ø x 45 LG.</td>
<td>2</td>
<td>PER TOWER</td>
</tr>
<tr>
<td>2</td>
<td>M 16Ø x 35 LG.</td>
<td>2</td>
<td>PER PIPE TYPE EARTHING</td>
</tr>
<tr>
<td>3</td>
<td>M 12Ø x 30 LG.</td>
<td>2</td>
<td>PER PIPE TYPE EARTHING</td>
</tr>
</tbody>
</table>

FOR BID PURPOSE ONLY

Torrent Power Grid Ltd.

PROJECT
400KV TRANSMISSION SYSTEM

TITLE
DETAILS FOR FLATS FOR EARTHING

ORD. NO.
TL/400KV/006 (SHEET 3/3)

REV.
0
NOTES:
1. ALL DIMENSIONS ARE IN MM.
2. LETTERING & FIGURE: RED ENAMELLED.
3. BACKGROUND: WHITE VITREOUS ENAMELLED.
4. BACK: BLACK VITREOUS ENAMELLED.
5. MINIMUM 1.6THK. M.S.PLATE AS PER IS:1079-1994 (GRADE-O).
6. GENERAL TOLERANCE ±2% UNLESS OTHERWISE SPECIFIED.
7. THE CORNERS OF THE PLATE SHOULD BE ROUNDED OFF.
8. ALL LETTERS SHOULD BE CENTRALLY SPACED.
9. BOLT / NUT TO BE GALVANIZED AS PER IS:1367 (P-13) - 1963.
10. DESIGN OF DANGER PLATE IS AS PER IS 2551:1982

**765000 VOLTS, 400000 VOLTS & 220000 VOLTS TO BE WRITTEN FOR 765 KV, 400 KV & 220 KV RESPECTIVELY.**

**IN CASE LOCAL LANGUAUGE IS OTHER THAN HINDI, HINDI LETTERS SHALL BE REPLACED BY LOCAL LANGUAGE TO BE CONFIRMED FROM SITE IN CHARGE.**

**LIST OF 16mm# BOLTS, NUTS & WASHER TO BE SUPPLIED WITH EACH PLATE**

<table>
<thead>
<tr>
<th>DETAILS</th>
<th>QTY</th>
</tr>
</thead>
<tbody>
<tr>
<td>M-16x35MM LONG HRE BOLT AS PER IS:12427-2001 CLASS 5.6 AND NUT AS PER IS:14394-1998 CLASS S</td>
<td>2</td>
</tr>
<tr>
<td>2MM THK. LEAD WASHER</td>
<td>4</td>
</tr>
</tbody>
</table>

**STANDARD DRAWING**

 Torrent Power Grid Ltd
65x65x6

200x200x6

NOTES
1: ALL DIM. ARE IN MM
2: CLEARANCE FROM OUTER SURFACE OF OUTER LAYER OF EARTH WIRE TO INNER SURFACE OF PROTECTIVE LEGGING IS AT LEAST 50 mm
3: TWO LENGTHS OF EARTH WIRE ARE WOUND ON EVERY DRUM
   THE LENGTHS ARE WELDED AND ENDS OF WELD ARE MARKED BY RED TAPE
4: THICKNESS OF PROTECTIVE LAGEING SHOULD BE 50 mm.
5: STANDARD LENGTH OF EARTH WIRE 2000m +/-5%
6: TOLERANCE ON WOOD DIMENSION = +3MM

<table>
<thead>
<tr>
<th>S.NO</th>
<th>DESCRIPTION</th>
<th>Qty</th>
<th>Material</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>BUSH PLATE</td>
<td>2</td>
<td>MS</td>
</tr>
<tr>
<td>9</td>
<td>SLOT FOR INNER END OF EARTH WIRE</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>8</td>
<td>WASHER</td>
<td>24</td>
<td>MS</td>
</tr>
<tr>
<td>7</td>
<td>BARREL SUPPORT</td>
<td>3</td>
<td>WOOD</td>
</tr>
<tr>
<td>6</td>
<td>TIE RODS</td>
<td>6</td>
<td>MS</td>
</tr>
<tr>
<td>5</td>
<td>MILD STEEL BUSH</td>
<td>2</td>
<td>MS</td>
</tr>
<tr>
<td>4</td>
<td>BARREL STUD</td>
<td>8</td>
<td>MS</td>
</tr>
<tr>
<td>3</td>
<td>BARREL</td>
<td>1</td>
<td>WOOD</td>
</tr>
<tr>
<td>2</td>
<td>FLANGE</td>
<td>2</td>
<td>WOOD</td>
</tr>
<tr>
<td>1</td>
<td>PROTECTIVE EXTERNAL LAGEING</td>
<td>1</td>
<td>WOOD</td>
</tr>
</tbody>
</table>

FOR BID PURPOSE ONLY

400 KV TRANSMISSION SYSTEM
DRUM FOR 7/3.66mm G.S EARTH WIRE
DRG. NO. TL400KV012
TYP. FOUNDATION SHAPE FOR P.C.C. TYPE

TYP. FOUNDATION SHAPE FOR R.C.C. TYPE

TYP. FOUNDATION SHAPE FOR HARD ROCK

FOR BID PURPOSE ONLY

Torrent Power Grid Ltd.

PROJECT
400 KV TRANSMISSION SYSTEM

TITLE
TENTATIVE SHAPE OF TOWER FOOTINGS

DRG. NO.
TL/400KV/010

REV. 0
NOTES

1: ALL DIM. ARE IN MM
2: STRIP IS TO BE PROVIDED ON ONE LEG OF EACH TOWER
3: STRIP WITH PIPE EARTH ARRANGEMENT IS TO BE PROVIDED ON ONLY ONE LEG
   FOR THE LOCATION WHERE TOWER FOOTING RESISTANCE IS MORE THAN 10 OHMS
4: 17.5 MM Ø HOLES SUITABLE FOR 16MM BOLTS FOR EARTHING DEVICES
5: FOR COUNTER POISE EARTHING STRIP 'C' SHALL BE CONNECTED WITH COUNTER POISE
   WIRE THROUGH 'A' LUG

FOR BID PURPOSE ONLY

Torrent Power Grid Ltd.

PROJECT
400KV TRANSMISSION SYSTEM

TITLE
DETAILS OF PIPE TYPE EARTHING

DRG. NO.
TL/400KV/006 (SHEET 1/3)

REV. 0
NOTES:
1. ALL DIMENSIONS ARE IN mm.
2. M.S. PLATE-1.6MM THK.(MIN) AS PER IS:1079 - 1994 (GRADE 0).
3. PHASE PLATE TO BE ENAMELLED RED, YELLOW AND BLUE ON FRONT AND BACK.
4. GENERAL TOLERANCE ±3% UNLESS OTHERWISE SPECIFIED.
5. PHASE PLATE SHALL BE AS PER IS:5613 (PART-2).
6. BOLT / NUT TO BE GALVANIZED AS PER IS:1367 (P-1.5) - 1983.
7. QUANTITY PER SET: ONE PLATE EACH OF RED, YELLOW & BLUE.
8. ONE SET FOR EACH CIRCUIT IS TO BE SUPPLIED.

LIST OF 16mmØ BOLTS, NUTS & WASHER
TO BE SUPPLIED WITH EACH SET

<table>
<thead>
<tr>
<th>DETAILS</th>
<th>QTY</th>
</tr>
</thead>
<tbody>
<tr>
<td>M-16x35MM LONG HRH BOLT AS PER IS:12427-2001</td>
<td>3</td>
</tr>
<tr>
<td>CLASS 5.6 AND NUT AS PER IS:14384-1996 CLASS 5</td>
<td></td>
</tr>
<tr>
<td>2MM THK. LEAD WASHER</td>
<td>6</td>
</tr>
</tbody>
</table>

STANDARD DRAWING

Torrent Power Grid Ltd

REV. 0

DESCRIPTION

CHECKED

APPROVED

REV.

SCALE

DRAWING NO: C01ENGG:TL:ACC:PP

REVISION

PROJECT:

135kV
765/400/220kV TRANSMISSION SYSTEM

TITLE:

PHASE PLATE
NOTES

1: ALL DIM. ARE IN MM UNLESS OTHERWISE SPECIFIED.
2: WEEP HOLES SHOULD BE OF SIZE 100mm x 100mm OR 150mm x 150mm IN CASE OF LARGE SIZE REVETMENT.
3: WEEP HOLES SHOULD BE 2.5M C-C APART HORIZONTAL.
4: CENTER OF TOP MOST WEEP HOLES TO BE NOT LESS THAN 300 mm BELOW TOP
5: THE MIN. DEPTH OF REVETMENT WALL BELOW G.L. WILL BE 600mm
6: DIM. 'B' ARE VALID ONLY FOR 'H' NOT EXCEEDING 5.00 METER
7: SIZE OF STONE FOR MASONARY WORK 300 x 150 x 150 & BELOW.
8: THE MASONARY WORK SHOULD BE CARRIED OUT IN 1:5 CEMENT MORTAR
9: SIZE OF STONE PACKING AT WEEP HOLE 75 mm TO 150mm

FOR BID PURPOSE ONLY

Torrent Power Grid Ltd.

PROJECT
400 KV TRANSMISSION SYSTEM

TITLE
PROTECTION OF TOWER FOOTING (DOWN/UP HILL)

DRG. NO.
TL/400KV/008

REV.
NOTE: -
1. ALL DIMENSIONS ARE IN MM.
3. WEIGHT/PIECE WITH TWO NUTS AND ONE SPRING WASHER=0.417 Kg
4. THREADS TO BE UNDER CUT BY 0.3MM.
5. THE STEP-BOLT SHALL BE CAPABLE OF WITHSTANDING A VERTICAL LOAD NOT LESS THAN 1.5KN.
7. GENERAL REQUIREMENT SHALL CONFORM TO IS 10238.
8. MECHANICAL PROPERTIES SHALL CONFORM TO CLASS 4.6 AS PER IS:1367(PART-3)
   FOR BOLT & CLASS 5 AS PER IS:1367 (P-V) FOR NUT.
9. THE STEP BOLT SHALL WITH STAND CANTILEVER TEST AS PER IS:10258

M-16 HEX. NUT AS
AS PER IS:14394-1996

3.5MM THK. SPRING WASHER
AS PER IS 3063

M-16 HEX. NUT AS
AS PER IS:14394-1996

+5

0

60

+4

THREAD PORTION TO SUIT
M-16 HEX. NUT

175

+1

0

6