VOLUME –II

TECHNICAL SPECIFICATIONS
FOR TRANSMISSION LINE

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1. **General Information and Scope**

1.1 **Scope**

1.1.1 The following transmission lines are included in the scope of the Contractor:

1. **220 kV D/C Kushma – New Butwal transmission line** - approx. 87.6 kms

2. **LILO of 132 kV D/C Butwal – Bardhaghat transmission line at New Butwal** - approx. 3.0 kms

1.1.2 This Specification covers the following scope of works:

(i) Detailed survey including route alignment, profiling (wherever route change is required), tower spotting, optimization of tower locations, soil resistivity measurement & geotechnical investigation (including special foundation locations viz. pile/well foundation locations, whenever applicable & covered under BPS);

(ii) Check survey;

(iii) Design, Proto type testing, fabrication and supply of all type of 220kV double circuit transmission line towers (Also to be used in 132 kV LILO line) including bolts, nuts and washers, step bolts, hangers, D-shackles etc.;

(iv) Supply of all types of tower accessories like phase plate, circuit plate (wherever applicable), number plate, danger plate, anti climbing device, Bird guard (wherever applicable);

(v) Supply of Conductor, Insulators, Earth wire, Hardware Fittings, Accessories for Conductor & Earth wire and OPGW & associated fittings & accessories;

(vi) Design of foundations for different soil conditions for different type of towers, classification of foundation for different type of towers and casting of foundation for tower footings as per approved drawings;

(vii) Supply & Installation of Tower Earthing;

(viii) Erection of towers, tack welding of bolts and nuts including supply and application of zinc rich paint, fixing of insulator strings, stringing of conductors and earth wires/OPGW 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)
(xi) Testing and commissioning of the erected transmission lines

(xii) Supply & Installation of PLS-CADD and PLS-Tower Softwares (10 multi-user licenses each) along with associated training and

(xiii) 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 Contractor shall develop design, structural drawings, shop drawings & Bill of Materials of all 220 kV Double circuit towers and carryout the proto testing of towers. Similarly, the design and drawings for all type of foundations for the towers shall also be developed by the contractor, in sequence, suiting the project requirement.

1.1.2.2 (a) The provisional quantities of fabricated & galvanised steel towers as per specifications requirement, foundation type and their numbers, quantity of various line materials and other items are given in appropriate Price Schedule in Volume-III of the bid documents. However, the work shall be executed as per approved construction drawings and project requirement.

(b) The various item of work is described very briefly in the appropriate Price Schedule. The various items of the Price Schedule shall be read in conjunction with the corresponding sections in the Technical Specifications including amendments and, additions, if any. The Bidder’s rates shall be based on the description of activities in the Price Schedule as well as necessary operations 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.

1.1.3 All the raw materials such as steel, zinc for galvanising, reinforcement steel and cement for tower foundation, coke and salt for tower earthing etc., bolts, nuts, washers, D-shackles, hangers, links, danger plates, phase plates, number plates. Circuit Plates, anti climbing device, bird guards, etc., required for tower manufacture and erection shall be included in the Contractor’s scope of supply. Bidder shall clearly indicate in the offer, the sources from where they propose to procure the raw materials and the components.

1.1.4 The installation & stringing of the HTLS conductor for the above transmission lines shall be carried out by the transmission line contractor under supervision of the HTLS conductor supplier.
The entire stringing work of conductor and earth wire/OPGW shall be carried out by tension stringing technique. The contractor 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 this project. The period of deployment of tension stringing equipment shall be as per actual site requirement.

Power line crossing, river crossings, railway crossings, other single span sections where deployment of tension stringing machine is not warranted and in hilly terrain, thick forest or areas with site constraints, where deployment of tension stringing machine is not feasible, manual stringing may be adopted after getting approval of Employer’s 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/OPGW which are installed at the prescribed sag-tension as per the approved stringing charts.

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.

The payment for stringing shall be done as per the unit rates of stringing under the contract irrespective of the methodology adopted for stringing.

1.1.5 The Bidder shall quote the unit rates for tower and foundation as per units mentioned in appropriate price schedules. However, payment of these items in the schedule of prices shall be made as follows:

- Tower Supply: On completion of respective complete tower
- Tower Erection: On erection of respective complete tower
- Tower Foundation: On completion of respective foundation in all respect

1.1.6 This specification also includes the supply of Conductor, Insulators, Earthwire, hardware fittings, all type of accessories for conductor and earth wire and OPGW and its associated hardware & accessories 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 relevant section of this Volume of the bidding documents.

1.1.7 Location Details and Terminal Points

The 220 kV (twin bundle) transmission line shall emanate from Kushma sub-station at Khurkot VDC of Parbat district and shall terminate at New-Butwal sub-station near Ramnagar at Makrarahar VDC of Rupandehi district in Western Development Region of Nepal. The transmission line shall be passing mainly through undulated hilly areas, cultivated land, barren land, forest stretches and terai regions.

The 132 kV transmission line LILO shall emanate from a suitable point on 132 kV D/C Butwal – Bardhaghat transmission line and shall terminate at New-
Butwal sub-station near Ramnagar at Makrahar VDC in Western Development Region of Nepal.

The Contractor shall have to construct the above 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.

### 1.2 Details of Transmission Line Routes and Terrain

Detailed survey including route alignment and profiling have been carried out by the Owner and these are not expected to vary substantially. The contractor has to carry out the tower spotting, optimization of tower locations, soil resistivity measurement & geotechnical investigation etc.

However, certain quantity of detailed survey including route alignment, profiling, tower spotting, optimization of tower locations soil resistivity measurement & geotechnical investigation etc. have been kept in the scope of the contractor for changes in the route, if any, necessitated during execution stage.

The details collected through detailed survey viz, route alignment maps, detailed survey reports etc. are enclosed with this specification. Bidders may visit the line route to acquaint themselves with terrain conditions and associated details of the proposed transmission lines.

### 1.3 Access to the Line and Right of Way

Right of way and way leave clearance shall be arranged by the Owner in accordance with work schedules. Owner will secure way leave and Right of way in the Forest area.

### 1.4 Contractor Execution Plan

After award of the contract, the contractor shall submit a detailed plan for resources mobilization & execution of various activities under the project scope along with the L2 network to be approved by owner. The detail should also cover the locations and size of stores to be established by the contractor. The contractor shall be required to open at least three offices with stores.

The contractor shall deploy a Project Manager at site who shall not be allowed to be changed without the consent from NEA, once deployed. The work at site shall be carried out after permission from the Site-in-charge and with proper consent of land owners and forest officials.

### 2.0 Line Data:

#### 2.1 Electrical System Data:

<table>
<thead>
<tr>
<th></th>
<th>Nominal Voltage</th>
<th>kV</th>
<th>220</th>
<th>132</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.</td>
<td>Maximum system voltage</td>
<td>kV</td>
<td>245</td>
<td>145</td>
</tr>
<tr>
<td>3.</td>
<td>BIL (Impulse)</td>
<td>kV (Peak)</td>
<td>1250</td>
<td>650</td>
</tr>
<tr>
<td>4.</td>
<td>Power frequency withstand voltage</td>
<td>kV (rms)</td>
<td>460</td>
<td>275</td>
</tr>
</tbody>
</table>
Details of Line Materials

A. Conductor and earth wire for lines

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Description</th>
<th>Conductor 220 kV line</th>
<th>Conductor 132 kV LILO</th>
<th>Earthwire</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Type</td>
<td>HTLS conductor</td>
<td>ACSR ‘BEAR’ conductor</td>
<td>GS EW / OPGW</td>
</tr>
<tr>
<td>2.</td>
<td>Stranding and wire diameter</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Aluminium / Al. Alloy</td>
<td>To be designed</td>
<td>30/3.35 Aluminium</td>
<td>-</td>
</tr>
<tr>
<td>3.</td>
<td>Core</td>
<td>To be designed</td>
<td>7/3.35</td>
<td>7/3.35</td>
</tr>
<tr>
<td>4.</td>
<td>Spacing between conductor of same phase(sub conductor spacing)(mm)</td>
<td>450 for twin bundle</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>5.</td>
<td>Configuration</td>
<td>Vertical</td>
<td>Vertical</td>
<td>One each to run horizontally on top</td>
</tr>
<tr>
<td>6.</td>
<td>Overall Diameter (mm)</td>
<td>28.62 max</td>
<td>23.45</td>
<td>10.05</td>
</tr>
<tr>
<td>7.</td>
<td>Unit mass (kg/km)</td>
<td>1621 max</td>
<td>1215</td>
<td>483</td>
</tr>
<tr>
<td>8.</td>
<td>Min. UTS (kN)</td>
<td>130.32</td>
<td>111.5</td>
<td>61.1</td>
</tr>
</tbody>
</table>

Details of Insulator Strings

2.3.1 with disc insulators

<table>
<thead>
<tr>
<th>Sl No.</th>
<th>Particulars</th>
<th>Single ‘I’ Suspension Pilot</th>
<th>Double tension</th>
<th>Triple Tension</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>No of Standard Insulator Discs</td>
<td>1 x 16</td>
<td>2 x 17</td>
<td>3 x 17</td>
</tr>
<tr>
<td>2.</td>
<td>Size of Disc</td>
<td>280 x 145</td>
<td>280 x 170</td>
<td>280 x 170</td>
</tr>
<tr>
<td>3.</td>
<td>E &amp; M Strength of each disc KN</td>
<td>120</td>
<td>160</td>
<td>160</td>
</tr>
<tr>
<td>4.</td>
<td>Size and Designation of pin ball shank (mm)</td>
<td>20</td>
<td>20</td>
<td>20</td>
</tr>
<tr>
<td>5.</td>
<td>Creepage distance of each disc (mm)</td>
<td>315</td>
<td>315</td>
<td>315</td>
</tr>
</tbody>
</table>
2.3.1 with composite long rod insulators

<table>
<thead>
<tr>
<th>SI No.</th>
<th>Particulars</th>
<th>Single ‘I’ Suspension Pilot</th>
<th>Double tension</th>
<th>Triple Tension</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>No of Standard Insulator units</td>
<td>1 x 1</td>
<td>2 x 1</td>
<td>3 x 1</td>
</tr>
<tr>
<td>2.</td>
<td>Size of Composite Insulator (Core dia x Nominal length) (mm)</td>
<td>24x2320</td>
<td>24x2890</td>
<td>24x2890</td>
</tr>
<tr>
<td>3.</td>
<td>E&amp; M Strength of each unit (KN)</td>
<td>120</td>
<td>160</td>
<td>160</td>
</tr>
<tr>
<td>4.</td>
<td>Size and Designation of pin ball shank (mm)</td>
<td>20</td>
<td>20</td>
<td>20</td>
</tr>
<tr>
<td>5.</td>
<td>Creepage distance of each unit (mm)</td>
<td>5040</td>
<td>5355</td>
<td>5355</td>
</tr>
</tbody>
</table>

Note: Bidder may quote for any of the above options of insulators.

2.4 Insulator String Hardware (As may be applicable)

a) Anchor Shackle
b) Chain Link
c) Ball Clevis
d) Arcing horn holding plate
e) Yoke plate
f) Socket clevis
g) Arcing horns
h) Corona control ring/grading ring.
i) Clevis Eye
j) Free center type/Armour grip suspension clamp for suspension strings.
k) Compression type dead end clamp.
l) Sag adjuster.
m) Balancing weight

2.5 Accessories for Conductor & Earth wire (As may be applicable)

a) Preformed Armour rods
b) Mid Span compression joint
c) Repair Sleeves
d) Flexible copper bonds
e) Vibration dampers
f) Rigid Spacers
g) Suspension clamp for earth wire.
h) Tension clamp for earth wire.

3.0 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) : 45
- Minimum ambient temperature (Degree Celsius) : 0
- Relative humidity (% range) : 10-100
- Wind zone (as per IS: 875) : 4
- Maximum wind velocity (m/sec.) : 47 m/sec
- Maximum altitude above mean sea level (Meters) : upto 2000 m
- Isoceraunic level (days/years) : 60

Climate varies from moderately hot and humid tropical climate to cold climate.
TECHNICAL SPECIFICATIONS

SECTION - II

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 Employer will cover only general conformance of the data to the specifications and not a through review of all dimensions, quantities and details of the materials, or items indicated or the accuracy of the information submitted. This review by the Employer 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 Employer 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 Employer, 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 Employer as far as practicable within 28 days and shall be modified by the Contractor if any modifications and/or corrections are required by the Employer. 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 Employer shall be in quadruplicate. One print of such drawings shall be returned to the Contractor by the Employer marked “approved/approved with corrections”. The contractor shall there upon furnish the Employer 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 Employer, 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 Employer.

1.3.7 The approval of the documents and drawings by the Employer shall mean that the Employer 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 Employer of any document does imply compliance with 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 acceptable. After final approval all the drawings shall be submitted to the Employer 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 Employer’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 Employer.

   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 (as applicable).

   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 and stringing chart.
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 Employer only and any designs/drawings/data sheets submitted by the contractor from time to time shall become the property of the Employer. Under no circumstances, the Contractor shall be allowed to use/offer above designs/drawings/data sheets to any other authority without prior written permission of the Employer. 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 Employer 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 co-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 Employer, and the consultants of the Employer during the period of Contract. The contractor shall attend such meetings at his own cost at the Corporate Office of the Employer 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 Employer 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 Employer.
(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 Employer 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 Employer's inspection of equipment/material.
1.7.1.2 The Employer 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 Employer'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 Employer, 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.

1.7.3 Inspection & Inspection Certificate

1.7.3.1 The Employer, his duly authorized representative and/or outside inspection agency acting on behalf of the Employer shall have, at all reasonable times, access to the premises and /or works of the contractor and/or their sub-contractor(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.

1.7.3.2 The Contractor shall give the Employer'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 Employer’s inspector. The Employer’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 which shall be deemed to have been made in the inspector's presence and he shall forthwith forward to the inspector duly certified copies of test reports / certificates in triplicate.

1.7.3.3 The Employer’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.

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

1.7.3.5 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 Employer’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 Employer’s Inspector or to his authorised representative to accomplish testing.

1.7.3.6 The inspection by Employer 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.

1.7.3.7 a) The Contractor shall keep the Employer informed in advance about the time of starting and of the progress of manufacture and fabrication of various 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 Specifications.

1.7.3.8 The Employer 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 Employer’s material for satisfying him that the fabrication is being done in accordance with the provisions of the Specifications.

1.7.3.9 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.
1.7.3.10 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 Employer or his authorised representative considers that the defects can be rectified.

1.7.3.11 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 Employer.

1.7.3.12 All gauges and templates necessary to satisfy the Employer shall be supplied by the contractor.

1.7.3.13 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.

1.7.4 Tests and Standards

1.7.4.1 Tests

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

1.7.4.1.1 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.

1.7.4.1.2 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.

1.7.4.1.3 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.

1.7.4.1.4 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.

1.7.4.1.5 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 Employer.

1.7.4.1.6 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 Employer in the Quality Assurance Programme.

1.7.4.1.7 For all type and acceptance tests, the acceptance values shall be the values specified in this Specification or guaranteed by the Bidder, as applicable.
1.7.4.2 Standards

The Codes and/or standards referred to in the specifications shall govern, in all cases wherever such references are made. In case of a conflict between such codes and/or standards and the specifications, the latter shall govern. Such codes and/or standards, referred to shall mean the latest revisions, amendments/changes adopted and published by the relevant agencies unless otherwise specified.

1.7.4.2.1 Other internationally accepted standards which ensure equal or better performance than those specified shall also be accepted, subject to prior approval by the *Owner/*Employer/*Employer.

1.7.4.2.2 The standards are available from

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1.8 **Standard Technical Particulars**

1.8.1 The Standard Technical Particulars of the various items are given in the relevant schedule of the specification. The bidder is required to comply with the same.

1.9 **Packing**

1.9.1 All the materials manufactured at the manufacturer's works shall be labeled "KB220KV/KB" before the inspection is being carried out.

1.9.2 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.

1.9.3 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.

1.9.4 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.

1.9.5 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.
1.9.6 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.

1.9.7 Angle section shall be wire bundled.

1.9.8 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.

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

1.9.10 The packing shall be properly done to avoid losses & damages during transit. Each bundle or package shall be appropriately marked.

1.10 Storage of Material

Brief guidelines for storage of different type of construction material used in the transmission line projects are as under:

1.10.1 Cement Storage

Cement received at site should be stored in a building or shed which is dry, leak proof and moisture proof. The building should have minimum numbers of windows. Cement bags stored and stacked off the floor on wooden planks in such a way so as to keep about 150 mm to 200 mm clearance from the ground. The floor may be of lean cement concrete or two layers of dry bricks laid on well consolidated earth. A minimum space of 600 mm shall be kept around and between the exterior walls and the stacks. In stacks, bags shall be kept close together to reduce air circulation. The height of the stack shall not be more than 12 bags and the width of the stack shall not be more than four bags or 3 meters. For extra safety during monsoon, or when it is expected to store for an unusually long period, the stack shall be completely enclosed by a waterproofing membrane such as polyethylene etc. Different type and make of cement shall be stacked and stored separately.

1.10.2 Aggregates

Aggregates shall be stored at site on a hard dry and level patch of ground. If such a surface is not available, a platform of planks or old corrugated iron sheets, or floor bricks or a thin layer of lean concrete shall be made so as to prevent contamination with clay, dust, vegetable and other foreign matter.

The stacks of fine and coarse aggregates shall be kept in separate stock piles sufficiently removed from each other to prevent the material at the edges of the piles from getting intermixed. Fine aggregate shall be stacked in a place where loss due to the effect of wind is minimum.

1.10.3 Reinforcement Steel

For each classification of steel, separate areas shall be earmarked. It is desirable that ends of bars and sections of each class be painted in distinct separate colors. Steel reinforcement shall be stored in such a way as to avoid
distortion and to prevent deterioration and corrosion. It is desirable to coat reinforcement with cement wash before stacking to prevent scaling and rusting in case of storage time exceeding one month. In store, reinforcement bars shall be stacked above ground level by at least 150 mm either on brick/cement/stone platform or concrete/bricks planks.

1.10.4 **Structural Steel or Tower Parts**

The structural steel of different classification, sizes and lengths shall be stored separately. These shall be stored above ground level at least 150 mm upon platforms, skids or any other suitable supports to avoid any distortion of sections. Also, in order to prevent white rust formation sufficient care should be exercised while storing, handling and transporting galvanized products. The structural steel/tower parts shall be stored in an adequately ventilated area. The article shall be stored with spacers in between them and kept at an inclination to facilitate easy drainage of any water collected on the structural steel/tower parts.

1.10.5 **Conductor & Earthwire Drums**

It is essential to save the conductor drums from damage during storage and transportation and the wooden battens and main wheel should be intact so that same can be successfully mounted on the conductor jacks to release the conductor during stringing. All the conductor and earthwire drums should be stored on a proper hard platform above ground to avoid deterioration of the drum and further avoiding the damage of conductor. The conductor & earthwire drums should be stored in such a manner that each drum can be accessed at any time for inspection purposes.

1.10.6 **Hardware fitting, Accessories & Insulators**

All the hardware fittings, accessories and insulators should be stored on raised platform above ground so as not to damage the packaging and to avoid further damage or denting on the fittings and chipping of insulators. All the aluminum parts should be stored on a plain/raised platform under a cover shed in such a way that the aluminum fittings cannot be distorted during storage.

2.0 **Environmental Mitigation Measures**

2.1 **Physical Environment**

The following mitigation measures shall be undertaken to reduce the adverse impacts on the physical environment during construction of the transmission line.

1. Discharge of cement slurry, garbage and other solid wastes generated by the construction activities and workforce should be avoided where possible.
2. Chemical and other hazardous materials should be dumped safely far away from the water bodies.
3. Disposal material of substation should be carried out within the acquired land for substation. The waste materials of the substation shall be minimized to avoid separate land for disposal.

2.2 **Biological Environment**

None

2.3 **Socio-economic and cultural Environment**

In the construction phase following mitigation measures shall be adopted in accordance with the EIA final report to minimize the impacts:

- Control of adverse socio interactions between local communities and construction work force.
- Awareness program regarding health and safety of transmission line.
- Awareness program for workforce.
- Insurance against health and safety.

2.4 **Employment**

The job preferences shall be given to local project affected family people.
TECHNICAL SPECIFICATIONS

SECTION - III

DETAILED SURVEY AND SOIL INVESTIGATION

1.0 Detailed Survey, Optimisation of Tower Location

1.1 Detailed survey along the route alignment has been carried out and profile has been plotted on the drawings by the Employer. Details of angle of deviation and section lengths along with route alignment drawings have been given in Section VIII/9 of Vol II. The Contractor shall have to do tower spotting on already prepared profile drawings, optimise tower locations and carry out the check survey for the total length of transmission line. Tower spotting, optimisation of tower locations and check survey shall have to be carried out by the Contractor in line with the provision stated in Clause 1.2 of Section – 1 of this Specification.

1.2 The Provisional quantity for detailed survey & check survey has been indicated in Price Schedule. The final quantity for the detailed survey shall be the route length along the revised route alignment, if any, and final quantity of check survey shall be the route length along the final route alignment. The tower spotting and optimisation of tower locations shall be carried out by the Contractor on the basis of approved Tower Spotting Data preferably using PLS-CADD software.

1.3 The Contractor shall submit the proposal for detailed survey, in case of change (if necessary) in the present route alignment finalised by the Employer and shall carry out the detailed survey, profiling & optimisation of tower locations only after getting approval from the Employer. The decision of Employer in this regard shall be final and binding for the Contractor. The Contractor shall finalise and submit results of detailed survey including changes suggested within the time schedule identified for completion of check survey and as agreed at the time of award. The soil investigation for the obligatory points are to be carried out by the Contractor as detailed out in this specification.

1.4 The Contractor should note that Employer will not furnish the topographical maps but will make available any assistance that may be required in obtaining the topographical maps.

1.5 The check survey shall be made along the approved route alignment after finalising the detailed survey.

1.6 Detailed Survey

Following activities shall be part of Detailed Survey work:

- Soil resistivity along the route alignment shall be measured in dry weather by four-electrode method keeping inter-electrode spacing of 50 meters. For calculating soil resistivity formula $2\pi ar$ (where $a=50$ meters and $r =$ megger reading in ohms) shall be adopted. Measurement shall be made at every 2 to 3 kms along the route of transmission lines. In case soil characteristic, changes within 2 to 3 kms., the value shall also have to be measured at intermediate locations. The megger reading and soil characteristics shall also be indicated in the soil resistivity results.
1.6.1 Route Marking

At the starting point of the commencement of route marking for detailed survey an angle iron spike of 65x65x6mm section and 1000mm long shall be driven firmly into the ground to project only 150 mm above the ground level. A punch mark on the top section of the angle iron shall be made to indicate location of the survey instrument.

All angle positions and terminal points shall be marked with concrete pillars and all intermediate points should also be marked with concrete pillars a interval not more than 300 meters. The concrete pillars of minimum 100x100x600 mm in size with NEA marked on them shall be embedded into the ground for easy identification. The concrete pillars shall be embedded firmly into the ground to project 150 mm only above ground level.

1.6.2 Profile Plotting & Tower Spotting

From the field book entries, the route plan with route details and level profile shall be plotted and prepared to scale of 1:2000 horizontal & 1:400 vertical on the paper having grid of 10mmX10mm as per approved procedure. Reference levels at every 20 meters along the profile are also to be indicated on the profile besides, R/Ls at undulations. Areas along the profile sheet, in the view of the contractor, are not suitable for tower spotting, shall also be clearly marked on the profile plots. If the difference in levels be too high, the chart may be broken up accordingly to requirement. A 10mm overlap shall be shown on each following sheet. The chart shall progress from left to right having width of Sheet 594 mm wide. For ‘as built’ profile these shall be in A1 size.

1.7 Spotting of Tower Location

1.7.1 Sag Template & Tower Spotting Data

Sag - tension calculation for conductor & earth wire and other necessary data (ground clearance, permissible sag error etc. are provided with the bid. On basis of these, the Contractor shall prepare the Sag template curve drawing and Tower Spotting Data and shall submit the same along with sag –tension calculations for the approval of the Employer. Sag template prepared based on the approved sag-template curve drawing shall only be used for tower spotting on the profiles. Two numbers of the approved template, prepared on rigid transparent plastic sheet, shall be provided by the Contractor to the Employer for the purpose of checking the tower spotting. The templates shall be on the same scale as that of the profile.

1.7.2 Tower Spotting

With the help of approved sag template and tower spotting data, tower locations shall be marked on the profiles. While locating the towers on the profile sheet, 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 DB type or DC type or DD type towers as applicable.
(b) Extension

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 and/or leg extension designed by the Contractor.

(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 employed at such positions.

(d) Road Crossing

At all important road crossings, the tower shall be fitted with double suspension or tension insulator strings depending on the type of tower but the ground clearance at the roads under maximum conductor design 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 7.5m for 220KV lines. At all national highways suspension / tension towers shall be used and crossing span will not be more than 250 meters.

(e) River Crossings

In case of major river crossings towers shall be of suspension type and the anchor towers on either side of the main river crossing shall be DD type tower. Clearance required by navigation authority shall be provided. For non-navigable river, clearance shall be reckoned with respect to highest flood level (HFL).

(f) Power Line Crossings

Where this line is to cross over another line of the same voltage or lower voltage, DA type tower with suitable extensions (if necessary) shall be used. Provisions to prevent the possibility of its coming into contact with other overhead lines shall be made in accordance with the directions of the Employer. All the works related to the above proposal shall be deemed to be included in the scope of the Contractor except if modifications are required to line below, in which case, the conditions to be agreed upon. The minimum clearance while crossing the 11 kV up to 132 kV lines shall be 4580 mm.

For power line crossings of voltage level of 132 kV and above, an angle towers shall be provided on either side of DA type tower which can be temporary dead end condition with proper guying.

(g) 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 Employer.

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.

(h) Details En-route

All topographical details, permanent features, such as trees, building etc. 20m for 220 kV and 10m for 132 kV on either side of the alignment shall be detailed on the profile drawing.

1.8 Clearance from Ground, Building, Trees etc.

Clearance from ground, buildings, trees and telephone lines shall be provided in conformity with the Electricity Regulations of Nepal, 2050 as amended up to date.

1.8.1 The tree cutting shall be the responsibility of the Employer except for that required during survey. However, 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 Employer at the time of actual execution of the work as detailed below. Contractor may please note that Employer shall not pay any compensation for any loss or damage to the properties or for tree cutting due to Contractor’s work.

1.8.2 Any way leave which may be required by the Contractor shall be arranged by the Employer as required by work programme.

1.8.3 To evaluate and tabulate the trees and bushes coming within 20m on either side of the central line alignment the trees will be numbered and marked with quality paint serially from angle point AP (I) onwards (where I is tree no.) 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 (circumference) 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 in the 40M belt should also be evaluated with its type, height, girth and area in square meters, clearly indicating the growth in the tree/bush statement.

1.8.4 Payment of compensation towards the clearance etc. will be the responsibility of the Employer.

1.9 Preliminary Tower Schedule

The profile sheets, duly spotted, along with preliminary schedules indicating type of towers, type of foundations, wind span, weight span, angle of
deviation, river / road crossing and other details shall be submitted for the approval of the Employer. After approval the Contractor shall submit four more sets of the approved reports along with one soft copy on CD of final profile drawings to the Employer for record purpose.

1.10 **Check Survey for Tower Location**

1.10.1 The check survey shall be conducted to locate and peg mark the tower positions on ground conforming to the approved profile and tower schedule. In the process, it is necessary to have the pit centers marked according to the excavation marking charts. The levels, up or down of each pit center with respect to the center of the tower location shall be noted and recorded for determining the amount of earthwork required to meet the approved design parameters &/or for determining the suitable leg extensions.

1.10.2 On tower locations having undulations, levels shall be taken at every 2 meter along the diagonals (connecting diagonal legs) of tower in area of 20 X 20 meters profile of the ground along the diagonal shall be plotted and submitted to the Employer.

1.10.3 Changes in the preliminary tower schedule after detailed / check survey, if required, shall be carried out by the Contractor and he shall thereafter submit a final tower schedule for the approval of Employer. The tower schedule shall show position of all towers, type of towers, span length, type of foundation for each towers and the deviation at all angles as set out with other details.

1.10.4 **Identification of ROW and land parcel**

1.10.4.1 The Scope of work of "Check Survey" also includes the identification of the land parcel and permanent structures owned by public as well as private individuals on the Right of Way of Transmission Line (ROW is 20m on either side of the entire length of the Route Alignment) The Contractor shall mark the tower locations showing its boundary covering all four foundation pads and submit the details of affected Land Parcel numbers along with their areas for all tower locations to the Employer after the approval of check survey. The detail of which should include land plot number, and owners name and address as obtained from the records of Land revenue Office (Maalpot) and Survey Division (Naapi Sakha) of the concerned districts. It will be the responsibility of the Contractor to hire the Land Surveyors (Amin) and other required manpower, survey instruments & accessories, cadastal maps and collect the required information as mentioned herein above.

1.10.4.2 The Contractor is also required to identify the land parcel, and its owners along with the detail of area of the land required for the foundation footing and submit the report to the Employer for the Purpose of permanent acquisition of land. The area of land required for permanent acquisition shall be based on the designed area of the foundation footing.

1.10.4.3 The Employer shall initiate the process for acquiring the ROW of Transmission Line as well as permanent land acquisition for plot of land area required for foundation footing after verification of the Contractors report. However, if any error is identified in the information submitted by the contractor needing re-identification of land plot and its owner’s names, the Contractor shall...
immediately mobilize the crews to rectify error and resubmit the report at no extra cost.

1.10.4.4 The Employer, at the request of the Contractor shall request the various Organizations or Offices of the Government of Nepal and local bodies to provide the necessary information to the Contractor. The Bidders are requested to familiarize themselves with the government rules & regulations and processes in the acquisition of land.

1.10.4.5 All cost incurred in this connection shall be included in Check Survey work. However, the compensation cost of land and permanent structures along the ROW and land costs for permanent acquisition of land for tower pads shall be borne by the Employer. Also, the cost of publication of notice and various meeting expenses that are likely to be incurred during price/compensation fixation shall be borne by the Employer.

1.10.4.6 **Loss of standing crops:** The Employer shall make compensation for the loss of standing crops due to project activities. However the Contractor shall assess the quantity of such losses and forward the Employer with the necessary field measurements to substantiate timely compensation to the owners.

1.10.5 **Right of Way (ROW) Clearance (Forest)**

1.10.5.1 The Scope of work in “Right of Way (ROW) Clearance” includes the marking of trees that are likely to be felled down to clear the ROW, taking detailed log of trees and its measurement with the help of forest technician as deputed by the District Forest Office of the concerned District, and submit the report to the Employer.

1.10.5.2 The Employer shall forward the report to the Forest Office and shall initiate the process of getting approval for felling of trees. Upon approval on the report from the District Forest Office, contractor shall initiate the process of marking (which is termed as “TANCHA”) of the trees in coordination with the concerned District Forest Office, the Contractor shall immediately mobilize the work force and cut the marked trees, make logs/firewood in required sizes and transport and stack them in the stockyard as designated by the concerned District/Community Forest Office) under the close monitoring of forest technicians deputed by the District/Community Forest Office. Usually the wooden logs and fire wood is stacked in the size of 6.0m x1.52m.x1.52m, which is called as “chatta”.

1.10.5.3 The wooden logs shall be measured in net excluding the bark thickness and firewood shall be measured in chatta and detail report shall be prepared by forest technician as deputed by the District Forest Office of the concerned District.

1.10.5.4 The per diem allowance of forest technician/guards etc as deputed by District/Community Forest Office shall be paid by the Contractor as of actual man days involved in the works. It will be the full responsibility of the Contractor to manage proper security of wooden logs unless those are handed over to the concerned District/Community Forest Office.
2.0 Environmental Conditions

2.1 Forest

The line route passing through forest stretches covered under this specification shall be furnished to the successful Bidder.

2.2 General Climatic Conditions

Climatic conditions shall be as indicated at Cl.5.0 of Section–1 of this Specification.

2.3 Statutory Regulations and Standards

2.3.1 Statutory Regulations

The Contractor is required to follow local statutory regulations stipulated in Electricity Regulations of Nepal, 2050 as amended and other local rules and regulations referred in this Specifications.

2.3.2 Reference Standard

2.3.2.1 The Codes and/or standards referred to in the specifications shall govern, in all cases wherever such references are made. In case of a conflict between such codes and/or standards and the specifications, latter shall govern. Such codes and/or standards, referred to shall mean the latest revisions, amendments/changes adopted and published by the relevant agencies unless otherwise specified.

2.3.2.2 Other internationally accepted standards which ensure equal or better performance than those specified shall also be accepted, subject to prior approval by the Employer.

3.0 Geotechnical Investigations

3.1 General

3.1.1 Employer desires 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 selected/designed rationally. The entire soil investigation work at river crossing locations (if required) shall be carried out by the Contractor. The range of load intensities from the various structures is expected to be between 100 KN/sq. m and 500 KN/sq.m.

3.1.2 These specifications provide general guidelines for geotechnical investigation of normal locations, including marshy locations and those affected by salt water or saltpeter. Any other specific information required for design of foundation suitable for such locations shall be obtained by the Contractor and furnished to the Employer.

3.2 Scope

3.2.1 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 considering detail soil investigation at selected
tension tower locations. 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 Employer. For other locations, trial pit of is to be done in every locations for foundation classification up to foundation depth and furnish bore log data including the depth of ground water table. No separate payment for trial pit shall be done. Based on the soil parameters, the Contractor has to recommend the type of foundation suitable for each locations and same shall be got approved by the Employer.

3.2.2 These specifications cover the technical requirements for a detailed Geotechnical investigation and preparation & 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 for carrying out the entire field investigation as well as laboratory tests, analysis and interpretation of data collected and preparation of the Geotechnical Report. The 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.

3.2.3 Contractor shall make its own arrangements to establish the co-ordinate system required to position boreholes, trial pits and other field test locations as per the drawings/sketches supplied by Employer. 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 Employer 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).

3.2.4 The field and laboratory data shall be recorded on the proforma recommended in relevant Indian Standards. Contractor shall submit to Employer two copies of field bore logs (one copy each to Employer’s site and corporate office) and the entire field records (countersigned by the Employer) soon after the completion of each borehole /test.

3.2.5 Whenever Contractor is unable to extract undisturbed samples, it shall immediately inform the Employer. Payment for boring charges shall be subject to Employer 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 numbers of vane shear tests are performed and the results correlated with other soil parameters.
3.2.6 One copy of all field records and laboratory test results shall be sent to Employer on a weekly basis. Employer may observe, the laboratory testing & procedures.

3.2.7 The Contractor shall interact with the Purchaser 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 etc.

3.2.8 After reviewing Contractor's geotechnical investigation draft report, Purchaser may call the contractor & his geotechnical engineer for discussions to be held at Employer’s site office / corporate office and give comments on the report. The report shall be redrafted & finalised by the contractor based on the comments and get the same approved from Employer’s site office. All expenditure associated with the redrafting and finalising the report including traveling etc. shall be deemed to have been included in the rates quoted for the geotechnical investigations.

3.2.9 Contractor shall carry out all work expressed and implied in Clause 3.2 of this specifications in accordance with requirements of the specification and satisfaction of the Employer.

3.3. General Requirements

3.3.1 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.

3.3.2 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.

3.3.3 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 landfills shall be studied to determine the characteristics of such land fill as well as the original soil strata.

3.3.4 The water level in neighboring streams and watercourses shall be noted. Contractor shall make inquiries and shall verify whether there are abandoned underground works e.g. worked out ballast pits, quarries, old brick fields, mines, mineral workings etc. The possibility of damage to the structure, sewers, conduits and drainage system by subsidence shall also be investigated.

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

3.4 Codes and Standards for Geotechnical Investigations
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 better performance than those specified shall also be accepted.

3.4.1 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 Recognize Standard/Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>IS: 1080-1990</td>
<td>Codes of Practice for Design and Construction of Simple Spread Foundations</td>
<td></td>
</tr>
<tr>
<td>IS: 1498-1992</td>
<td>Classification and identification of Soils for General Engineering purposes.</td>
<td>ASTM D 2487/ ASTM D 2488</td>
</tr>
<tr>
<td>IS: 1888-1982</td>
<td>Method of load tests on soil</td>
<td></td>
</tr>
<tr>
<td>IS: 1892-1992</td>
<td>Code of Practice for Subsurface Investigation for Foundation</td>
<td></td>
</tr>
<tr>
<td>IS: 2132-1992</td>
<td>Code of Practice for Thin Walled Sampling of Soils</td>
<td>ASTM D 1587</td>
</tr>
<tr>
<td>IS: 2720-1992</td>
<td>Method of Test for Soils (Relevant Parts)</td>
<td>ASTM D 420</td>
</tr>
<tr>
<td>IS: 2809-1991</td>
<td>Glossary of Terms and symbols Relating to Soil Engineering</td>
<td>ASTM D 653</td>
</tr>
<tr>
<td>IS: 2810-1979</td>
<td>Glossary of terms and symbols related to soil dynamics</td>
<td></td>
</tr>
<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: 4078-1990</td>
<td>Code of Practice for Indexing and Storage of Drill Cores.</td>
<td></td>
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</tbody>
</table>


IS: 4464-1990  Code of Practice for Presentation of Drilling Information and core description in Foundation Investigation

IS: 4968- (Part-II)-1992  Method for Subsurface sounding for soils, dynamic method using cone and Bentonite slurry

IS: 5313-1989  Guide for Core Drilling observations.

IS: 6403-1990  Code Practice for Determination of Allowable Bearing Pressure on Shallow Foundation.  ASTM D 194


IS: 7422-1990  Symbols and Abbreviations for use in Geological Maps Sections and subsurface Exploratory Logs (Relevant parts).


IS: 8764-1991  Method of Determination of Point Load Strength Index of Rocks.


IS: 9179-1991  Method of Preparation of Rock Specimen for Laboratory Testing.  ASTM D 4543

3.5 Field Investigation for Soils

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

3.5.1 Boring

Boreholes are required for detailed soil investigations.

3.5.1.1 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 this specification:

b) All boreholes shall be minimum 7m deep for normal open cast type foundations. If the strata with Standard Penetration Test—N value measured greater than 100 with characteristics of rock is met, the borehole shall be advanced by coring at least 3m further, limited to total 7m depth, with prior approval of the Purchaser.

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 cohesion less 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 borehole 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 Purchaser.

3.5.1.2 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 bore log as per IS: 1498. No water shall be introduced from the top while conducting auger boring.

3.5.1.3 Shell and Auger Boring

3.5.1.3.1 Shell and auger boring may be used in all types of soil that 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.

3.5.1.3.2 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 borehole through local obstructions such as old construction, boulders, rocky formations, etc. The requirements in Clause 3.5.1.2 shall apply for this type of boring also.

3.5.1.4 Rotary Boring

Rotary boring 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.

3.5.2 Standard Penetration Test (SPT)

3.5.2.1 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. No extra payment shall be made for carrying out Standard Penetration Tests. The test shall be conducted at depths as follows:

<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</td>
</tr>
</tbody>
</table>

3.5.2.2 The spacing between the levels of standard penetration testing and next undisturbed sampling shall not be less than 1.0m. The Equipments, other accessories, procedures for conducting the test and collection of the disturbed soil samples shall conform to IS: 2131 and IS: 9640. The rods shall
be straight, tightly coupled and the air release valve shall be checked. The test shall be conducted immediately after reaching to the test depth and cleaning of bore hole.

3.5.2.3 The test shall be carried out by driving a standard split spoon sampler in the borehole by means of a 650N hammer falling freely from a height of 750mm for 450mm depth, recording the number of blows for every 75mm. The number of blow for the last 300mm drive shall be reported as measured N value.

3.5.2.4 This test shall be discontinued when blow count has reached 100 or the penetration is less than 25 mm for 50 blows, whichever is earlier, or sampler starts jumping. 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.

3.5.3 Sampling

3.5.3.1 General

a) Sufficient number of soil samples shall be collected. Disturbed soil samples shall be collected for field identification and for conducting laboratory tests such as grain size (sieve) analysis, index properties, specific gravity, chemical analysis etc. Undisturbed samples shall be collected to estimate the physical, strength, swelling and consolidation properties of the soil.

b) All accessories and sampling methods shall conform to IS: 2132. All the representative disturbed and undisturbed samples collected in the field shall be classified at site as per IS: 1498. The specification for thin wall sampling tube and sampler heads should be as per IS: 11594.

c) All samples shall be identified with date, borehole or test pit number, date of sampling, etc. It is also essential to mark an arrow pointing towards the top surface of the undisturbed sample tube as the soil in-situ. Care shall be taken to keep the core and box samples vertically, with the arrow mark directing upwards. All undisturbed samples shall be properly trimmed at one end and suitably capped and sealed with molten paraffin wax on both sides. 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 proper protection against loss and damage.

3.5.3.2 Disturbed Samples

a) Disturbed soil samples shall be collected in boreholes at regular intervals. Jar samples weighing approximately (10 N)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 and at the levels of Standard Penetration Tests (SPT), obtained in a SPT sampler shall also be collected. Samples shall be stored immediately in airtight 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 (250 N) 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 shall be kept in wooden boxes for transportation.

3.5.3.3 Undisturbed Samples

The undisturbed soil samples shall be collected immediately after drilling and cleaning the borehole up to the desired depth. Effort shall be made that the preparations are made before hand to collect the sample after reaching to the desired depth. 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 foundations</td>
<td>1.0, 4.0, 6.0</td>
</tr>
</tbody>
</table>

3.5.3.3.1 The depth interval 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, density and moisture content of the soil. Accessories required for sampling and sampling procedures shall conform to IS: 1892 and IS: 2132 and other related IS Codes. Undisturbed sampling in sand shall be done using compressed air technique mentioned in IS: 8763.

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. Inside clearance ratio and outside clearance ratio shall be as specified by IS code.

b) Undisturbed samples in very loose saturated sandy and silty soils and very soft clays shall be obtained by using a piston sampler consisting of a sampling 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 samplers in the presence of expert supervision.

Accurate measurements of the sampling depth, height of sampler, stroke and length of sample recovered shall be recorded. After the sampler is pushed to the required depth, the cylinder and piston system shall be drawn up together, ensuring that there shall not any disturbance to the sample.

c) Undisturbed sampling in cohesion less soil

Undisturbed samples in cohesion less soils shall be obtained as per the procedure given in IS: 8763. Compressed air Sampler shall be used to take sample of cohesion less soils below water table.
d) The sampler should be cleaned (not rusted), oiled and connected with straight drill rods coupled tightly. The air-released valve should be checked every time before lowering the sampler. At the time of lowering the sampler it should be ensured that bore hole is cleaned, casing is not below the depth of sampling and water level in the bore hole is above the water table preferably up to ground surface if sampling is done below water table.

e) The collected sample should be sealed on both ends of the sampler with wax. They should be given identification numbers and kept in the airtight wooden boxes. They should be transported in truck with a care that the structure of soil samples would not change due to vibration during transportation. They should be kept in a testing laboratory and should be tested within seven days or before.

3.5.4 Ground Water Table

3.5.4.1 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 Purchaser:

a) In permeable soils, the water level in the borehole shall be allowed to stabilise 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.

3.5.4.2 If any variation of the ground water level is observed in any specific boreholes, the water level in these boreholes shall be recorded daily during the course of the filed investigation. Levels in nearby wells, streams, etc., if any, shall also be noted in parallel. Care should be taken to ensure any abrupt change in water level in borehole is recorded.

3.5.4.3 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 Purchaser.

3.5.5 Dynamic Cone Penetration Test (For marshy locations, with bentonite slurry)
Dynamic cone penetration test shall be conducted with bentonite slurry to predict stratification, density, bearing capacity of granular soils, etc. The test shall be conducted by driving a standard size cone attached to the bottom of a string of straight and tightly coupled drill rods to the specified depth or refusal, whichever comes first. Refusal shall be considered when the blow count exceeds 100 for 300mm penetration. The Equipment, accessories required for performing the test, 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 having a free fall of 750mm. The cone shall be 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 format approved by the Purchaser.

3.5.6 Dynamic cone penetration test without slurry

The test shall be conducted for prediction of different soil strata, their relative strength or density or both. The 50mm diameter 60° cone shall be fitted loosely to the driving rod through a cone adopter. The cone shall be driven into the soil by allowing the 650 N weight hammer to 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 and report should be prepared as per guidelines of IS: 4968 (Part I).

3.5.7 Vane Shear Test (required for boreholes where UDS is not possible in marshy locations)

Field vane shear test shall be performed inside the borehole to determine the shear strength of cohesive soils, especially of soft and sensitive clays, which are highly susceptible to sampling disturbance. This test shall be conducted by advancing a four-winged vane of suitable size (75mm or 100mm diameter as per the soil condition) into the soil at the desired depth and measuring the torque required to rotate the vane. The equipments and accessories required for conducting test, test procedures and field observations shall correspond to IS: 4432. 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 is likely to influence the test results substantially, the test at that particular depth may be omitted with the permission of the Purchaser. 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 Performa as specified in IS: 4434, Appendix-A.

3.6 Field Investigation for Rock

3.6.1 Rock Drilling
3.6.1.1 If, during the investigations, large hard fragments or natural rock beds like but not limited to igneous, sedimentary and metamorphic formations 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 Purchaser. 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.

3.6.1.2 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: 6929. 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 and triple 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 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 Purchaser, and his decision as to whether a TC or a diamond bit is to be used shall be final and binding on Contractor.

3.6.1.3 No drilling run shall exceed 1.5m in length. 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, loss of water, rate of penetration etc. shall be made and reported 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,

e) 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 proforma as given in IS: 5313, Appendix A.

3.6.2 Core Sampling

3.6.2.1 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 maintain the direction of extrusion of sample same as while coring, to avoid stress reversal.
3.6.2.2 Immediately after withdrawal from the core barrel; the cores shall be placed in a tray and transferred to core boxes specially prepared for this purpose. The boxes shall be made from seasoned timber or any other durable 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 records of core recovery and rock quality designation (RQD) are to be mentioned in the bore log in accordance with IS: 11315 (Part-II). Color photograph of cores shall be taken. The core shall be put in sealed polythene bags. The core boxes should be transported carefully so that core should not be broken. They should be stored in dry place and should be sent for testing immediately.

3.7 Laboratory Testing

3.7.1 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 Purchaser 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 fieldwork. A schedule of laboratory tests shall be established by Contractor to the satisfaction of the Purchaser within one week of completion of 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 ensure that its direction of movement is the same as that during sampling to avoid stress reversal.

f) The preparation of soil samples should be conforming to guide lines of IS: 2720 (Part – I).

3.7.2 Tests

Tests as indicated in this specification and as may be requested by the Purchaser, 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
   - 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.

3.7.3 Salient Test Requirement

a) Triaxial shear tests shall be conducted on undisturbed or remolded 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 KN/sq.m respectively or as required depending on the soil conditions. Great care shall be taken to select the rate of shearing depending upon the soil type and drainage condition. The filter paper and the porous stone shall be cleaned and de-aired properly by boiling in water (for a minimum of 10 minutes after reaching the boiling temperature) before commencement of each test.

b) Direct shear test shall be conducted on undisturbed or remolded soil samples. The three normal vertical stresses for each test shall be preferably 100, 200 and 300 KN/sq.m. and or simulating with stresses in field conditions. Cohesive soil shall be compacted to the required density and moisture content in mould and remolded sample shall be extracted and trimmed to require size. Cohesion less soil shall be tamped in the shear box itself. The plane grid plate, perforated shall be used in shear box as per requirement of drainage condition of test. The serration of grid plate shall be right angle to the direction of shear. The filter paper and the porous stone shall be cleaned and de-aired properly by boiling in water (for a minimum of 10 minutes after reaching the boiling temperature) before commencement of each test. The rate of shearing shall be simulating with drainage condition based upon design requirement and soil type. The density and water content of soil shall be measured in each test.

c) Consolidation test shall have loading stages of 10, 25, 50, 75, 100, 200, 400 and 800 KN/sq.m. and simulating with stresses in field condition. For each loading stage, the settlement shall be recorded at convenient time interval till settlement is very negligible or completely over. Usually a period of 24 hours will be sufficient. While putting soil specimen in consolidation ring the unnatural voids shall not be left against the inner face of the ring. The top and bottom shall project above and below the edges of the ring to enable final trimming. The density and water content of soil sample shall be measured. Rebound curve shaft 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 Purchaser;

d) Chemical analysis of subsoil shall include determination of PH value, carbonate, sulphate (both SO3 and SO4), chloride and nitrate contents,
organic matter, salinity and any other chemicals, which may be harmful to the foundation material. The 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 both at 25°C, and chemical contents such as chlorides, nitrates, carbonates, sulphates (both SO₃ and SO₄), organic matter and any other chemical harmful to the foundation material. The contents shall be indicated as parts per million (PPM) by weight.

3.8 Geotechnical Investigation Report

3.8.1 General

a) On completion of all the field and laboratory work, the Contractor shall submit a formal report containing geological information of the region, procedures adopted for geotechnical investigation, field observations and test results, laboratory observations and test results, summarized 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 graphical form, practical and theoretical considerations for the interpretation of test results, supporting calculations for the conclusions drawn, etc.

b) Initially, Contractor shall submit three copies of the draft report for Purchaser’s review. After receiving Purchaser's comments, if any, Contractor shall incorporate the same in the report and resubmit the revised report for approval. Ten copies of the detailed final approval report shall be submitted to Purchaser 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 as discussed in Clause 2.3 of Section-IV of this specification.

3.8.2 Data to be furnished

3.8.2.1 The report shall also include but not limited to the following:

a) A plot plan/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., properly 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 geomorphic, geological structure, lithology, stratigraphy and tectonics, core recovery and rock
quality designation (RQD), quantitative description of discontinuities in rock mass along the line route etc.;

d) Observations and data regarding change of course of rivers, velocity, flood details (including past history) etc. in the vicinity of the 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 summarized 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 backpressure 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. If it is not possible to get proper c-ϕ values of Mohr circles, the same may be obtained from p-q plots.

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 Compression vs \sqrt{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.

k) In static cone penetration test, plot of penetration resistance and friction jacket resistance with depth along with log of borehole shall be shown.

l) In field Vane shear test the calculations, results and interpretation shall be submitted

m) A set of longitudinal and transverse soil/rock profiles connecting various boreholes in order to give a clear picture of the variation of the sub soil strata as per IS: 6065.

n) For Rock, drilling procedure adopted, drilling parameters, core recovery, RQD, core logs, joint parameters, core boxes with proper numbering, core box photographs and water levels etc. should be furnished in the report.
### 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) | Pl |
| d) | L1 |
| 8. | Soil |
| a) | Classification-IS |
| b) | Description |
| c) | Specific gravity |
| 9. | Strength Test |
| a) | Type |
| b) | c (Cohesion) |
| c) | Φ (angle of internal friction) |
| 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 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)  
O - 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)
mv - Coefficient of Volume Compressibility (m2/KN)
Cv - Coefficient of Consolidation (m2/hr)

IV. For Chemical Test
As per Specifications - Clause 3.8.4

**Rock samples**

1. Drill hole no., location
2. Depth
3. Method of drilling
4. Mineral composition
5. Density
6. Moisture content
7. Specific gravity
8. Hardness
9. Sonic wave velocity
10. Slake durability index
11. Unconfined compressive strength, $\sigma_c$
   - Saturated
   - In situ water content
12. Modulus of Elasticity, $E_t$
13. Poisson’s ratio, $\nu$
14. Brazilian tensile strength, $\sigma_{tp}$
15. Point load strength, $\sigma_{tp}$
16. Shear strength parameter, $c, \varphi$ (Triaxial compression)
17. Rock joint parameters
18. Percentage core recovery
19. RQD (Rock Quality Designation)

**3.8.3 Recommendations**
3.8.3.1 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, as discussed in this part but not limited to Clause 2.3 of Section IV of this specification and the following

a) The subsurface material must provide safe bearing capacity and uplift resistance by incorporating appropriate safety factors specified in Clause 2.3 of Section IV of this specification all the while experiencing small deformations throughout, 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. Cone resistance, fractional total resistance, relation between core resistance, Standard Penetration Test No value, and settlement analysis for different sizes of foundation based on static cone penetration test.

d) For locations where use of shallow foundation may be required the following shall be indicated with comprehensive supporting calculations:

i) Net Safe allowable bearing pressure for isolated square footing of sizes 2.0, 3.0, and 4.0 m at three different founding depths of 1,2 and 3m 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 in both natural and log graph, variation of Modulus of sub grade reaction with size, shape and depth of 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 or any other type of 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 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 fraction 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 block 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 even 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.

3.8.4 Hydro-geological Conditions

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

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 Mg2+
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

3.9 Rates and Measurements

3.9.1 Rate

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

SECTION- IV

TOWER, FOUNDATION, ERECTION, STRINGING
AND COMMISSIONING OF LINE

1.0 Transmission Tower

1.1 General Description of the Tower

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

1.1.2 The tower shall be fully galvanised using mild steel or/and high tensile steel sections as specified in clause no. 1.6. Bolts and nuts with spring washer are to be used for connections.

1.1.3 The towers shall be of the following types:

A) Double Circuit towers (DA, DB, DC & DD/DDE)
B) Special towers.

1.2 Classification of Towers

1.2.1 The towers for 220 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>DA</td>
<td>0 to 2 degrees</td>
<td>To be used as tangent / suspension Tower with suspension insulator string</td>
</tr>
</tbody>
</table>
| DB            | 2 to 15 degrees | a) Angle towers with tension insulator string.  
b) Also to be used for uplift force resulting from an uplift span up to 360m under broken wire conditions.  
c) Also to be used for Anti Cascading Condition. |
| DB            | 0 degree        | To be used as Section Tower. |
| DC            | 15 to 30 degrees| a) Angle tower with tension insulator string.  
b) Also to be used for uplift forces resulting from an uplift span up to 360m under broken wire condition.  
c) Also to be used for anti cascading condition. |
| DC            | 0 deg.          | To be used as Section tower. |
| DD            | 30 - 60 deg.    | a) Angle tower with tension insulator string.  
b) Also to be used for uplift forces resulting |
Design, Supply, Installation and Commissioning of Kushma-New Butwal 220 kV Transmission Line

from an uplift span up to 600m under broken wire condition.
c) Dead end with 0 deg to 15 deg deviation both on line side and sub-station side (slack span)

<table>
<thead>
<tr>
<th>DDE</th>
<th>0 deg.</th>
</tr>
</thead>
<tbody>
<tr>
<td>a)</td>
<td>Complete dead end.</td>
</tr>
<tr>
<td>b)</td>
<td>For river crossing anchoring with longer wind span &amp; 0 deg. deviation on crossing span side and 0 deg to 30 deg. deviation on other side.</td>
</tr>
</tbody>
</table>

Notes
i) All above towers shall be designed for single circuit strung condition also considering that all conductors and earthwire of one circuit would be placed on one side of tower.
ii) All above towers can also be used for longer span with smaller angle of deviations without infringement of ground clearance.
iii) The above table provides indicative classification of Towers. Tower spotting data for various towers to be used in the transmission lines shall be given by the contractor during execution stage.

1.2.2 Towers for Major Crossings

The above towers shall also be used with suitable modifications for very long spans (spans more than that of given in clause no. 1.3) which can not be crossed by normal tower with extensions as given in clause no. 1.2.3 like valley and river crossings etc. These Towers shall be developed by strengthening the above DA, DB, DC and DD type towers as per the site requirement. Additional weight of tower due to strengthening shall be paid on pro-rata basis derived from the quoted price and final weight of the standard (+/- 0) tower after successful testing.

1.2.3 Extensions

1.2.3.1 The Double Circuit towers shall be designed so as to be suitable for adding –3M, -1.5M, 1.5M, 3M, 4.5M, 6M, 7.5M and 9M body extensions / leg extensions for maintaining adequate ground clearances without reducing the factor of safety (actual stress /allowable stress) available for the members of tested extensions in any manner. Reference drawing for leg extension arrangement is enclosed in the Bid Document.

1.2.3.2 The provision for addition of 18/25M body extension to tower types DA and DD is also kept. For Power Line Crossing or any other obstacle, tower types DA or DD can be used with 18/25 M extensions depending, upon the merit of the prevailing site condition. The maximum reduced spans for DA and DD type towers shall be mentioned in the tower spotting data. However this shall, in no case be less than 250 meters. Payment for the additional weight due to 18/25M extension shall be made as described in clause no. 1.2.2.

1.2.3.3 The towers shall be designed for providing unequal leg extensions with maximum difference between the shortest and the longest leg of 3M for DA tower and 6M for DB, DC & DD towers. These unequal leg extensions to be provided in the design shall
be used during tower spotting / execution stage to optimise the benching / revetment requirement.

1.2.3.4 In situations where difference in leg differential does not suit the standard unequal leg extension provisions on the towers mentioned above, suitable chimney extensions shall be provided to reduce benching/revetment requirement. Additional volumes of foundation due to chimney extensions shall be paid on pro-rata basis derived from the quoted price and final volumes of the standard foundation of same classification for that tower.

1.2.3.5 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 evaluation.

1.2.3.6 All above body / leg extension provisions to towers shall be treated as part of normal tower only.

1.3 Spans

1.3.1 Design Span or Normal Span

The Design Span or Normal Ruling Span of the line is 350m for 220KV transmission line.

1.3.2 Wind Span

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

1.3.3 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 are given in Table 1.1 below

<table>
<thead>
<tr>
<th>TOWER TYPE</th>
<th>NORMAL CONDITION</th>
<th>BROKEN WIRE CONDITION</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>MAX. (m)</td>
<td>MIN. (m)</td>
</tr>
<tr>
<td>DA</td>
<td>600</td>
<td>200</td>
</tr>
<tr>
<td>DB, DC</td>
<td>600</td>
<td>-600</td>
</tr>
<tr>
<td>DD</td>
<td>1000</td>
<td>-1000</td>
</tr>
<tr>
<td>DDS</td>
<td>1500</td>
<td>-1500</td>
</tr>
</tbody>
</table>

1.3.4 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 design, structural & shop drawings for the modified/ reinforced towers will be prepared by the Contractor as per requirement on basis of approved line diagram without any additional financial implications to the Employer for the design and drawings.

1.4 Electrical Clearances
1.4.1 **Ground Clearance**

The minimum ground clearance from the bottom conductor shall not be less than 7500 mm for 220KV lines at the maximum sag conditions i.e at 80°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 suitable temperature, lower than the stringing temperature.

1.4.3 **Power Line Crossing**

Minimum clearance between power lines to power line crossing should be 4580 mm.

1.4.4 **Live Metal Clearance**

The minimum live metal clearance to be provided between the live parts and steel work of superstructure shall be as given in Table 1.2

<table>
<thead>
<tr>
<th>DESCRIPTION</th>
<th>SWING ANGLE</th>
<th>LIVE METAL CLEARENCE</th>
</tr>
</thead>
<tbody>
<tr>
<td>2000 M EL</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Suspension String</td>
<td>NIL</td>
<td>2400 mm</td>
</tr>
<tr>
<td>(Single / Double)</td>
<td>15 Degree</td>
<td>2230 mm</td>
</tr>
<tr>
<td></td>
<td>30 Degree</td>
<td>2060 mm</td>
</tr>
<tr>
<td></td>
<td>45 Degree</td>
<td>1885 mm</td>
</tr>
<tr>
<td>Tension String</td>
<td>--</td>
<td>2400 mm</td>
</tr>
<tr>
<td>(Single / Double)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Jumper</td>
<td>NIL</td>
<td>2400 mm</td>
</tr>
<tr>
<td></td>
<td>10 Degree</td>
<td>2400 mm</td>
</tr>
<tr>
<td></td>
<td>20 Degree</td>
<td>2060 mm</td>
</tr>
</tbody>
</table>

NOTE: in case of pilot insulator strings, the angle of swing of the jumper alongwith the pilot string shall be considered as 15 degree.

1.4.5 Bidder shall adopt same cross arm design where jumper is projecting outside of cross-arm for DD/DDE type tower, used as dead end and angle tower.

1.4.6 For computing the live metal clearances the dimensions of Single Suspension, Double Suspension, Single Suspension Pilot, Single Tension and Double Tension strings shall be taken as given in enclosed drawings. The design of the tower shall be such that it should satisfy all the above conditions when clearances are measured from any live point of the strings. As the Contractor may use & supply insulator strings with disc insulators or long rod insulators or polymer insulators, the tower design shall be such that it satisfies the clearance requirements in that particular case.

1.4.7 Cross arm projections for Dead end towers shall be fixed in such a way that it can accommodate a condition of 15 degree deviation of conductors towards tower at...
both Left and Right side cross arms on slack span side and 0-15 degrees deviation on line side.

1.4.8 Angle of Shielding

The angle of shielding is defined as the angle formed by the line joining the centre lines of the earthwire and outer power conductor in still air at tower supports, to the vertical line through the centre line of the earthwire. Bidders shall design the tower in such a way that the angle of shielding does not exceed 20 deg for all towers. The drop of the earthwire clamp equal to 150 mm should be considered while calculating the minimum angle of protection.

1.4.9 Mid Span Clearance

The minimum vertical mid span clearance between the earthwire and the nearest power conductor shall not be less than 8.5 metres, which shall mean the vertical clearance between earthwire and the nearest conductor under all temperatures and still air condition in the normal ruling span. Further, the tensions of the earthwire and power conductor, shall be so co-ordinated that the sag of earthwire shall be at least 10% less than that of power conductors under all temperature loading conditions.

1.5 Normal Loading Conditions

1.5.1 Loads at Conductor and Earthwire Points

Employers has calculated the ultimate external loadings at conductor and earthwire points and are enclosed along with the specification. The Contractor shall develop the tower designs based on the loadings given by the Employer only.

1.5.2 Wind Loads on Tower Body

The wind load on tower body shall be calculated by the Contractor as per clause 9.1 of IS 802(Part 1/Sec 1):1995. The following data shall be considered for calculating wind load on tower body.

a) Dynamic reference wind pressure shall be considered as 71.5 Kg/m².

b) Terrain category shall be considered as 2.

c) The angle of incidence of Wind θ (Theta) = 0 Degree.

1.5.3 Maximum Tension

1.5.3.1 Max. tension shall be based on either

a) at 0 deg C with 36 percent full wind pressure, or

b) at 32 deg C with full wind pressure whichever is more stringent.

1.5.3.2 Employer has calculated sag tension calculation for a normal span of 350 meters for the purpose of tower design. Sag tensions calculations are furnished alongwith the specification.

1.5.3.3 The initial conductor and earthwire tension (maximum) at 32ºC and without wind shall be 22% of the ultimate tensile strength of the conductor and 20% of the ultimate tensile strength of the earthwire.
1.5.4 Limiting Tensions of Conductor & Earthwire

The ultimate tension of conductor and earthwire shall not exceed 70 per cent of the ultimate tensile strengths.

1.5.5 Broken Wire Condition

1.5.5.1 Suspension Tower Type DA

Any one phase (both sub-conductors) or earthwire broken; whichever is more stringent for a particular member.

1.5.5.2 Tension Tower Type DB and DC

Breakage of any two phases (both sub-conductors) on the same side and on the same span or breakage of any one phase (both sub-conductors) and one earthwire on the same side and same span whichever combination is stringent for a particular member.

1.5.5.3 Tower Type DD

Breakage of all the three phases (both sub-conductors) on the same side and on the same span or breakage of two phases (both sub-conductors) and one earthwire on the same side and on the same span, whichever combination is more stringent for a particular member.

1.6 Design of Towers

1.6.1 Design Criteria

Towers shall be designed based on spans and clearances as per Clause 1.3 & 1.4 and loading conditions as per Clause 1.5 above.

1.6.2 Design Temperatures

The following temperature range for the conductors and ground wires shall be adopted for line design:

i) Minimum Temperature : 0 deg.C

ii) Every day temperature of conductor : 32 deg.C

iii) Max. temperature of

   a) Conductor : 80 deg.C
   b) Earthwire exposed to sun : 53 deg.C

1.6.3 Conductor and Earthwire Configuration

For double circuit towers the three phases shall be in vertical formation. The phase to phase spacing for conductors shall be not less than 4.9 meters vertically for DA/DB/DC towers and 8.30 meters for DD tower. However, the minimum horizontal separation between phase conductors of two circuits shall be 8.4 meters.

1.6.4 Redundant Design
1.6.4.1 All redundant in the tower are to be triangulated.

1.6.4.2 All bracing and redundant members of the towers which are horizontal or inclined up to 15° from horizontal shall be designed to withstand an ultimate vertical load of 1500 N considered acting at centre independent of all other loads. The bending moment for designing of redundant members shall be considered as WL/4 irrespective of end connections and continuity. The contractor has to furnish the calculations for the same (where W is ultimate load of 1.5 kN and ‘L’ is the length of redundant from bolt to bolt).

1.6.4.3 All redundant shall be designed individually for 2.5% of maximum axial load of connecting members (i.e. leg members, bracing members etc.) as per drawing no.K-D/220kV/0013. The contractor has to furnish the calculations for the same.

1.6.4.4 Connection of single Redundant to leg member having a section of 110 x 110 x 10 and above shall be done with minimum of 2 bolts.

1.6.5 THICKNESS OF MEMBERS

The minimum thickness of angle sections used in the design of towers, unless otherwise specified elsewhere in this Specification, shall be kept not less than the following values:

a) Main corner leg members including the earthwire peak and main cross arm: 5 mm

b) For all other members: 4 mm

1.6.6 BOLTS AND NUTS

1.6.6.1 The minimum bolt spacing and rolled edge distance and sheared edge distance from the centers of bolt holes to be maintained are given in Table 1.3

<table>
<thead>
<tr>
<th>Diameter of Bolt (mm)</th>
<th>Hole Diameter (mm)</th>
<th>Min. Bolt Spacing (mm)</th>
<th>Min. Rolled Distance (mm)</th>
<th>Min. Sheared Edge Distance (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>16</td>
<td>17.5</td>
<td>40</td>
<td>20</td>
<td>23</td>
</tr>
<tr>
<td>24</td>
<td>25.5</td>
<td>60</td>
<td>33</td>
<td>38</td>
</tr>
</tbody>
</table>

Bolts sizes mentioned above shall only be used. The minimum width of the flanges without bolt holes shall be 30 mm

1.6.6.2 For the purpose of calculating shearing stress and bearing stress for bolts clause 5.4 of IS: 802 (Part-1/Sec 2):1992 shall be referred.

1.6.7 SLENDERNESS RATIO
Slenderness ratio for members shall be computed in accordance with clause 6.4 of IS: 802 (Part-1/Sec 2):1992.

1.6.7.1 802(Part-1) 1977. Slenderness ratio for compression and tension members shall not exceed the values specified therein.

1.6.7.2 The following maximum limit of the slenderness ratio i.e. the ratio of unsupported length of the section in any plane to the appropriate radius of gyration will be adopted:

\[
\text{VALUE OF } \frac{KL}{R}
\]

a) For main corner leg members including the corner members of earthwire peak and the lower corner members of the cross-arms

\[ 120 \]

b) For other members having calculated stresses

\[ 200 \]

c) For redundant members

\[ 250 \]

d) For members having tensile stress only

\[ 375 \]

1.6.8 ERECTION STRESS

Where erection stress combined with other permissible co-existent stresses could produce a working stress in any members appreciably above the specified working stress, such other provision are to be made as may be necessary to bring the working stress within the specified limit.

1.6.9 STRUCTURAL ARRANGEMENT OF MEMBERS IN A TOWER

1.6.9.1 Lifting Points shall be provided in the tension tower and shall be designed for a load of 1020 Kgs assumed as acting at a 600 mm distance from the tip of the cross arm.

1.6.9.2 Internal angle between two members shall not be less than 15 degrees.

1.6.10 Design Calculation and Drawings

1.6.10.1 The following design calculation and drawings are required to be furnished to the Employer:

A) Alongwith the bid:

Detailed design calculations and drawings for DD type tower only.

B) After award of contract:

The Contractor shall submit detailed design of tower & extension alongwith stress diagram / computer output together with sample calculations for few critical members etc., stub templates and loading / rigging arrangement of tower testing to enable the Employer to make a preliminary check regarding structural stability of tower (before) tests.

1.6.10.2 After successful testing of tower and subsequent approval of design, drawings and bill of materials, the Contractor shall furnish the following in ten (10) copies to the Employer for necessary distribution with in fifteen(15) days after approval of drawings:

a) Detailed design calculation and drawing for towers and foundations.
b) Detailed structural drawings indicating section size, length of members, sizes of plates along with hole to hole distance & joint details etc.

c) Bill of materials, indicating cutting and bending details against each member.

d) Shop drawings showing all details relevant to fabrication.

e) All the drawings for the tower accessories.

1.6.10.3 The Contractor is required to submit four copies of the drawings as mentioned in clause 1.6.10.2 for Employer’s approval. While submitting the designs, structural drawings bill of materials and any other drawing pertaining to the subject transmission line, the Contractor shall clearly indicate on each drawing NEA Specification No., Name of the 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.

1.6.10.4 The design and drawings as covered in clause 1.6.10.1 (B) above shall be approved / commented by the Employer as the case may be within twenty eight (28) days of receipt of design / drawings in NEA office. If the design / drawings are commented by the Employer, the Contractor shall submit revised designs / drawings with in fifteen (15) days of date of issue of comments.

1.6.10.5 The Contractor is required to furnish the progress of submissions and approvals of designs and drawings on twenty fifth day of every month till the completion of all the design activities.

The details shall include description of design / drawing, schedule date of submission, actual date of submission schedule date of approval, actual date of approval, schedule date of submission of distribution copies, actual date of submission of distribution copies, schedule date of tower test, actual date of tower test and ‘Remarks’ column. Provision of six additional columns shall also be made in the above progress report to indicate date of comments issued by the Employer and details of submission of revised designs / drawings.

1.6.10.6 The tower accessories drawings like name plate, danger plate, phase plate, circuit plate, anticlimbing device, step bolt, D-shackle etc. shall also be prepared by the Contractor and shall be submitted to the Employer, in three copies, along with one reproducible, for record. These drawings shall be prepared in A4 size only.

1.6.10.7 All the drawings shall have a proper name plate clearly displaying the name of Employer on right hand bottom corner. The approval for exact format of the nameplate shall be obtained by the successful bidder from the Employer for adopting 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 NEPAL ELECTRICITY AUTHORITY (NEA). UNDER NO CIRCUMSTANCES THIS DRAWING SHALL BE USED BY ANYBODY WITHOUT PRIOR PERMISSION FROM NEA IN WRITING.

1.7 Materials

1.7.1 Tower Steel Sections
1.7.1.1 IS Steel Sections of tested quality of conformity with IS:2062:2011 grade E250 (Designated Yield Strength. 250 MPa) and/ or grade E350 (Designated Yield Strength 350 MPa) are to be used in towers, extensions, stubs and stub setting templates. For Snow Zone towers MS & HT Steel Sections shall conform to E250 Grade-C & E350 Grade-C respectively. The Contractor can use other equivalent grade of structural steel angle sections and plates conforming to latest International Standards viz BSEN 10025. 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.

1.7.1.2 Steel plates below 6mm size exclusively used for packing plates/packing washers produced as per IS : 1079 (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 or equivalent standard meeting mechanical strength/metallurgical properties corresponding to grade E250 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. SAILMA 350HI grade plate can also be accepted in place of HT plates (EN 10025 grade S355 JR/JO / IS 2062:2011 – grade E350, as applicable) provided SAILMA 350HI grade plate meet all the mechanical properties of plate as per EN 10025 grade S355 JR/JO (designated yield strength 355 MPa) / IS 2062: 2011 – grade E350.

1.7.1.3 For designing of towers, preferably rationalised steel sections shall be used. During execution of the project, if any particular section is not available, the same shall be substituted by higher section at no extra cost to Employer and the same shall be borne by the Contractor. However, design approval for such substitution shall be obtained from the Purchaser before any substitution.

1.7.2 Fasteners: Bolts, Nuts and Washers

1.7.2.1 All tower members shall be joined together with 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.

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

1.7.2.2 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).

1.7.2.3 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.

1.7.2.4 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.
1.7.2.5 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.

1.7.2.6 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.

1.7.2.7 Flat and tapered washers shall be provided wherever necessary. Spring washers shall be provided for insertion under all nuts. These washers shall be steel electro-galvanised, positive lock type and 3.5mm in thickness for 16mm diameter bolt and 4.5 mm for 24 mm bolt.

1.7.2.8 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.

1.7.2.9 The bolt positions in assembled towers shall be as per IS: 5613 (Part-II / Section 2) - 1976.

1.7.2.10 Bolts at the joints shall be so staggered that nuts shall be tightened with spanners without fouling.

1.7.2.11 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.

1.8 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.

1.8.1 Step Bolts & Ladders

Each tower shall be provided with step bolts conforming to IS: 10238 of not less than 16mm diameter and 175 mm 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 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 Employer’s 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.
1.8.2 **Insulator String 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 240KN for double suspension string for 220KV suspension towers. The design and supply of hanger, D-shackles, strain plates 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 by 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.

1.8.3 **Earth wire Clamp Attachments**

a) **Suspension Clamps**

Earth wire suspension clamps will be supplied by the contractor. The detailed drawing shall be submitted by the Contractor for Employer’s approval. The Contractor shall also supply U-bolts, D-shackles wherever required.

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 Employer’s approval for details of the attachments before the mass fabrication.

1.8.4 **Anti Climbing Device**

Barbed wire type anti climbing device, as per enclosed drawing 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.

1.8.5 **Danger, Number, Circuit and Phase plate**

Danger plates, Number plates, Circuit plates and Phase plates shall be provided and installed by the Contractor.

a) Each tower shall be fitted with a danger plate, number plate and one set of phase plates for double circuit tower. Circuit plates shall be provided on all The Double 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.
1.8.6 Aviation Requirements

1.8.6.1 Aviation requirements viz Span marker, night marker (obstruction light) and painting of towers conforming to IS: 5613 shall be in the scope of Contractor, wherever indicated in BPS.

1.8.6.2 Night Markers (Obstruction lights)

1.8.6.2.1 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.

1.8.6.2.2 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.

1.8.6.2.3 One set of Aviation Lights shall consist 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.

1.8.6.4 Medium Intensity Light

Medium Intensity light shall be provided on the top of each tower. The medium light should have 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 sequences 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 even if the pendency of contract expires. The light shall be equipped with radio suppression facility conforming to BS800 in order to avoid any interference with signals of PLCC etc.

1.8.6.5 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.

1.8.6.2.6 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.

1.8.6.2.7 Battery Box

The battery box suitable for mounting on 220kV 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.

1.8.6.2.8 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.

### 1.8.6.2.9 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 painted. 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.

### 1.8.6.2.10 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.

### 1.8.6.2.11 Earthing

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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.

1.9 Tower Fabrication

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

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

1.9.2 Butt splices shall be used and the inside angle and outside plate shall be designed to transmit the load. Inside cleat angle shall not be less than half the thickness of the heavier member connected plus 2mm. Lap splice may be used for connecting members of unequal sizes and the inside angle of lap splice shall be rounded at the heel to fit the root radius of the outside angle. All the splices shall develop full strength in the member connected through bolts. Butt as well as lap splice shall be made as above and as close to the main panel point as possible.

1.9.3 Joints shall be so designed as to avoid eccentricity as far as possible. The use of gusset plates for joining tower members shall be avoided as far as possible. However, where the connections are such that the elimination of the gusset plates would result in eccentric joints, gussets plates and spacers plates may be used in conformity with modern practices. The thickness of the gusset plates, required to transit stress shall not be less than that of members connected.

1.9.4 The use of filler in connection shall be avoided as far as possible. The diagonal web members in tension may be connected entirely to the gusset plate wherever necessary to avoid the use of filler and it shall be connected at the point of intersection by one or more bolts.

1.9.5 The tower structures shall be accurately fabricated to connect together easily at site without any undue strain on the bolts.

1.9.6 No angle member shall have the two leg flanges brought together by closing the angle.

1.9.7 Drilling and Punching

1.9.7.1 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.
1.9.7.2 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 punched 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.

1.9.7.3 All burrs left by drills or punch shall be removed completely. When the tower members are in position the holes shall be truly opposite to each other. Drilling or reaming to enlarge holes shall not be permitted.

1.9.8 Erection mark

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

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

A = Employer’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”

1.10 Quantities and weights

1.10.1 The provisional quantity of towers & extensions are mentioned in the respective Schedule of Prices. Final quantities shall be determined after completion and approval of the tower spotting & check survey. The final quantities of tower shall be confirmed by the Employer based on the required quantities of various towers & extensions furnished by the Contractor after completion of final tower spotting & check survey. Hence, it will be responsibility of the Contractor to intimate the exact requirements of all towers and various line materials required for line immediately after the tower spotting & check survey.

The Employer 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.

1.10.2 The estimated unit weight of each type of galvanized towers, stubs and leg extensions shall be furnished by the bidder. The weight of tower shall mean the weight of tower calculated by using the black sectional (i.e. un galvanized) 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 bevel cuts etc. but taking into consideration the weight of the anticlimbing devices, D shackles, hangers, strain plates, pack plates, gusset plates and pack washers etc. The weight of gusset plates shall mean the weight of its
circumscribing rectangle, without taking into consideration the reduction in weights 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, stubs and leg extensions as approved by the Employer. The rate quoted by the bidder for supply of tower / tower parts is deemed to be inclusive of galvanising charges including the cost of zinc.

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

1.11 Galvanising

1.11.1 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 stains, bulky white deposits / wet storage stains 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 sulfuric 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 Purchaser 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
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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 Purchaser 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 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 Purchaser 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 sulfuric 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
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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 Employer for approval as part of Quality Assurance Plan.

1.11.2. 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.

1.12 Earthing

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


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

1.12.1 The details for pipe & counterpoise type earthing are given in the drawings enclosed with these specifications.

1.12.2 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. In case resistivity does not come down less than 10 ohms even after providing 70 m counterpoise wire, Contractor shall submit a statement in this regard to Employer to know further course of action.

1.12.3 The provisional quantities for pipe type earthings and counterpoise earthing are furnished in the Price Schedule. The bidders are required to quote unit rates for the same in appropriate Price Schedule. 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 quotation shall be based on 120 meters of wire per tower.

1.12.4 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.

1.13 Inspection and Tests

1.13.1 General

All standard tests, including quality control tests, in accordance with appropriate Indian / International Standard, shall be carried out unless otherwise specified herein.

1.13.2 Inspection

In addition to the provision of GCC and Cl.1.7.3 of Section II of this Specification, the following shall also apply:

1.13.2.1 a) The Contractor shall keep the Purchaser 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.

1.13.2.2 The Employer 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 Employer’s material for satisfying himself that the fabrication is being done in accordance with the provisions of the Specification.

1.13.2.3 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.

1.13.2.4 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 Purchaser or his authorised representative considers that the defects can be rectified.

1.13.2.5 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 Employer.

1.13.2.6 All gauges and templates necessary to satisfy the Purchaser shall be supplied by the Contractor.

1.13.2.7 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.
1.14 Tower Load Tests

1.14.1 Testing of Tower

A Galvanized tower of each type complete with 9 M extension shall be subjected to design and destruction tests by first applying test loads applied in a manner approved by the Employer. The tower shall withstand these tests without showing any sign of failure or permanent distortion in any part. Thereafter the tower shall be subjected to destruction by increasing the loads further in an approved manner till it fails. The tower shall be tested for all the conditions considered for the design of tower. The Contractor shall submit to the Employer, for approval, the detailed programme and proposal for testing the towers showing the methods of carrying out the tests and manner of applying the loads. After the Employer has approved the test procedures and programmes the Contractors will intimate the Employer about carrying out the tests at least 30 days in advance of the scheduled date of tests during which the Employer will arrange to depute his representative to be present at the time of carrying out the tests. Six copies of the test reports shall be submitted. The Contractor shall submit one set of shop drawings along with the bill of materials at the time of prototype tower testing for checking the tower material. Further at the time of submitting test report, the contractor has to submit the final drawings of shop drawings and Bill of materials for Employer’s reference and record. The type testing charges shall be released only after approval of test report, structural drawings, bill of material and shop drawings of tower.

1.14.1.1 In case of premature failure the tower shall be retested and steel already used in the earlier test shall not be used again. However, in case of minor failures, the contractor can replace the members with higher section and carry out the testing. The Contractor shall provide facilities to the Employer or their representatives for inspection of materials during manufacturing stage and also during testing of the same.

1.14.1.2 In case of any premature failure even during waiting period, the tower is to be retested with rectified members. However, if the failures are major in nature and considerable portion of tower is to be re-erected, in such cases all the tests which has been carried out earlier are required to be re-conducted again in compliance with Specification.

1.14.1.3 No part of any tower subject to test shall be allowed to be used on the line. The price for the tower tests will be quoted after allowing rebate for the scrap value of the tower material which will be retained by the Contractor.

1.14.1.4 The Contractor shall ensure that the specification of materials and workmanship of all towers actually supplied conform strictly to the towers which have successfully under gone the tests. In case any deviation is detected, the Contractor shall replace such defective towers free of cost to the Employer. All expenditure incurred in erection, to and fro transportation and any other expenditure or losses incurred by Employer on this account shall be full born by the Contractor. No extension in delivery time shall be allowed on this account.

1.14.1.5 Each type of tower to be tested shall be a full scale prototype galvanized tower and shall be erected vertically on rigid foundation of the stub protruding above ground level as provided in the design/drawing between ground level and concrete level. This portion of the stub shall be kept un-braced while testing. The tower erected on test bed shall not be out of plumb by more than 1 in 360.
1.14.1.6 All the measuring instruments shall be calibrated in systematic / approved manner with the help of standard weight / device. Calibration shall be done before commencing the test of each tower up to the maximum anticipated loads to be applied during testing.

1.14.1.7 The suspension tower is to be tested with an arrangement similar to ‘I’ string. The tension tower is to be tested with strain plate as per approved design / drawings.

1.14.1.8 The sequence of testing shall be decided by the Employer at the time of approving the rigging chart / test data sheet.

1.14.1.9 The Employer may decide to carry out the tensile test, bend test etc. as per the relevant IS on few members of the test tower after completion of the test or in case of any premature failure. The Contractor shall make suitable arrangement for the same without any extra cost to the Employer.

1.14.1.10 Prefix ‘T’ shall be marked on all members of test tower in addition to the Mark No. already provided.

1.14.2 Method of Load Application

1.14.2.1 Loads shall be applied according to the approved rigging arrangement through normal wire attachments angles on bent plates.

1.14.2.2 The various types of loads, transverse, vertical and longitudinal shall be applied in such a way that there is no impact loading on the tower due to jerks from the winches.

1.14.2.3 All the loads shall be measured through a suitable arrangement of strain devices or by using weights. Positioning of the strain devices shall be such that the effect of pulley friction is eliminated. In case the pulley friction cannot be avoided, the same will be measured by means of standards weights and accounted for in the test loads.

1.14.3 Tower Testing Procedure

The procedure for conducting the tower test shall be as follows:

1.14.3.1 Bolt Slip Test

In a bolt slip test the test loads shall be gradually applied up to the 50% of design loads under normal condition, kept constant for two (2) minutes at that loads and then released gradually.

For measurement of deflection the initial and final readings on the scales(in transverse & longitudinal directions) before application and after the release of Loads respectively shall be taken with the help of theodolite. The difference between readings gives the values of the bolt slip.

1.14.3.2 Normal Broken Wire Load Tests

All the loads, for a particular load-combination test, shall be applied gradually up to the full design loads in the following steps and shall also be released in the similar manner:

25 percent,
50 percent,
75 per cent,
90 percent,
95 percent and
100 percent

1.14.3.3 **Observation Periods**

Under normal and broken wire load tests, the tower shall be kept under observation for sign of any failure for two minutes (excluding the time of adjustment of loads) for all intermediate steps of loading up to and including 95 percent of full design loads.

For normal, as well as broken wire tests, the tower shall be kept under observation for five (5) minutes (excluding the time for adjustment of loads) after it is loaded up to 100 percent of full design loads.

While the loading operations are in progress, the tower shall be constantly watched, and if it shows any tendency of failure anywhere, the loading shall be immediately stopped, released and then entire tower shall be inspected. The reloading shall be started only after the corrective measures are taken.

The structure shall be considered to be satisfactory, if it is able to support the specified full design loads for five (5) minutes, with no visible local deformation after unloading (such as bowing, buckling etc.) and no breakage of elements or constitute parts.

Ovalization of holes and permanent deformation of bolts shall not be considered as failure.

1.14.3.4 **Recording**

The deflections of the tower in transverse and longitudinal directions shall be recorded at each intermediate and final stage of normal load and broken wire load tests by means of a theodolite and graduated scale. The scale shall be of about one meter long with marking up to 5 mm accuracy.

1.14.3.5 **Destruction Test**

The destruction test shall be carried out under normal condition or broken wire condition. Under which load condition the destruction test is to be carried out shall be intimated to the contractor at the time of approving rigging chart / test data sheet.

The procedure for application of load for normal/broken wire test shall also be applicable for destruction test. However, the load shall be increased in steps of five (5) per cent after the full design loads have been reached.

1.15 **Packing**

1.15.1 Angle section shall be wire bundled.
1.15.2 Cleat angles, gusset plates, brackets, fillet plate, hanger and similar loose pieces shall be tied and bolted together in multiples or securely wired through holes.

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

1.15.4 The packing shall be properly done to avoid losses & damages during transit. Each bundle or package shall be appropriately marked.

1.16 Standards

1.16.1 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.

1.16.2 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 Standard</th>
<th>Title</th>
<th>International Standard</th>
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<tbody>
<tr>
<td>2.</td>
<td>IS 278-1991</td>
<td>Galvanised Steel Barbed wire</td>
<td>ASTM A131</td>
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<td>3.</td>
<td>IS 800-1991</td>
<td>Code of Practice for General Building Construction in Steel</td>
<td>CSA 6.1</td>
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<td></td>
<td>Sec 1-1995</td>
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<td></td>
<td>Sec 2-1992</td>
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<td></td>
<td>1990</td>
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<td>4(c).</td>
<td>IS:802(Part 3)-</td>
<td>Code of Practice for use of structural steel in Overload Transmission Line: Tower testing</td>
<td>ASCE 52 IEC 652</td>
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<td></td>
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<td>5.</td>
<td>IS:808-1991</td>
<td>Dimensions for Hot Rolled Steel Beam, Column, Channel and Angle Sections.</td>
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<td>7.</td>
<td>IS:1363-1990</td>
<td>Hexagon Nuts (size range M5 to M36)</td>
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<td>10.</td>
<td>IS:1573-1991</td>
<td>Electro-Plated Coatings of iron and Steel</td>
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<td>11.</td>
<td>IS:1852-1993</td>
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<td>17.</td>
<td>IS:2629-1990</td>
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<td>21.</td>
<td>IS:3757-1992</td>
<td>High Strength Structural Bolts</td>
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<tr>
<td>22.</td>
<td>IS:4759-1990</td>
<td>Specification for Hot zinc coatings on structural steel and other Allied products</td>
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<tr>
<td>23.</td>
<td>IS:5369-1991</td>
<td>General Requirements for Plain Washers</td>
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<tr>
<td>Sl. No.</td>
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</tbody>
</table>
  Section-1: Design Part 2,  
  Section-2: Installation and Maintenance |
| 25.    | IS:6610-1991    | Specification for Heavy Washers for Steel structures |
| 27.    | IS:6639-1990    | Hexagon Bolts for Steel Structure. |
  ASTM A394  
  ASTM A90 |
<p>| 29.    | IS:8500-1992    | Specification for Weldable Structural Steel (Medium &amp; High Strength Qualities) |
| 30.    | IS:10238-1989   | Step Bolts for Steel Structures |
| 32.    |                 | Indian Electricity Rules. |
| 33.    | Publication No. 19(N)/700 | Regulation for Electrical Crossing of Railway Tracks |</p>
<table>
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<tr>
<th><strong>Design, Supply, Installation and Commissioning of Kushma-New Butwal 220 kV Transmission Line</strong></th>
</tr>
</thead>
</table>
| **Rexdale (Ontario)**  
**Canada, M9W 1R3** |
| **DIN**  
**Deutsches Institute fiir Normung,**  
**Burggrafenstrasse 4-10**  
**Post Farh 1107**  
**D-1000, Berlin 30**  
**GERMANY** |
| **ASTM**  
**American Society for testing and Material**  
**1916 Race Street**  
**Philadelphia. PA**  
**1903-1187**  
**USA** |
| **Indian electricity Rules**  
**Regulation for electricity crossing**  
**of railway Tracks**  
**Kitab Mahal**  
**Baba Kharak singh Marg**  
**New Delhi-110001**  
**INDIA** |
| **ASTM**  
**American Society of civil Engineers**  
**345 East 47th Street**  
**New York, NY**  
**10017-2398**  
**USA** |
| **IEEE**  
**Institute of Electrical and Electronics Engineers 445 Hoes LanePiscataway, NJ**  
**0085-1331, USA** |
| **IEC**  
**International Electro technical Commission,**  
**Bureau Central de la Commission,**  
**electro Technique international,**  
**1 Rue de verembe,**  
**Geneva**  
**SWITZERLAND** |
2.0 **Foundations**

2.1 The foundation shall generally be of open cast type. Reinforced Cement concrete footing shall be used for all types of towers in conformity with the present day practices and the specification laid herein. Footings for all the four legs (without unequal chimney extension) of the tower and their extension shall be similar, irrespective of down thrust and uplift.

2.2 Foundation includes supply of all labour, tools & machineries, materials such as cement, sand, coarse aggregates and reinforcement steel. Rates quoted for foundations in appropriate schedules shall include transportation of construction materials to site, excavation, stub setting, concreting, reinforcement, shoring, shuttering, dewatering, stock piling, dressing, curing, backfilling the foundation after concreting with excavated / borrowed earth (irrespective of leads), consolidation of earth and carriage of surplus earth to the suitable point of disposal as required by the Employer or any other activities related to completion of foundation works.

2.3 **Classifications of Foundations**

Classification of foundations and design of foundation depend upon the type of soil, sub-soil water level and the presence of surface water which have been classified as follows:

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 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. If the clay content is more than 10% met in dry condition, the foundation shall be classified as Normal Dry.

2.3.3 **Wet**

To be used for locations where sub-soil water table is met between 1.5 meters from ground level and the depth of foundation below the ground level.

2.3.4 **Wet Cultivated**

To be used for locations where there is no sub-soil water within the foundation depth but which are in surface water for long period with water penetration not exceeding one meter below the ground level e.g paddy fields/cultivated field. However, if water penetration due to surface water is more than one meter below ground level, the adoption of suitable foundation shall be decided by site In-charge in consultation with corporate engineering deptt.

2.3.5 **Partially Submerged**

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

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

2.3.7 **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.

2.3.8 **Fissured - Rock**

To be used at locations where decomposed or fissured rock, hard gravel, kankar, limestone, laterite, conglomerates 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 1.5 meter below ground level, submerged fissured rock foundations shall be adopted. In case of dry locations dry fissured rock foundations shall be adopted.

2.3.9 **Hard Rock**

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

For quoting prices of Hard Rock foundations, Rock level shall be assumed at 1.5 meters below the ground level. Due to change in Rock level, no extra payment shall be payable on account of increase in concrete volume, excavation volume and weight of reinforcement, also no recovery shall be made if the actual volume of concrete, excavation and weight of reinforcement are less than that quoted in Schedule of prices. However, for design purpose, Rock level shall be considered at ground level and no over burden soil weight shall be considered for resisting the uplift.

2.3.10 The sub-soil water table is not constant and its level changes during different seasons due to various factors. In case during soil investigation/trial pit or during excavation, if wet soil / fissures rock is encountered within the foundation depth, it is to be considered that water table has been encountered (considering that water table had reached that level sometime in past) and accordingly type of foundation shall be classified.

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

2.3.12 The foundation classification at any particular location shall be based on the type of soil (clay / sandy / silt / fissured rock etc) and water table, presence of surface water, etc. at the location. However, in case of locations which are in vicinity of rivers, depending upon case to case, type of foundation is to be decided considering other aspects also e.g. in case RL (reduced level) of a location in comparison to the HFL is lower and there is possibility of submergence at the time of floods due to absence of river bunds / protection etc., FS type foundation with suitable raised chimney is to be
adopted. Further in case there is a possibility of change in river course, considering the nature and turbulence of probable water flow and subsequent scouring of soil, pile type or special foundation may be considered for these locations.

2.3.13 In addition to above, if required, depending on the site conditions special type foundations shall also be provided by the contractor suitable for intermediate conditions under the above classifications to effect more economy for following reasons:

(a) Shallow Depth or Raised Chimney foundations are necessarily required to suit the site condition or
(b) Soil properties as per the soil report at particular location are found inferior than that considered in design. However, in case, soil properties as per soil report are found superior than that considered in design, no change in foundation design / price shall be applicable.

2.3.14 The proposal for special foundations shall be submitted by the Contractor based on the detailed soil investigation report / to suit site conditions and approval for the same shall be obtained from the Employer. Decision of the Employer shall be final and binding with respect to requirement of special foundation. Payment for special foundation shall be made as explained in clause 6.3.2 of this section.

2.4 Type of Foundations

The Bidder shall offer open type of foundation (i.e. slab and chimney) with maximum depth of foundation as 3.0 meters for above classification of foundations depending on economy and feasibility of construction at site.

Bidder has to furnish along with the bid one sample calculation for each type of foundation required as per BPS for verification of correctness of design procedure adopted by the Bidder.

2.5 Soil Investigation

The contractor shall undertake soil investigation as per clause 4.0 of Section-3 at tower locations as approved by the Employer. The provisional number of soil testing locations is furnished in Schedule of Prices. Unit rates for the same are to be furnished by the bidder in appropriate Schedules of Price, for adjustment purpose with actual quantities required for soil testing.

2.6 Design of Foundations

2.6.1 Loads on Foundations

2.6.1.1 The foundations shall be designed to withstand the specific loads of the superstructure and for the full footing reactions obtained from the structural stress analysis in conformity with the relevant factors of safety.

2.6.1.2 The reactions on the footings shall be composed of the following type of loads for which these shall be required to be checked:

a) Max. Tension or uplift along the leg slope.

b) Max. Compression or down-thrust along the leg slope.
c) Max. Horizontal shear or side thrust.

2.6.1.3 Overload Factor for Foundation Loads:

The overload factor for foundation loads shall be considered as 1.1 i.e. the reaction on the foundations shall be increased by 10 percent.

2.6.2 Stability Analysis

2.6.2.1 In addition to the strength design, stability analysis of the foundation shall be done to check the possibility of failure by over-turning, uprooting, sliding and tilting of the foundation.

2.6.2.2 The following primary types of soil resistance shall be assumed to act in resisting the loads imposed on the footing in earth:

A) Resistance Against Uplift

The uplift loads will be assumed to be resisted by the weight of earth in an inverted frustum of a conical pyramid of earth as per formula detailed in Annexure -A of this Section on the footing pad whose sides make an angle equal to the angle of repose of the earth with the vertical, in average soil. The weight of concrete embedded in earth and that above the ground will also be considered for resisting the uplift. In case where the frustum of earth pyramids of two adjoining legs super-imposed each other, the earth frustum will be assumed truncated by a vertical plane passing through the centre line of the tower base.

B) Resistance Against Down Thrust

The down-thrust loads combined with the additional weight of concrete above earth will be resisted by bearing strength of the soil assumed to be acting on the total area of the bottom of the footings.

C) Resistance Against Side-Thrust

The lateral load capacity of a chimney foundation shall be based on chimney acting as a cantilever aided by passive earth resistance developed 500 mm below the ground level.

The chimney shaft shall be reinforced for the combined action of axial force, tension and compression and the associated maximum bending moment. In these calculations, the tensile strength of concrete shall be ignored.

The increase in vertical toe pressure due to maximum bending moment at the bottom of the slab shall be taken into account and the base itself shall be designed for structural adequacy. In this case, the allowable vertical toe pressure may be increased by 25%. The unit weight of reinforced concrete is stipulated in Table 2-2.

2.7 Design Criteria

2.7.1 As per IS: 456-2002 Partial safety factor shall be considered 1.5 for concrete and 1.15 for steel.
2.7.2 The overload factors for open type foundations shall be as 1.1 i.e. all the reactions (compression, tension and side thrust) on foundations shall be increased by 10 percent for development of foundation design.

2.7.3 The physical properties of soil under various conditions are furnished in TABLE 2.1 to be considered for the design of foundations. These type of foundations correspond to list of foundations furnished in Schedule of prices VOL III.

2.7.4 The composite rates quoted in Schedule of prices shall be payable for foundations developed based on above soil properties and classified as clause 4.2 of this Technical Specification. The composite rate shall be paid to the contractor for above foundations irrespective of change in approved design volumes in comparison to estimated Volumes. No extra payment shall be payable on account of increase in concrete volume, excavation volume, and at the same time no recovery shall be made from the composite foundation rates when the approved foundation volumes are less than quoted volumes. Further, once the foundations are classified based on the preponderant soil, the payment shall be made based on composite rate and extra claim is not admissible for excavation in different kinds of soil encountered inside the pit.

However, it may be noted that the soil properties furnished in TABLE 2.11 are tentative in nature. After soil investigations, if it is found that the foundations listed in Schedule of Prices Vol. III cannot be used at that location; new foundation design shall be developed by the Contractor based on properties furnished in soil report. The payment for these foundations shall be made based on unit rate quoted for excavation, concreting and reinforcement.

2.7.5 Particulars of the foundations, along with the estimated volumes of concrete weight of reinforcing bars and excavation volumes for the various types of towers shall be given in the bid. The foundation shall be designed such as to satisfy the following conditions:

2.7.6 The thickness of concrete in the chimney portion of the tower footing would be such that it provides minimum cover of not less than100 mm from any part of the stub angle to the nearest outer surface of the concrete in respect of all dry locations limiting the minimum section of chimney to 300 mm square .In respect of all wet location, the chimney should have all around clearance of 150 mm from any part of stub angle limiting to 450 mm square minimum.

2.7.7 The chimney top or muffing must be at least 225 mm above ground level and also the coping shall be extended up to lower most joint level between the bottom lattices and the main corner legs of the tower.

2.7.8 The centroidal axis of slab shall coincide with the axis of the chimney and pass through the center of foundation base. The design of the foundation(base slab and its reinforcement) shall take into account the additional stresses in the foundation resulting from the eccentricity introduced due to non-compliances of this requirement.

2.7.9 At least 100 mm thick pad of size equal to the base of slab with its sides vertical will be provided below the slab for R.C.C. type foundations.

2.7.10 In case of reinforced concrete slab, the slab thickness should not be less than 300 mm.
2.7.11 The minimum distance between the lowest edge of the stub angle and the bottom surface of concrete footing shall not be less than 100 mm or more than 150 mm in case of dry locations and not less than 150 mm or more than 200 mm in case of wet locations.

2.7.12 The total depth of open type foundations below the ground level shall not be less than 1.5 meters and more than 3.5 meters. To maintain the interchangeability of stubs for all types of foundations, for each type of tower, almost the same depths of foundations shall be used for different types of foundations.

2.7.13 The portion of the stub in the slab shall be designed to take full down-thrust or uplift loads by the cleats combined with the bond between stub angles and slab concrete. The Contractor shall furnish the calculation for uprooting of stub along with the foundation design. Bolted cleat angles evenly spaced in sets of 4 along all sides of embedded portion of the stub shall be provided to act as shear connector with sufficient number of bolts.

2.7.14 In case of R.C.C. foundations are having steel reinforcement in base slab, at least 50 mm. thick pad of lean concrete corresponding to 1:3:6 nominal mixes shall be provided to avoid the possibility of reinforcement rod being exposed due to unevenness of the bottom of the excavated pit.

2.7.15 The base slab of the foundation shall be designed for additional moments developing due to eccentricity of the loads.

2.7.16 The additional weight of concrete in the footing below ground level over the earth weight and the full weight of concrete above the ground level in the footing and embedded steel parts will also be taken into account adding to the down thrust.

<table>
<thead>
<tr>
<th>TABLE 2.1</th>
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<td><strong>PROPERTIES OF SOIL</strong></td>
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<td>1. <strong>For Normal Soil</strong></td>
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<tr>
<td>(a) Normal Dry Soil</td>
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<tr>
<td>(b) Wet Soil Due to Presence of Subsoil/Surface Water</td>
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<td>(c) Wet Black Cotton</td>
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<td>2. <strong>WEIGHT OF EARTH for Normal soil</strong></td>
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</table>
(a) Dry  
\[ \text{KN/M3 (Kg/M3)} = 14.12 \ (1440) \]

(b) In presence of Surface Water  
\[ \text{KN/M3 (Kg/M3)} = 14.12 \ (1440) \]

(c) In presence of Subsoil Water  
\[ \text{KN/M3 (Kg/M3)} = 9.22 \ (940) \]

3. **FISSURED ROCK**
   
   (a) Ultimate Bearing Capacity (both for Dry & Wet Fissured Rock)  
   \[ \text{KN/M2 (Kg/M2)} = 498 \ (50800) \]

   (b) WEIGHT OF FISSURED ROCK
   
   i) Dry  
   \[ \text{KN/M3 (Kg/M3)} = 14.12 \ (1440) \]

   ii) In presence of Subsoil Water  
   \[ \text{KN/M3 (Kg/M3)} = 9.22 \ (940) \]

   (c) ANGLE OF REPOSE
   
   i) Fissured Rock in Dry Portion  
   Degrees = 20

   ii) Fissured Rock in Presence of Water  
   Degrees = 10

4. **HARD ROCK**
   
   a) Ultimate Bearing Capacity  
   \[ \text{KN/M2 (Kg/M2)} = 1225.83 \ (125000) \]

   b) Ultimate Bond between steel  
   \[ \text{KN/M2 (Kg/M2)} = 0.147 \ (15) \]

5. **SANDY SOIL**
   
   (a) Ultimate Bearing Capacity  
   \[ \text{KN/M2 (Kg/M2)} = 498 \ (50800) \]

   (b) WEIGHT  
   \[ \text{KN/M3 (Kg/M3)} = 14.12 \ (1440) \]

   (c) ANGLE OF REPOSE  
   Degrees = 20

The above soil properties of the earth will be measured by the Contractor at the various locations in conformity with the standard method of testing and the foundation design will be revised suiting the site conditions from such tests.

2.8 **Properties of Concrete**

The cement concrete used for the foundations shall generally be of grade M-20 having 1:1.5:3 nominal volumetric mix ratio with 20mm coarse aggregate for chimney portion and 20mm/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.
2.8.1 The weight of concrete to be considered for design of foundations is given in TABLE 2.2.

### TABLE 2.2

**WEIGHT OF CONCRETE**

<table>
<thead>
<tr>
<th>TYPE OF CONCRETE</th>
<th>WEIGHT OF DRY REGION (\text{KN} / \text{M}^3(\text{Kg}/\text{m}^3))</th>
<th>WEIGHT IN PRESENCE OF SUB-SOIL WATER (\text{KN} / \text{M}^3(\text{Kg}/\text{m}^3))</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plain Concrete</td>
<td>21.96 (2240)</td>
<td>12.16 (1240)</td>
</tr>
<tr>
<td>Reinforced Concrete</td>
<td>23.54 (2400)</td>
<td>13.73 (1400)</td>
</tr>
</tbody>
</table>

2.8.2 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>

In this regard utilisation record is to be maintained at site.

2.8.3 Alternatively, Ready Mix concrete from batching plant as per IS 4925 can also be used used with no extra payment and without any recovery. However Cement content shall be as per IS 456. The ready mix concrete shall conform to IS:4926. The selection and use of Materials for the ready mix concrete shall be in accordance with IS:456. The concrete shall be of M20 grade design mix as per IS:456. The transport of concrete and transportation time shall be as per IS:4926.

2.8.4 a) 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.

b) Alternatively, other varieties of cement other than ordinary Portland Cement such as Portland Pozolana 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 from a reputed laboratory which will be obtained and submitted by the Contractor.

2.8.5 Concrete aggregates shall conform to IS: 383-1970.

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

2.8.7 Reinforcement shall conform to IS: 432-1966 for M.S bars and hard drawn steel wires and to IS: 1138-1966 and IS: 1786-1966 for deformed and cold twisted bars respectively. 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 intent of drawings and specifications.

2.9 Measurement, Unit Rates and Payment for Foundation

2.9.1 Measurement

2.9.1.1 The indicative shape of foundations is enclosed in this Specification. The bidder is required to quote the unit rates for different foundation types for a particular tower in the relevant Price Schedule.

2.9.1.2 The Bidder has to provide in the Bid the guaranteed foundation quantities (i.e. Excavation volume, Concrete volumes and Weight of Reinforcements) and unit rates for excavation, concreting and reinforcement for each type of foundation (as classified in clause 2.2 of this section) for each type of tower. Composite price quoted (as described in clause 3.4 of this section) in respective Schedule for each type of foundation must comply with unit rate quoted and guaranteed foundation quantities mentioned.

2.9.1.3 The concrete volume and dimensions of the foundation shall be determined from the drawing approved. Measurement of concrete volume shall be in cubic meters and shall be worked out to the second place of decimal

2.9.1.4 The excavation volumes for each tower footing shall be estimated assuming the faces of surrounding earth as vertical keeping a distance of 150 mm clearances from the extreme edge of the base slab of footing. For footings with undercut, excavation volumes shall be calculated as per drawings without any side clearance.

2.9.1.5 The steel required for reinforcement of foundation shall be provided by the Contractor. Measurement will be based on the calculated weights of actually used in tonnes corrected to third place of decimal, no allowance being made for wastage. No payments will be made for wire required for binding the reinforcement, chairs, bolsters and spacers, as the cost of these is deemed to be included in the unit rate quoted for the item of reinforcement.
2.9.2 UNIT RATE

2.9.2.1. 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 Employer or any other activity related to completion foundation work in all respect.

2.9.2.2 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 to completion of concreting works of foundation.

2.9.2.3 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.

2.9.3 Payment for Foundation

2.9.3.1 Normal Foundations

Payment of normal foundations classified under clause 4.2 of this section shall be made as described in clause 5.4 of this section. The rate of foundation per tower shall include transportation of construction materials to the Site, excavation, concreting, reinforcement, shoring, shuttering, dewatering, stock piling, dressing, curing, backfilling the foundation after concreting with excavated / borrowed earth (irrespective of leads), consolidation of earth and carriage of surplus earth to the suitable point of disposal as required by the Employer or any other activities related to completion of foundation works.

2.9.3.2 Special Foundations

Unit rates for the payment purpose for special foundations (excavation, concreting and reinforcement) shall be based on the unit rates quoted by the Bidder as per Clause 6.1.2 for the same soil type.

2.9.3.2.1 Excavation

The measurement for this item 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 Contract. 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 Employer shall be final and binding with respect to classification of soil and foundations. In case unit rates for the same soil type under different tower types are different then the lowest rate among them shall be used for the payment purpose.

2.9.3.2.2 Concrete
The payment for this item shall be made as per the actual volumes of concreting but limited to design volume based on unit rates for these items indicated in Contract.

2.9.3.2.3 Reinforcement

The measurement of reinforcement steel for payments shall be made based on the calculated weight of reinforcement steel as per relevant Indian Standard actually used in tones corrected to third place of decimal as calculated weight of steel as per design / working drawing whichever is less. No allowance will be made for wastage and others as per Clause 6.1.5.

2.10 CONSTRUCTION OF TOWER FOUNDATION

2.10.1 TESTING OF SOIL

2.10.1.1 The Contractor shall be required to undertake testing of soil for the tower locations in the manner specified under Clause 4.0 of section-3 of this Specification and shall submit his report about the subsoil water table, type of soil encountered, bearing capacity of soil, possibility of submergence and other soil properties required for the design of foundations. The Contractor shall also furnish soil resistivity values to the Employer along the line alignment.

2.10.2 Excavation

2.10.2.1 The excavation work for foundations shall be taken up by the Contractor after obtaining approval from Employer for the proposed stretch wise / section wise tower schedule, profile etc. prepared during Check / Detailed survey along the approved route alignment.

2.10.2.2 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 drawings 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 Employer. 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.

2.10.2.3 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, means of a spade and shovel or mechanically by proclains, excavator etc. Excavation done in dry soil for wet and fully submerged 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 and fully submerged 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 or by mechanical shovels 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.

2.10.2.4 However, where soil is of composite in nature, classification of foundation shall be according to the type of soil predominant in the footing and payment shall be made accordingly.

2.10.2.5 No extra payment shall be admitted for the removal of fallen earth into a pit or borehole once excavated. Shoring and timbering / shuttering as approved by authorised representative of the Employer shall be provided by the Contractor when the soil condition is so bad that there is likelihood of accident due to the falling of earth.

2.10.2.6 Where rock is encountered, the holes for tower footings shall preferably be drilled. Blasting where resorted to as an economy measure, if permitted by the Employer shall be done with utmost care to minimise fracturing of 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 Employer or his authorised representatives.

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

2.10.3 **Setting of Stubs**

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

2.10.3.2 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 Employer’s representative available at site where required and for which adequate advance intimation shall be given to Employer by Contractor. Tolerances as per provisions of IS: 5613 shall be allowed for stub setting.

2.10.3.3 Setting of stub at each location shall be approved by Employer.

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

2.10.3.5 As per the schedule testing of all four towers must be completed before the start of casting foundations. However, for any reason if the testing of tower gets delayed Contractor shall not hold the casting of foundation work and shall cast the foundations with the stub of untested tower as per the design at his own risk and cast. Accordingly Contractor shall keep enough safety while choosing the section for the stub /leg of last panel of tower to ensure that that the section for stub / leg of last panel shall not change during completion of tower testing.

2.10.4 **Stub Setting Templates / Props**

2.10.4.1 Stub setting templates shall be designed and arranged by the Contractor at his own cost for all types of towers with or without body extension. Stub templates for standard towers and towers with body extension upto 9 M 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 Employer. Stub templates / props should be painted.

2.10.4.2 The Contractor shall deploy sufficient number of templates / props (where ever required) for timely completion of the line without any extra cost to Employer.

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

2.10.4.4 Generally for a transmission line following number of stub setting templates shall be deployed by the Contractor:

<table>
<thead>
<tr>
<th>Templates for tower type</th>
<th>Nos. to be deployed</th>
</tr>
</thead>
<tbody>
<tr>
<td>DA</td>
<td>3</td>
</tr>
<tr>
<td>For each type of DB, DC</td>
<td>6 for DB and 3 Each for others</td>
</tr>
<tr>
<td>and DD type</td>
<td></td>
</tr>
</tbody>
</table>

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

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 **Mixing, Placing and Compacting of Concrete**

2.10.5.1 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 Employer. The water for mixing concrete shall be fresh, clean and free from oil, acids and alkalis. salty or blackish water shall not be used.
Alternatively, Ready Mix concrete from batching plant as per IS 4925 can also be used used with no extra payment and without any recovery. However Cement content shall be as per IS 456. The ready mix concrete shall conform to IS:4926. The selection and use of Materials for the ready mix concrete shall be in accordance with IS:456. The concrete shall be of M20 grade design mix as per IS:456. The transport of concrete and transportation time shall be as per IS:4926.

2.10.5.2 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.

2.10.5.3 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.

2.10.5.4 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.

2.10.5.5 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 compaction of the concrete. However, in case of difficult terrain, manual compaction may be permitted at the discretion of the Employer. 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 Employer. 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.

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

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

2.10.6 Curing

The concrete shall be cured by maintaining the concrete wet continuously 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 empty gunny bags around it and wetting the bags continuously during the critical 10 days period.

2.10.7 Backfilling and Removal of Stub Templates

2.10.7.1 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.

2.10.7.2 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 number 200 sieve as well as a black cotton soil is unacceptable for backfilling. The earth shall be deposited in maximum 200mm layers, leveled, 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 Geotechnical Report, Clause 3.0 of section 3. The density of the compacted backfill material may further be verified to the satisfaction of the Employer based on the sand-cone method described in the ASTM D1556-82 standard.

2.10.7.3 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 (Bandh) 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.

2.10.8 Benching

When the line passes through hilly / undulated terrain, leveling 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 Employer. Benching shall be resorted to only after approval from Employer. Volume of the earth to be cut shall be measured before cutting and approved by Employer for payment purposes. Further, to minimize benching, unequal leg extensions shall be considered and provided if found economical. If the levels of the pit centers be in sharp contrast with the level of tower centre, suitable leg extensions may be deployed as required. The proposal shall be submitted by the Contractor with detailed justification to the Employer.

2.10.9 Protection of Tower and Tower Footing

2.10.9.1 Tower shall be spotted such that the quantity of revetment is 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.

2.10.9.2 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 small water streams (Nalas), 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.

2.10.9.3 In protection of tower footings works the backfilling shall generally be done using soil excavated at site unless deemed 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 Price Schedules shall include the required lead and consolidation and leveling of earth after backfilling.

2.10.9.4 The provisional quantities for protection work of foundations are furnished in Price Schedule of Bid. The unit rates shall also be applicable for adjusting the actual quantities of protection works done. These unit rates shall hold good for protection work carried out on down hills or up hills slopes applicable for the tower locations.

2.10.9.5 The unit rates for random rubble masonry revetment quoted in price schedule shall also include excavation & (1:5) 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 quoted rates indicated in price schedule.

No extra rates shall be paid for allied work 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. The locations where both benching and protection of tower footing are envisaged, an economy got to be established against providing unequal leg extension.

2.10.9.6 For some of the locations in small water streams (Nalas), 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 (maximum.) 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 bidders shall indicate in the offer the sets of stringing equipment he would deploy exclusively for this transmission line package. The stringing equipment shall be of sufficient capacity to string simultaneously a bundle of TWIN ZEBRA Conductors.

3.1.2 The Contractor shall be responsible for transportation to site of all the materials to be provided by the Contractor as per the scope of work to site, proper storage and preservation at his own cost, till such time the erected line is taken over by the Employer.

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 Employer. Purchaser supplied items shall be dispatched to nearest store set up by the Contractor. At the store receipt, unloading and further transportation to the site shall be the entire responsibility of the Contractor.

3.1.4 Payment for stringing shall be done on the basis of per kilometer of line route length (conductor: comprising of three (3) phases with two (2) conductors per phase and earth wire: comprising of one (1) wire) and irrespective of number of tension/suspension towers. The units of measurement for erection of tower and its body extensions, installation of tower earthing and tower accessories, installation of
insulators, hardware fittings and conductor & earth wire accessories are indicated in the relevant Price Schedules

3.2 Treatment of Minor Damage in Galvanisation

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 Employer before erection.

3.3 Assembly of Tower

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 450 mm 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 plates, danger plates, phase plates, Circuit Plates and 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 10 mm. The welding shall be provided from ground level 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.

3.4.3 In addition to the tack welding of nuts with bolts, as described above, the Contractor can also propose some alternative arrangements, like use of epoxy resin adhesive which can serve the purpose of locking the nut permanently with the bolt and thus preventing pilferage of the tower members.

3.5 Insulator Hoisting

Suspension insulator strings shall be used on Suspension towers (DA) and double 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 5 kV (DC) Meger shall be carried out on 100% insulators. Corona control rings/arcing horn shall be fitted in an approved manner. The yoke arrangements be horizontal for tension string and vertical (parallel to transverse face of tower) for suspension strings. 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 from 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 to downwards 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.

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 Though towers shall be designed for one side stringing condition, towers shall be well guyed and all necessary steps shall be taken by the Contractor to avoid damage tower / conductor during stringing operations. Guying proposal along with necessary calculations shall be submitted by the Contractor to Employer for approval. All expenditure related to this work is deemed to be included in the Price quoted for stringing and no extra payment shall be made for the same.
3.6.1.6 When the line under construction 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 sides. 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 necessary, 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 cause damage to property, shall be used during stringing operations where roads, channels, telecommunication lines and power 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

3.3.1 The stringing of the conductor for 220 kV line 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.

3.3.2 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 Employer.
3.3.3 A controlled stringing method suitable for simultaneous stringing of the sub conductors shall be used. The two conductors making 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.

3.3.4 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 recommendations of the accessories manufacturer.

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 and small rivers with tension spans. 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 sleeve shall have all corners rounded, burrs and sharp edges removed and smoothened.

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 Tensioning and Sagging operations shall be done in accordance with the `approved stringing charts or sag tables before conductors and earth wire are finally attached to the towers through insulator strings and earth wire clamps respectively. 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 Dynamometers shall be employed for measuring tension in the conductor and earthwire. Dynamometers employed shall be periodically checked and calibrated with the standard Dynamometer.

3.9.3 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.

3.9.4 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.

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

3.9.6 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. Conductor shall be fitted with armor rods where it is made to pass through suspension clamps.

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 (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 / earthwire 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 conductors. Torque wrench shall be used for fixing the Spacers, Vibration 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 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.
Quantify of Conductor = Final Line Length as per Detailed/Check survey x 3 phases x Nos. of conductor per bundle (for Single Circuit Strung Double Circuit Line)

Quantity of Earth wire = Final Line Length as per Detailed/Check survey x nos. of ground wires to be strung.

3.13.2 All though extra consumption over and above the quantities incorporated in the works is not permitted, the Contractor shall make every effort to minimise breakage, losses and wastage of the line materials during erection.

3.13.3 The quantity of conductor and earth wire as described above shall also consider necessary sag, jumpering, damage, loss and wastage etc.

3.13.4 The Contractor shall not be required to return to the Employer 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 Employer and the unused conductor or earth wire in such drums shall be treated as waste.

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

3.13.7 The quantities of line materials to be supplied by the contractor (i.e. Conductor, Earth wire, Hardware fittings & Accessories) as indicated in the bill of quantities are tentative and the actual quantity shall depend upon detailed survey/check survey. Contractor shall be responsible for regulating the supplies of contractor supplied materials in the basis of actual requirements.

3.14 Final checking, Testing and Commissioning

3.14.1 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 Employer. 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 from 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 etc. 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 foundation design & working drawings, tower design, structural drawings, bill of material and shop drawings of all towers are submitted to the Employer for reference and record.

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

k) All towers are properly grounded.

l) The line is tested satisfactorily for commissioning purpose.

m) The right of way along the route of line is clear of all obstructions and meets requirements of clause 5.3 of IS:5613 (Part-3, Section – 2)

n) Any defect found as a result of testing shall be rectified by the contractor forthwith to the satisfaction of the Employer without any extra charges.

o) Before taking over the line by the Employer, the line shall be energized at full specified voltage.

3.14.2 The contractor should also fulfill the requirements of pre-commissioning

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.
Field Quality Plan for Transmission Lines

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Description of Activity</th>
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<th>Tests/Checks to be done</th>
<th>Ref. documents</th>
<th>Check/Testing</th>
<th>Counter Check/Test by Owner</th>
<th>Accepting authority in Owner</th>
</tr>
</thead>
</table>
|        |                         | b. Route profiling & | b. Topographical map  
|        |                         | tower spotting.     | c. Tower spotting datas given by Engg. |  | Contractor | 100% at Field | 100% based on record documents | To be notified by the Owner (NEA) |
|        |                         |                     |                         | a. Sag template  
|        |                         | b. Tower Spotting data | b. Tower Spotting data | Contractor | 100% at Field | 100% based on record documents | To be notified by the Owner (NEA) |
|        |                         | c. Route alignment  | c. Route alignment | Contractor | 100% at Field | i) All angle towers in plains and 50% in hilly terrains.  
|        |                         |                     |                         |  |  | ii) Final length to be checked on 100% basis based on records/documents | To be notified by the Owner (NEA) |
| 2.     | Check Survey            | Tower Location & Final Length | i) Alignment  
|        |                         |                     | ii) Final Length  
|        |                         | a. Route alignment  | a. Route alignment | Contractor | 100% at Field | i) All angle towers in plains and 50% in hilly terrains.  
<p>|        |                         | b. Tower Schedule  | b. Tower Schedule | Contractor | 100% at Field | ii) Final length to be checked on 100% basis based on records/documents | To be notified by the Owner (NEA) |
|        |                         | c. Profile          | c. Profile            |  |  |  | To be notified by the Owner (NEA) |
|        |                         |                     | 2. SPT Test            | As per Owner Specification | Contractor | 100% at Field | To witness 20% at Field | To be notified by the Owner (NEA) |</p>
<table>
<thead>
<tr>
<th>S. No.</th>
<th>Description of Activity</th>
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<th>Check/Testing</th>
<th>Counter Check/Test by Owner</th>
<th>Accepting authority in Owner</th>
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<tbody>
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<tr>
<td>b.</td>
<td>Tests on samples</td>
<td></td>
<td></td>
<td>As per tech. Specs.</td>
<td>Lab appd. By Owner</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>As per Owner Specification</td>
<td></td>
<td></td>
<td>To be notified by the Owner(NEA)</td>
</tr>
<tr>
<td>A.</td>
<td>Materials</td>
<td></td>
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</tr>
<tr>
<td>1.</td>
<td>Cement</td>
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</tr>
<tr>
<td>1.</td>
<td>Source approval</td>
<td></td>
<td></td>
<td>Source meeting Owner Specification/Approved vendor</td>
<td>Contractor</td>
<td>As proposed by Contractor</td>
<td>To verify the proposal based on the supply made and factory test results.</td>
</tr>
<tr>
<td>2.</td>
<td>Physical tests</td>
<td></td>
<td></td>
<td>As per document at Annexure-I of this FQP at Pg. 12, 13 &amp; 14.</td>
<td>Samples to be taken jointly with Owner and tested at Owner approved lab</td>
<td>Review of all MTC’s and one sample for every 500 MT</td>
<td>100% review of lab test results</td>
</tr>
<tr>
<td>3.</td>
<td>Chemical Tests</td>
<td></td>
<td></td>
<td>-do-</td>
<td>Contractor to submit MTC</td>
<td>100% review of MTC by Contractor</td>
<td>100% review of MTC</td>
</tr>
<tr>
<td>2.</td>
<td>Reinforcement Steel</td>
<td></td>
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</tr>
<tr>
<td>1.</td>
<td>Source approval</td>
<td></td>
<td></td>
<td>To be procured from main producers only.</td>
<td>Contractor</td>
<td>As proposed by Contractor</td>
<td>To review the proposal based on the documents.</td>
</tr>
<tr>
<td>2.</td>
<td>Physical and Chemical analysis test</td>
<td></td>
<td>As per annexure-2 of this FQP at pg. 15</td>
<td>Contractor to submit MTC</td>
<td>All MTC’s</td>
<td>100% review of MTC</td>
<td>-do-</td>
</tr>
</tbody>
</table>

**Design, Supply, Installation and Commissioning of Kushma-New Butwal 220 kV Transmission Line**

**SECTION-IVA**

(Volume-II)

ICB-PMD-KGTC0-072/73-04
### Design, Supply, Installation and Commissioning of Kushma-New Butwal 220 kV Transmission Line

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<tr>
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<th>Check/Testing</th>
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</tr>
<tr>
<td>3.</td>
<td>Coarse Aggregates</td>
<td>1. Source approval</td>
<td>Source meeting Owner 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 Owner approved lab</td>
<td>To review the proposal based on the documents</td>
<td>To be notified by the Owner(NEA)</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 Owner approved lab</td>
<td>One sample per lot of 200 cum or part thereof</td>
<td>100% review of lab test results</td>
<td>- do-</td>
</tr>
<tr>
<td>4.</td>
<td>Fine aggregate</td>
<td>1. Source approval</td>
<td>Source meeting Owner 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 Owner approved lab</td>
<td>To review the proposal based on the documents</td>
<td>- do-</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 Owner approved lab</td>
<td>One sample per lot of 200 cum or part thereof</td>
<td>100% review of lab test results</td>
<td>- do-</td>
</tr>
<tr>
<td>5.</td>
<td>Water</td>
<td>1. Cleaniness (Water shall be fresh and clean)</td>
<td>Owner Specification</td>
<td>Contractor</td>
<td>100% visual check at Field</td>
<td>Verification at random</td>
<td>- do-</td>
</tr>
</tbody>
</table>
## Design, Supply, Installation and Commissioning of Kushma-New Butwal 220 kV Transmission Line

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<tr>
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<th>Check/Testing</th>
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</tr>
<tr>
<td>2.</td>
<td>Suitability of water for concreting</td>
<td>Owner Specification</td>
<td>Contractor</td>
<td>100% Visual Check at Field</td>
<td>Verification at random</td>
<td></td>
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<tr>
<td><strong>B. Classification</strong></td>
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</tr>
<tr>
<td>1.</td>
<td>Visual observation of soil strata</td>
<td>Owner Specification</td>
<td>Contractor</td>
<td>100% at Field</td>
<td>100% at Field</td>
<td>- do-</td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td>Ground water level</td>
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<tr>
<td>3.</td>
<td>History of water table in adj. Area/surface water</td>
<td></td>
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<tr>
<td>4.</td>
<td>Soil Investigation wherever required</td>
<td></td>
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<tr>
<td><strong>C. Concrete Works</strong></td>
<td></td>
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</tr>
<tr>
<td>a.</td>
<td>Before concreting</td>
<td></td>
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<td></td>
<td></td>
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<tr>
<td>1.</td>
<td>Bottom of excavated earth</td>
<td>Depth of foundation</td>
<td>Appl. Drgs.</td>
<td>Contractor</td>
<td>100% at Field</td>
<td>100% check by Owner</td>
<td>- do-</td>
</tr>
<tr>
<td>2.</td>
<td>Stub setting</td>
<td>1) Centre Line</td>
<td>-do-</td>
<td>-do-</td>
<td>-do-</td>
<td>-do-</td>
<td>-do-</td>
</tr>
<tr>
<td>3.</td>
<td>Reinforcement steel</td>
<td>Placement</td>
<td>Bar bending schedule</td>
<td>-do-</td>
<td>-do-</td>
<td>-do-</td>
<td>-do-</td>
</tr>
<tr>
<td>b.</td>
<td>During concreting</td>
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</tbody>
</table>
### Design, Supply, Installation and Commissioning of Kushma-New Butwal 220 kV Transmission Line

#### SECTION-IVA (Volume-II)

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<tr>
<th>No. of Activity</th>
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<th>Extent</th>
<th>Counter Check/Test by Owner</th>
<th>Accepting authority in Owner</th>
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</thead>
<tbody>
<tr>
<td>1. 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>- do-</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. 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 Owner 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 Owner officials</td>
<td>- do-</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Erection of Super-structure</td>
<td>1. Sequence of erection</td>
<td>As per Appd. Drgs./Owner</td>
<td>Contractor</td>
<td>100% at field</td>
<td>100% check</td>
<td>- do-</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### Design, Supply, Installation and Commissioning of Kushma-New Butwal 220 kV Transmission Line

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<tr>
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<th>Check/Testing Agency</th>
<th>Extent</th>
<th>Counter Check/Test by Owner</th>
<th>Accepting authority in Owner</th>
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</thead>
<tbody>
<tr>
<td>2.</td>
<td>Check for completeness</td>
<td>-do-</td>
<td>-do-</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>Tightening of nuts and bolts</td>
<td>-do-</td>
<td>-do-</td>
<td>-do-</td>
<td>-do-</td>
<td>-do-</td>
<td>-do-</td>
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<tr>
<td>4.</td>
<td>Check for verticality</td>
<td>-do-</td>
<td>-do-</td>
<td>-do-</td>
<td>-do-</td>
<td>-do-</td>
<td>-do-</td>
<td>-do-</td>
</tr>
<tr>
<td>5.</td>
<td>Tack welding for bolts &amp; nuts</td>
<td>Owner Specification</td>
<td>Contractor</td>
<td>100% at Field</td>
<td>100% Check</td>
<td>- do-</td>
<td>- do-</td>
<td>- do-</td>
</tr>
<tr>
<td>3.</td>
<td>Tower footing resistance (TFR)</td>
<td>TFR at locations before and after earthing.</td>
<td>Owner Specification</td>
<td>Contractor</td>
<td>100% at Field</td>
<td>20% locations to be verified</td>
<td>- do-</td>
<td>- do-</td>
</tr>
<tr>
<td>7.</td>
<td>Stringing</td>
<td>1. Materials</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>- do-</td>
<td>- do-</td>
</tr>
<tr>
<td>a.</td>
<td>Insulators</td>
<td>1. Visual check for cleanliness/glazing/ cracks/and white spots.</td>
<td>Owner Specification</td>
<td>Contractor</td>
<td>100% at Field</td>
<td>100% verification of records and to carry random checks 10%</td>
<td>- do-</td>
<td>- do-</td>
</tr>
<tr>
<td>2.</td>
<td>IR Value</td>
<td>(min. 50M Ohms)</td>
<td>-do-</td>
<td>One test per sample size of 20 for every lot of 10,000</td>
<td>To verify Contractor’s records 100% and joint check 20% of total tests</td>
<td>-do-</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.</td>
<td>E&amp;M test</td>
<td>-</td>
<td>Insulator supplier</td>
<td>a. 20 per 10,000 for discs</td>
<td>Collection of samples, sealing them and handing</td>
<td>Tests to be witnessed/</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>4. Traceability (Make/batch No./Locations where installed)</td>
<td>Packing list/CIP</td>
<td>Contractor</td>
<td>100% at field</td>
<td>100% Review of records</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
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<td></td>
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<td></td>
</tr>
</tbody>
</table>

b. 3 per 1500 for long rod over by Owner to Insulator supplier

Appd. at Manufacturer's works

To be notified by the Owner (NEA)
## Design, Supply, Installation and Commissioning of Kushma-New Butwal 220 kV Transmission Line

<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 Owner</th>
<th>Accepting authority in Owner</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>b. Conductor</td>
<td>On receipt,</td>
<td></td>
<td>Packing list</td>
<td>Contractor</td>
<td>100% at stores</td>
<td>20% check</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1. Visual check of drum.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>To be notified by the Owner(NEA)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2. Check for seals at both ends, and Owner sticker on outer end</td>
<td>-do-</td>
<td>-do-</td>
<td>-do-</td>
<td>-do-</td>
<td>-do-</td>
</tr>
<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>
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<tr>
<td>2</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>
</tr>
<tr>
<td>3</td>
<td>2. Field activity</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>a. Before Stringing</td>
<td>Readiness for stringing</td>
<td>Stringing procedures as per Owner specification</td>
<td>Contractor</td>
<td>Readiness certificate to be submitted by the Contractor</td>
<td>Review of Certificate</td>
<td>-do-</td>
</tr>
<tr>
<td></td>
<td>b. During stringing</td>
<td>(Conductor/Earthwire)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>-do-</td>
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</tbody>
</table>
# Design, Supply, Installation and Commissioning of Kushma-New Butwal 220 kV Transmission Line

<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>
</tr>
</thead>
<tbody>
<tr>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Check/Testing</td>
<td>Counter Check/Test by Owner</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Agency</td>
<td>Extent</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Contractor</td>
<td>100% at Field</td>
</tr>
<tr>
<td>1.</td>
<td>Scratch/cut check (Visual)</td>
<td></td>
<td></td>
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<tr>
<td>2.</td>
<td>Repair sleeve</td>
<td>-do-</td>
<td>-do-</td>
<td>-do-</td>
<td></td>
</tr>
<tr>
<td>3.</td>
<td>Mid span Joints</td>
<td>-do-</td>
<td>-do-</td>
<td>-do-</td>
<td></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>
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<tr>
<td></td>
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</tr>
<tr>
<td>c.</td>
<td>After stringing</td>
<td>Check for,</td>
<td></td>
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<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.</td>
<td>Sag/Tension chart/tower Spotting data</td>
<td>-do-</td>
<td>-do-</td>
<td>100% record &amp; Field check 20%</td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td>As per appd. Drgs./Owner specifications</td>
<td>-do-</td>
<td>-do-</td>
<td></td>
<td></td>
</tr>
<tr>
<td>i)</td>
<td>Ground clearance</td>
<td>-do-</td>
<td>-do-</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ii)</td>
<td>Live metal clearance etc.</td>
<td>-do-</td>
<td>-do-</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.</td>
<td>Jumpering</td>
<td>-do-</td>
<td>-do-</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**S. No.**

**Description of Activity**

**Items to be Checked**

**Tests/Checks to be done**

**Ref. documents**

**Check/Testing**

**Counter Check/Test by Owner**

**Accepting authority in Owner**

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(Volume-II)  
ICB-PMD-KGTCP-072/73-04  
9
### Design, Supply, Installation and Commissioning of Kushma-New Butwal 220 kV Transmission Line

<table>
<thead>
<tr>
<th>No. of Activity</th>
<th>done</th>
<th>Agency</th>
<th>Extent</th>
<th>authority in Owner</th>
</tr>
</thead>
<tbody>
<tr>
<td>4. Copper bond</td>
<td>As per Appd. Drgns./Owner Specification</td>
<td>Contractor</td>
<td>100% at Field</td>
<td>100% record &amp; Field Check 20%</td>
</tr>
<tr>
<td>5. Placement of spacer/damper</td>
<td>As per Specn./drgs/placement chart</td>
<td>-do-</td>
<td>-do-</td>
<td>-do-</td>
</tr>
<tr>
<td>8. Final Testing</td>
<td></td>
<td></td>
<td></td>
<td>-do-</td>
</tr>
<tr>
<td>a. Pre-commissioning of lines</td>
<td>a. Readiness of lines for pre-commissioning</td>
<td>1. Completeness of line. 2. Meggar test of line</td>
<td>Owner latest pre-commissioning procedures (Doc. No. D-2-01-70-01-00)</td>
<td>Contractor</td>
</tr>
<tr>
<td>b. Commissioning of line</td>
<td>Readiness of lines for commissioning</td>
<td>2. Digital photograph of each tower to ascertain the completeness of tower.</td>
<td>a. Owner latest pre-commissioning procedures b. Pre-commissioning Report</td>
<td>-do-</td>
</tr>
</tbody>
</table>
### Design, Supply, Installation and Commissioning of Kushma-New Butwal 220 kV Transmission Line

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Description of Activity</th>
<th>Tests/Checks to be done</th>
<th>Ref. documents</th>
<th>Check/Testing</th>
<th>Counter Check/Test by Owner</th>
<th>Accepting authority in Owner</th>
</tr>
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</tr>
<tr>
<td>3.</td>
<td>Electrical Inspectors clearance</td>
<td>-do-</td>
<td></td>
<td>-do-</td>
<td></td>
<td>-do-</td>
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</table>
### ORDINARY PORTLAND 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></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>To be conducted in apprd. Lab</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>Blaine’s air permeability method as per IS 4031 (Part-2)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>168+/−2 hour : Not less than 22 Mpa (22 N/mm²)</td>
<td>168+/−2 hour : Not less than 33 Mpa (33 N/mm²)</td>
<td>168+/−1 hour : Not less than 37 Mpa (37 N/mm²)</td>
<td>As per IS 4031 (Part-6)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>672+/−4 hour : Not less than 33 Mpa (33 N/mm²)</td>
<td>672+/−4 hour : Not less than 43 Mpa (43 N/mm²)</td>
<td>672+/−1 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></td>
</tr>
<tr>
<td>(iv)</td>
<td>Soundness</td>
<td>Uneaerated cement shall not have an expansion of more than 10mm when tested by Le Chatlier and 0.8% Autoclave test.</td>
<td>Uneaerated cement shall not have an expansion of more than 10mm when tested by Le Chatlier and 0.8% Autoclave test.</td>
<td>Uneaerated 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>
</tbody>
</table>
### Design, Supply, Installation and Commissioning of Kushma-New Butwal 220 kV Transmission Line

<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></td>
<td>b) Chemical composition tests</td>
<td></td>
<td></td>
<td></td>
<td>Review of MTCC only</td>
</tr>
<tr>
<td></td>
<td>a) 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></td>
<td>b) 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></td>
<td>c) 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></td>
<td>d) 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></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>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>
</tbody>
</table>

**SELECTION-IVA**
(Volume-II)  
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### Design, Supply, Installation and Commissioning of Kushma-New Butwal 220 kV Transmission Line

#### 2. POZZOLANA PORTLAND CEMENT AS PER IS 1489

<table>
<thead>
<tr>
<th>a) Physical tests</th>
<th>i) Fineness</th>
<th>Specific surface area shall not be less than 300 sq.m. per Kg. or 3000 Cm²/gm</th>
</tr>
</thead>
</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 |

<table>
<thead>
<tr>
<th>b) Chemical composition tests</th>
<th>a) Magnesia percentage by mass Max. 6%</th>
<th>Review of MTCC only</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>b) Insoluble material, percentage by mass x + 2 (100-x)/100 where x is the declared % of pozzolana in the PPC</td>
<td>-do-</td>
</tr>
<tr>
<td></td>
<td>c) Total sulphur content calculated as sulphuric 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.</td>
<td>-do-</td>
</tr>
</tbody>
</table>

| 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></td>
<td>Sulphur 0.055%</td>
<td>Sulphur 0.060%</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Phosphorus 0.055%</td>
<td>Phosphorus 0.060%</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Sulphur &amp; Phosphorus 0.11%</td>
<td></td>
</tr>
<tr>
<td>ii)</td>
<td>Physical tests</td>
<td>a) Ultimate Tensile stress</td>
<td>a) Ultimate Tensile stress</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>For all dia bars 410 N/Sq.mm. (min.)</td>
<td>10% more than actual 0.2% proof stress but not less than 485 N/Sq.mm.</td>
<td>Testing in approved lab</td>
</tr>
<tr>
<td></td>
<td></td>
<td>b) Yield stress (N/Sq.mm) min.</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>For bars upto 20 mm dia 250</td>
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<td></td>
<td>For bars above 20 mm dia 240</td>
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<tr>
<td></td>
<td></td>
<td>c) Percentage of elongation 23%</td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>b) 0.2% of proof stress/Yield stress</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>(N/Sq.mm) min.</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>For bars upto 20 mm dia 415</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>c) Percentage of elongation 14.5% (min.)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>iii)</td>
<td>Bend &amp; Rebend tests</td>
<td>Pass</td>
<td>Pass</td>
<td></td>
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<td></td>
<td></td>
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</tbody>
</table>
### 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>%age passing for Single-Sized Aggregate of nominal size</th>
<th>Percentage Passing for grades Aggregate of nominal size</th>
</tr>
</thead>
<tbody>
<tr>
<td>40 mm</td>
<td>63 mm</td>
<td>100</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>40 mm</td>
<td>85 to 100</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td>20 mm</td>
<td>0 to 20</td>
<td>85 to 100</td>
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<tr>
<td></td>
<td>16 mm</td>
<td>-</td>
<td>85 to 100</td>
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<tr>
<td></td>
<td>12.5 mm</td>
<td>-</td>
<td>85 to 100</td>
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<td></td>
<td>10 mm</td>
<td>0 to 5</td>
<td>0 to 20</td>
</tr>
<tr>
<td></td>
<td>4.75 mm</td>
<td>-</td>
<td>0 to 5</td>
</tr>
<tr>
<td></td>
<td>2.36 mm</td>
<td>-</td>
<td>0 to 5</td>
</tr>
<tr>
<td>b.</td>
<td>Flakiness index</td>
<td>Not to exceed 25%</td>
<td></td>
</tr>
<tr>
<td>c.</td>
<td>Crushing Value</td>
<td>Not to exceed 45%</td>
<td></td>
</tr>
<tr>
<td>d.</td>
<td>Presence of deletrious material</td>
<td>Total presence of deleterious materials not to exceed 5%</td>
<td></td>
</tr>
<tr>
<td>e.</td>
<td>Soundness test (for concrete work subject to frost action)</td>
<td>12% when tested with sodium sulphate and 18% when tested with magnesium sulphate</td>
<td></td>
</tr>
</tbody>
</table>
## ACCEPTANCE CRITERIA AND PERMISSIBLE LIMITS FOR FINE AGGREGATES AS PER IS 383

<table>
<thead>
<tr>
<th>i) Physical Tests</th>
<th>IS Sieve Designation</th>
<th>Percentage passing for graded aggregate of nominal size</th>
</tr>
</thead>
<tbody>
<tr>
<td>a) Determination of particle size</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10 mm</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>4.75 mm</td>
<td>90-100</td>
<td>90-100</td>
</tr>
<tr>
<td>2.36 mm</td>
<td>60-95</td>
<td>75-100</td>
</tr>
<tr>
<td>1.18 mm</td>
<td>30-70</td>
<td>55-90</td>
</tr>
<tr>
<td>600 microns 12.5 mm</td>
<td>15-34</td>
<td>35-59</td>
</tr>
<tr>
<td>300 microns</td>
<td>5 to 20</td>
<td>8 to 30</td>
</tr>
<tr>
<td>150 microns</td>
<td>0-10</td>
<td>0-10</td>
</tr>
<tr>
<td>b) Silt content</td>
<td></td>
<td>Not to exceed 8%</td>
</tr>
<tr>
<td>c) Presence of deleterious material</td>
<td></td>
<td>Total presence of deleterious materials shall not exceed 5%</td>
</tr>
<tr>
<td>d) Soundness Applicable to concrete work subject to frost action</td>
<td></td>
<td>12% when tested with sodium sulphate and 15% when tested with magnesium sulphate</td>
</tr>
</tbody>
</table>
ACCEPTANCE CRITERIA AND PERMISSIBLE LIMITS FOR CONCRETE WORK

| 1) | Concrete | a) Workability | Slump shall be recorded by slump cone method and it shall 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 aggregate: 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%, Project Manager, 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 Project Manager.
   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 be 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 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) Contractor shall be responsible for implementing/documenting the FQP. Documents shall be handed over by the contractor to Owner after the completion of the work.

3) Acceptance criteria and permissible limits for tests are indicated in the Annexure. However for further details/tests Owner specification and relevant Indian standards shall be referred.

4) Tests as mentioned in this FQP shall generally be followed.
## TECHNICAL SPECIFICATIONS

### SECTION-V-B

## CONTENTS

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<th>Description</th>
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<td>Technical Description of HTLS conductor</td>
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<td>3.0</td>
<td>Annexure-A</td>
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</table>
1. Description of High Temperature Low Sag Conductor and its Technical Requirements

1.1 The offered HTLS Conductor shall be capable of providing the maximum ampacity of 1200 A at a continuous operating conductor temperature not exceeding the maximum permissible operating temperature for continuous operation of the offered HTLS Conductor and without exceeding the level of maximum permissible sag indicated below at Clause 1.2.1

The physical and operating performance requirements of the transmission line with HTLS conductor are mentioned below. The bidder shall offer HTLS conductor complying with the specified requirements. The Bidder shall indicate particulars of the proposed conductor in the relevant GTP schedule of BPS along with calculations to establish compliance with the specified requirements.

1.2 Current Carrying Capacity/Ampacity Requirements

1.2.1 Each conductor shall be suitable to carry minimum 1200 Amperes of 50 Hz alternating current under the ambient conditions & maximum conductor sag specified below while satisfying other specified technical requirements/parameters:

- Elevation above sea level = 0 m
- Ambient temperature: 45 deg C
- Solar Absorption coefficient = 0.8
- Solar Radiation = 1045 watt/sq.m
- Emisitivity Constant = 0.45
- Wind velocity considering angle between wind & axis of conductor as 90 degrees = 0.56 m/sec
- Effective angle of incidence of sun’s rays = 90 deg

Maximum permissible Conductor sag for 350 m span at steady state conductor temperature and nil wind corresponding to 50 Hz alternating current of 1200 Amperes per conductor under ambient conditions specified above = 9.75 m

The calculations for Ampacity shall be based on IEEE Standard 738-2006 in SI units. Ratio of AC resistance & DC resistance for HTLS conductor shall be calculated on the basis of Chapter-2, *EPRI AC Transmission Line Reference Book – 200 kV and Above* or the formulae indicated as follows:-

\[ R_{ac} = R_{dc} \times (1 + 0.00519 \times (mr)^n \times k_1 + k_2) \]

where,

\[ mr = \frac{0.3544938}{(R_{dc})^{1/2}} \]

if \( mr < 2.8 \), then \( n = 4 - 0.0616 + 0.0896 \times X \times mr - 0.0513 \times X(mr)^2 \)
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ifmr > 2.8 < 5.0, then n = 4+ 0.5363 -0.2949X mr +0.0097

\[ X(\text{mr})^2 \]

\[ k_1 = \{\cos \left(90 \left(\frac{d}{D}\right)^{0.235}\right)\} \]

where,

\[ p = 0.7 + 0.11X\text{mr} - 0.04X\text{mr}^2 + 0.0094X\text{mr}^3 \]

- \( k_2 = 0.15 \) for single aluminium layer INVAR type HTLS conductor
- \( k_2 = 0.03 \) for three aluminium layer INVAR type HTLS conductor
- \( k_2 = 0.003 \) for two or four aluminium layer INVAR type HTLS conductor
- \( k_2 = 0 \) for composite core type HTLS conductor

where,

\[ D = \text{conductor outer diameter in metres} \]
\[ d = \text{conductor inner diameter in metres} \]
\[ R_{\text{dc}} = \text{dc resistance of conductor at given temperature, ohms/ km} \]
\[ R_{\text{ac}} = \text{ac resistance of conductor at given temperature, ohms/ km} \]

The bidder in his bid shall furnish calculations for the ampacity based on the above for the proposed HTLS conductor.

1.2.2 The design of conductor shall be suitable for operation at a steady state conductor temperature experienced for a sub conductor AC current flow of 1200 Amperes under the above ambient conditions based on ampacity calculations mentioned above. The bidder shall also indicate the maximum permissible conductor temperature for continuous operation without any deterioration of its electrical, mechanical & metallurgical properties. In case of INVAR conductor & metal-matrix composite core conductor, the maximum permissible conductor temperature for continuous operation shall not be considered more than 210 deg C and in case of carbon fibre composite core conductor, the same shall not be considered more than 180 deg C. The bidder shall also furnish the maximum permissible conductor temperature for short term operations including permissible duration of such short term operation. The UTS of conductor declared in the GTP shall hold good up to the designed maximum temperature (i.e. the steady state conductor temperature corresponding to 1200A)

1.3 Technical Particulars of HTLS Conductor

The HTLS conductor shall meet the following minimum requirements:

<table>
<thead>
<tr>
<th>Overall diameter of complete conductor (mm)</th>
<th>Not exceeding 28.62 mm and Not less than 25 mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Approx. mass of complete conductor (kg/km)</td>
<td>Less than or equal to1621 kg/km</td>
</tr>
<tr>
<td>Direction of lay of outer layer</td>
<td>Right Hand</td>
</tr>
</tbody>
</table>
The bidder shall indicate the technical particulars and details of the construction of the conductor in the relevant schedule of GTP. The bidder shall also guarantee the DC resistance of conductor at 20 deg C and AC resistance at the calculated temperature corresponding to 50Hz alternating current flow of 1200 amperes at specified ambient conditions (designed maximum temperature).

The bidder shall submit the supporting calculations for the AC resistance at 1200 Amperes and at 615 Amperes indicating details & justifications of values of temperature coefficient of resistance & DC to AC resistance conversion factor(s) with due reference to construction / geometry of the conductor.

1.4  Sag-Tension Requirements

1.4.1  The HTLS conductor shall meet the following sag tension requirements for ruling span of 350 meters:

<table>
<thead>
<tr>
<th>Particulars</th>
<th>Limiting value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tension at every day condition (32°C, no wind)</td>
<td>Not exceeding 25% of UTS of proposed conductor</td>
</tr>
<tr>
<td>Sag at designed maximum temperature (corresponding to 1200 amperes and ambient conditions specified at 1.2.1)</td>
<td>≤ 9.75 meters</td>
</tr>
<tr>
<td>Tension at following wind pressure:</td>
<td></td>
</tr>
<tr>
<td>i) Tension at 32 deg C, full wind (166.8kg/m²)</td>
<td>≤ 6892kg &amp; not exceeding 70% of UTS of proposed conductor</td>
</tr>
</tbody>
</table>

The calculations for Sag & tension shall be as described below:-

a) **In case of INVAR Conductor:** Sag-Tension calculations for INVAR conductor can be carried out using conventional methodology or by using PLSCAD.

   i) **Conventional Method:** This methodology is illustrated at Annexure-B to the section. Following values shall be considered for the purpose of sag-tension calculation:-

   i) Modulus of Elasticity of Thermal resistant Al alloy strands: 55 GPa to 61.8 GPa

   ii) Modulus of Elasticity of INVAR core strands: 155 GPa

   iii) Coefficient of Linear Expansion of Thermal resistant Al. Alloy: 23 X 10⁶ /deg C

   iv) Coefficient of Linear Expansion of INVAR core strands (max.): 3.7 X 10⁶ /deg C

   v) Initial temperature in manufacturing conductor- not less than 15 deg C
In case the bidder proposes the coeff. of linear expansion of INVAR core strands less than $3.7 \times 10^{-6}$/deg C, the bidder shall submit proper justification in the form of test reports, documents, etc. along with the bid.

II) PLS CAD Method: Following values shall be considered for the purpose of sag-tension calculation:

i) Final values of modulus of elasticity of Aluminium Alloy/ Core strands, Coefficient of Linear Expansion of Aluminium Alloy/ Core strands, Stress-Strain coefficients & Creep coefficients of aluminium alloy / core strands in the cable data (.wir file) used for calculation of sag in PLSCAD shall be based on either of the following:

   a) Existing standard files on PLS website

   b) A file derived from existing standard file for conductor of equivalent/ near equivalent stranding.

   c) A file derived from type test conducted on conductor of same stranding.

However, value of Final values of modulus of elasticity of Aluminium Alloy/ Core strands, Coefficient of Linear Expansion of Aluminium Alloy/ Core strands shall be within the limits defined under I) above

In each of the above cases, proper justification in the form of test reports/ calculations/ print out of ‘.wir’ file as available on PLS website, etc. shall be required to be submitted by the bidder along with the bid.

ii) PLSCAD Sagging criteria/conditions shall be based on the sag tension limits specified above at Clause 1.4.1 and shall be carried out in a manner that the above mentioned sag-tension limits are met in “After Creep” as well as in “After Load” condition.

b) In case of composite core conductor: Sag-Tension calculations for composite core conductor can be carried by using PLSCAD. Following values shall be considered for the purpose of sag-tension calculation:

   i) Final values of modulus of elasticity of Aluminium/ composite core, Coefficient of Linear Expansion of Aluminium/ composite core, Stress-Strain coefficients & Creep coefficients of aluminium/ composite core in the cable data (.wir file) used for calculation of sag in PLSCAD shall be based on either of the following:

      a) Existing standard files on PLS website
b) A file derived from existing standard file for conductor of equivalent/near equivalent stranding.

c) A file derived from type test conducted on conductor of same stranding.

In each of the above cases, proper justification in the form of test reports/calculations print out of '.wir' file as available on PLS website, etc. shall be required to be submitted by the bidder along with the bid.

ii) PLSCAD Sagging criteria/conditions shall be based on the sag tension limits specified above at Clause 1.4.1 and shall be carried out in a manner that the above mentioned sag-tension limits are met in “After Creep” as well as in “After Load” condition.

1.4.2 Various conductor parameters (viz. modulus of elasticity, coefficient of linear expansion, stress-strain and creep, etc.) considered above in the sag tension calculation shall be verified during detailed engineering based on type tests conducted.

1.4.3 The bidder shall also furnish sag & tensions under no wind for various temperatures starting from 0 deg C to designed maximum temperature in steps of 5 deg C.

1.4.4 After award of the contract, the Supplier shall submit Sag-Tension calculations corresponding to specified conditions and for the ruling span and also all the spans as per detailed survey and spans ranging from 100 m to 1100 m in intervals of 50 m.

1.4.5 Besides above, the Supplier shall also furnish during detailed engineering details of creep characteristics in respect of the offered type of HTLS conductor based on laboratory investigations/experimentation (creep test as per IEE1138 or IEC 61395) conducted on similar type of conductor and shall indicate creep strain values corresponding to 1 month, 6 month, 1 year, 10 year & 20 year creep at everyday tension & designed maximum temperature as well as at room temperature.

1.4.6 The installation & stringing of the offered HTLS conductor shall be carried out by the transmission line contractor under supervision of the HTLS conductor supplier.

The supplier shall supervise the stringing at site as per the approved stringing procedure. The supplier shall prepare stringing charts for the HTLS conductor showing the initial and final sags and tension for various temperatures and spans along with equivalent spans on the basis of tower schedule prepared by transmission line contractor and submit the same for the approval of the Employer. Site visit for supervision shall be carried out as per instructions of the Employer. The supervision/Inspection work in supplier’s scope shall mainly include inspection as per stringing...
procedure, proper location of drum site, installation of stringing blocks/pulley, proper sagging, proper installation of its fittings & accessories, proper tension as per sag-Tension chart etc. The supervision shall also include arranging all necessary special tools & tackles required for stringing of the offered HTLS conductor free of cost.

1.4.7 The above stringing work including installation of its fittings & accessories shall be supervised by a team of supplier’s engineers / supervisory staff/ workmen already experienced in stringing work associated with the type of HTLS conductor being supplied. The bidder shall furnish experience details of the engineers /supervisory staff proposed to be deployed.

1.4.8 The cost of conductor shall also include supply of one set of all the special tools & tackles required for stringing of the offered HTLS conductor.

1.5 Workmanship

1.5.1 All the conductor strands shall be smooth, uniform and free from all imperfections, such as spills and splits, cracks, die marks, scratches, abrasions, rust etc.

1.5.2 The finished conductor shall be smooth, compact, uniform and free from all imperfections including kinks (protrusion of wires), wire cross over, over riding, looseness (wire being dislocated by finger/hand pressure and/or unusual bangle noise on tapping), material inclusions, white rust, powder formation or black spot (on account of reaction with trapped rain water etc.), dirt, grit etc.

1.6 Joints in Wires

1.6.1 Aluminium/ Aluminium Alloy Wires

1.6.1.1 During stranding, no Aluminium/ Alloywire welds shall be made for the purpose of achieving the required conductor length.

1.6.1.2 No joints shall be permitted in the individual wires in the outer most layer of the finished conductor. However joints are permitted in the inner layer(s) of the conductor unavoidably broken during stranding provided such breaks are not associated with either inherently defective wire or with the use of short lengths of Aluminium/ Alloywires. Such joints shall not be more than four (4) per conductor length and shall not be closer than 15 meters from joint in the same wire or in any other Aluminium/Alloywire of the completed conductor. A record of such joints for each individual length of the conductor shall be maintained by The Contractor for Employer’s review.

1.6.1.3 Joints shall be made by cold pressure butt welding and shall withstand a stress of not less than the breaking strength of individual strand guaranteed.

1.6.2 Core Wires
There shall be no joint of any kind in the finished wire entering into the manufacture of the strand. There shall also be no joints or splices in any length of the complete stranded core.

1.7 Tolerances

Manufacturing tolerances on the dimensions to the extent of one percent (+/-1 %) shall be permitted for individual strands and the complete conductor.

1.8 Materials

The materials used for construction of the conductor shall be such that the conductor meets the specified technical and performance requirements.

1.8.1 Outer layer

The material of outer layer of HTLS conductor shall be of high temperature resistant aluminum alloy added with zirconium or any other suitable element(s) etc. to electrolytic aluminium or annealed aluminium (0 tempered) having purity not less than 99.5% and a copper content not exceeding 0.04%. The strands shall be manufactured through appropriate manufacturing process to ensure consistent electrical, mechanical and metallurgical properties under continuous high temperature operation. Bidder shall guarantee the chemical composition in the schedule GTP of BPS and also furnish description of the manufacturing process in the Bid.

In case of fully annealed type (0 tempered), aluminium strands trapezoidal/ Z-shaped wires shall only be accepted.

1.8.2 Core

The core wire strand(s) shall be of Zinc-5% Aluminium – Mischmetal alloy coated invar wires/ galvanized invar wires/ aluminium clad invar wires/composite materials, etc. and shall have properties conforming to the technical performance requirements of the finished conductor. Bidder shall furnish properties and composition of the core wire strand(s) in the schedule GTP of BPS.

The zinc used for galvanizing of core (if used) shall be electrolytic High Grade Zinc of 99.95% purity. It shall conform to and satisfy all the requirements of IS:209. The minimum mass of zinc coating shall conform to the requirements of relevant standard. Zinc-5% Aluminium – Mischmetal alloy coating, if used, shall conform to and satisfy all the requirements of ASTM B 803 / B 958.

The aluminium cladding of invar wires shall be with aluminium having purity not less than 99.5% and shall be thoroughly bonded to the core wire strand(s). The minimum thickness of aluminium cladding shall be 0.07mm to achieve a minimum conductivity of 14% of IACS. The aluminium matrix core strands shall conform to minimum conductivity of 24% IACS.
Where composite material for core is offered, the materials shall be of such proven quality that its properties are not adversely influenced by the normal operating conditions of a 220 kV transmission line in tropical environment conditions these lines will be exposed to as detailed in Section-I. The bidder shall provide adequate details including specifications/testreports/operating experience details/performance certificates etc. in support of the suitability of the offered materials along with the bid.

1.9 Standard Length

1.9.1 The standard length of the conductor shall be indicated by the bidder in the guaranteed technical particulars of offer. A tolerance of +/-5% on the standard length offered by the Bidder shall be permitted. Standard Length shall not be more than 2500 m. All lengths outside this limit of tolerance shall be treated as random lengths.

1.9.2 Random lengths will be accepted provided no length is less than 70% of the standard length and the total quantity of such random lengths shall not be more than 10% of the total quantity ordered. At any point, the cumulative quantity supplied of such random lengths shall not be more than 12.5% of the total cumulative quantity supplied including such random lengths. However, the last 20% of the quantity ordered shall be supplied only in standard lengths as specified.

1.9.3 Bidder shall also indicate the maximum single length, above the standard length, he can manufacture in the guaranteed technical particulars of offer. This is required for special stretches like river crossing etc. The Employer reserves the right to place orders for the above lengths on the same terms and conditions applicable for the standard lengths during the pendency of the Contract.

1.10 Evaluation of Ohmic Losses & Differential Price Loading

1.10.1 Based on the conductor parameters guaranteed by the bidders, average ohmic losses for different type of conductors offered by the bidders shall be calculated as per the following formula:

\[
\text{Average Ohmic loss (kW)} = \text{Loss Load Factor} \times \text{Conductor length} \times (\text{Continuous operating current under normal condition})^2 \times \text{AC Resistance corresponding to continuous operating current}
\]

For 1062 kms conductor length, loss load factor = 0.325, continuous operating current of 615 Amp;

\[
\text{Average Ohmic loss (kW)} = 0.325 \times 1062 \times (615)^2 \times \frac{\text{Rac}}{1000} = 7.965 \times 103 \times \text{Rac}
\]
Where $R_{ac}$ is the AC resistance per km guaranteed by the bidder at temperature corresponding to the continuous operating current of 615 A under normal condition.

Differential price evaluation for the conductors offered by the bidders shall be carried out considering the average ohmic losses calculated as above and considering US$ 2,962.00 per kW.

The best parameter of loss (lowest ohmic loss for conductor) corresponding to lowest AC resistance quoted among bidders by any technically responsive and qualified bidder shall be taken as basis and that quoted by the particular bidder shall be used to arrive at differential price to be applied for each bid.

2.0 Tests and Standards

2.1 Type Tests

2.1.1 Type Tests on Stranded Conductor/Stranded wire

The following tests shall be conducted once on sample/samples of conductor from each manufacturing facility:

(i) **On complete Conductor**

a) DC resistance test on stranded conductor : As per Annexure-A  
b) UTS test on stranded conductor : As per Annexure-A  
c) Radio interference voltage test (dry) : As per Annexure-A  
d) Corona extinction voltage test (dry) : As per Annexure-A  
e) Stress-Strain test on stranded conductor and core at room temperature : IEC 1089  
f) Stress-strain test on stranded conductor and core at elevated temperature : As per Annexure-A  
g) High temperature endurance & creep test on stranded conductor : As per Annexure-A  
h) Sheaves Test : As per Annexure-A  
i) Axial Impact Test : As per Annexure-A  
j) Radial Crush Test : As per Annexure-A  
k) Torsional Ductility Test : As per Annexure-A  
l) Aeolian Vibration Test : As per Annexure-A  
m) Temperature Cycle Test : As per Annexure-A  

(ii) **On Conductor Strand/core**

a) Heat resistance test on Aluminium Alloy strands or core : As per Annexure-A  
b) Bending test on aluminium clad core (if applicable) : As per Annexure-A
c)  Compression test on aluminium clad core (if applicable) : As per Annexure-A

d)  Coefficient of linear expansion on core wire : As per Annexure-A

e)  Strand Brittle fracture test (for Carbon fibre composite core only) : As per Annexure-A

2.1.2 Type tests specified under Clause 2.1.1 shall not be required to be carried out if a valid test certificate is available for the offered 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 POWERGRID or NEA or Utility or witnessed by an ISO/IEC 17025 Accredited Laboratory. The accreditation shall be by an agency that is certified to ISO/IEC 17011 with an ILAC-mutual recognition agreement.

In the case of composite core conductors, the tests specified under Clause 2.1.1 shall be carried out before stranding on as-manufactured samples.

In the event of any discrepancy in the test report (i.e., any test report not applicable due to any design / material/manufacturing process 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 Employer/ Employer/ Purchaser.

2.2 Acceptance Tests

a)  Visual and dimensional check on drum : As per Annexure-A

b)  Visual check for joints scratches etc. and length measurement of conductor by rewinding : As per Annexure-A

c)  Dimensional check on core or core strands and Aluminium or Aluminium Alloy strands : As per Annexure-A

d)  Check for lay-ratios of various layers : As per Annexure-A

e)  Galvanising test on core strands (if applicable) : As per Annexure-A

f)  Coating Test on Zinc-5% Al-Mischmetal alloy coating (if applicable) : As per ASTM B803/B 958

g)  Adherence of Coating Test on Zinc-5% Al-Mischmetal alloy coating (if applicable) : As per ASTM B803/B 958

h)  Thickness of aluminum on aluminium clad wires : As per Annexure-A
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<table>
<thead>
<tr>
<th></th>
<th>Test Description</th>
<th>Standard/Annexure</th>
</tr>
</thead>
<tbody>
<tr>
<td>i</td>
<td>Torsion and Elongation tests on core strands</td>
<td>As per Annexure-A</td>
</tr>
<tr>
<td>j</td>
<td>Breaking load test on core strands and Aluminium/Aluminium Alloy strands</td>
<td>As per Annexure-A</td>
</tr>
<tr>
<td>k</td>
<td>Wrap test on core strands and Aluminium Alloy strands (not applicable for carbon fibre composite core)</td>
<td>As per IEC:888 &amp; IES:889</td>
</tr>
<tr>
<td>l</td>
<td>Minimum conductivity test on Aluminium/ thermal resistant Aluminium Alloy strands</td>
<td>As per IEC : 889</td>
</tr>
<tr>
<td>m</td>
<td>Procedure qualification test on welded joint of Aluminium/Aluminium Alloy strands</td>
<td>As per Annexure-A</td>
</tr>
<tr>
<td>n</td>
<td>Heat resistance test on Aluminium Alloy strands</td>
<td>As per Annexure-A</td>
</tr>
<tr>
<td>o</td>
<td>Ageing test on filler (if applicable)</td>
<td>As per Annexure-A</td>
</tr>
<tr>
<td>p</td>
<td>Minimum conductivity test on aluminium clad core wires (if applicable)</td>
<td>As per Annexure-A</td>
</tr>
<tr>
<td>q</td>
<td>Glass transition temperature test (For Carbon fibre composite core only)</td>
<td>As per Annexure-A</td>
</tr>
<tr>
<td>r</td>
<td>Flexural Strength test(For Carbon Fibre composite core only)</td>
<td>As per Annexure-A</td>
</tr>
<tr>
<td>s</td>
<td>Galvanic layer thickness test (for Carbon fibre composite core only)</td>
<td>As per ASTM B987</td>
</tr>
<tr>
<td>t</td>
<td>Bending test on composite core (for Carbon fibre composite core only)</td>
<td>As per ASTM B987</td>
</tr>
</tbody>
</table>

Note: All the above tests except (m) shall be carried out on Aluminium Alloy and core / core strands after stranding only. For composite core (k) is not applicable and (i), (j), (q), (r), (s) shall be carried out before stranding.

The testing and requirements listed in this specifications are based on as manufactured properties of the materials. If tests on strands or core materials are made after field exposure, the Employer and the Manufacturer should agree on the properties to be met.

2.3 Routine Test

a) Check to ensure that the joints are as per Specification
b) Check that there are no cuts, fins etc., on the strands.

c) Check that drums are as per Specification

d) All acceptance tests as mentioned above to be carried out on 10 % of drums

2.4 Tests During Manufacture

a) Chemical analysis of zinc used for galvanizing : As per Annexure-A

b) Chemical analysis of Aluminium alloy used for making Aluminium Alloy strands : As per Annexure-A

c) Chemical analysis of core strands : As per Annexure-A

2.5 Testing Expenses

2.5.1 As indicated in Clause 2.1.2, no type test charges shall be payable to the supplier.

2.5.2 In case of failure in any type test the Supplier is either required to manufacture fresh sample lot and repeat the entire 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 a fresh lot is manufactured for testing then the lot already manufactured shall be rejected.

2.5.3 Bidder shall indicate the laboratories in which they propose to conduct the type tests, if required. They shall ensure that adequate facilities are available in the laboratories and the tests can be completed in these laboratories within the time schedule guaranteed by them.

2.5.4 The entire cost of testing for the acceptance and routine tests and Tests during manufacture as well as type tests, if required, specified herein shall be treated as included in the quoted unit price of conductor, except for the expenses of the inspector/Employer’s representative.

2.5.5 In case of failure in any type test, if repeat type tests are required to be conducted, then all the expenses for deputation of Inspector/Employer's representative shall be deducted from the contract price. Also if on receipt of the Supplier's notice of testing, the Employer's representative does not find material/ testing facilities to be ready for testing the expenses incurred by the Employer for re-deputation shall be deducted from contract price.

2.5.6 The Supplier shall intimate the Employer about carrying out of the type tests alongwith detailed testing programme at least 3 weeks in advance (in case of testing in India) and at least 6 weeks in advance (in case of testing abroad) of the schedule date of testing during which the Employer will arrange to depute his representative to be present at the time of carrying out the tests.
### 2.6 Additional Tests

2.6.1 The Employer reserves the right of having at his own expenses any other test(s) as agreed between the Employer and the Supplier of reasonable nature carried out at Supplier’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 Employer 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 Supplier’s premises or at any other test centre. Samples that have been damaged from misuses, improper use, improper storage or that have been degraded by environmental exposure shall not be required to meet the original values. In case of evidence of non compliance, it shall be binding on the part of Supplier 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 Employer.

### 2.7 Sample Batch For Type Testing

2.7.1 The Supplier shall offer material for selection of samples for type testing only after getting Quality Assurance Plan approved from Employer’s Quality Assurance Deptt. The sample shall be manufactured strictly in accordance with the Quality Assurance Plan approved by Employer.

2.7.2 The Supplier shall offer at least three drums for selection of sample required for conducting all the type test.

2.7.3 The Supplier is required to carry out all the acceptance tests successfully in presence of Employer’s representative before sample selection.

### 2.8 Test Reports

2.8.1 Copies of type test reports shall be furnished in at least three copies along with one original. One copy will be returned duly certified by the Employer only after which the commercial production of the material shall start.

2.8.2 Record of routine test reports shall be maintained by the Supplier at his works for periodic inspection by the Employer’s representative.

2.8.3 Test Certificates of tests during manufacture shall be maintained by the Supplier. These shall be produced for verification as and when desired by the Employer.

### 2.9 Inspection

2.9.1 The Employer’s representative shall at all times be entitled to have access to the works and all places of manufacture, where conductor shall be manufactured and representative shall have full facilities for unrestricted inspection of the Supplier’s works, raw materials and process of manufacture for conducting necessary tests as detailed herein.
2.9.2 The Supplier shall keep the Employer informed in advance of the time of starting and of the progress of manufacture of conductor in its various stages so that arrangements can be made for inspection.

2.9.3 No material shall be dispatched from its point of manufacture before it has been satisfactorily inspected and tested, unless the inspection is waived off by the Employer in writing. In the latter case also the conductor shall be dispatched 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 Supplier 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 Supplier’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 conductor 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

2.11.1 The conductor shall be supplied in non-returnable, strong, wooden/painted steel/hybrid (painted steel cum wood) drums provided with lagging of adequate strength, constructed to protect the conductor against all damage and displacement during transit, storage and subsequent handling and stringing operations in the field. As an alternative to wooden drum Bidder may also supply the conductors in returnable painted steel drums or returnable wood-Steel hybrid drums. The Supplier shall select suitable drums for supply of conductor and shall be responsible for any loss or damage to conductor and/or drum during transportation handling and storage due to improper selection of drum or packing. Wooden/Steel drum/Wood-Steel hybrid drum will be treated at par for evaluation purpose and accordingly the Bidder should quote in the package.

2.11.2 After completion of stringing works, the supplier shall take back or dispose off the empty drums on his own, except for the drums of spare conductor, if any, which shall be kept by the Owner.
2.11.3 The drums shall be suitable for wheel mounting and for letting off the conductor under a minimum controlled tension of the order of 5 KN.

2.11.4 The Bidder should submit their proposed drum drawings along with the bid.

2.11.5 One conductor length only shall be wound on each drum.

2.11.6 The conductor ends shall be properly sealed and secured on the side of one of the flanges to avoid loosening of the conductor layers during transit and handling.

2.11.7 **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 conductor

(f) Length of conductor in meters

(g) Arrow marking for unwinding

(h) Position of the conductor ends

(i) Distance between outer-most Layer of conductor and the inner surface of lagging.

(k) Barrel diameter at three locations & an arrow marking at the location of the measurement.

(l) Number of turns in the outer most layer.

(m) Gross weight of drum after putting lagging.

(n) Tear weight of the drum without lagging.

(o) Net weight of the conductor in the drum.

(p) CIP/MICC No.

The above should be indicated in the packing list also.

2.12 **Verification of Conductor Length**

The Employer reserves the right to verify the length of conductor after unreeling at least ten (10) percent of the drums in a lot offered for inspection.
2.13 Standards

2.13.1 The conductor 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.

2.13.2 In the event of the supply of conductor 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 Supplier and those specified in this document will be provided by the Supplier to establish their equivalence.

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Title</th>
<th>International Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Specification for zinc</td>
<td>BS:3436-1986</td>
</tr>
<tr>
<td>5.</td>
<td>Reels and Drums for Bare Conductors</td>
<td>BS:1559-1949, ASTM B987</td>
</tr>
<tr>
<td>7.</td>
<td>Recommended Practice for Hot Dip Galvanising of Iron and Steel</td>
<td></td>
</tr>
<tr>
<td>8.</td>
<td>Method of Testing Uniformity of Coating on Zinc Coated Articles</td>
<td></td>
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### Design, Supply, Installation and Commissioning of Kushma-New Butwal 220 kV Transmission Line

<p>| | |</p>
<table>
<thead>
<tr>
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<th></th>
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</thead>
<tbody>
<tr>
<td>16.</td>
<td>Aluminium clad steel wires</td>
</tr>
<tr>
<td>17.</td>
<td>Method of measurement of resistivity of metallic materials</td>
</tr>
<tr>
<td>18.</td>
<td>Ampacity</td>
</tr>
<tr>
<td>19.</td>
<td>Thermal resistant Aluminium Alloy</td>
</tr>
</tbody>
</table>

The standards mentioned above are available from:

<table>
<thead>
<tr>
<th>Reference Abbreviation</th>
<th>Name and Address</th>
</tr>
</thead>
<tbody>
<tr>
<td>BS</td>
<td>British Standards, British Standards Institution 101, Pentonvile Road, 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>
</tr>
<tr>
<td>BIS/IS</td>
<td>Beureau Of Indian Standards. ManakBhavan, 9, Bahadur Shah ZafarMarg, New Delhi - 110001. INDIA</td>
</tr>
<tr>
<td>ISO</td>
<td>International Organisation for Standardization. Danish Board of Standardization Danish Standardizing Sraat, Aurehoegvej-12 DK-2900, Heeleprup, DENMARK.</td>
</tr>
<tr>
<td>NEMA</td>
<td>National Electric Manufacture Association, 155, East 44th Street. New York, NY 10017 U.S.A.</td>
</tr>
<tr>
<td>ASTM</td>
<td></td>
</tr>
</tbody>
</table>
1. Tests on Conductor

1.1 UTS Test on Stranded Conductor

Circles perpendicular to the axis of the conductor shall be marked at two places on a sample of conductor of minimum 5 m length between fixing arrangement suitably fixed by appropriate fittings on a tensile testing machine. The load shall be increased at a steady rate up to 50% of minimum specified 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 minimum UTS and held for one minute. The Conductor 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 Corona Extinction Voltage Test

Two samples of conductor of minimum 5 m length each shall be strung in horizontal twin bundle configuration with spacing of 450 mm between subconductors at a height not exceeding 7.01 m above ground. The sample assembly when subjected to power frequency voltage shall have a corona extinction voltage of not less than 154 kV (rms) line to ground under dry condition. There shall be no evidence of corona on any part of the samples. The test should be conducted without corona control rings. However, small corona control rings may be used to prevent corona in the end fittings. The voltage should be corrected for standard atmospheric conditions.

1.3 Radio Interference Voltage Test

Under the conditions as specified under (1.2) above, the conductor samples shall have radio interference voltage level below 1000 microvolts at one MHz when subjected to 50 Hz AC voltage of 154 kV line to ground under dry conditions. This test may be carried out with corona control rings and arcing horns.

1.4 D.C. Resistance Test on Stranded Conductor

On a conductor 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 or using micro ohm meter of suitable accuracy by placing the clamps initially zero metre and subsequently one metre 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 20deg C as per IS:398-(Part-IV)/(Part-V). The resistance corrected at 20deg C shall conform to the requirements of this Specification.

1.5 Stress-strain test at elevated temperature
Stress-strain test as per IEC-1089 shall be conducted keeping conductor temperature at designed maximum temperature. UTS for this test shall be as guaranteed in the GTP.

1.6 High Temperature endurance & creep test

Two conductor samples of length equal to at least 100 X d + 2 X a (where, d is the conductor diameter and a is the distance between the end fitting and the gauge length) shall be strung at tension equal to 25% of conductor UTS. The distance, a, shall be at least 25% of the gauge length or 2 m whichever is the smaller. The conductor samples shall be subjected to tests as indicated below:

(i) On one of the conductor samples, the conductor temperature shall be maintained at 20 deg C for 1000 hours. The elongation/creep strain of the conductor during this period shall be measured and recorded at end of 1 hour, 10 hour, 100 hour and subsequently every 100 hour upto 1000 hours time period.

(ii) On other conductor sample, the conductor temperature shall be increased to designed maximum temperature in steps of 20 deg. C and thermal elongation of the conductor sample shall be measured & recorded at each step. The temperature shall be held at each step for sufficient duration for stabilisation of temperature. Further, the temperature of the conductor shall be maintained at maximum continuous operating temperature (+10 Deg. C) for 1000 hours. The elongation/creep strain of the conductor during this period shall be measured and recorded at end of 1 hour, 10 hour, 100 hour and subsequently every 100 hour upto 1000 hours time period. After completion of the above, the core of the conductor sample shall be subjected to UTS test as mentioned above at clause 1.1 of Annexure-A. The conductor core shall withstand a load equivalent to 95% of UTS. In case of the carbon fibre composite the flexural strength should not be less than 90% of the value guaranteed in GTP after thermal cycling. Flexural strength shall be obtained as per test condition specified in 1.32

The supplier shall furnish details of creep characteristic in respect of the conducted based on laboratory test and other laboratory investigations/experimental conducted on similar type of conductor and shall indicate creep strain values corresponding to 1 month, 6 month, 1 year, 10 year & 20 year creep at everyday tension & designed maximum temperature as well as room temperature.

1.7 Sheaves Test

The conductor sample of minimum length of 35 meter shall be tensioned at 22% of the UTS and shall be passed through pulleys having diameter of 32 times that of the conductor with angle of 20 deg. between the pulleys. The conductor shall be passed over the pulleys 36 times a speed
of 2 m/sec. After this test UTS test on the conductor shall be carried out. In case of composite core conductors, the core shall be inspected for any sign of damage or cracking through dye penetration test as per ASTM B987.

1.8 Axial Impact Test

The conductor sample shall be suspended vertically and load applied by dropping a 650 Kg from an elevation of 4 meters above the sample. The impact velocity shall be not be less than 8 m/sec. with an intial pre-tension of 200 kgs. The curve for load vs time shall be recorded and recorded load of failure for core shall not be less than UTS of core.

1.9 Radial Crush Test

A section of conductor is to be crushed between two six inch steel platens. Load shall be held at 350 Kgs for 1 minute and then released. Core/core strands shall be subsequently disassembled and tensile tested. Core/core strands shall exhibit full strength retention vis-a-vis guaranteed breaking strength of core wires (after stranding).

1.10 Torsional Ductility Test

The conductor sample of 10-15 m shall be loaded to 20% of UTS and then rotated in increasing steps of +/-180 deg. In case of INVAR type HTLS conductor, the entire conductor shall withstand atleast 16 such rotation and there shall not be any damage to Aluminium Alloy or INVAR core wires.

In case of carbon-fibrecomposite core conductors, after 4 rotations or after separation of aluminium strands, the aluminium wires shall be cut and removed from the conductor and the exposed core shall be twisted upto 16 rotations. The composite core shall not break after completion of 16 rotations.

1.11 Aeolian Vibration Test

The conductor and supporting hardware shall be loaded to 25% of UTS. A dynamometer, load cell, calibrated beam or other device shall be used to measure the conductor tension. Some means should be provided to maintain constant tension to allow for temperature fluctuations during the testing. The overall span between system terminations shall be a minimum of 30 m. The span shall be supported at a height such that the static sag angle of the cable to horizontal is (1.5 ± 0.5) deg in the active span. Means shall be provided for measuring and monitoring the mid-loop (antinode) vibration amplitude at a free loop, not a support loop. An electronically controlled shaker shall be used to excite the conductor in the vertical plane. The shaker armature shall be securely fastened to the conductor so it is perpendicular to the conductor in the vertical plane. The shaker should be located in the span to allow for a minimum of six vibration loops between the suspension assembly and the shaker.
The test shall be carried out at one or more resonance frequencies (more than 10 Hz). The amplitude (peak-to-peak) at the antinode point shall be one third of conductor diameter. The assembly shall be vibrated for not less than 10 million cycles without any failure. After the test, the conductor should not exhibit any damage (broken strands). The conductor shall be tested to demonstrate that it retains at least 95% UTS.

1.12 Temperature Cycle Test

The purpose of this test is verification of degradation characteristics of metallic and non-metallic material when subjected to thermal cycling. Temperature cycling can create large internal stresses due to thermal expansion mismatch between constituents.

Test Methods:
- Mechanical tension, 20 % UTS, marks on the conductor at the edge of the conductor
- 100 cycles from room temperature up to designed maximum temperature. Hold at designed maximum temperature ± 2.5deg.C for 5 minutes
- After the above mentioned 100 cycles, the mechanical tension shall be increased up to 70 % UTS at room temperature and kept at this tension for 24hrs. Thereafter, release to 20 % UTS.
- This cycling test shall be repeated 5 times.
- During the test, temperature of connectors, conductor and resistance are recorded according to ANSI C 119.
- A breaking load test is applied at the end of the test. Conductor strength has to be higher than 95 % UTS.
- In case of carbon-fibre composites, the flexural strength should not be less than 90% of the value guaranteed in GTP and the Glass Transition temperature shall not be less than 90% of the value guaranteed in GTP after thermal cycling. Flexural strength shall be obtained on the basis of test procedure indicated at 1.32 below.

1.13 Heat Resistance test on Aluminium Alloy wire

Breaking load test as per clause 1.21 above shall be carried out before and after heating the sample in uniform heat furnace at following temperature for one hour. The breaking strength of the wire after heating shall not be less than the 90% of the breaking strength before heating:

<table>
<thead>
<tr>
<th>Maximum continuous operating temperature of the conductor</th>
<th>Test Temperature</th>
</tr>
</thead>
<tbody>
<tr>
<td>Upto 150 deg. C</td>
<td>230 degC (+5/-3 degC)</td>
</tr>
<tr>
<td>More than 150 deg. C &amp; up to 210 deg. C</td>
<td>280 degC (+5/-3 degC)</td>
</tr>
<tr>
<td>More than 210 deg. C &amp; up to 230 deg. C</td>
<td>400 degC (+5/-3 degC)</td>
</tr>
</tbody>
</table>
1.14 **Bending test on aluminium clad core wire (if applicable)**

A sample of aluminium clad invar strand measuring 30 cm in length shall be subject to bending with help of a vise. The vised length of wire should be 5 cm and radius of bend 4.8 mm. The bending should be first 90 degrees left and 90 degree right. After this operation the strand should cut at the bending point. There should be no separation of core and aluminium at the bending point after this operation.

1.15 **Compression test on aluminium clad wires (if applicable)**

A sample of aluminium clad core strand 10 mm in length is to be compressed by a plate with a load of 3600 kgs. The aluminium clad core strand should not break.

1.16 **Coefficient of linear expansion for core/ core wires**

The temperature and elongation on a sample shall be continuously measured and recorded at interval of approximately 15 degree C from 15 degree C to designed maximum temperature corresponding to rated current(1200A) by changing the temperature by suitable means. Coefficient of linear expansion shall be determined from the measured results.

1.17 **Strand Brittle fracture test (for carbon-fibre composite core only)**

The sample shall be tensioned to approx. 25 % of UTS with simultaneous application of 1N-HNO₃ acid directly in contact with naked polymer composite core for 96 hrs. The contact length of acid shall not be less than 40mm and thickness around the core not less than 10mm. The rod shall withstand UTS test after 96 hours.

1.18 **Visual and Dimensional Check on Drums**

The drums shall be visually and dimensionally checked to ensure that they conform to the approved drawings.

1.19 **Visual Check for Joints, Scratches etc.**

Conductor drums shall be rewound in the presence of the Employer. The Employer shall visually check for scratches, joints etc. and that the conductor generally conform to the requirements of this Specification. Ten percent (10%) drums from each lot shall be rewound in the presence of the Employer's representative.

1.20 **Dimensional Check on Core/ Core Wires and Aluminium/ Aluminium Alloy Wires**

The individual strands shall be dimensionally checked to ensure that they conform to the requirement of this Specification. Diameter of formed wires shall be determined as per Clause 6.3.1.2 of IEC 62420.
1.21 Check for Lay-ratios of Various Layers
The lay-ratios of various layers shall be checked to ensure that they conform to the guaranteed values furnished by the Contractor.

1.22 Galvanising Test
The test procedure shall be as specified in IEC: 888. 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.

1.23 Aluminum thickness on aluminum clad wires (if applicable)
The thickness of aluminium of the specimen shall be determined by using suitable electrical indicating instruments operating on the permeameter principle, or direct measurement. Measurements shall be read to three decimal places, and number rounded to two decimal places is considered as measured thickness. For reference purposes, direct measurement shall be used to determine aluminium thickness on specimens taken from the end of the coils.

1.24 Torsion and Elongation Tests on Composite Core/ INVAR Core wires
For INVAR type HTLS conductor, the test procedures for Torsion and Elongation tests on core wires shall be as per clause No. 6.3.3 and Clause 6.3.2 (b) of IEC 61232 respectively. In torsion test, the number of complete twists before fracture shall not be less than the value specified in the GTP on 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. In elongation test, the elongation of the strand shall not be less than the value specified in the GTP for a gauge length of 250 mm.

In case of carbon-fibre composite core HTLS conductor, the following procedure shall be applicable:-

i) Elongation Test: The elongation of the composite core sample at fracture shall be determined using extensometer. The load along the core shall be gradually increased. The elongation achieved on reaching the tensile strength of the core shall not be less than the value guaranteed in the GTP.

ii) Torsion Test: The purpose of the test is to determine the resilience of the composite core to twisting and to show that after the composite core has experienced the prescribed twisting, it will not crack or have a loss in tensile strength due to the twisting. A sample length that is 170 times the diameter of the composite core being tested is mounted in the gripping
fixtures. One grip shall then be fixed so that it does not twist and the other end shall be twisted a full 360 degrees and then fixed in this position for 2 minutes. Once the twist time is completed, the core is untwisted and inspected for any crazing or other damage. If no damage is observed, the composite core is then tensile tested to failure and the final load recorded. For the test to be accepted, the composite core must withstand at least 100% of its rated tensile strength. Two samples need to be completed in order to satisfy the testing requirement.

1.25 Breaking load test on Aluminium/ Aluminium Alloy & Composite core/ INVAR Corewires and D.C Resistance test on Aluminium/ Aluminium Alloy wire

The above tests shall be carried out as per IEC: 888/889 or relevant international standards and the results shall meet the requirements of the specification.

1.26 Wrap test on Corewires(Applicable for steel/Al clad Steel/invar core only)

The wrap test on core strands shall meet the requirements of IEC: 888. In case of aluminium clad core wire, the same shall be wrapped around a mandrel of diameter of five times that of the strand to form a helix of eight turns. The strand shall be unwrapped. No breakage of strand shall occurred.

1.27 Minimum conductivity test on thermal resistant aluminium alloy wire

Resistivity test as per IEC-468/IEC 889 shall be conducted to confirm minimum conductivity as per specification requirement.

1.28 Procedure Qualification test on welded Aluminium/ Aluminium Alloy wire.

Two Aluminium/ Aluminium Alloy wire shall be welded as per the approved quality plan and shall be subjected to tensile load. The breaking strength of the welded joint of the wire shall not be less than the guaranteed breaking strength of individual strands.

1.29 Ageing Test on Filler (if applicable)

The test shall be done in accordance with Grease drop point test method. The specimen should be drop as a droplet when kept at a temperature 40 deg. C above designed maximum operating temperature of the conductor for 30 minutes. The temperature shall then be increased till one droplet drops and the temperature recorded.

1.30 Aluminium conductivity test on aluminium clad wire (if applicable)

Resistivity test as per IEC-468 shall be conducted to confirm minimum conductivity as per specification requirement.
1.31 Glass Transition Temperature Test (for carbon-fibre composite core only)
Test method shall be as per ASTM D7028, A Standard Test Method for Glass Transition Temperature of Polymer Matrix Composites by Dynamic Mechanical Analysis. The glass transition temperature shall be greater than the designed maximum temperature of the offered HTLS conductor +25 °C, and Tg measured as the peak in Loss Modulus curve as per ADTM B987.

1.32 Flexural Strength Test (for carbon-fibre composite core only)
Test method shall be as per ASTM D7264, ASTM D4475 or ISO 14125.

1.33 Chemical Analysis of Aluminium/Aluminium Alloy and Composite metal core/INVAR Core Wires
Samples taken from the Aluminium /Aluminium Alloy and core coils/strands shall be chemically/spectrographically analysed. The same shall be in conformity to the particulars guaranteed by the bidder so as to meet the requirements stated in this Specification.

1.34 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.

1.35 Bending test on composite fibre core
Two composite core samples shall be tensioned to 7.5% of the rated tensile strength of the composite core and wrapped 180 degrees around a cylindrical mandrel. Tension may be measured on one of the conductor ends or at the bending mandrel. If tension is measured at the bending mandrel, the load shall be 15% of the rated tensile strength. The application of bending and tension loads may be independent or combined provided that full bending load and tension load are simultaneously held for a minimum of 1 minute. The mandrel diameter shall be not more than 50 times the diameter of the composite core. After completion of the two bending tests, one core sample shall withstand UTS test and one core sample shall be subjected to dye penetration test for per ASTM B987 section 14. Dye penetrant exposure time shall be 30 +1/-0 minutes.
### Calculation of sag & tension for INVAR type HTLS Conductor

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<tr>
<th>Range of temperature ( t )</th>
<th>( t &lt; t_c )</th>
<th>( t = t_c )</th>
<th>( t_c &lt; t \leq 230 )</th>
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<td>Tension equation</td>
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<td>( f \left[ f - \alpha \varepsilon (t - t_{\text{max}}) \right] = M )</td>
<td>( f \left[ f - \left( K - \alpha \varepsilon (t - t_{\text{c}}) \right) \right] = M )</td>
</tr>
</tbody>
</table>

where

\[
K = f_{\text{max}} - \frac{E}{24} \left( \frac{\delta S}{f_{\text{max}}} \right)^{3} \\
M = \frac{E}{24} (\delta S)^{3} \\
T_{c} = \frac{f_{c}}{A} \\
f_{\text{max}} = \frac{T_{\text{max}}}{A} \\
\delta = \frac{W_{c}}{A} \\
q = \frac{W_{\text{max}}}{W_{c}} = \frac{(W_{c} + W_{r})^{2} + W_{w}^{2}}{W_{c}} \\
t_{\text{c}}: \text{Temperature at } T_{\text{c}} \\
W_{c}: \text{Snow ice weight} \\
W_{w}: \text{Wind load}
\]

After tension equation was solved, \( t_{c} \) is calculated by

\[
t_{c} = \frac{f_{c}}{E (\alpha \varepsilon - \alpha_{\varepsilon})} + t_{o}.
\]

### Sag of conductor \( d \)

- \( t < t_{c} \): \( d = \frac{\delta S^{3}}{8 f} \)
- \( t = t_{c} \): \( d = \frac{\delta S^{2}}{8 f} \)
- \( t_{c} < t \leq 230 \): \( d = \frac{\delta S^{2}}{8 f} \)
**Definition of Symbols** are as follows:

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>tc</td>
<td>Knee point Temperature</td>
</tr>
<tr>
<td>Tc</td>
<td>Tension at Knee point temperature, tc</td>
</tr>
<tr>
<td>( \Delta L )</td>
<td>Elongation and thermal expansion of conductor (m)</td>
</tr>
<tr>
<td>( \Delta L_a )</td>
<td>Elongation and thermal expansion of aluminum part (m)</td>
</tr>
<tr>
<td>( \Delta L_i )</td>
<td>Elongation and thermal expansion of invar core (m)</td>
</tr>
<tr>
<td>( \alpha )</td>
<td>Equivalent coefficient of linear expansion for conductor (1/°C)</td>
</tr>
<tr>
<td>( \alpha_a )</td>
<td>Coefficient of linear expansion for aluminum alloy wire (1/°C)</td>
</tr>
<tr>
<td>( \alpha_{ii} )</td>
<td>Coefficient of linear expansion for aluminum-clad invar wire between room temperature and 230°C (1/°C)</td>
</tr>
<tr>
<td>( \alpha_{i2} )</td>
<td>Coefficient of linear expansion for aluminum-clad invar wire between 230°C and 290°C (1/°C)</td>
</tr>
<tr>
<td>( E )</td>
<td>Equivalent modulus of elasticity for conductor (kgf/mm²)</td>
</tr>
<tr>
<td>( E_a )</td>
<td>Modulus of elasticity for aluminum alloy wire (kgf/mm²)</td>
</tr>
<tr>
<td>( E_i )</td>
<td>Modulus of elasticity for aluminum-clad invar wire (kgf/mm²)</td>
</tr>
<tr>
<td>( A )</td>
<td>Nominal cross sectional area of conductor (mm²)</td>
</tr>
<tr>
<td>( A_i )</td>
<td>Nominal cross sectional area of invar core (mm²)</td>
</tr>
<tr>
<td>( W_c )</td>
<td>Nominal weight of conductor (kg/m)</td>
</tr>
<tr>
<td>( T )</td>
<td>Tension of conductor (kgf)</td>
</tr>
<tr>
<td>( t_0 )</td>
<td>Initial temperature in manufacturing conductor (°C)</td>
</tr>
<tr>
<td>( s )</td>
<td>Span length (m)</td>
</tr>
</tbody>
</table>
SAMPLE CALCULATION

Actual calculation of sag and tension for Linnet ZTACIR/AS

(1) Calculation condition

i) Properties of Linnet ZTACIR/AS

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>D (Diameter of conductor)</td>
<td>18.2 mm</td>
</tr>
<tr>
<td>A (Nominal cross sectional area of conductor)</td>
<td>196.5 mm²</td>
</tr>
<tr>
<td>A₁ (Nominal cross sectional area of invar core)</td>
<td>37.16 mm²</td>
</tr>
<tr>
<td>W (Nominal weight of conductor)</td>
<td>0.7066 kg/m</td>
</tr>
<tr>
<td>E</td>
<td>8040 kgf/mm²</td>
</tr>
<tr>
<td>(Equivalent modulus of Elasticity for conductor)</td>
<td>(78.8 CPa)</td>
</tr>
<tr>
<td>E₁</td>
<td>16,600 kgf/mm²</td>
</tr>
<tr>
<td>(Modulus of Elasticity for aluminum-clad invar wire)</td>
<td>(162.0 GPa)</td>
</tr>
<tr>
<td>α (Equivalent coefficient of linear expansion for</td>
<td></td>
</tr>
<tr>
<td>conductor)</td>
<td>16.0 x 10⁻⁶ 1/C</td>
</tr>
<tr>
<td>αₚ (Coefficient of linear expansion for aluminum</td>
<td></td>
</tr>
<tr>
<td>alloy wire)</td>
<td>23 x 10⁻⁶ 1/C</td>
</tr>
<tr>
<td>αₐ₁ (Coefficient of linear expansion for aluminum</td>
<td></td>
</tr>
<tr>
<td>clad invar wire between transition temp. and 230°C)</td>
<td>3.7 x 10⁻⁴ 1/C</td>
</tr>
</tbody>
</table>

ii) Loading condition under maximum tension

<table>
<thead>
<tr>
<th>Condition</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temperature under maximum tension</td>
<td>15°C</td>
</tr>
<tr>
<td>Wind pressure</td>
<td>100 kgf/m²</td>
</tr>
<tr>
<td>Thickness of snow ice (snow ice weight)</td>
<td>0 mm (0 kgf/m)</td>
</tr>
<tr>
<td>Maximum tension</td>
<td>2,300 kgf</td>
</tr>
<tr>
<td></td>
<td>(22.6 kN)</td>
</tr>
</tbody>
</table>

iii) Span length

S = 200 m

(2) Calculation of sag and tension at continuous operation temperature

The sag and tension at the continuous operation temperature (235°C) are calculated by the method described in Table

i) Tension at the transition temperature \( T_c \)

\[
T = \frac{W_{max}}{W_c} = \frac{\sqrt{0.7066^2 + (18.2 \times 100 / 1000)^2}}{0.7066}
\]

\[= 2.7636\]

\[f_{max} = \frac{T_{max}}{A} = \frac{2300}{196.5}\]

\[= 11.705\]
Design, Supply, Installation and Commissioning of Kushma-New Butwal 220 kV Transmission Line

\[ \delta = \frac{W_e}{A} = \frac{0.7066}{196.5} = 3.5959 \times 10^{-3} \]

\[ K = f_e \frac{E}{24} \left( \frac{g \delta}{f_{\text{max}}} \right)^2 - 11.705 - \frac{8040}{24} \times \left( \frac{2.7630 \times 0.0035959 \times 300}{11.705} \right)^{1/3} \]

\[ = -10.018 \]

\[ M = \frac{E}{24} (\delta s)^2 = \frac{8040}{24} \times (0.0035959 \times 300)^2 \]

\[ = 389.85 \]

\[ \alpha_s - \alpha = \frac{23 - 160}{23} = 0.30435 \]

\[ f_e^2 \left[ f_e - 0.30435 \times \left\{ -10.018 - 160 \times 10^{-6} \times 8040 \times (15 - 15) \right\} \right] = 0.30435 \times 389.85 \]

\[ f_e^2 [f_e + 3.0490] = 118.65 \]

\[ f_e = 4.0796 \]

\[ T_e = f_e A = 4.0796 \times 196.5 \]

\[ = 801.64 \text{ kgf} \]

ii) Transition temperature \( t_e \)

\[ t_e = \frac{4.0796}{8040 \times (23 - 160) \times 10^{-6} + 15} \]

\[ = 87.49 \text{ °C} \]

iii) Sag \( d \) and tension \( T \) at the continuous operation temperature (205°C)

\[ f_e = \frac{T_{\text{max}}}{A} = \frac{801.64}{37.16} \]

\[ = 21.573 \]

\[ \delta_t = \frac{W_e}{A} = \frac{0.7066}{37.16} \]

\[ = 1.9015 \times 10^{-2} \]

\[ K = f_e \frac{E_L}{24} \left( \frac{L}{f_e} \right)^3 = 21.573 - \frac{15500}{24} \times \left( \frac{0.019015 \times 300}{21.573} \right)^3 \]

\[ = -23.585 \]

\[ M = \frac{E_L}{24} (\delta s)^2 = \frac{15500}{24} \times (0.019015 \times 300)^2 \]

\[ = 21016 \]

\[ f^2 \left[ f \left\{ -23.585 - 3.7 \times 10^{-4} \times 15500 \times (205 - 87.49) \right\} \right] = 10901 \]

\[ f^2 [f + 30.324] = 21016 \]

\[ f = 20.362 \]

\[ T = fA_t = 20.362 \times 37.16 \]

\[ = 756.7 \text{ kgf at 205°C (7.42kN)} \]

\[ \left( \delta s^2 \right) = 0.019015 \times 300^2 \]

\[ d = \frac{8f}{8f} = \frac{8 \times 20.362}{8 \times 20.362} \]

\[ = 10.51 \text{ m at 205°C} \]
# TECHNICAL SPECIFICATIONS

## SECTION-V A

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<th>Description</th>
<th>Page No.</th>
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</thead>
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<td>5.0</td>
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<td>17</td>
</tr>
</tbody>
</table>
TECHNICAL SPECIFICATIONS

SECTION-VA

1. Technical Description of ACSR BEAR Conductor

1.1 Details of Conductor

1.1.1 The ACSR BEAR Conductor shall generally conform to IEC: 1089/ IS: 398 except where otherwise specified herein.

1.1.2 The salient parameters of the ACSR BEAR Conductor are indicated below.

**ACSR BEAR**

a) Stranding and wire diameter  
   54/3.53mmAl +7/3.53 mm steel

b) Number of Strands
   - 1st steel layer  
     1
   - 2nd steel layer  
     6
   - 1st Aluminium layer  
     12
   - 2nd Aluminium layer  
     18

c) Sectional area of Aluminium  
   264.4

d) Total sectional area  
   326.1

1.1.3 Standard Technical Particulars

1.1.3.1 The Standard Technical Particulars (STP) of the ACSR conductor are enclosed at Annexure-B of this section. The values indicated in the STP are the minimum and/or maximum values required to be met by the Supplier.

1.2 Workmanship

1.2.1 All the Aluminium and steel strands shall be smooth, uniform and free from all imperfections, such as spills and splits, die marks, scratches, abrasions, etc., after drawing and also after stranding.

1.2.2 The finished conductor shall be smooth, compact, uniform and free from all imperfections including kinks (protusion of wires), wire cross over, over riding, looseness (wire being dislocated by finger/hand pressure and/or unusual bangle noise on tapping), material inclusions, white rust, powder formation or black spot (on account of reaction with trapped rain water etc.), dirt, grit etc.

1.2.3 The steel strands shall be hot dip galvanised and shall have a minimum zinc coating as indicated in the STP. The zinc coating shall be smooth, continuous, of uniform thickness, free from imperfections and shall withstand number of dips in standard Preece test as indicated in STP. The steel wire rods shall be of such quality and purity that, when drawn to the size of the strands specified and coated with zinc, the finished strands and the individual wires shall be of uniform quality and have the same properties and characteristics as prescribed in IEC: 888.
1.2.4 The steel strands shall be preformed and post formed in order to prevent spreading of strands in the event of cutting of composite core wire. Care shall be taken to avoid damages to galvanisation during pre-forming and post-forming operation.

1.3 Joints in Wires

1.3.1 Aluminium Wires

1.3.1.1 During stranding, no aluminium wire welds shall be made for the purpose of achieving the required conductor length.

1.3.1.2 No joints shall be permitted in the individual wires in the outer most layer of the finished conductor. However joints are permitted in the inner layer of the conductor unavoidably broken during stranding, provided such breaks are not associated with either inherently defective wire or with the use of short lengths of aluminium wires. Such joints shall not be more than four (4) per conductor length and shall not be closer than 15 meters from joint in the same wire or in any other aluminium wire of the completed conductor.

1.3.1.3 Joints shall be made by cold pressure butt welding and shall withstand a stress of not less than the breaking strength of individual strand guaranteed.

1.3.2 Steel Wires

There shall be no joint of any kind in the finished wire entering into the manufacture of the strand. There shall also be no strand joints or strand splices in any length of the completed stranded steel core of the conductor.

1.4 Tolerances

The manufacturing tolerances to the extent indicated in the STP shall be permitted in the diameter of individual aluminium and steel strands and lay-ratio of the conductor.

1.5 Materials

1.5.1 Aluminium

The aluminium strands shall be hard drawn from electrolytic aluminium rods having purity not less than 99.5% and a copper content not exceeding 0.04%. They shall have the same properties and characteristics as prescribed in IEC: 889.

1.5.2 Steel

The steel wire strands shall be drawn from high carbon steel wire rods produced by either the acid or the basic open-hearth process, the electric furnace process, or the basic oxygen process and shall conform to the chemical composition indicated in the STP.

The Steel wire strands shall have the same properties and characteristics as prescribed for regular strength steel wire in IEC : 888.

1.5.3 Zinc

The zinc used for galvanizing shall be electrolytic High Grade Zinc of 99.95% purity as per IS209. It shall conform to and satisfy all the requirements of IS:209.
1.6 Standard Length

1.6.1 The standard length of the conductor shall be as indicated in the STP. All lengths outside this limit of tolerance shall be treated as random lengths. Not less than 90% of the total quantity of the conductor shall be supplied in standard lengths.

1.6.2 Random lengths will be accepted provided no length is less than 70% of the standard length and the total quantity of such random lengths shall not be more than 10% of the total quantity ordered. When one number random length has been manufactured at any time, five (5) more individual lengths each equivalent to the above random length with a tolerance of +/- 5% shall also be manufactured and all the above six random lengths shall be despatched in the same shipment. At no point, the cumulative quantity supplied of such random lengths shall not be more than 12.5% of the total cumulative quantity supplied including such random lengths. However, the last 20% of the quantity ordered shall be supplied only in standard lengths as specified.

1.6.3 The Employer reserves the right to place orders for the lengths above the standard length on the same terms and conditions applicable for the standard lengths during the pendency of the Contract.

2.0 Tests and Standards

2.1 Type Tests

2.1.1 The required type tests on conductor are stipulated hereunder. The specified type tests under the following clause shall not be required to be carried out if a valid test certificate is available for the same conductor with same bundle configuration. The tests certificate shall be considered valid if:

i. Tests conducted earlier is either conducted in accredited laboratory (accredited based on ISO/IEC vide 25/17025 or EN 45001 by the National accreditation body of the country where laboratory is located) or witnessed by the representative(s) of any utility and

ii. Tests have been conducted not prior to 5 (five) years from the date of bid opening.

In case the test have been conducted earlier than the above stipulated period or in the event of any discrepancy in the test report (i.e., any test not applicable due to any design/manufacturing change including substitution of components or due to non-compliance with the requirement stipulated in the Technical Specifications), the tests shall be conducted by the Supplier at no extra cost to the Purchaser.

2.1.2 The following tests are required on samples of conductor from each manufacturing facility:

a) DC resistance test on stranded conductor

b) UTS test on stranded conductor

2.2 Acceptance Tests
a) Visual and dimensional check on drum
b) Visual check for joints scratches etc. and length measurement of conductor by rewinding
c) Dimensional check on Steel and Aluminium strands
d) Check for lay-ratios of various layers

e) Galvanizing test on steel strands
f) Torsion and Elongation tests on steel strands
g) Breaking load test on steel and Aluminium strands

h) Wrap test on Steel & Aluminium strands IEC : 888 & 889
i) DC resistance test on Aluminium strands IEC : 889
j) Procedure qualification test on welded joint of Aluminium strands

k) Barrel Batten strength test Annexure-A

Note: All the above tests except (j) shall be carried out on Aluminium and steel strands after stranding only.

2.3 Routine Test

a) Check to ensure that the joints are as per Specification
b) Check that there are no cuts, fins etc., on the strands.
c) Check that drums are as per Specification
d) All acceptance test as mentioned above to be carried out on each coil/ drum (as applicable)

2.4 Tests During Manufacture

a) Chemical analysis of zinc used for galvanizing
b) Chemical analysis of Aluminium used for making Aluminium strands As per Annexure-A
c) Chemical analysis of steel used for making steel strands

2.5 Testing Expenses

2.5.1 No type test charges shall be payable to the supplier.

2.5.2 Bidder shall indicate the laboratories in which they propose to conduct the type tests, if required. They shall ensure that adequate facilities are available in the laboratories and 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 Supplier 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 a fresh lot is manufactured for testing then the lot already manufactured shall be rejected.

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 of conductor, except for the expenses of the inspector/Employer’s representative.

2.5.5 In case of failure in any type test, if repeat type tests are required to be conducted, then all the expenses for deputation of Inspector/Employer’s representative shall be deducted from the contract price. Also if on receipt of the Supplier’s notice of testing, the Employer’s representative does not find ‘plant’ to be ready for testing the expenses incurred by the Employer for re-deputation shall be deducted from contract price.

2.6 Additional Tests

2.6.1 The Employer reserves the right of having at his own expenses any other test(s) of reasonable nature carried out at Supplier’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 Employer 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 Supplier’s premises or at any other test centre. In case of evidence of non compliance, it shall be binding on the part of Supplier 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 Employer.

2.7 Sample Batch For Type Testing

2.7.1 The Supplier shall offer material for selection of samples for type testing only after getting Quality Assurance Plan approved from Employer’s Quality Assurance Deptt. The sample shall be manufactured strictly in accordance with the Quality Assurance Plan approved by Employer.

2.7.2 The Supplier shall offer at least three drums for selection of sample required for conducting all the type test.

2.7.3 The Supplier is required to carry out all the acceptance tests successfully in presence of Employer’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 alongwith one original. One copy will be returned duly certified by the Employer only after which the commercial production of the material shall start.

2.8.2 Record of routine test reports shall be maintained by the Supplier at his works for periodic inspection by the Employer’s representative.
2.8.3 Test Certificates of tests during manufacture shall be maintained by the Supplier. These shall be produced for verification as and when desired by the Employer.

2.9 Inspection

2.9.1 The Employer’s representative shall at all times be entitled to have access to the works and all places of manufacture, where conductor shall be manufactured and representative shall have full facilities for unrestricted inspection of the Supplier’s works, raw materials and process of manufacture for conducting necessary tests as detailed herein.

2.9.2 The Supplier shall keep the Employer informed in advance of the time of starting and of the progress of manufacture of conductor in its various stages so that arrangements can be made for inspection.

2.9.3 No material shall be dispatched from its point of manufacture before it has been satisfactorily inspected and tested, unless the inspection is waived off by the Employer in writing. In the latter case also the conductor shall be dispatched 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 Supplier 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 Supplier’s works:

a) Calibration of various testing and measuring equipment including tensile testing machine, resistance measurement facilities, burette, thermometer, barometer, digital ohm metre etc.

b) Standard resistance for calibration of resistance bridges.

c) Finished conductor 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

2.11.1 The conductor shall be supplied in non-returnable, strong, wooden drums provided with lagging of adequate strength, constructed to protect the conductor against all damage and displacement during transit, storage and subsequent handling and stringing operations in the field. The Supplier 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, except as otherwise specified hereinafter.

2.11.2 The drums shall be suitable for wheel mounting and for letting off the conductor under a minimum controlled tension of the order of 5 KN.
2.11.3 The general outline of the drum for conductor shall be as in the annexed drawings. The Bidder should submit their proposed drum drawings along with the bid.

2.11.4 For conductor, one standard length shall be wound on each drum.

2.11.5 All wooden components shall be manufactured out of seasoned soft wood 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 conductor.

2.11.6 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 3mm from that indicated in the figure. There shall be at least 3 nails per plank of ply with maximum nail spacing of 75mm. Where a slot is cut in the flange to receive the inner end of the conductor the entrance shall be in line with the periphery of the barrel.

2.11.7 The wooden battens used for making the barrel of the conductor 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 conductor.

2.11.8 Barrel studs shall be used for the construction of drums. The flanges shall be holed and the barrel supports slotted to receive them. The barrel studs shall be threaded over a length on either end, sufficient to accommodate washers, spindle plates and nuts for fixing flanges at the required spacing.

2.11.9 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.

2.11.10 The inner cheek of the flanges and drum barrel surface shall be painted with a bitumen based paint.

2.11.11 Before reeling, cardboard or double corrugated or thick bituminised water-proof 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 conductor, the exposed surface of the outer layer of conductor shall be wrapped with water proof thick bituminised bamboo paper to preserve the conductor from dirt, grit and damage during transport and handling.

2.11.12 A minimum space of 75 mm for conductor shall be provided between the inner surface of the external protective tagging and outer layer of the conductor.

2.11.13 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.
2.11.14 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.

2.11.15 A steel collar shall be used to secure all barrel studs. This collar shall be located between the washers and the steal drum and secured to the central steel plate by welding.

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 conductor ends shall be properly sealed and secured on the side of one of the flanges to avoid loosening of the conductor layers during transit and handling.

2.11.18 As an alternative to wooden drum Bidder may also supply the conductors in non-returnable painted steel drums. After preparation of steel surface according to IS:9954, synthetic enamel paint shall be applied after application of one coat of primer. Wooden/Steel drum will be treated at par for evaluation purpose and accordingly the Bidder should quote in the package.

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 conductor
(f) Length of conductor in meters
(g) Arrow marking for unwinding
(h) Position of the conductor ends
(i) Distance between outer-most Layer of conductor and the inner surface of lagging.
(k) Barrel diameter at three locations & an arrow marking at the location of the measurement.
(l) Number of turns in the outer most layer.
(m) Gross weight of drum after putting lagging.
(n) Tear weight of the drum without lagging.
(o) Net weight of the conductor in the drum.
(p) CIP/MICC No.

The above should be indicated in the packing list also.

2.13 **Verification of Conductor Length**
The Employer reserves the right to verify the length of conductor after unreeling. The quantity for verification shall be between a minimum of five percent (5%) to a maximum of ten percent (10%) of the drums in a lot offered for inspection. The actual quantity will be discussed and mutually agreed to by the Supplier & Employer in the Quality Assurance Programme.

2.14 Standards

2.14.1 The conductor 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.

2.14.2 In the event of the supply of conductor 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 Supplier and those specified in this document will be provided by the Supplier to establish their equivalence.

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Indian Standard</th>
<th>Title</th>
<th>International Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.</td>
<td>IS : 1778-1980</td>
<td>Reels and Drums for Bare Conductors</td>
<td>BS:1559-1949</td>
</tr>
<tr>
<td>7.</td>
<td>IS : 2629-1990</td>
<td>Recommended Practice for Hot Dip Galvanising of Iron and Steel</td>
<td></td>
</tr>
<tr>
<td>12.</td>
<td>Zinc Coated steel wires for stranded Conductors</td>
<td>IEC : 888-1987</td>
<td></td>
</tr>
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</table>
The standards mentioned above are available from:

<table>
<thead>
<tr>
<th>Reference Abbreviation</th>
<th>Name and Address</th>
</tr>
</thead>
<tbody>
<tr>
<td>BS</td>
<td>British Standards, British Standards Institution 101, Pentonville Road, 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>
</tr>
<tr>
<td>BIS/IS</td>
<td>Bureau Of Indian Standards. Manak Bhavan, 9, Bahadur Shah Zafar Marg, New Delhi - 110001. INDIA</td>
</tr>
<tr>
<td>ISO</td>
<td>International Organisation for Standardization. Danish Board of Standardization Danish Standardizing Sraat, Aurehoegvej-12 DK-2900, Heeleprup, DENMARK.</td>
</tr>
<tr>
<td>NEMA</td>
<td>National Electric Manufacture Association, 155, East 44th Street. New York, NY 10017 U.S.A.</td>
</tr>
</tbody>
</table>
1. Tests on Conductor

1.1 UTS Test on Stranded Conductor

Circles perpendicular to the axis of the conductor shall be marked at two places on a sample of conductor of minimum 5 m length between fixing arrangement suitably fixed on a tensile testing machine. The load shall be increased at a steady rate upto 50% of minimum specified 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 the UTS of conductor and held for one minute. The Conductor sample shall not fail during this period. The applied load shall then be increased until the failing load is reached and this value shall be recorded.

1.2 D.C. Resistance Test on Stranded Conductor

On a conductor 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 or digital ohm-metre of sufficient accuracy by placing the clamps initially zero metre and subsequently one metre 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 20°C as per IS:398. The resistance corrected at 20°C shall conform to the requirements indicated in the STP.

1.3 Chemical Analysis of Aluminium and Steel

Samples taken from the Aluminium and steel ingots/coils/strands shall be chemically/spectrographically analysed. The same shall be in conformity to the requirements stated in this Specification.

1.4 Visual and Dimensional Check on Drums

The drums shall be visually and dimensionally checked to ensure that they conform to the requirements of this Specification.

1.5 Visual Check for Joints, Scratches etc.

Conductor drums shall be rewound in the presence of the Employer. The Employer shall visually check for scratches, joints etc. and that the conductor generally conform to the requirements of this Specification. Five percent (5%) to ten percent (10%) drums from each lot shall be rewound in the presence of the Employer's representative. The actual quantity will be discussed and mutually agreed to by the Supplier & Employer in the Quality Assurance Programme.

1.6 Dimensional Check on Steel and Aluminium Strands

The individual strands shall be dimensionally checked to ensure that they conform to the requirement of this Specification.

1.7 Check for Lay-ratios of Various Layers

The lay-ratios of various layers shall be checked to ensure that they conform to the requirements of this Specification.

1.8 Procedure Qualification test on welded Aluminium strands.

Two Aluminium wire shall be welded as per the approved quality plan and shall be subjected to tensile load. The breaking strength of the welded joint of the wire shall not be less than the breaking strength of individual strands.
1.9 **Chemical Analysis of Zinc**
Samples taken from the zinc ingots shall be chemically/ spectrographically analyzed. The same shall be in conformity to the requirements stated in the Specification.

1.10 **Galvanizing Test**
The test procedure shall be as specified in IEC : 888. 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.

1.11 **Torsion and Elongation Tests on Steel Strands**
The test procedures shall be as per clause No. 10.3 of IEC : 888. In torsion test, the number of complete twists before fracture shall not be less than that indicated in the STP. 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. In elongation test, the elongation of the strand shall not be less than 4% for a gauge length of 250 mm.

1.12 **Check on Barrel Batten strength of Drums**
The details regarding barrel batten strength test will be discussed and mutually agreed to by the Supplier & Employer in the Quality Assurance Programme.
# STANDARD TECHNICAL PARTICULARS OF ACSR BEAR CONDUCTOR

<table>
<thead>
<tr>
<th>Sl.</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 Wire / Rods</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.1</td>
<td>Aluminium</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>a) Minimum purity of Aluminium</td>
<td>%</td>
<td>99.50</td>
</tr>
<tr>
<td></td>
<td>b) Maximum copper content</td>
<td>%</td>
<td>0.04</td>
</tr>
<tr>
<td>1.2</td>
<td>Steel wires/ rods</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>a) Carbon</td>
<td>%</td>
<td>0.50 to 0.85</td>
</tr>
<tr>
<td></td>
<td>b) Manganese</td>
<td>%</td>
<td>0.50 to 1.10</td>
</tr>
<tr>
<td></td>
<td>c) Phosphorous</td>
<td>%</td>
<td>Not more than 0.035</td>
</tr>
<tr>
<td></td>
<td>d) Sulphur</td>
<td>%</td>
<td>Not more than 0.045</td>
</tr>
<tr>
<td></td>
<td>e) Silicon</td>
<td>%</td>
<td>0.10 to 0.35 (Max.)</td>
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<tr>
<td>1.3</td>
<td>Zinc</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>a) Minimum purity of Zinc</td>
<td>%</td>
<td>99.95</td>
</tr>
<tr>
<td>2.0</td>
<td>Aluminum strands after stranding</td>
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<td></td>
</tr>
<tr>
<td>2.1</td>
<td>Diameter</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>a) Nominal</td>
<td>mm</td>
<td>3.35</td>
</tr>
<tr>
<td></td>
<td>b) Maximum</td>
<td>mm</td>
<td>3.37</td>
</tr>
<tr>
<td></td>
<td>c) Minimum</td>
<td>mm</td>
<td>3.33</td>
</tr>
<tr>
<td>2.2</td>
<td>Minimum breaking load of strand</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>a) Before stranding</td>
<td>KN</td>
<td>1.41</td>
</tr>
<tr>
<td></td>
<td>b) After stranding</td>
<td>KN</td>
<td>1.34</td>
</tr>
<tr>
<td>2.3</td>
<td>Maximum resistance of 1 m length of strand at 20 deg. C</td>
<td>Ohm</td>
<td>0.003245</td>
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<tr>
<td>3.0</td>
<td>Steel strand after stranding</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.1</td>
<td>Diameter</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>a) Nominal</td>
<td>mm</td>
<td>3.35</td>
</tr>
<tr>
<td></td>
<td>b) Maximum</td>
<td>mm</td>
<td>3.41</td>
</tr>
<tr>
<td></td>
<td>c) Minimum</td>
<td>mm</td>
<td>3.29</td>
</tr>
<tr>
<td>3.2</td>
<td>Minimum breaking load of strand</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>a) Before stranding</td>
<td>KN</td>
<td>11.37</td>
</tr>
<tr>
<td></td>
<td>b) After stranding</td>
<td>KN</td>
<td>10.80</td>
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### STANDARD TECHNICAL PARTICULARS OF ACSR BEAR CONDUCTOR

<table>
<thead>
<tr>
<th>Sl.</th>
<th>Description</th>
<th>Unit</th>
<th>Guaranteed Values</th>
</tr>
</thead>
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<tr>
<td>3.3</td>
<td><strong>Galvanising</strong></td>
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<td></td>
</tr>
<tr>
<td>a)</td>
<td>Minimum weight of zinc coating per sq.m.</td>
<td>gm</td>
<td>250</td>
</tr>
<tr>
<td>b)</td>
<td>Minimum number of dips that the galvanised strand can withstand in the standard preece test</td>
<td>Nos.</td>
<td>2 dips of one minute &amp; 1 dip of half minute</td>
</tr>
<tr>
<td>c)</td>
<td>Min. No. of twists in gauge length equal 100 times the dia. of wire which the strand can withstand in the torsion test (after stranding)</td>
<td>Nos</td>
<td>16</td>
</tr>
<tr>
<td></td>
<td><strong>Stranded Conductor</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4.1</td>
<td>UTS of the conductor</td>
<td>kN</td>
<td>111.50 (Min.)</td>
</tr>
<tr>
<td>4.2</td>
<td>Lay length of outer steel layer</td>
<td>mm</td>
<td>Max</td>
</tr>
<tr>
<td>a)</td>
<td>Outer Steel layer</td>
<td>mm</td>
<td>18</td>
</tr>
<tr>
<td>b)</td>
<td>12 wire Aluminium layer</td>
<td>mm</td>
<td>14</td>
</tr>
<tr>
<td>c)</td>
<td>18 wire Aluminium layer</td>
<td>mm</td>
<td>13</td>
</tr>
<tr>
<td>d)</td>
<td>24 wire Aluminium Layer</td>
<td>mm</td>
<td>12</td>
</tr>
<tr>
<td>4.3</td>
<td>DC resistance of the conductor at 20°C</td>
<td>ohm/km</td>
<td>0.1093</td>
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<tr>
<td>4.4</td>
<td>Standard length of the conductor</td>
<td>m</td>
<td>1800</td>
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<tr>
<td>4.5</td>
<td>Tolerance on Standard length</td>
<td>%</td>
<td>(+/-) 5</td>
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<tr>
<td>4.6</td>
<td>Direction of lay of outer layer</td>
<td></td>
<td>Right Hand</td>
</tr>
<tr>
<td>4.7</td>
<td>Linear mass of the conductor</td>
<td>kg/km</td>
<td>1215</td>
</tr>
</tbody>
</table>
1.0 Technical Description of 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 details of the earth wire for 220 kV are tabulated below:

<table>
<thead>
<tr>
<th>Description</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>a) Stranding and wire diameter</td>
<td>7/3.35 mm steel</td>
</tr>
<tr>
<td>b) Number of strands</td>
<td></td>
</tr>
<tr>
<td>Steel core</td>
<td>1</td>
</tr>
<tr>
<td>Outer steel layer</td>
<td>6</td>
</tr>
<tr>
<td>c) Total sectional area</td>
<td>61.7 sqmm.</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. 2.0 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 Clause 2.0, 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 Clause 2.0, 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 Clause 2.0, 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.

2.0 Standard Technical Particulars

2.1 The standard Technical Particulars to be adhered by the contractor/manufacturer are furnished in Annexure-B if this section.

3.0 Tests and Standards

3.1 Type Tests on Earthwire

3.1.1 The required type tests on earthwire are stipulated hereunder. The specified type tests under the following clause shall not be required to be carried out if a valid test certificate is available for the same earthwire. The tests certificate shall be considered valid if:

i. Tests conducted earlier is either conducted in accredited laboratory (accredited based on ISO/IEC vide 25/17025 or EN 45001 by the National accreditation body of the country where laboratory is located) or witnessed by the representative(s) of any utility and

ii. Tests have been conducted not prior to 5 (five) years from the date of bid opening.

In case the test have been conducted earlier than the above stipulated period or in the event of any discrepancy in the test report (i.e., any test not applicable due to any design/manufacturing change including substitution of components or due to non-compliance with the requirement stipulated in the
Technical Specifications), the tests shall be conducted by the Supplier at no extra cost to the Purchaser.

3.1.2 The following tests are required on samples of earthwire from each manufacturing works:

- **a)** UTS test : As per Annexure - A
- **b)** DC resistance test : As per Annexure - A

### 3.2 Acceptance Tests on Earthwire

- **a)** Visual and dimensional check on drum : As per Annexure - A
- **b)** Visual check for joints scratches etc. and lengths of earthwire : As per Annexure - A
- **c)** Dimensional check : As per Annexure - A
- **d)** Lay length check : As per Annexure - A
- **e)** Galvanising test : As per Annexure - A
- **f)** Torsion test : As per Annexure - A
- **g)** Elongation test : As per IS:398 (Part-II)
- **h)** Wrap test : As per IS:398 (Part-II)
- **i)** DC resistance test : As per IS:398 (Part-II)
- **j)** Breaking load test : As per IS:398 (Part-II)
- **k)** Chemical Analysis of steel : As per Annexure - A

### 3.3 Routine Tests on Earthwire

- **a)** Check for correctness of stranding : As per Annexure - A
- **b)** Check that there are no cuts, fins etc. on the strands. : As per Annexure - A
- **c)** Check that drums are as per Specification. : As per Annexure - A

### 3.4 Tests During Manufacture Earthwire

- **a)** Chemical analysis of zinc used for galvanising : As per Annexure - A
- **b)** Chemical analysis of steel : As per Annexure - A
3.5 Testing Expenses

3.5.1 No type test charges shall be payable to the supplier.

3.5.2 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.

3.5.3 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.

3.5.4 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/ Employer’s representative.

3.5.5 In case of failure in any type test, repeat type tests are required to be conducted, then all the expenses for deputation of Inspector/ Employer’s representative shall be deducted from the contract price. Also if on receipt of the Contract’s notice of testing the Employer’s representative/Inspector does not find ‘materials and facilities’ to be ready for testing, the expenses incurred by the Employer for re-deputation shall be deducted from the contract price.

3.6 Additional Tests

3.6.1 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.

3.6.2 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.

3.7 Sample Batch for Type Testing

3.7.1 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.
3.7.2 The Contractor shall offer at least three drums for selection of sample required for conducting all the type test.

3.7.3 The Contractor is required to carry out all the Acceptance tests successfully in presence of Owner’s representative before sample selection.

3.8 Test Reports

3.8.1 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.

3.8.2 Record of routine test reports shall be maintained by the Contractor at his works for periodic inspection by the Owner’s representative.

3.8.3 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.

3.9 Inspection

3.9.1 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.

3.9.2 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.

3.9.3 No material shall be dispatched 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 dispatched only after satisfactory testing for all tests specified herein have been completed.

3.9.4 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.

3.10 Test Facilities

3.10.1 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.
3.11 Packing for Earth wire

3.11.1 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 778-1980, except as otherwise specified hereinafter.

3.11.2 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.

3.11.3 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.

3.11.4 For Earth wire, two standard lengths shall be wound on each drum.

3.11.5 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.

3.11.6 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.

3.11.7 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.

3.11.8 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.

3.11.9 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.

3.11.10 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.

3.11.11 The inner cheek of the flanges and drum barrel surface shall be painted with a bitumen based paint.

3.11.12 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 water proof 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.

3.11.13 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.

3.11.14 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.

3.11.15 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.

3.11.16 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.

3.11.17 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.

3.12 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

3.13 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.

3.14 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.

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Indian Standard</th>
<th>Title</th>
<th>International Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Standard Number</td>
<td>Description</td>
<td>Reference</td>
</tr>
<tr>
<td>---</td>
<td>----------------</td>
<td>------------------------------------------------------------------------------</td>
<td>-----------------</td>
</tr>
<tr>
<td>6</td>
<td>IS : 1778-1997</td>
<td>Reels and Drums for Bare Conductors</td>
<td>BS:1559-1949</td>
</tr>
<tr>
<td>8</td>
<td>IS : 2629-1990</td>
<td>Recommended Practice for Hot Dip Galvanising of Iron and Steel</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>IS : 2633-1992</td>
<td>Method of Testing Uniformity of Coating on Zinc Coated Articles</td>
<td></td>
</tr>
<tr>
<td>14</td>
<td></td>
<td>Zinc Coated steel wires for stranded Conductors</td>
<td>IEC : 888-1987</td>
</tr>
<tr>
<td>15</td>
<td></td>
<td>Hard drawn Aluminium wire for overhead line conductors</td>
<td>IEC : 889-1987</td>
</tr>
</tbody>
</table>
The standards mentioned above are available from:

<table>
<thead>
<tr>
<th>Reference Abbreviation</th>
<th>Name and Address</th>
</tr>
</thead>
<tbody>
<tr>
<td>BS</td>
<td>British Standards, British Standards Institution 101, Pentonvile Road, 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>
</tr>
<tr>
<td>BIS/IS</td>
<td>Bureau Of Indian Standards. Manak Bhavan, 9, Bahadur Shah Zafar Marg, New Delhi - 110001. INDIA</td>
</tr>
<tr>
<td>ISO</td>
<td>International Organisation for Standardization. Danish Board of Standardization Danish Standardizing Sraat, Aurehoegvej-12 DK-2900, Heeleprup, DENMARK.</td>
</tr>
<tr>
<td>NEMA</td>
<td>National Electric Manufacture Association, 155, East 44th Street. New York, NY 10017 U.S.A.</td>
</tr>
</tbody>
</table>
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 an 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 20°C. The resistance corrected at 20°C 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.
A) Standardized Technical Particulars of 7/3.35 mm Galvanised Steel Earth wire

<table>
<thead>
<tr>
<th>Sl. no.</th>
<th>Description</th>
<th>Unit</th>
<th>Standard 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>
<td>%</td>
<td>Not more than 0.04</td>
</tr>
<tr>
<td>d)</td>
<td>Sulphur</td>
<td>%</td>
<td>Not more than 0.04</td>
</tr>
<tr>
<td>e)</td>
<td>Silicon</td>
<td>%</td>
<td>0.15 to 0.35</td>
</tr>
<tr>
<td>1.2</td>
<td>Zinc</td>
<td></td>
<td></td>
</tr>
<tr>
<td>a)</td>
<td>Minimum purity of Zinc</td>
<td>%</td>
<td>99.95</td>
</tr>
<tr>
<td>2.0</td>
<td>Steel strands</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.1</td>
<td>Diameter</td>
<td></td>
<td></td>
</tr>
<tr>
<td>a)</td>
<td>Nominal</td>
<td>mm</td>
<td>3.35</td>
</tr>
<tr>
<td>b)</td>
<td>Maximum</td>
<td>mm</td>
<td>3.40</td>
</tr>
<tr>
<td>c)</td>
<td>Minimum</td>
<td>mm</td>
<td>3.30</td>
</tr>
<tr>
<td>2.2.</td>
<td>Minimum breaking load of strand</td>
<td></td>
<td></td>
</tr>
<tr>
<td>a)</td>
<td>After stranding</td>
<td>KN</td>
<td>8.98</td>
</tr>
<tr>
<td>2.3</td>
<td>Galvanising</td>
<td></td>
<td></td>
</tr>
<tr>
<td>a)</td>
<td>Minimum weight of zinc coating</td>
<td>Gms.</td>
<td>275</td>
</tr>
<tr>
<td>b)</td>
<td>Maximum number of dips that the</td>
<td>Nos.</td>
<td>3 dips of 1 minute and one dip of ½ minute</td>
</tr>
<tr>
<td></td>
<td>galvanized strand can withstand</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>in the standard preece test</td>
<td></td>
<td></td>
</tr>
<tr>
<td>c)</td>
<td>Minimum number of twists in a</td>
<td>Nos.</td>
<td>18</td>
</tr>
<tr>
<td></td>
<td>gauge length equal to 100 times</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>diameter of wire which the strand</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>can withstand in the torsion test</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>after stranding</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.0</td>
<td>Stranded Earth wire</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.1</td>
<td>UTS of Earth wire</td>
<td>KN</td>
<td>61.1 (min.)</td>
</tr>
<tr>
<td>3.2</td>
<td>Lay length of outer steel layer</td>
<td></td>
<td></td>
</tr>
<tr>
<td>a)</td>
<td>Standard</td>
<td>mm</td>
<td>181</td>
</tr>
<tr>
<td>b)</td>
<td>Maximum</td>
<td>mm</td>
<td>198</td>
</tr>
<tr>
<td>c)</td>
<td>Minimum</td>
<td>mm</td>
<td>165</td>
</tr>
<tr>
<td>3.3</td>
<td>Maximum DC resistance of earth</td>
<td>Ohm/</td>
<td>2.5</td>
</tr>
<tr>
<td>Sl. no.</td>
<td>Description</td>
<td>Unit</td>
<td>Standard Values</td>
</tr>
<tr>
<td>--------</td>
<td>--------------------------------------</td>
<td>------</td>
<td>-----------------</td>
</tr>
<tr>
<td>3.4</td>
<td>Standard length of earth wire</td>
<td>M</td>
<td>2000</td>
</tr>
<tr>
<td>3.5</td>
<td>Tolerance on standard length</td>
<td>%</td>
<td>±5</td>
</tr>
<tr>
<td>3.6</td>
<td>Direction of lay for outside layer</td>
<td></td>
<td>Right hand</td>
</tr>
<tr>
<td>3.7</td>
<td>Linear mass</td>
<td></td>
<td></td>
</tr>
<tr>
<td>a)</td>
<td>Standard</td>
<td>Kg/km</td>
<td>482</td>
</tr>
<tr>
<td>b)</td>
<td>Maximum</td>
<td>Kg/km</td>
<td>496</td>
</tr>
<tr>
<td>c)</td>
<td>Minimum</td>
<td>Kg/km</td>
<td>468</td>
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</table>
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<tr>
<th>Clause</th>
<th>Description</th>
<th>Page No.</th>
</tr>
</thead>
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<td>Equipment Marking</td>
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<td>Bid Drawings</td>
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<tr>
<td>4.</td>
<td>Test and Standards</td>
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<td></td>
<td>Annexure-A</td>
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</tr>
</tbody>
</table>
TECHNICAL SPECIFICATIONS

SECTION – VII A

1.0 Technical Description of Disc Insulators

1.1 Details of Disc Insulators

1.1.1 The Insulator strings shall consist of Standard discs for a three phase, 50 Hz, effectively earthed 220 kV transmission system in a lightly polluted atmosphere. The discs shall be cap and pin, ball and socket type.

1.1.2 Supplier may quote for disc insulator, made of either electro-porcelain or toughened glass.

1.1.3 The size of disc insulator, minimum creepage distance, the number to be used in different type of strings, their electromechanical strength and mechanical strength of insulator string along with hardware fittings shall be as follows:

<table>
<thead>
<tr>
<th>Sl. No</th>
<th>Type of string</th>
<th>Size of disc insulators (mm)</th>
<th>Minimum creepage distance of each disc (mm)</th>
<th>No. of discs</th>
<th>Electromechanical strength of insulator disc (kN)</th>
<th>Mechanical strength of insulator string along with hardware fittings (kN)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Single “I” suspension Pilot</td>
<td>255x145 or 280x145</td>
<td>15</td>
<td>1 x 16</td>
<td>120</td>
<td>120</td>
</tr>
<tr>
<td>2.</td>
<td>Double Tension String</td>
<td>280 x 170</td>
<td>15</td>
<td>2 x 17</td>
<td>160</td>
<td>2 x 160</td>
</tr>
<tr>
<td>3.</td>
<td>Triple Tension String</td>
<td>280 x 170</td>
<td>15</td>
<td>3 x 17</td>
<td>160</td>
<td>3 x 160</td>
</tr>
</tbody>
</table>

1.2 Pin and Cap

1.2.1 Pin and Cap shall be designed to transmit the mechanical stresses to the shell by compression and develop uniform mechanical strength in the insulator. The cap shall be circular with the inner and outer surfaces concentric, of such design that it will not yield or distort under load conditions.

1.2.2 The pin ball shall move freely in the cap socket but without danger of accidental uncoupling during erection or in position. The design of the disc should be such that stresses due to expansion or contraction in any part of the insulator shall not lead to deterioration.
1.3 **Security clip**

1.3.1 Security clip for use with ball and socket coupling shall be of R-shaped hump type which shall provide positive locking of the coupling as per IS:2486-(Part-III)/IEC : 372. The legs of the security clips shall be spread after installation 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 locking device allow separation of insulator units or fittings.

1.3.2 The hole for the security clip shall be countersunk and the clip shall 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 50N (5 kg) or more than 500N (50 kg).

1.4 **Ball and Socket Designation**

The dimensions of the balls and sockets shall be 20 mm designation for 120 and 160 kN disc insulator in accordance with the standard dimensions stated in IS:2486 - (Part - II)/ IEC:120.

1.5 **Dimensional Tolerance of Insulator Disc (Standard)**

It shall be ensured that the dimensions of the disc insulators are within the limits specified below :

a) **Diameter of Disc (mm)**

<table>
<thead>
<tr>
<th></th>
<th>Diameter of Disc (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Standard</td>
</tr>
<tr>
<td>120 kN Disc</td>
<td>255/280</td>
</tr>
<tr>
<td>160 kN Disc</td>
<td>280</td>
</tr>
</tbody>
</table>

b) **Ball to ball spacing between discs (mm)**

<table>
<thead>
<tr>
<th></th>
<th>Ball to ball spacing between discs (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Standard</td>
</tr>
<tr>
<td>120 kN Disc</td>
<td>145</td>
</tr>
<tr>
<td>160 kN Disc</td>
<td>170</td>
</tr>
</tbody>
</table>

1.6 **Interchangeability**

The disc insulators inclusive of the ball and socket fittings shall be of standard design suitable for use with the hardware fittings of any make conforming to relevant Indian/International Standards.

1.7 **Corona and RI Performance**
All surfaces must be clean, smooth, without cuts, abrasions or projections. No part shall be subjected to excessive localised pressure. The metal parts shall be so designed and manufactured that it shall not generate any Radio Interference beyond specified limit and not produce any noise generating corona under the operating conditions.

1.8 Maintenance

1.8.1 The disc insulators offered shall be suitable for employment of hot line maintenance techniques so that the usual hot line operations can be carried out with ease, speed and safety.

1.8.2 Bidders shall indicate the methods generally used in the routine hot and dead line maintenance of EHV Lines for which similar disc insulators have been supplied by them. Bidders shall also indicate the recommended periodicity of such maintenance.

1.9 Materials

1.9.1 Porcelain

The porcelain used in the manufacture of shells shall be sound, free from defects thoroughly vitrified and smoothly glazed. The porcelain used shall be non-porous of high dielectric, mechanical and thermal strength, free from internal stress blisters, laminations, voids, foreign matter, imperfections or other defects which might make it any way unsuitable for insulator shells. Porcelain shall remain unaffected by climatic conditions, ozone, acid, alkalis, zinc or dust.

1.9.2 Glaze

The finished porcelain shall be glazed in brown colour. The glaze shall cover all exposed parts of the insulator and shall have a good lusture, smooth surface and good performance under the extreme weather conditions of a tropical climate. It shall not crack or chip by ageing under the normal service conditions. The glaze shall have the same coefficient of expansion as of the porcelain body throughout the working temperature range.

1.9.3 Toughened Glass

The glass used for the shells shall be sound, free from defects such as flaws, bubbles, inclusions etc. and be of uniform toughness over its entire surface. All exposed glass surfaces shall be smooth.

1.9.4 Cement

Cement used in the manufacture of the insulator shall not cause fracture by expansion or loosening by contraction. The cement shall not give rise to chemical reaction with metal fittings and its thickness shall be as small and uniform as possible. Proper care shall be taken to correctly centre and locate individual parts during cementing.

1.9.5 Pins and Caps

Pins and Caps shall be made of drop forged steel and malleable cast iron/spheriodal graphite iron/drop forges steel respectively, duly hot dip
galvanised and shall not be made by jointing, welding, shrink fitting or any other process from more than one piece of material.

1.9.6 Security Clips

Security clips shall be made of good quality stainless steel or phosphor bronze as per IS: 1385/IEC 60372. 2.5% extra security clip shall be provided.

1.10 Workmanship

1.10.1 All the material shall be of the latest design and conform to the best modern practices adopted in the extra high voltage field. Suppliers shall offer only such insulators as are guaranteed by him to be satisfactory and suitable for 220 kV Transmission lines and will give continued good service.

1.10.2 The design, manufacturing process and material control at various stages shall be such as to give maximum working load, highest mobility, best resistance to corrosion, good finish and elimination of sharp edges and corners to limit corona and radio interference.

1.10.3 The design of the insulators shall be such that stresses due to expansion and contraction in any part of the insulator shall not lead to deterioration.

1.10.4 Metal caps shall be free from cracks, seams, shrinks, air holes, burrs and rough edges. All surfaces of the metal parts shall be perfectly smooth with no projecting points or irregularities which may cause corona. All load bearing surfaces shall be smooth and uniform so as to distribute the loading stresses uniformly.

1.10.5 All ferrous parts shall be hot dip galvanised to give a minimum average coating of Zinc equivalent to 600 gm/sq.m. and shall be in accordance with the requirement of IS:2629/ISO-1461(E) and shall satisfy the tests mentioned in IS:2633 or equivalent international standard. The zinc used for galvanising shall be of Grade Zn 99.95 as per IS:209/BS 3436. The zinc coating shall be uniform, adherent, smooth, reasonably bright, continuous and free from imperfections such as flux, ash, rust stains, bulky white deposits and blisters. The galvanised metal parts shall be guaranteed to withstand atleast six successive dips each lasting for one (1) minute duration under the standard preece test.

1.10.6 Before ball fittings are galvanised, all die flashing on the shank surface of the ball shall be carefully removed without reducing the dimensions below the design requirements.

1.10.7 The design of the insulators shall be such that the shell shall not engage directly with hard metal. The design shall also be such that when units are coupled together there is no contact between the shell of one unit and metal of the next adjacent unit. The design of the shell ribs shall be such that the security clip of the insulator can be engaged and disengaged easily with hot stick without damaging the shell ribs.

1.10.8 Insulator units after assembly shall be concentric and co-axial within limits as permitted by the relevant Indian Standards.

1.10.9 The manufacturer of the insulators shall guarantee an insulator failure rate not exceeding 1 (one) per 10000 (ten thousand) per year for disc insulator
per year. In case the annual failure rate during the first ten years of service exceeds the above figure, under normal operating condition, as will be determined by check to be conducted as per mutually agreed procedure and conditions up to ten years, (as permitted by the operating situation), the Supplier shall supply to the Employer free of cost spare insulators equal to 10 times the excess failure.

1.10.10 The Supplier shall guarantee that there shall not be any decapping/breaking of insulators on line under normal operating conditions. In the event of any decapping/breaking and subsequent line drop, during the first ten years of service the Supplier shall have to pay NPRs. 1,00,000/- (NPRs. One hundred thousand only) per dropped string towards expenditure to be incurred by MEW for this line repair.

2.0 Equipment Marking

2.1 Each insulator disc shall be legibly and indelibly marked with the trade mark of the manufacturer, name of MEW and month & year of manufacture. The guaranteed combined mechanical and electrical strength shall be indicated in kilo Newton followed by the word ‘kN’ to facilitate easy identification and to ensure proper use.

2.2 For porcelain insulator, the marking shall be on porcelain. The marking shall be printed, not impressed and shall be applied before firing. For toughened glass insulators the marking shall be on the metal parts.

2.3 One 10 mm thick ring or 20 mm thick spot of suitable quality of paint shall be marked on the cap of each porcelain insulator disc of particular strength for easy identification of the type of insulator. The paint shall not have any deteriorating effect on the insulator performance. Following codes shall be used as identification mark:

For 120 kN disc : Yellow
For 160 kN disc : Green

3.0 Bid Drawings

3.1 The Bidder shall furnish full description and illustration of the material offered.

3.2 The Bidder shall furnish along with the bid the outline drawing (6 copies) of each insulator unit including a cross sectional view of the insulator shell. The drawing shall include but not limited to the following information:

(a) Shell diameter and ball to ball spacing with manufacturing tolerances
(b) Minimum Creepage distance with positive tolerance
(c) Protected creepage distance
(d) Eccentricity of the disc
   (i) Axial run out
   (ii) Radial run out
(e) Unit mechanical and electrical characteristics
(f) Size and weight of ball and socket parts
(g) Weight of unit insulator disc/long rod units
(h) Materials
(i) Identification mark
(j) Manufacturer's catalogue number

3.3 After placement of award, the Supplier shall submit full dimensioned insulator drawings containing all the details as given in Clause No. 3.2 above, in four (4) copies to Employer for approval. After getting approval from Employer and successful completion of all the type tests, the Supplier shall submit 10 more copies of the same drawing to the Employer for further distribution and field use at Employer's end.

3.4 After placement of award the Supplier shall also submit fully dimensioned insulator crate drawing for different type of insulators.

3.5 After placement of award, the Supplier shall submit full dimensioned manufacturing drawing of insulator cap, pin and insulator shell in six (6) copies to the Employer for reference and record.

4.0 Tests and Standards

4.1 Type Tests

The required type tests on individual standard disc insulators, components, materials or complete strings are stipulated hereunder.

The specified type tests under the following clause shall not be required to be carried out if a valid test certificate is available for a similar design. The tests certificate shall be considered valid if:

i. Tests conducted earlier is either conducted in accredited laboratory (accredited based on ISO/IEC vide 25/17025 or EN 45001 by the National accreditation body of the country where laboratory is located) or witnessed by the representative(s) of any utility and

ii. Tests have been conducted not prior to 5 (five) years from the date of bid opening.

In case the test have been conducted earlier than the above stipulated period or in the event of any discrepancy in the test report (i.e., any test not applicable due to any design/manufacturing change including substitution of components or due to non-compliance with the requirement stipulated in the Technical Specifications), the tests shall be conducted by the Supplier at no extra cost to the Purchaser.

4.1.1 On unit disc Insulators (120 kN and 160 kN)

a) Verification of dimensions As per IEC :60383
b) Thermal mechanical performance test As per Annexure-A
c) Power frequency voltage withstand and flashover test under (i) dry (ii) wet condition
   As per IEC : 60383

d) Impulse voltage withstand and flashover test (dry)
   As per IEC : 60383

e) Visible Discharge test (dry)
   As per IS:731, Cl. 10.2

f) RIV test (dry)
   As per IEC:60437

g) Residual strength Test
   As per Annexure-A

h) Steep wave front Test
   As per Annexure-A

i) Impact Test
   As per Annexure-A

4.1.2 On the complete Disc Insulator String with Hardware Fittings

a) Power frequency voltage withstand test with corona control rings/grading ring and arcing horns under wet condition
   As per IEC : 60383

b) Switching surge voltage withstand test under wet condition
   As per IEC: 60383

c) Impulse voltage withstand test under dry condition
   As per IEC : 60383

d) Impulse voltage flash over test under dry condition
   As per IEC : 60383

e) Voltage distribution test
   As per Annexure-A

f) Corona and RIV test under dry condition
   As per Annexure-A

g) Mechanical Strength test
   As per Annexure-A

h) Vibration test
   As per Annexure-A

i) Power-Arc Test
   As per Annexure-A

4.1.3 All the type test given in Clause No. 4.1.2 for disc insulator string shall be conducted on Double tension insulator strings along with hardware fittings.

4.1.4 All the type test given in Clause No. 4.1.2 a) to g) for disc insulator string shall be conducted on Single 'I' suspension pilot and Triple tension insulator strings along with hardware fittings.

4.2 Acceptance Tests

4.2.1 For Disc Insulators (Both porcelain and glass)

a) Visual examination
   As per IEC : 60383

b) Verification of dimensions
   As per IEC : 60383

c) Temperature cycle test
   As per IEC : 60383

d) Galvanising test
   As per IEC : 60383
e) Mechanical performance test  As per IEC:60575 Cl 4.0
f) Test on locking device for ball and socket coupling  As per IEC:60372
g) Eccentricity test  As per IEC:60383
h) Residual Strength Test  As per IEC:797 Clause 4.4 & 4.5
i) Metallurgical Test (For metal fittings only in black condition)
   i) Grain size
   ii) Inclusion rating
   iii) Chemical analysis
   iv) Microstructure
j) Chemical analysis of Zinc Sleeve  As per Annexure-A
k) IR Measurement  As per Annexure-A
l) Impact Test  As per Annexure-A
m) Steep Wave front test  As per Annexure-A
n) Thermal Mechanical performance test  As per Annexure-A

4.2.2 For Porcelain disc Insulators Only
a) Electro-mechanical strength test  As per Annexure-A
b) Porosity test  As per IEC : 60383
c) Puncture test  As per IEC : 60383

4.2.3 For Glass Insulators Only
a) Thermal shock test  As per IEC : 60383
b) Steep wave front test/Puncture test  As per Annexure-A
c) Mechanical failing load Test  As per Annexure-A

4.3 Routine Tests
4.3.1 For Disc Insulators
a) Visual Inspection  As per IS:731, Cl.10.13
b) Mechanical routine test  As per IS:731 Cl. 10.14
  c) Electrical routine test (for porcelain disc insulator only)  As per IS:731 Cl. 10.15
  d) Thermal shock routine test (for glass insulator only)  As per IEC:60383
Design, Supply, Installation and Commissioning of Kushma-New Butwal 220 kV Transmission Line

4.4 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.

c) Chemical analysis hardness tests and magnetic particle inspection for forgings

d) Hydraulic Internal Pressure tests on disc insulator shells

e) Autoclave Test on Cement

4.5 Testing Expenses

4.5.1 As mentioned under clause 4.1 above, no type test charges shall be payable to the supplier.

4.5.2 In case of failure in any type test, the supplier is either required to modify the design of the material & successfully carryout all the type tests as has been detailed out in Clause 4.1 of this specifications or to repeat that particular type test at least three times successfully at his own expenses.

4.5.3 Supplier shall indicate the laboratories in which they propose to conduct the type tests. They shall ensure that adequate facilities 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.

4.5.6 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.

4.5.7 In case of failure in any type test, if repeat type tests are required to be conducted, then all the expenses for deputation of Inspector/ Employer's representative shall be deducted from the contract price. Also if on receipt of the Supplier's notice of testing, the Employer's representative does not find 'plant' to be ready for testing the expenses incurred by the Employer for redeputation shall be deducted from contract price.

4.5.8 The Supplier shall intimate the Employer about carrying out of the type tests along with detailed testing programme at least 3 weeks in advance (in case of Domestic Supplier) and at least 6 weeks advance (in case of foreign Supplier) of the scheduled date of testing during which the Employer will arrange to
depute his representative to be present at the time of carrying out the tests.

4.6 **Sample Batch for Type Testing**

4.6.1 The Supplier shall offer material for sample selection for type testing only after getting Quality Assurance Programme approved by the Employer. The Supplier 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 Employer.

4.6.2 Before sample selection for type testing, the Supplier shall be required to conduct all the acceptance tests successfully in presence of Employer's representative.

4.7 **Schedule of Testing**

4.7.1 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, if required.

4.8 **Additional Tests**

4.8.1 The Employer reserves the right of having at his own expenses any other test(s) of reasonable nature carried out at Supplier'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.

4.8.2 The Employer 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 Supplier's premises or at any other test centre. In case of evidence of non compliance, it shall be binding on the part of the Supplier 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 Employer.

4.9 **Co-ordination for Testing**

The Supplier shall have to co-ordinate testing of insulators, if required, with hardware fittings to be supplied by other Supplier.

4.10 **Guarantee**

The Supplier of insulators shall guarantee overall satisfactory performance of the insulators with the hardware fittings.

4.11 **Test Reports**

4.11.1 Copies of type test reports shall be furnished in at least six (6) copies along with one original. One copy shall be returned duly certified by the Employer only after which the commercial production of the concerned material shall
4.11.2 Copies of acceptance test reports shall be furnished in at least six (6) copies. One copy shall be returned duly certified by the Employer, only after which the material shall be dispatched.

4.11.3 Record of routine test reports shall be maintained by the Supplier at his works for periodic inspection by the Employer’s representative.

4.11.4 Test certificates of test during manufacture shall be maintained by the Supplier. These shall be produced for verification as and when desired by the Employer.

4.12 Inspection

4.12.1 The Employer’s representative shall at all times be entitled to have access to the works and all places of manufacture, where insulator, and its component parts shall be manufactured and the representatives shall have full facilities for unrestricted inspection of the Supplier’s and sub-Supplier’s works, raw materials, manufacture of the material and for conducting necessary test as detailed herein.

4.12.2 The material for final inspection shall be offered by the Supplier only under packed condition. The Employer shall select samples at random from the packed lot for carrying out acceptance tests. Insulators shall normally be offered for inspection in lots not exceeding 10,000 nos. for disc insulator. The lot should be homogeneous and should contain insulators manufactured in 3-4 consecutive weeks.

4.12.3 The Supplier shall keep the Employer informed in advance of the time of starting and the progress of manufacture of material in their various stages so that arrangements could be made for inspection.

4.12.4 No material shall be dispatched from its point of manufacture before it has been satisfactorily inspected and tested unless the inspection is waived off by the Employer in writing. In the latter case also the material shall be dispatched only after satisfactory testing for all tests specified herein have been completed.

4.12.5 The acceptance of any quantity of material shall be no way relieve the Supplier 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.

4.13 Packing and Marking

4.13.1 All insulators shall be packed in strong seasoned wooden crates. The gross weight of the crates along with the material shall not normally exceed 200 Kg to avoid handling problem. For marine transportation crates shall be palleted.

4.13.2 The packing shall be of sufficient strength to withstand rough handling during transit, storage at site and subsequent handling in the field.

4.13.3 Suitable cushioning, protective padding, or dunnage or spacers shall be
provided to prevent damage or deformation during transit and handling.

4.13.4 All 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 dispatched on account of faulty packing and faulty or illegible markings. Each wooden case/crate shall have all the markings stencilled on it in indelible ink.

4.14 Standards

The insulator strings and its components shall conform to the following Indian/ International Standards which shall mean latest revision, with amendments/ changes adopted and published, unless specifically stated otherwise in the Specification.

4.14.1 In the event of supply of insulators 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 Supplier to establish equivalence.
<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Indian Standard</th>
<th>Title</th>
<th>International Standard</th>
</tr>
</thead>
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<tr>
<td>2.</td>
<td>IS:406-1991</td>
<td>Method of Chemical Analysis of Slab Zinc</td>
<td>BS:3436</td>
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<tr>
<td>3.</td>
<td>IS:731-1991</td>
<td>Porcelain insulators for overhead Power lines with a nominal voltage greater than 1000 V</td>
<td>BS:137- (I&amp;II) IEC:60383</td>
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<tr>
<td>6.</td>
<td>IS:2629-1990</td>
<td>Recommended Practice for Hot, Dip Galvanisation for iron and steel</td>
<td>ISO-1461 (E)</td>
</tr>
<tr>
<td>11.</td>
<td>IS:8269-1990</td>
<td>Methods for Switching Impulse test on HV insulators</td>
<td>IEC:60506</td>
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<td>12.</td>
<td></td>
<td>Thermal Mechanical Performance test and mechanical performance test on string insulator units</td>
<td>IEC: 60575</td>
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<td>13.</td>
<td></td>
<td>Salt Fog Pollution Voltage Withstand Test</td>
<td>IEC:60507</td>
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<tr>
<td>14.</td>
<td></td>
<td>Residual Strength of String Insulator Units of Glass or Ceramic Material for Overhead Lines after Mechanical Damage of the Dielectric</td>
<td>IEC:60797</td>
</tr>
<tr>
<td>No.</td>
<td>Description</td>
<td>Reference</td>
<td></td>
</tr>
<tr>
<td>-----</td>
<td>-----------------------------------------------------------------------------</td>
<td>-----------------</td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>Guide for the selection of insulators in respect of polluted conditions</td>
<td>IEC:60815</td>
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<tr>
<td>16</td>
<td>Tests on insulators of Ceramic material or glass or glass for overhead lines with a nominal voltage greater than 1000V</td>
<td>IEC:60383</td>
<td></td>
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<tr>
<td>17</td>
<td>Characteristics of string insulator units of the long rod type</td>
<td>IEC : 60433</td>
<td></td>
</tr>
<tr>
<td>19</td>
<td>American National Standard for Insulators wet process porcelain and toughened glass suspension type</td>
<td>ANSI C29-2-1992</td>
<td></td>
</tr>
</tbody>
</table>
1. **Tests on Complete Strings with Hardware Fittings**

1.1 **Voltage Distribution Test**

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.

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 154 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: 383.

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 154 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 metres. 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 four 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/f1.8 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 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 insulators after the vibration test. The insulators shall be subjected to the following tests as per relevant standards:

<table>
<thead>
<tr>
<th>Tests Percentage of</th>
<th>Percentage of units to be tested</th>
</tr>
</thead>
<tbody>
<tr>
<td>Disc insulators</td>
<td></td>
</tr>
<tr>
<td>a) Temperature cycle test followed by mechanical performance test</td>
<td>60</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</th>
<th>Number and duration of test</th>
</tr>
</thead>
<tbody>
<tr>
<td>B</td>
<td>I_n = I_sys = 35 KA</td>
<td>Two of t_n = 0.2s and one of t_n = 0.5s</td>
</tr>
</tbody>
</table>

The acceptance criteria after the completion of test series shall be following.

a) Insulator separation not permitted.

b) Burning/melting of metal components, breakage of insulator sheds, glaze removal are permitted.

c) The complete insulator string alongwith its hardware fitting excluding arching horn, corona control ring/grading ring shall withstand 80% of UTS.
2. On Disc Insulator Units

2.1 Steep Wave Front Test

Test following test shall be performed on 10 insulator units in case of disc insulators selected at random from the lot offered for selection of sample for type test.

a) Each insulator unit shall be subjected to five successive positive and negative impulse flashovers with a wave having minimum effective rate of rise of 2500 kV per microseconds.

b) Each unit shall then be subjected to three dry power frequency voltage flashovers.

Acceptance Criteria

An insulator shall be deemed to have met the requirement of this test if, having been successfully subjected to the ten impulse flashovers, the arithmetic mean of the three subsequent dry/power frequency voltage flashover values equals or exceeds 95% of the rated dry power frequency flashover voltage.

An insulator shall be deemed to have failed to meet the requirement of above testing if,

(a) It has not flash over when the oscillogram or peak voltage indicator shows a marked reduction in voltage.

or

(b) Any one of the subsequent three dry power frequency voltage flashover value is less than 80% of the value specified.

Failure of any one unit either in the steep wave front or subsequent low frequency voltage test shall cause for testing on double number of units.

2.2 Polarised Light Inspection (only for Glass Disc Insulator)

The disc insulator shall be held over a polarised light source and the stress lines viewed thereon. There shall be no uneven stress distribution in the toughened glass insulators. This shall be carried out on 100% glass shells.

2.3 Hydraulic Internal Pressure Test on Shells

The test shall be carried out on 100% shells before assembly. The details regarding test will be as discussed and mutually agreed to by the Supplier and Employer in Quality Assurance Programme. However in no case the value of pressure shall be 120kg/cm square

2.4 Thermal Mechanical Performance Test

Thermal Mechanical Performance Test shall be performed in accordance with IEC-60383-1 Clause 20 with the following modifications:

(1) The applied mechanical load during this test shall be 70% of the rated electromechanical or mechanical value.
(2) The acceptance criteria shall be

(a) \( X \) greater than or equal to \( R + 3S \).

Where

\( X = \) Mean value of the individual mechanical failing load.

\( R = \) Rated electro-mechanical/mechanical failing load.

\( S = \) Standard deviation.

(b) The minimum sample size shall be taken as 20 for disc insulator units and 5 units for long rod units.

(c) The individual electromechanical failing load shall be at least equal to the rated value. Also puncture shall not occur before the ultimate fracture.

2.5 Electromechanical/Mechanical Failing Load Test

This test shall be performed in accordance with clause 18 and 19 of IEC 383 with the following acceptance

(i) \( X \) greater than or equal to \( R + 3S \)

Where

\( X = \) Mean value of the electro-mechanical/mechanical failing load.

\( R = \) Rated electro-mechanical/mechanical failing load.

\( S = \) Standard deviation.

(ii) The minimum sample size shall be taken as 20 for disc insulators units and 5 for long rod units. However, for larger lot size, IEC 591 shall be applicable.

(iii) The individual electro-mechanical/mechanical failing load shall be at least equal to the rated value. Also electrical puncture shall not occur before the ultimate fracture.

2.6 Residual Strength Test

The above test shall be performed as per clause 4.4 and 4.5 of IEC 797 preceded by the temperature cycle test, on both glass and porcelain disc insulators. The Sample size shall be 25 and the evaluation of the results and acceptance criteria shall be as per clause No. 4.6 of IEC:797.

2.7 IR Measurements

IR measurement shall be carried out by the instrument operating at 1 kV DC. IR value when measured under fair weather condition, shall not be less than 50 M-ohm.

2.8 Impact Test

The Impact Test shall be carried out in accordance with ANSI-C-29.2 Clause 8.2.8 with the following modification.

The breaking point of the pendulum shall be so adjusted that, when released
the copper nose will strike the outer rim of the shell or the most protuded rim of the shell squarely in a direction parallel to the axis of the unit and towards the cap.

The test specimen shall receive an impact of 7 N-m for 120 kN Disc by releasing the pendulum.

3. Tests on All components (As applicable)

3.1 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%.

3.2 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 Supplier and Employer in Quality Assurance Programme.

3.3 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 Supplier and Employer in Quality Assurance Programme.

3.4 Autoclave Test

For cement used in the assembly of the insulators six samples from different batches shall be tested in accordance with ASTM C-151. The cement shall have an expansion less than 0.12%.
## TECHNICAL SPECIFICATIONS

### SECTION-VIIB

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TECHNICAL SPECIFICATIONS

SECTION VIIB

1.0 Technical Description of Composite Long Rod Insulators

1.1 Details of Composite Long Rod Insulators

1.1.1 The insulators strings shall consist of composite long rod insulators for a three phase, 50 Hz, effectively earthed 220 kV transmission system application in a lightly polluted environment. Couplings shall be ball and socket type.

1.1.2 Bidder shall quote such composite insulators which have proven use under foggy/humid operational conditions in lightly polluted industrial environment combined with smoke and dust particles. The Bidder shall furnish evidence in the form of certification from the power utilities that the similar type of product supplied to them had been performing satisfactory. The Bidder shall also submit certified test report for an accelerated ageing test of 5000 hours such as that described in Appendix-C of IEC-61109.

1.1.3 Insulators shall have sheds of the “open aerodynamic profile without any under ribs” with good self-cleaning properties. Insulator shed profile, spacing projection etc. shall be strictly in accordance with the recommendation of IEC-60815.

1.1.4 The size of long rod insulator, minimum creepage distance, the number to be used in different type of strings, their electromechanical strength and mechanical strength of insulator string alongwith hardware fittings shall be as follows:

<table>
<thead>
<tr>
<th>S. No</th>
<th>Type of String</th>
<th>*Size of Composite Insulator (Core dia x Nominal length) (mm)</th>
<th>Minimum Creepage Distance (mm) per unit</th>
<th>No. of individual Units per String (Nos.)</th>
<th>Electromechanical Strength of Insulator Unit (kN)</th>
<th>Mechanical Strength of Insulator String along with Hardware Fittings (kN)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Single Suspension ‘Pilot’</td>
<td>24x2320</td>
<td>5040</td>
<td>1x1</td>
<td>120</td>
<td>120</td>
</tr>
<tr>
<td>2.</td>
<td>Double Tension</td>
<td>24x2890</td>
<td>5355</td>
<td>2x1</td>
<td>160</td>
<td>2x160</td>
</tr>
<tr>
<td>3.</td>
<td>Triple Tension</td>
<td>24x2890</td>
<td>5355</td>
<td>3x1</td>
<td>160</td>
<td>3x160</td>
</tr>
</tbody>
</table>

Note: *The core dia of composite insulators mentioned at column No.3 is for indicative purpose. The bidder shall offer composite long rod insulators of suitable core dia to meet specified E&M and torsion strength requirements. For offered core dia, less than indicated in table above the bidder shall submit documentary evidence of past supplies & satisfactory operation of the same for minimum period of three*
years. However, the overall string length shall be within the limits specified in the drawing.

1.2 Pin and Cap

1.2.1 Pin and cap shall be designed to transmit the mechanical stress and develop uniform mechanical strength in the insulator. The cap shall be circular with the inner and outer surfaces concentric of such design that it will not yield or distort under load conditions.

1.2.2 The design shall be such as to permit easy removal of replacement of either insulator units or fittings under the live line conditions.

1.3 Ball and Socket Designation

The dimensions of the Ball and Socket shall be of 20 mm designation for 120kN and 160 kN Insulators in accordance with the standard dimensions stated in IEC:60120/IS:2486 (Part-II).

1.4 Dimensional Tolerance of Composite Insulators

The tolerances on all dimensions e.g. diameter, length shall be allowed as follows:

± (0.04d+1.5) mm when d≤300 mm.
± (0.025d+6) mm when d>300 mm.

Where, d being the dimensions in millimeters for diameter, length as the case may be.

The tolerance in creepage distance shall be based on design dimensions and their tolerances. However, no negative tolerance shall be applicable to creepage distance specified in clause 1.1.4.

1.5 Interchangeability

The composite long rod insulators inclusive of the ball & socket connection shall be standard design suitable for use with the hardware fittings of any make conforming to relevant IEC standards.

1.6 Corona and RI Performance

All surfaces shall be clean, smooth, without cuts, abrasions or projections. No part shall be subjected to excessive localized pressure. The insulator and metal parts shall be so designed and manufactured that it shall avoid local corona formation and shall not generate any radio interference beyond specified limit under the operating conditions.

1.7 Maintenance
1.7.1 The long rod insulators offered shall be suitable for employment of hot line maintenance technique so that usual hot line operation can be carried out with ease, speed and safety.

1.7.2 All insulators shall be designed to facilitate cleaning and insulators shall have the minimum practical number of sheds and grooves. All grooves shall be so proportioned that any dust deposit can be removed without difficulty either by wiping with a cloth or by remote washing under live line condition.

1.8 Materials

1.8.1 Core

It shall be a glass-fiber reinforced (FRP rod) epoxy resin rod of high strength. The rod shall be resistant to hydrolysis. Glass fibers and resin shall be optimized. The rod shall be electrical grade corrosion resistant (ECR), boron free glass and shall exhibit both high electrical integrity and high resistance to acid corrosion.

1.8.2 Housing & Weathersheds

The FRP rod shall be covered by a seamless sheath of a silicone rubber compound of a thickness of minimum 3mm. The housing & weathersheds should have silicon content of minimum 30% by weight. It should protect the FRP rod against environmental influences, external pollution and humidity. It shall be extruded or directly molded on the core. The interface between the housing and the core must be uniform and without voids. The strength of the bond shall be greater than the tearing strength of the polymer. The manufacturer shall follow non-destructive technique (N.D.T.) to check the quality of jointing of the housing interface with the core. The technique to be followed with detailed procedure and sampling shall be furnished by the Supplier and finalized during finalization of MQP.

The weathersheds of the insulators shall be of alternate shed profile. The weathersheds shall be vulcanized to the sheath (extrusion process) or molded as part of the sheath (injection moulding process) and free from imperfections. The vulcanization for extrusion process shall be at high temperature and for injection moulding shall be at high temperature & high pressure. Any seams / burrs protruding axially along the insulator, resulting from the injection moulding process shall be removed completely without causing any damage to the housing. The track resistance of housing and shed material shall be class 1A4.5 according to IEC60587. The strength of the weathershed to sheath interface shall be greater than the tearing strength of the polymer. The composite insulator shall be capable of high pressure washing.

1.8.3 End Fittings

End fittings transmit the mechanical load to the core. They shall be made of malleable cast iron spheroidal graphite or forged steel. They shall be connected to
the rod by means of a controlled compression technique. The manufacturer shall have in-process Acoustic emission arrangement or some other arrangement to ensure that there is no damage to the core during crimping. This verification shall be in-process and done on each insulator. The system of attachment of end fitting to the rod shall provide superior sealing performance between housing and metal connection. The gap between fitting and sheath shall be sealed by a flexible silicone rubber compound. The sealing shall stick to both housing and metal end fitting. The sealing must be humidity proof and durable with time.

End fittings shall have suitable provisions for fixing grading rings at the correct position as per design requirements.

1.8.4 Grading Rings

Grading rings shall be used at both ends of each composite insulator unit for reducing the voltage gradient on and within the insulator and to reduce radio and TV noise to acceptable levels. The size and placement of the metallic grading rings shall be designed to eliminate dry band arcing/corona cutting/exceeding of permissible electrical stress of material. The insulator supplier shall furnish design calculations using appropriate electric field software showing electric field at surface of housing, inside housing & core and at the interface of housing and metal fittings with the proposed placement and design of corona ring. Grading rings shall be capable of installation and removal with hot line tools without disassembling any other part of the insulator assembly.

The design & supply of grading rings shall be in the scope of the composite insulator supplier.

1.9 Workmanship

1.9.1 All the materials shall be of latest design and conform to the best modern practices adopted in the extra high voltage field. Bidders shall offer only such insulators as are guaranteed by him to be satisfactory and suitable for transmission lines specified and will give continued good service.

1.9.2 The design, manufacturing process and material control at various stages shall be such as to give maximum working load, highest mobility, best resistance to corrosion, good finish and elimination of sharp edges and corners to limit corona and radio interference.

1.9.3 The design of the insulators shall be such that stresses due to expansion and contraction in any part of the insulator shall not lead to deterioration.

1.9.4 The core shall be sound and free of cracks, impurities and voids that may adversely affect the insulators.

1.9.5 Weathersheds / Housing shall be uniform in quality. Weathersheds / Housing shall be clean, sound, smooth and free from gross defects, voids, impurities and excessive flashing at parting lines.
1.9.6 End fittings shall be free from cracks, seams, shrinks, air holes and rough edges. End fittings should be effectively, sealed to prevent moisture ingress, effectiveness of sealing system must be supported by test documents. All surfaces of the metal parts shall be perfectly smooth with the projecting points or irregularities which may cause corona. All load bearing surfaces shall be smooth and uniform so as to distribute the loading stresses uniformly.

1.9.7 All ferrous parts shall be hot dip galvanized to give a minimum average coating of zinc equivalent to 600 gm/sq.m. and shall be in accordance with the requirement of ISO:1461 (E) and shall satisfy the tests mentioned in ISO:1460 (E). The zinc used for galvanizing shall be of purity of 99.95%. The zinc coating shall be uniform, adherent, smooth, reasonably bright continuous and free from imperfections such as flux, ash rust stains, bulky white deposits and blisters. The galvanized metal parts shall be guaranteed to withstand at least six successive dips each lasting for one (1) minute duration under the standard preece test. The galvanizing shall be carried out only after any machining.

1.9.8 The supplier shall guarantee that there shall not be any failure/ decapping / breaking of insulators on line under normal operating condition. In the event of any failure/ decapping /breaking of insulators during the first ten years of service, Supplier shall supply to the Purchaser free of cost spare insulators equal to 10 times the failed insulator quantity. Further, in case of decapping / Breaking and subsequent line drop, during the first ten years of service, the supplier shall also have to pay Rs 100000/ (Rs one lakh only) per dropped string towards expenditure to be incurred by POWERGRID for this line repair.

2.0 Equipment Marking

2.1 Each composite long rod unit shall be legibly and indelibly marked with the trade mark of the manufacturer, name of POWERGRID and month & year of manufacture. The guaranteed combined mechanical and electrical strength shall be indicated in kilo Newton followed by the word ‘kN’ to facilitate easy identification and to ensure proper use.

2.2 One 10 mm thick ring or 20 mm thick spot of suitable quality of paint shall be marked on the cap/end fitting of each composite long rod of particular strength for easy identification of the type of insulator. The paint shall not have any deteriorating effect on the insulator performance. Following codes shall be used as identification mark:

- For 120 kN Long rod unit : Yellow
- For 160 kN Long rod unit : Green

3.0 Bid Drawings

3.1 The Bidder shall furnish full description and illustration of the material offered.

3.2 The Bidder shall furnish along with the bid the outline drawing of each insulator unit along with grading rings including a cross sectional view of the long rod insulator unit. The drawing shall include but not limited to the following information:

(a) Major Dimensions with manufacturing tolerances
(b) Minimum Creepage distance with positive tolerance
(c) Protected creepage distance
(d) Unit mechanical and electrical characteristics
(e) Size and weight of ball and socket parts
(f) Weight of composite long rod units
(g) Materials

3.3 After placement of award, the Supplier shall submit full dimensioned insulator drawings containing all the details as given in Clause No. 3.2 above, in four (4) copies to Purchaser for approval. After getting approval from Purchaser and successful completion of all the type tests, the Supplier shall submit 10 more copies of the same drawing along with a soft copy to the Purchaser for further distribution and field use at Purchaser’s end.

3.4 After placement of award the Supplier shall also submit fully dimensioned insulator crate drawing for different type of insulators.

4.0 Tests and Standards

4.1 Type Tests

The required type tests on composite longrod units, components, materials and complete strings are stipulated hereunder.

The specified type tests under the following clause shall not be required to be carried out if a valid test certificate is available for a similar design. The tests certificate shall be considered valid if:

i. Tests conducted earlier is either conducted in accredited laboratory (accredited based on ISO/IEC vide 25/17025 or EN 45001 by the National accreditation body of the country where laboratory is located) or witnessed by the representative(s) of any utility and

ii. Tests have been conducted not prior to 5 (five) years from the date of bid opening.

In case the test have been conducted earlier than the above stipulated period or in the event of any discrepancy in the test report (i.e., any test not applicable due to any design/manufacturing change including substitution of components or due to non-compliance with the requirement stipulated in the Technical Specifications), the tests shall be conducted by the Supplier at no extra cost to the Purchaser.

4.1.1 On the complete composite Long Rod Insulator String with Hardware Fittings
For 220 kV AC Transmission Lines with Twin Moose Conductor

Strings on which test to be conducted
(a) Power frequency voltage withstand test with corona control rings/grading ring and arcing horns under wet condition
IEC:383-1993/
Annex-A
SISP, DT, TT

(b) Switching surge voltage withstand test under wet condition
IEC:383-1993
SISP, DT, TT

(c) Impulse voltage withstand test under dry condition
IEC:383-1993
SISP, DT, TT

(d) Corona and RIV test under dry condition
Annex-A
SISP, DT, TT

(e) Mechanical Strength test
Annex-A
SISP, DT, TT

(f) Vibration test
Annex-A
DT

(g) Salt-fog pollution withstand test
Annex-A
DT

SISP: Single I Suspension Pilot; DT: Double Tension, TT: Triple Tension

4.1.2 On Composite Insulator Units

(a) Tests on interfaces and connections of metal fittings
IEC: 61109-2008

(b) Assembled core load time test
IEC: 61109-2008

(c) Damage limit proof test and test of tightness of interface between end fittings and insulator housing.
IEC: 61109-2008

(d) High Pressure washing test
Annexure-A

(e) Brittle fracture resistance test
Annexure-A

(f) Dye penetration test
IEC: 61109-2008

(g) Water diffusion test
IEC: 61109-2008

(h) Tracking and erosion test
IEC: 61109-2008

(i) Hardness test
IEC: 61109-2008

(j) Accelerated weathering test
IEC: 61109-2008

(k) Flammability test
IEC: 61109-2008

(l) Silicone content test
Annexure-A

(m) Recovery of Hydrophobicity test
Annexure-A

(n) Torsion test
Annexure-A
4.1.5 Hardness test, Accelerated weathering test & Flammability test specified under Clause No. 4.1.2 above shall be conducted on housing/weather shed of either 120kN or 160kN composite long rod for the same type of material.

4.2 Acceptance Tests:

4.2.1 For Composite Long Rod Insulators

a) Verification of dimensions IEC : 61109-2008
b) Galvanising test IEC : 60383
c) Verification of end fittings IEC: 61109 -2008
d) Recovery of Hydrophobicity Annexure-A
e) Verification of tightness of interface between end fittings and insulator housing and of specified mechanical load IEC : 61109-2008
f) Tests on interfaces and connections of metal fittings IEC: 61109-2008
g) Silicone content test Annexure-A
h) Brittle Fracture Resistance Test Annexure-A
i) Dye Penetration Test IEC :61109-2008
j) Water Diffusion Test IEC : 61109-2008

The tests mentioned at 4.2.1.(f) to (j) shall be carried out as acceptance tests on any one lot.

In the event of failure of the sample to satisfy the acceptance test(s) specified in 4.2 above, the retest procedure shall be as per IEC 61109.

4.3 Routine Tests

4.3.1 For Composite Long Rod Insulator Units

a) Visual Examination As per IEC:61109-2008
b) Mechanical routine test As per IEC:61109 -2008

4.4 Tests During Manufacture

On all components as applicable

a) Chemical analysis of zinc used for galvanising As per Annexure-A

b) Chemical analysis, mechanical, metallographic test and magnetic particle inspection for malleable castings. As per Annexure-A
c) Chemical analysis hardness tests and magnetic particle inspection for forgings  As per Annexure-A

d) Tracking and erosion test on insulating material  IEC 60587

4.5 **Testing Expenses**

4.5.1 As mentioned under clause 4.1 above, no type test charges shall be payable to the supplier.

4.5.2 For Type Tests which involves the tests on the complete insulator string with hardware fitting, standard hardware fittings similar to existing insulator strings shall be arranged and used by the insulator supplier at his own cost.

4.5.3 In case of failure in any type test the supplier is either required to modify the design of the material & successfully carryout all the type tests as has been detailed out in Clause 4.1 of this specifications or to repeat that particular type test at least three times successfully at his own expenses.

4.5.4 Bidder shall indicate the laboratories in which they propose to conduct the type tests. They shall ensure that adequate facilities 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.

4.5.5 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.

4.5.6 In case of failure in any type test, if 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 Supplier's notice of testing, the Owner's representative does not find the material or test setup / equipments to be ready for testing, the expenses incurred by the Owner for re-deputation shall be deducted from contract price.

4.5.7 The Supplier shall intimate the Owner about carrying out of the type tests alongwith detailed testing programme at least 3 weeks in advance (in case of testing in India) and at least 6 weeks advance (in case of testing abroad) 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.

4.6 **Sample Batch for Type Testing**

4.6.1 The Supplier shall offer material for sample selection for type testing only after getting Quality Assurance Programme approved by the Purchaser. The Supplier 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 Purchaser.

4.6.2 Before sample selection for type testing, the Supplier shall be required to conduct all the acceptance tests successfully in presence of Purchaser’s representative.

4.7 **Schedule of Testing**
4.7.1 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.

4.8 Additional Tests

4.8.1 The Purchaser reserves the right of having at his own expenses any other test(s) of reasonable nature carried out at Supplier'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.

4.8.2 The Purchaser 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 Supplier's premises or at any other test centre. In case of evidence of non-compliance, it shall be binding on the part of the Supplier 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 Purchaser.

4.9 Guarantee

The Supplier of insulators shall guarantee overall satisfactory performance of the insulators.

4.10 Test Reports

4.10.1 Copies of type test reports shall be furnished in at least six (6) copies along with one original. One copy shall be returned duly certified by the Purchaser only after which the commercial production of the concerned material shall start.

4.10.2 Copies of acceptance test reports shall be furnished in at least six (6) copies. One copy shall be returned duly certified by the Purchaser, only after which the material shall be dispatched.

4.10.3 Record of routine test reports shall be maintained by the Supplier at his works for periodic inspection by the Purchaser's representative.

4.10.4 Test certificates of test during manufacture shall be maintained by the Supplier. These shall be produced for verification as and when desired by the Purchaser.

4.11 Inspection

4.11.1 The Purchaser's representative shall at all times be entitled to have access to the works and all places of manufacture, where insulator, and its component parts shall be manufactured and the representatives shall have full facilities for unrestricted inspection of the Supplier's and sub-Supplier's works, raw materials, manufacture of the material and for conducting necessary test as detailed herein.

4.11.2 The material for final inspection shall be offered by the Supplier only under packed condition as detailed in clause No. 4.12 of the specification. The Purchaser shall select samples at random from the packed lot for carrying out acceptance tests. The
lot should be homogeneous and should contain insulators manufactured in 3-4 consecutive weeks.

4.11.3 The Supplier shall keep the Purchaser informed in advance of the time of starting and the progress of manufacture of material in their various stages so that arrangements could be made for inspection.

4.11.4 No material shall be dispatched from its point of manufacture before it has been satisfactorily inspected and tested unless the inspection is waived off by the Purchaser in writing. In the latter case also the material shall be dispatched only after satisfactory testing for all tests specified herein have been completed.

4.11.5 The acceptance of any quantity of material shall be no way relieve the Supplier 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.

4.12 Packing and Marking

4.12.1 All insulators shall be packed in suitable PVC/ plastic tubes/any other suitable packing. The packing shall provide protection against rodent. The Supplier shall furnish detailed design of the packing. For marine transportation, crates shall be palleted.

4.12.2 The packing shall be of sufficient strength to withstand rough handling during transit, storage at site and subsequent handling in the field.

4.12.3 Suitable cushioning, protective padding, or dunnage or spacers shall be provided to prevent damage or deformation during transit and handling.

4.12.4 All 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 dispatched on account of faulty packing and faulty or illegible markings. Each case/crate shall have all the markings stenciled on it in indelible ink.

4.12.5 The Supplier shall guarantee the adequacy of the packing and shall be responsible for any loss or damage during transportation, handling, storage and installation due to improper packing.

4.13 Standards

The insulator strings and its components shall conform to the following Indian/ International Standards which shall mean latest revision, with amendments/changes adopted and published, unless specifically stated otherwise in the Specification.

4.13.1 In the event of supply of insulators conforming to standards other than specified, the Bidder shall confirm in his bid that these standards are equivalent or better 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 Supplier to establish equivalence.
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<td>14.</td>
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<td>Selection and dimensioning of high voltage insulators intended for use in polluted conditions: Polymer Insulators for AC systems</td>
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<td>15.</td>
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<td>Tests on insulators of Ceramic material or glass or glass for overhead lines with a nominal voltage greater than 1000V</td>
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<td>BS</td>
<td></td>
<td>British Standards, British Standards Institution 101, Pentonville Road, N - 19-ND, UK</td>
</tr>
<tr>
<td>IEC/CISPR</td>
<td></td>
<td>International Electro technical Commission, Bureau Central de la Commission, electro Technique international, 1 Rue de verembe, Geneva, SWITZERLAND</td>
</tr>
<tr>
<td>BIS/IS</td>
<td></td>
<td>Beureau Of Indian Standards. Manak Bhavan, 9, Bahadur Shah Zafar Marg, New Delhi - 110001. INDIA</td>
</tr>
<tr>
<td>ISO</td>
<td></td>
<td>International Organisation for Standardization. Danish Board of Standardization Danish Standardizing Sraat, Aurehoegvej-12 DK-2900, Heeleprup, DENMARK</td>
</tr>
<tr>
<td>NEMA</td>
<td></td>
<td>National Electric Manufacture Association, 155, East 44th Street.</td>
</tr>
<tr>
<td></td>
<td>New York, NY 10017  U.S.A.</td>
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ANNEXURE-A

1.0 Tests on Complete Strings with Hardware Fittings

1.1 Corona Extinction Voltage Test (Dry)
The sample assembly when subjected to power frequency voltage shall have a corona extinction voltage of not less than 154 kV (rms) line to ground under dry condition for 220 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 IEC : 60383.

1.2 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 154 kV line to ground under dry condition for 220 kV line. The test procedure shall be in accordance with IS:8263/IEC : 60437.

1.3 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.

1.4 Vibration Test
The suspension string shall be tested in suspension mode, and tension string in tension mode itself in laboratory span of minimum 30 metres. 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 the sub-conductors (each tensioned at 25% of UTS of Conductor) shall be secured with clamps. The system shall be suitable to maintain constant tension on each sub-conductor throughout the duration of the test. Vibration dampers shall not be used on the test span. All 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 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 insulators after the vibration test. The insulators shall be subjected to the Mechanical performance test followed by mechanical strength test as per relevant standards.

1.5 Salt-fog pollution withstand test

This test shall be carried out in accordance with IEC: 60507. The salinity level for composite long rod insulators shall be 40 Kg/m3 NACL.

2.0 Composite Longrod Insulator Units

2.1 Brittle Fracture Resistance Test

The test arrangement shall be according to Damage limit proof test with simultaneous application of 1N-HNO₃ acid directly in contact with naked FRP rod. The contact length of acid shall not be less than 40mm and thickness around the core not less than 10mm. The rod shall withstand 80% of SML for 96 hours.

2.2 Recovery of Hydrophobicity Test

(1) The surface of selected samples shall be cleaned with isopropyl alcohol. Allow the surface to dry and spray with water. Record the HC classification. Dry the sample surface.

(2) Treat the surface with corona discharges to destroy the hydrophobicity. This can be done utilizing a high frequency corona tester, Holding the electrode approximately 3mm from the sample surface, slowly move the electrode over an area approximately 1” x 1”. Continue treating this area for 2 – 3 minutes, operating the tester at maximum output.

(3) Immediately after the corona treatment, spray the surface with water and record the HC classification. The surface should be hydrophilic, with an HC value of 6 or 7. If not, dry the surface and repeat the corona treatment for a longer time until an HC of 6 or 7 is obtained. Dry the sample surface.

(4) Allow the sample to recover and repeat the hydrophobicity measurement at several time intervals. Silicone rubber should recover to HC 1 – HC 2 within 24 to 48 hours, depending on the material and the intensity of the corona treatment.

2.3 Silicone content test

Minimum content of silicone as guaranteed by supplier shall be verified through FT-IR spectroscopy & TGA analysis or any other suitable method mutually agreed between Purchaser & Supplier in Quality Assurance Programme.
2.4 High Pressure washing test

The washing of a complete insulator of each E&M rating is to be carried out at 3800 kPa with nozzles of 6 mm diameter at a distance of 3m from nozzles to the insulator, the washing shall be carried out for 10 minutes. There shall be no damage to the sheath or metal fitting to housing interface. The verification shall be 1 minute wet power frequency withstand test at 460 kV r.m.s.

2.6 Torsion Test

Three complete insulators of each E&M rating shall be subjected to a torsional load of 55Nm. The torsional strength test shall be made with test specimen adequately secured to the testing machine. The torsional load shall be applied to the test specimen through a torque member so constructed that the test specimen is not subjected to any cantilever stress. The insulator after torsion test must pass the Dye Penetration Test as per IEC 61109.

3. Tests on All components (As applicable)

3.1 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%.

3.2 Tests for Forgings

The chemical analysis hardness tests and magnetic particle inspection for forgings, will be as per the internationally recognized 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 Supplier and Purchaser in Quality Assurance Programme.

3.3 Tests on Castings

The chemical analysis, mechanical and metallographic tests and magnetic, particle inspection for castings will be as per the internationally recognized 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 Supplier and Purchaser in Quality Assurance Programme.
### TECHNICAL SPECIFICATIONS

#### SECTION-VIII

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TECHNICAL SPECIFICATIONS
(SECTION-VIII)

1. Technical Description of Hardware Fittings

1.1 General

This section details technical particulars of hardware fittings and suspension clamps & compression type dead end clamps for the HTLS Conductor to be supplied by the bidder. Each fitting shall be supplied complete in all respects.

1.2 The hardware fittings shall be suitable for use with composite insulators/ disc insulators having ball and socket fittings. Each hardware fitting shall be supplied complete in all respects and shall include the following hardware parts:

1.2.1 Suitable arcing horn as specified in clause 1.8 hereinafter.

1.2.2 Suitable yoke plates complying with the specifications given hereinafter.

1.2.3 Corona control rings/grading ring with fittings for attachment to line side yoke plate.

1.2.4 Sag adjustment plate for Double tension hardware fittings

1.2.5 Suspension and dead end assembly to suit conductor size as detailed in clause 1.13, 1.14 and 1.15 hereinafter.

1.2.6 Provisions for attaching balancing weights on the line side yoke plate of single suspension pilot hardware fittings.

1.2.7 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.

1.2.8 2.5% extra fasteners.

1.3 The Clamps fittings shall be suitable for attachment to suspension and tension insulator strings alongwith hardware fittings for normal stretches as well as river crossing stretches and shall include 2.5 % extra fasteners. The supplier shall be responsible for satisfactory performance of complete conductor system along with fittings offered by them for continuous operation at the designed maximum temperature specified by them for the conductor.

1.4 Dimensions of Insulator String Along with Hardware Fitting

The various limiting dimensions of the insulator strings shall generally be in conformity with the dimensions of the existing hardware fittings. The Contractor shall be required to verify the dimensions of the existing insulator strings and shall ensure that the new fittings are generally conforming to the dimensions of the existing fittings.

1.5 Interchangeability

The hardware for insulator strings with composite/ disc 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.

1.6 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 Supplier shall be responsible for satisfactory corona and radio interference performance of the materials offered by him.

1.7 Maintenance

1.7.1 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.

1.7.2 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.

1.8 Designation

1.8.1 Ball and Socket Designation

The dimensions of the ball and socket shall be 20mm designation for 120kN & 160kN. The designation should be in accordance with the standard dimensions stated in IS:2486-(Part-II)/IEC:60120. The dimensions shall be checked by the appropriate gauge after galvanising only.

1.9 Security Clips and Split Pins

1.9.1 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 : 60372. 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.

1.9.2 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).

1.9.3 Split pins shall be used with bolts & nuts.

1.10 Arcing Horn

1.10.1 The arcing horn / shall be either ball ended rod type or tubular type.
### 1.10.2 The arcing horn shall be provided generally as per existing fitting and shall conform to specification requirements.

### 1.10.3 The air gap shall be so adjusted to ensure effective operation under actual field conditions.

### 1.11 Yoke Plates

The strength of yoke plates shall be adequate to withstand the minimum ultimate tensile strength as specified.

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 at least 3 mm. Design calculations i.e. for bearing & tensile strength, for deciding the dimensions of yoke plate shall be furnished by the contractor. The holes provided for bolts in the yoke plate should satisfy shear edge condition as per Clause No. 10.2.4.2 of IS:800-2007.

### 1.12 Corona Control Rings/Grading Ring

#### 1.12.1 The Corona control rings/grading ring shall be provided with hardware fittings. It shall also improve corona and radio interference performance of the complete insulator string along with hardware fittings.

#### 1.12.2 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 grinded before buffing. Alternately, Aluminium tube/flats of suitable dimensions welded to the corona control rings/grading rings may be used for connection to yoke plate.

#### 1.12.3 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.

#### 1.12.4 The limiting dimensions of corona control ring shall be as per the specification drawings.

#### 1.12.5 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 buffed.

### 1.13 Sag Adjustment Plate

#### 1.13.1 The sag-adjustment plate to be provided with the Quad 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.

1.13.2 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.

1.13.3 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.

1.14 Turn Buckle

1.14.1 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.

1.14.2 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.

1.15 Suspension Assembly

1.15.1 The suspension assembly shall be suitable for the HTLS Conductor, the bidder intends to supply. The technical details of the conductor shall be as proposed by the bidder.

1.15.2 The suspension assembly shall include either free centre type suspension clamp alongwith standard preformed armour rods or armour grip suspension clamp.

1.15.3 The suspension clamp alongwith 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.

1.15.4 The suspension clamp suitable for various type of Conductor alongwith standard preformed armour rods/armour grip suspension clamp set shall have a slip strength in conformity with relevant Indian/International standards.

1.15.5 The suspension clamp shall be designed for continuous operation at the temperature specified by the bidder for conductor.

1.15.6 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.

1.15.7 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.
1.16 **Free Centre Type Suspension Clamp**

For the Free Centre 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.

1.16.1 **Standard Preformed Armour Rod Set**

1.16.2 The Preformed Armour Rods Set shall be used to minimise the stress developed in the 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.

1.16.3 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.

1.16.4 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.

1.16.5 The length and diameter of each rod shall be furnished by the bidder in the GTP. The tolerance in length of the rods between the longest and shortest rod in complete set should be within the limits specified in relevant Indian/International Standards. The ends of armour rod shall be parrot billed.

1.16.6 The number of armour rods in each set shall be as per supplier’s design to suit HTLS conductor offered Standards. Each rod shall be marked in the middle with paint for easy application on the line.

1.16.7 The armour rod shall not loose their resilience even after five applications.

1.16.8 The conductivity of each rod of the set shall not be less than 40% of the conductivity of the International Annealed Copper Standard (IACS).

1.17 **Armour Grip Suspension Clamp**

1.17.1 The armour grip suspension clamp shall comprise of retaining strap, support housing, elastomer inserts with aluminium reinforcements and AGS preformed rod set.

1.17.2 Elastomer insert shall be resistant to the effects of temperature up to designed maximum conductor temperature guaranteed by the bidder corresponding to peak current, 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.
1.17.3 The supplier shall submit relevant type/performance test certificates as per applicable standard/product specifications for elastomer to confirm suitability of the offered elastomer for the specified application.

1.17.4 The AGS preformed rod set shall be as detailed in clause 1.16.4 to 1.16.7 in general except for the following.

1.17.5 The length of the AGS preformed rods shall be such that it shall ensure sufficient slipping strength and shall not introduce unfavourable stress on the conductor under all operating conditions. The length of the AGS preformed rods shall be indicated in the GTP.

1.18 Envelope Type Suspension Clamp

1.18.1 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.

1.19 Dead end Assembly

1.19.1 The dead end assembly shall be suitable for the offered HTLS Conductor.

1.19.2 The dead end assembly shall be of compression type with provision for compressing jumper terminal at one end. The angle of jumper terminal to be mounted (including angle of pad) 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 $I^2R$ losses. The resistance of the clamp when compressed on Conductor shall not be more than 75% of the resistance of equivalent length of Conductor.

1.19.3 Die compression areas shall be clearly marked on each dead-end assembly designed for continuous die compressions and shall bear the words ‘COMPRESS 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 dimensions of dead end assembly before & after compression alongwith tolerances shall be guaranteed in the relevant schedules of the bid and shall be decided by the manufacturer so as to suit the conductor size & conform to electrical & mechanical requirement stipulated in the specification. These shall be guaranteed in the relevant schedules of bid.

1.19.4 The assembly shall not permit slipping of, 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.

1.19.5 Jumper bolting arrangement between jumper terminal/cone and terminal pad/plate of dead end assembly of tension hardware fittings shall be designed to
suit the specification requirement of 1000A current and shall conform to the relevant Indian/International standards.

1.19.6 For composite core HTLS conductor, dead end assembly shall inter-alia include collets, collet housing, inner sleeve etc., suitable for the offered design of HTLS conductor.

1.20 Balancing Weights

For holding the single suspension pilot insulator string used for jumper connections from excessive deflection, suitable balancing weights, weighing 200 kg, are to be suspended through the line side yoke plate. It shall consist of four weights, each weighing 50 Kgs. and shall be connected to the yoke plate by means of eye bolt and shackle arrangement. The bottom weight shall be provided with recess to shield the ends of eye bolts. The same shall be suitable for use on specific transmission lines.

1.21 Fasteners: Bolts, Nuts and Washers

1.21.1 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.

1.21.2 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.

1.21.3 Nuts should be double chamfered as per the requirement of IS 1363 Part-III 1984. It should be ensured by the manufacturer that nuts should not be over tapped beyond 0.4 mm oversize on effective diameter for size upto M16.

1.21.4 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.

1.21.5 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.

1.21.6 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.

1.21.7 The Contractor 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.
1.21.8 To obviate bending stress in bolt, it shall not connect aggregate thickness more than three time its diameter.

1.21.9 Bolts at the joints shall be so staggered that nuts may be tightened with spanners without fouling.

1.21.10 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.

1.21.11 Fasteners of grade higher than 8.8 are not to be used and minimum grade for bolt shall be 5.6.

1.21 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.

1.21.1 The details of materials for different component are listed as in Table -1.

1.22 Workmanship

1.22.1 All the equipment shall be of the latest design and conform to the best modern practices adopted in the High Voltage field. The Bidder shall offer only such equipment as guaranteed by him to be satisfactory and suitable for 220 kV transmission lines and will give continued good performance. For employer’s review of the offered design of clamps/ fittings, the supplier shall submit document/design details of similar type of clamps/ fittings used in past for similar type of HTLS conductor application

1.22.2 High current, heat rise test shall be conducted by the supplier to determine the maximum temperature achieved in different components of fittings under simulated service condition corresponding to continuous operation of conductor at designed maximum temperature. The material of the components should be suitable for continued good performance corresponding to these maximum temperatures. The supplier shall submit relevant type/performance test certificates as per applicable standards/product specifications to confirm suitability of the offered material.

1.22.3 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.

1.22.4 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
/ IS 1367 (Part-13) and shall satisfy the tests mentioned in IS 2633. Fasteners shall
withstand four dips while spring washers shall withstand three dips of one minute
duration in the standard Preece test. Other galvanised materials shall have a
minimum average coating of zinc equivalent to 600 gm/sq.m., shall be guaranteed
to withstand at least six successive dips each lasting one (1) minute under the
standard preece test for galvanising.

1.22.5 Before ball fittings are galvanized, 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.

1.22.6 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
grade Zn 99.95 as per IS:209.

1.22.7 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.

1.22.8 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.

1.22.9 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.

1.22.10 All current carrying parts shall be so designed and manufactured that contact
resistance is reduced to minimum.

1.22.11 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.

1.22.12 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.

1.22.13 All fasteners shall have suitable corona free locking arrangement to guard against
vibration loosening.

1.22.14 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.

1.23

**Bid Drawings**

1.23.1 The Bidder shall furnish full description and illustrations of materials offered.

1.23.2 Fully dimensioned drawings of the hardwares and their component parts shall be
furnished in five (5) copies alongwith 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 1.10 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.

1.23.3 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

(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 terminal details.

1.23.4 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.

TABLE-1

(Details of Materials)

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Name of item</th>
<th>Material treatment</th>
<th>Process of Standard</th>
<th>Reference</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Security Clips</td>
<td>Stainless Steel/ Phospber Bronze</td>
<td>-</td>
<td>AISI 302 or 304-L/ IS-1385</td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td>For Free Centre /Envelope type clamps</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(a)</td>
<td>Clamp Body, Keeper Piece</td>
<td>High Strength Al. Alloy 4600/ LM-6 or 6061/65032</td>
<td>Casted or forged &amp; Heat treated</td>
<td>IS:617or ASTM-B429</td>
<td></td>
</tr>
<tr>
<td>(b)</td>
<td>Cotter bolts/ Hangers, Shackles, Brackets</td>
<td>Mild Steel</td>
<td>Hot dip galvanised</td>
<td>As per IS-226 or IS-2062</td>
<td></td>
</tr>
<tr>
<td>(c)</td>
<td>U Bolts</td>
<td>Stainless Steel or High Strength Al alloy 6061/65032</td>
<td>Forged &amp; Heat treated</td>
<td>AISI 302 or 304-L ASTM-B429</td>
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</tr>
<tr>
<td>(d)</td>
<td>P. A. Rod</td>
<td>High Strength Al. Alloy 4600/ LM-6 or 6061/65032</td>
<td>Heat treatment during manufacturing</td>
<td>ASTM-B429</td>
<td>Min. tensile strength of 35 kg/mm²</td>
</tr>
<tr>
<td>3.</td>
<td>For AGS type clamp</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(a)</td>
<td>Supporting House</td>
<td>High Strength Corrosion resistant Al. Alloy 4600/ LM-6 or 6061/65032</td>
<td>Casted or forged &amp; Heat treated</td>
<td>IS:617or ASTM-B429</td>
<td></td>
</tr>
<tr>
<td>(b)</td>
<td>Al insert &amp; Retaining strap</td>
<td>High Strength Al. Alloy 4600/ LM-6 or 6061/65032</td>
<td>Casted or forged &amp; Heat treated</td>
<td>IS:617or ASTM-B429</td>
<td>High Strength Al. Alloy 4600/ LM-6 or 6061/65032</td>
</tr>
<tr>
<td>(c)</td>
<td>Elastomer</td>
<td>Moulded on Al.</td>
<td></td>
<td></td>
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### Design, Supply, Installation and Commissioning of Kushma-New Butwal 220 kV Transmission Line

**SECTION VII**

**Volume II**

**ICB-PMD-KGTC-072/73-04**

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<th>Notes</th>
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<td>4.</td>
<td>For Dead End Assembly</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(a)</td>
<td>Outer Sleeve</td>
<td>EC grade Al of purity not less than 99.50%</td>
<td></td>
</tr>
<tr>
<td>(b)</td>
<td>Steel Sleeve</td>
<td>Mild Steel</td>
<td>Hot Dip Galvanised</td>
</tr>
<tr>
<td>5.</td>
<td>Ball &amp; Socket Fittings</td>
<td>Class-IV Steel</td>
<td>Drop forged &amp; normalized Hot dip galvanised</td>
</tr>
<tr>
<td>6.</td>
<td>Yoke Plate</td>
<td>Mild Steel</td>
<td>Hot dip galvanised</td>
</tr>
<tr>
<td>8(a)</td>
<td>Corona Control ring/ Grading ring</td>
<td>High Strength Al. Alloy tube (6061/ 6063/1100 type or 65032/63400 Type)</td>
<td>Heat treated Hot dip galvanised</td>
</tr>
<tr>
<td>8(b)</td>
<td>Supporting Brackets &amp; Mounting Bolts</td>
<td>High Strength Al Alloy 7061/6063/65032/63400 Type or Mild Steel</td>
<td>Heat treated Hot dip galvanised</td>
</tr>
</tbody>
</table>

**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 comparrison of material offered viz a viz specified in the bid or else the bids are liable to be rejected.
2.0 Accessories for the HTLS Conductor

2.1 General

2.1.1 This portion details the technical particulars of the accessories for Conductor.

2.1.2 2.5% extra fasteners, filler plugs and retaining rods shall be provided.

2.1.3 The supplier shall be responsible for satisfactory performance of complete conductor system along with accessories offered by him for continuous operation at temperature specified for the HTLS Conductor.

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 resistively 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 thereof at a load less than 95% of the ultimate tensile strength of the conductor. It must be able to withstand the continuous design temperature of conductor.

2.2.2 The dimensions of mid span compression joint before & after compression alongwith tolerances shall be shall be guaranteed in the relevant schedules of the bid and shall be decided by the manufacturer so as to suit the conductor size & conform to electrical & mechanical requirement stipulated in the specification. For composite core conductor, suitable sleeve, collets, collet housing shall be used for core jointing.

2.3 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 / aluminium alloy and shall have a smooth surface. It shall be able to withstand the designed maximum operating temperature of conductor. 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 of Repair sleeve alongwith tolerances shall be guaranteed in the relevant schedules of the bid and shall be decided by the manufacturer so as to suit the conductor size & conform to electrical & mechanical requirement stipulated in the specification.

2.4 Vibration Damper

2.4.1 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 are installed in the existing line at suspension and tension points on each conductor in each span to damp out aeolian vibration as well as sub- span oscillations. One damper minimum on each side per conductor for suspension points and two dampers minimum on each side per conductor for tension points shall be used for a ruling design span of 350 meters.
2.4.2 The bidder shall offer damping system including Stockbridge type dampers for HTLS conductor for its protection from wind induced vibrations which could cause conductor fatigue /strand breakage near a hardware attachment, such as suspension clamps.

Alternate damping systems with proven design offering equivalent or better performance also shall be accepted provided the manufacturer meets the qualifying requirements stipulated in the Specifications. Relevant technical documents including type test reports to establish the technical suitability of alternate systems shall be furnished by the Bidder alongwith the bid. The damper shall be designed to have resonance frequencies to facilitate dissipation of vibration energy through interstrand friction of the messenger cable and shall be effective in reducing vibration over a wide frequency range (depending upon conductor dia) or wind velocity range specified above. The vibration damper shall meet the requirement of frequency or wind velocity range and also have mechanical impedance closely matched with the offered HTLS conductor. The vibration dampers shall be installed at suitable positions to ensure damping effectiveness across the frequency range. The power dissipation of the vibration dampers shall exceed the wind power so that the vibration level on the conductor is reduced below its endurance limit ie 150 micro strain. The bidder shall clearly indicate the method for evaluating performance of dampers including analytical and laboratory test methods. The bidder shall indicate the the type tests to evaluate the performance of offered damping system.

2.4.3 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 chafing 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.

2.4.4 The messenger cable shall be made of high strength galvanised steel/stainless steel with a minimum strength of 135 kg/sqmm. It shall be of preformed and postformed quality in order to prevent subsequent droop of weight and to maintain consistent flexural stiffness of the cable in service. The number of strands in the messenger cable shall be 19. The messenger cable other than stainless steel shall be hot dip galvanised in accordance with the recommendations of IS:4826 for heavily coated wires.

2.4.5 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 blowholes etc. The surface of the damper masses shall be smooth.
2.4.6 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.

2.4.7 The damper assembly shall be so designed that it shall not introduce radio interference beyond acceptable limits.

2.4.8 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.

2.4.9 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.

2.4.10 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 i) Ruling design span</td>
<td>350 meters</td>
</tr>
<tr>
<td>2.</td>
<td>Configuration</td>
<td>Double Circuit twin bundle conductor per phase in vertical configuration. One e/w &amp; one OPGW continuously in horizontal configuration.</td>
</tr>
<tr>
<td>3.</td>
<td>Tensile load in 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 ie endurance limit.</td>
<td>+/- 150 micro strains</td>
</tr>
</tbody>
</table>
2.4.11 The damper placement chart shall be submitted for spans ranging from 100m to 1100m. Placement charts should be duly supported with relevant technical documents and sample calculations.

2.4.12 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 centre 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.

2.5 **Bundle Spacer/ Rigid Spacer**

2.5.1 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.

2.5.2 Spacers offering equivalent or better performance shall also be accepted provided offer meets the qualifying requirements stipulated in the Specification.

2.5.3 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.

2.5.3.1 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.

2.5.3.2 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 350 m shall however be six with no sub-span greater than 70m and no end sub-span longer than 40m.

2.5.3.3 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.

2.5.3.4 The Bidder shall also furnish all the relevant technical documents in support of their placement charts along with the bid.

2.5.4 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 for twin bundle conductors. 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.
2.5.5 The spacer offered by the Bidder shall satisfy the following requirements.

2.5.5.1 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.

2.5.5.2 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.

2.5.5.3 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 + 0.1 mm and the length of the rods shall not be less than 1100 mm.

2.5.5.4 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.

2.5.5.5 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.

2.5.5.6 Clamp with cap shall be designed to prevent its cap from slipping out of position when being tightened.

2.5.5.7 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.

2.5.5.8 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.

2.5.5.9 Universal type bolted clamps, covering a range of conductor sizes, will not be permitted.

2.5.5.10 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.

2.5.5.11 The spacer shall be suitably designed to avoid distortion or damage to the conductor or to themselves during service.

2.5.5.12 Rigid spacers shall be acceptable only for jumpers.
2.5.5.13 The spacer shall not damage or chafe the conductor in any way which might affect its mechanical and fatigue strength or corona performance.

2.5.5.14 The clamping system shall be designed to compensate for any reduction in diameter of conductor due to creep.

2.5.5.15 The spacer assembly shall not have any projections, cuts, abrasions etc. or chattering parts which might cause corona or RIV.

2.5.5.16 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.

2.5.5.17 Elastomer, if used, shall be resistant to the effects of temperature upto the designed maximum temperature specified for the conductor, 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. The supplier shall submit relevant type/ performance test certificate as per applicable standard/ product specification for elastomer to confirm suitability of the offered elastomer for the specified application.

2.5.5.18 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.

2.5.5.19 The spacer assembly shall have complete ease of installation and shall be capable of removal/reinstallation without any damage.

2.5.5.20 The spacer assembly shall be capable of being installed and removed from the energised line by means of hot line technique.

2.6 Spacer Damper (Alternative to Vibration Damper & Bundle Spacer)

2.6.1 Suitable spacer dampers for offered type of HTLS conductor can be offered as an alternative to the combination of Vibration Damper and Bundle Spacer. The spacer damper covered by this specification shall be designed to maintain the bundle spacing of 450 mm under all normal operating conditions and to effectively control Aeolian vibrations as well as sub span oscillation and to restore conductor spacing after release of any external extraordinary load. The nominal sub conductor spacing shall be maintained within ±5 mm.

2.6.2 The spacer damper shall restore the normal sub-conductor spacing due to displacement by wind, electromagnetic and electrostatic forces including the specified short circuit level without permanent deformation or damage either to bundle conductors or to spacer damper itself.

2.6.3 The design offered shall be presented as a system consisting of spacer dampers and their staggering scheme for spans ranging from 100 m to 1100 m.

2.6.4 Under the operating conditions specified, the spacer damper system shall adequately control Aeolian vibrations throughout the life of the transmission line.
Design, Supply, Installation and Commissioning of Kushma-New Butwal 220 kV Transmission Line

with wind velocity ranging from 0 to 30 km per hour in order to prevent damage to conductor at suspension clamps, dead end clamps and spacer damper clamps.

2.6.5 The spacer damper system shall also control the sub-span oscillations in order to prevent conductor damage due to chaffing and severe bending stresses at the spacer damper clamps as well as suspension and dead end clamps and to avoid wear to spacer damper components.

2.6.6 The spacer damper shall consist of a rigid central body called the frame linked to the conductor by two articulated arms terminated by suitable clamping system. The articulation shall be designed to provide elastic and damping forces under angular movement of the arms. The dynamic characteristics of the articulations shall be maintained for the whole life of the transmission line.

2.6.7 The clamping system shall be designed to provide firm but gentle and permanent grip while protecting the conductor against local static or dynamic stresses expected during normal operating conditions. The clamping system shall be designed to compensate for any reduction of conductor diameter due to creep.

2.6.8 Bolted type clamps shall allow installation without removal of the bolts or the clamps from clamp body. Locking mechanism shall be suitable to prevent bolt loosening. Clamp locking devices with small loose components shall not be accepted. Nut cracker, hinged open or boltless type clamps are acceptable provided adequate grip can be maintained on the conductor.

2.6.9 Bolts and nuts shall be of mild steel, stainless steel, or high strength steel in accordance with the design of the spacer damper.

2.6.10 Where elastomer surfaced clamps are used, the elastomer elements shall be firmly fixed to the clamp. The insert should be forged from aluminium alloy of type 6061 or equivalent aluminium alloy having minimum tensile strength of 25 kg/mm2. The insert shall be moulded on the insert surface. The insert shall be duly heat treated and aged to retain its consistent characteristics during service. The grain flow of the forged insert shall be in the direction of the maximum tension and compression loads experienced.

2.6.11 If clamps involving preformed rods are used, these rods shall be designed for specific conductor size. They shall be made of high strength aluminium alloy of type 6061 or equivalent aluminium alloy having a minimum tensile strength of 35 kg/mm3. The rods shall be ball ended. The rods shall be heat treated and aged to achieve specified mechanical properties and to retain the same during service. The length of the rods shall be such that the ends fall inside the imaginary square whose sides are vertical and horizontal outer tangents to the conductor sections.

2.6.12 The spacer damper body shall be cast/ forged from suitable high strength corrosion resistant aluminum alloy. The aluminium alloy shall be chosen in relation with the process used.
2.6.13 The rubber components involved in the design such as damping elements shall be made with rubber compound selected specifically for that particular application. The Contractor shall submit a complete list of physical and mechanical properties of the elastomer used. This list shall make reference to all applicable ASTM standards.

2.6.14 The rubber components used shall have good resistance to the effects of temperature up to the designed maximum temperature of the conductor and to ultraviolet radiation, ozone and other atmospheric contaminants. The rubber shall have good wear and fatigue resistance and shall be electrically semi-conductive.

2.6.15 The spacer damper involving ferrous material shall not have magnetic power loss more than 1 watt.

2.6.16 The spacer damper assembly shall have electrical continuity. The electrical resistance between the sub-conductors across the assembly in case of spacer damper involving elastomer surfaced clamps shall be suitably selected by the manufacturer to ensure satisfactory electrical performance and avoid deterioration of elastomer under service conditions.

2.6.17 The spacer damper assembly shall have complete ease of installation and shall be capable of removal/reinstallation without any damage.

2.6.18 The spacer damper assembly shall have complete ease of installation and shall be capable of being installed and removed from the energized line by means of hot line techniques. The Bidder shall supply with the bid the complete description of the installation, removal and reinstallation procedure.

2.6.19 The Bidder shall recommend the staggering scheme for installation of spacer dampers on the line which shall ensure most satisfactory fatigue performance of the line as specified. The scheme shall indicate the number of spacer dampers per phase per span and the sub span lengths to be maintained between spacer dampers while installing on the bundle conductors.

2.6.20 The staggering scheme shall be provided for spans ranging from 100 m to 1100 m. The number of spacer dampers for a nominal ruling span of 350 m shall not be less than six.

2.6.21 No sub span shall be greater than 70 m and no end sub span shall be longer than 40 m.

2.6.22 The staggering scheme shall be such that the spacer dampers be unequally distributed along the span to achieve sufficient detuning of adjacent subs pans for oscillations of sub span mode and to ensure bundle stability for wind speeds up to 60 km/hr.

2.6.23 The manufacturer / supplier shall supply free of cost 25 number fixed setting torque wrench (of torque as per spacer damper design) along with 1st batch of
supply of spacer dampers for installation of spacer damper on the line by the tower contractors.

2.6.24 The Bidder shall furnish all the relevant technical documents in supports of the staggering scheme recommended for the spacer damper.

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 high voltage field. The Bidder shall offer only such equipment as guaranteed by him to be satisfactory and suitable for 220 kV transmission line application with twin conductors and will give continued good performance at all service conditions. For employer’s review of the offered design of accessories, the supplier shall submit document/design details of similar type of accessories used in past for similar type of HTLS conductor application.

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 High current, heat rise test shall be conducted by the supplier to determine the maximum temperature achieved in different components of fittings/accessories under simulated service condition corresponding to continuous operation of conductor at designed maximum temperature. The material of the components should be suitable for continued good performance corresponding to these maximum temperatures. The supplier shall submit relevant type/performance test certificates as per applicable standards/product specifications to confirm suitability of the offered material.

2.7.4 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. 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 average 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.

2.7.5 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 of grade Zn 99.95 as per IS:209.

2.7.6 In case of castings, the same shall be free from all internal defects like shrinkage, inclusion, blow holes, cracks etc.

2.7.7 All current carrying parts shall be so designed and manufactured that contact resistance is reduced to minimum and localised heating phenomenon is averted.
2.7.8 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.

2.7.9 Particular care shall be taken during manufacture and subsequent handling to ensure smooth surface free from abrasion or cuts.

2.7.10 The fasteners shall conform to the requirements of IS:6639-1972. 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/spacer damper 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 Owner for approval. After Owner’s approval and successful completion of all type tests, 20 (twenty) more sets of drawings shall be submitted to Owner for further distribution and field use at Owner’s end.
3.0 Accessories for Earthwire

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 exceed the value as stipulated in the Standard Technical Particulars. The steel sleeve shall be hot dip galvanised. The aluminium sleeve shall have aluminium of purity not less than that stipulated in the Standard Technical Particulars. Filler aluminium sleeve shall also be provided at the both ends. The joints shall not permit slipping off, damage to or failure of the complete earth wire or any part thereof at a load not less than 95% of the ultimate tensile strength of the earth wire. The joint shall have resistivity less than 75% of resistivity of equivalent length of earth wire. The dimensions and the dimensional tolerances of the joint shall be as stipulated in the Standard Technical Particulars.

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 350 meters.

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.</th>
<th>Description</th>
<th>Technical particulars</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Configuration</td>
<td>Two continuously steel earthwire 10.98 mm diameter / ACSR Earthwire 18.12 mm Dia in horizontal configuration. Refer to Section-I for mechanical properties of the earthwire.</td>
</tr>
<tr>
<td>2.</td>
<td>Span length in meters</td>
<td>350 meters</td>
</tr>
<tr>
<td></td>
<td>i) Ruling design span</td>
<td>1100 meters</td>
</tr>
<tr>
<td></td>
<td>ii) Maximum span</td>
<td>100 meters</td>
</tr>
<tr>
<td></td>
<td>iii) Minimum span</td>
<td></td>
</tr>
<tr>
<td>3.</td>
<td>Tensile load in Conductor at temperature of 0°C and still air</td>
<td>As per sag tension calculations.</td>
</tr>
<tr>
<td>4.</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 adhere to the values stipulated in the Standard Technical Particulars.

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 Material and Workmanship

Same as Clause 2.7 of this section

3.8 Compression Marking

Same as Clause 2.8 of this section

4.0 Tests and Standards

4.1 Type Tests

4.1.1 On the complete Insulator Strings with Hardware Fittings

a) Power frequency voltage withstand test with corona control rings/grading ring and arcing horns under wet condition : As per IEC:60383

b) Impulse voltage withstand test under dry condition : As per IEC:60383

c) Mechanical Strength test : As per Annex-A

d) Voltage distribution test : As per Annex-A

e) Corona and RIV test : As per Annex-A

f) Vibration test : As per Annex-A

Note: 1) All the type test given in Clause No. 3.1.1 shall be conducted on Single "T" suspension & Double Tension insulator string.

2) All the type tests given under Clause No. 3.1.1 (a) to (e) shall also be conducted on Single I Pilot insulator strings
On Hardware Fittings

4.1.2

a) Mechanical Strength Test on Tension Hardware fitting : As per Annex-A
b) Mechanical Strength Test on Suspension Hardware fitting : As per Annex-A

4.1.3 On Suspension Clamp

a) Magnetic power loss test : As per Annexure-A
b) Clamp slip strength Vs torque test : As per Annexure-A
c) Ozone Test on elastomer : As per Annexure-A
d) Vertical damage load & Failure load test : IEC:61284

4.1.4 On Dead end Tension Assembly

a) Electrical resistance test for dead end Assembly : As per IS:2486-(Part-I)
b) Heating cycle test for dead end Assembly : As per Annexure-A
c) Slip strength test for dead end assembly : As per Annexure-A
d) Ageing test on filler (if applicable) : As per Annexure-A

4.1.5 Mid Span Compression Joint for Conductor & Earthwire

a) Chemical analysis of materials : As per Annexure-A
b) Electrical resistance test : As per IS:2121 (Part-II)
c) Heating cycle test : As per Annexure-A
d) Slip strength test : As per Annexure-A
e) Corona extinction voltage test (dry) : As per Annexure-A
f) Radio interference voltage test (dry) : As per Annexure-A

Note: Tests mentioned at (c), (e) & (f) are not applicable to mid span compression joints for earthwire

4.1.6 Repair Sleeve for Conductor

a) Chemical analysis of materials : As per Annexure-A
b) Corona extinction voltage test (dry) : As per Annexure-A
c) Radio interference voltage test (dry) : As per Annexure-A
4.1.7 Vibration Damper for Conductor & Earthwire

a) Chemical analysis of materials : As per Annexure-A
b) Dynamic characteristics test* : As per Annexure-A
c) Vibration analysis : As per Annexure-A
d) Clamp slip test : As per Annexure-A
e) Fatigue tests : As per Annexure-A
f) Magnetic power loss test : As per Annexure-A
g) Corona extinction voltage test (dry) : As per Annexure-A
h) Radio interference voltage test (dry) : As per Annexure-A
i) Damper efficiency test : As per IS:9708

* Applicable for 4 R Stockbridge dampers. For alternate type of vibration dampers (permitted as per clause 2.4.2), as an alternative to dynamic characteristic test, damper efficiency test as per IEEE-664 may be proposed/ carried out by the supplier.

Note: Tests mentioned at (f),(g) & (h) are not applicable to Vibration Damper for earthwire.

4.1.8 Flexible Copper Bond

a) Slip strength test : As per Annexure-A

4.1.9 Bundle Spacer for line

a) Chemical analysis of materials : As per Annexure-A
b) Clamp slip test : As per Annexure-A
c) Vibration Test
   (i) Vertical vibration : As per Annexure-A
   (ii) Longitudinal vibration : As per Annexure-A
   (iii) Sub-span oscillation : As per Annexure-A
d) Magnetic power loss test (if applicable) : As per Annexure-A
e) Compressive and Tension Test : As per Annexure-A
f) Corona extinction voltage test (dry) : As per Annexure-A
g) Radio interference voltage test (dry) : As per Annexure-A
h) Ozone test on elastomer : As per Annexure-A
4.1.10 Rigid spacer for jumper

a) Chemical analysis of materials : As per Annexure-A
b) Clamp slip test : As per Annexure-A
c) Magnetic power loss test (if applicable) : As per Annexure-A
d) Tension-compression Test : As per Annexure-A
e) Corona extinction voltage test (dry) : As per Annexure-A
f) Radio interference voltage test (dry) : As per Annexure-A

4.1.11 Spacer Damper (Alternative to combination of Vibration Damper & Bundle spacer)

a) Chemical analysis of materials : As per Annexure-A
b) Clamp slip test : As per Annexure-A
c) Vibration Test : As per Annexure-A
   (i) Vertical Vibration : As per IS 10162
   (ii) Longitudinal Vibration : As per IS 10162
   (iii) Sub-span oscillation : As per IS 10162
d) Dynamic characteristics test : As per Annexure-A
e) Fatigue tests : As per Annexure-A
d) Magnetic power loss test (if applicable) : As per Annexure-A
e) Compressive and Tension Test : As per Annexure-A
f) Corona extinction voltage test (dry) : As per Annexure-A
g) Radio interference voltage test (dry) : As per Annexure-A
h) Ozone test on elastomer : As per Annexure-A
k) Log decrement test : As per Annexure-A

4.1.12 On Suspension clamp Assembly for GS Earthwire

a) Chemical analysis of materials : As per Annexure-A
b) Clamp slip strength Vs torque test for suspension clamp : As per Annexure-A
c) Mechanical strength Test : As per Annexure-A

4.1.13 On Earthwire Tension clamp Assembly for GS Earthwire

a) Chemical analysis of materials : As per Annexure-A
b) Mechanical strength test (excluding clamp) : As per Annexure-A

c) Slip strength test for tension assembly : As per Annexure-A

d) Electrical resistance test for tension clamp : As per Annexure-A

4.1.14 Type tests specified under Clause 4.1.1 to 4.1.13 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 POWERGRID or Utility.

In the event of any discrepancy in the test report (i.e., any test report not applicable due to any design / material/manufacturing process 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 Employer/ Employer/ Purchaser.

4.2 Acceptance Tests

4.2.1 On Both Suspension and Tension Hardware Fittings

a) Visual Examination : As per IS:2486-(Part-I)

b) Verification of dimensions : As per IS:2486-(Part-I)

c) Galvanising/Electroplating test : As per IS:2486-(Part-I)

d) Mechanical strength test of each component (excluding corona control rings grading ring and arcing horn) : As per Annexure-A

e) Mechanical strength test for corona control ring/ grading ring and arcing horn : As per BS:3288(Part-I)

f) Test on locking device for ball and socket coupling : As per IEC:372 (2)

g) Mechanical Strength test of welded joint : As per Annexure-A

h) Chemical analysis, hardness tests, grain size, inclusion rating & magnetic particle inspection for forgings/castings : As per Annexure-A

4.2.2 On Suspension Hardware Fittings only

a) Clamp Slip strength Vs Torque test for suspension clamp : As per Annexure-A

b) Shore hardness test of elastomer cushion for AG : As per Annexure-A
Design, Supply, Installation and Commissioning of Kushma-New Butwal 220 kV Transmission Line

4.2.3 On Tension Hardware Fittings only

a) Slip strength test for dead end assembly : As per IS:2486 (Part-I) Clause 5.4

d) Ageing test on filler (if applicable) : As per Annexure-B

4.2.4 On Mid Span Compression Joint for Conductor

a) Visual examination and dimensional verification : As per IS:2121 (Part-II), Clause 6.2, 6.3 6.7

b) Galvanising test : As per Annexure-B

c) Hardness test : As per Annexure-B

d) Ageing test on filler (if applicable) : As per Annexure-B

4.2.5 Repair Sleeve for Conductor

a) Visual examination and dimensional verification : As per IS:2121(Part-II) Clause 6.2, 6.3

4.2.6 Flexible Copper Bond

a) Visual examination and dimensional verification : As per IS:2121(Part-II) Clause 6.2, 6.3

b) Slip strength test : As per annexure-A

4.2.7 Spacer Damper/ Bundle Spacer for line / Rigid spacer for Jumper

a) Visual examination and dimensional verification : As per IS:2121(Part-II) Clause 6.2, 6.3 6.7

b) Galvanising test : As per Annexure-B

c) Movement test (except for spacer jumpers) : As per Annexure-B

d) Clamp slip test : As per Annexure-B

e) Clamp bolt torque test : As per Annexure-B

f) Compression-tension test : As per Annexure-B
g) Assembly torque test : As per Annexure-B
h) Hardness test for elastomer (if applicable) : As per Annexure-B

4.2.8 **GS Earthwire Tension Clamp Assembly**

a) Visual examination and dimensional verification : As per IS:2121(Part-II)
b) Galvanising test : As per Annexure-A
c) Slip strength test for tension clamp : As per Annexure-A
d) Mechanical strength test on each component (excluding clamp) : As per Annexure-A
e) Hardness test : As per Annexure-A

4.2.9 **GS Earthwire Suspension Clamp Assembly**

a) Visual examination and dimensional verification : As per IS:2121(Part-II)
b) Galvanising test : As per Annexure-A
c) Clamp slip strength test : As per Annexure-A
d) Mechanical strength test on each component (excluding clamp) : As per Annexure-A

4.2.10 **Vibration Damper for Conductor & Earthwire**

a) Visual examination and dimensional verification : As per IS:2121(Part-II)
   Clause 6.2, 6.3 7 6.7
b) Galvanising test : As per Annexure-B
   i) On damper masses : As per Annexure-B
   ii) On messenger cable : As per Annexure-B
c) Verification of resonance frequencies : As per Annexure-B
d) Clamp slip test : As per Annexure-B
e) Clamp bolt torque test : As per Annexure-B
f) Strength of the messenger cable : As per Annexure-B
g) Mass pull off test : As per Annexure-B
h) Dynamic characteristics test* : As per Annexure-B

* Applicable for 4 R stockbridge dampers. For alternate type of vibration dampers (permitted as per clause 2.4.2), as an alternative to dynamic characteristic test, damper efficiency test as per IEEE-664 may be proposed/carried out by the supplier.

4.3 **Routine Tests**
4.3.1 **For Hardware Fittings**

a) Visual examination  
   IS:2486-(Part-I)

b) Proof Load Test  
   : As per Annexure-A

4.3.2 **For conductor and earthwire accessories**

a) Visual examination and dimensional verification  
   : As per IS:2121(Part-II) Clause 6.2, 6.3 6.7

4.4 **Tests During Manufacture on all components as applicable**

a) Chemical analysis of Zinc used for galvanising  
   IS:2486-(Part-I)

b) Chemical analysis mechanical metallographic test and magnetic particle inspection for malleable castings  
   : As per Annexure-A

c) Chemical analysis, hardness tests and magnetic particle inspection for forging  
   : As per Annexure-A

4.5 **Testing Expenses**

4.5.1 As indicated in clause 4.1.14 no type test charges shall be payable.

4.5.2 In case type testing is required due to non availability of type test reports, for type test on the complete insulator string, the Contractor has to arrange similar insulators at his own cost.

4.5.3 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.

4.5.4 The entire cost of testing for type tests, acceptance and routine tests and tests during manufacture specified herein shall be treated as included in the quoted Ex-works/CIF Price.

4.5.5 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 Contractor’s notice of testing, the Owner’s representative/Inspector does not find material & facilities to be ready for testing the expenses incurred by the Owner’s for redeputation shall be deducted from contract price.

4.5.6 The Contractor shall intimate the Owner about carrying out of the type tests alongwith detailed testing programme at least 3 weeks in advance (in case of testing in India and at least 6 weeks advance in case of testing abroad) 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.
4.6 **Sample Batch For Type Testing**

4.6.1 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.

4.6.2 Before sample selection for type testing the Contractor shall be required to conduct all the acceptance tests successfully in presence of Owner’s representative.

4.7 **Schedule of Testing and Additional Tests**

4.7.1 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.

4.7.2 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.

4.7.3 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 centre. 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.

4.9 **Test Reports**

4.9.1 Copies of type test reports shall be furnished in atleast six copies alongwith one original. One copy shall be returned duly certified by the Owner, only after which the commercial production of the concerned material shall start.

4.9.2 Copies of acceptance test report shall be furnished in atleast six copies. One copy shall be returned, duly certified by the Owner, only after which the materials will be despatched.

4.9.3 Record of routine test report shall be maintained by the Contractor at his works for periodic inspection by the Owner’s representative.

4.9.4 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.

4.10 **Inspection**
4.10.1 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.

4.10.2 The material for final inspection shall be offered by the Contractor only under packed condition as detailed in respective clause of this part of the Specification. The engineer shall select samples at random from the packed lot for carrying out acceptance tests.

4.10.3 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.

4.10.4 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.

4.10.5 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.

4.11 Packing and Marking

4.11.1 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.

4.11.2 The packing shall be of sufficient strength to withstand rough handling during transit, storage at site and subsequent handling in the field.

4.11.3 Suitable cushioning, protective padding, dunnage or spacers shall be provided to prevent damage or deformation during transit and handling.

4.11.4 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.

4.11.5 Each component part shall be legibly and indelibly marked with trade mark of the manufacturer and year of manufacture. However, in such type of component/item, which consists of many parts and are being supplied in assembled condition( suspension clamp, vibration damper, etc.), the complete assembly shall be legibly and indelibly marked on main body/on one of the parts.

4.11.6 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 stencilled on it in indelible ink.

4.12 Standards
4.12.1 The Hardware fittings; conductor and earthwire 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.

4.12.2 In the event of the supply of hardware fittings; conductor 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 Standard</th>
</tr>
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<tr>
<td>3.</td>
<td>IS 1573</td>
<td>Electroplated Coating of Zinc on iron and Steel</td>
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<td>4.</td>
<td>IS : 2121 (Part-II)</td>
<td>Specification for Conductor and Earthwire Accessories for Overhead Power lines: Mid-span Joints and Repair Sleeves for Conductors</td>
<td></td>
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<tr>
<td>5.</td>
<td>IS:2486 (Part-I)</td>
<td>Specification for Insulator Fittings for Overhead power Lines with Nominal Voltage greater than 1000 V: General Requirements and Tests</td>
<td></td>
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<td>6.</td>
<td>IS:2629</td>
<td>Recommended Practice for Hot Dip Galvanising of Iron and Steel</td>
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<td>7.</td>
<td>IS:2633</td>
<td>Method of Testing Uniformity of Coating on Zinc Coated Articles</td>
<td></td>
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<tr>
<td>8.</td>
<td>IS:2633</td>
<td>Ozone test on Elastomer</td>
<td>ASTM- D1 171</td>
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<td>10.</td>
<td>IS:6745</td>
<td>Methods of Determination of Weight of Zinc Coating of Zinc Coated Iron and Steel Articles</td>
<td>BS:433 ISO : 1460 (E)</td>
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<tr>
<td>12.</td>
<td>IS:6639</td>
<td>Hexagonal Bolts for Steel Structures</td>
<td>ISO/R-272</td>
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<tr>
<td>13.</td>
<td>IS:9708</td>
<td>Specification for Stock</td>
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The standards mentioned above are available from:

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<tr>
<th>Reference Abbreviation</th>
<th>Name and Address</th>
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<tr>
<td>BS</td>
<td>British Standards, British Standards Institution 101, Pentonville Road, 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>
</tr>
<tr>
<td>BIS/IS</td>
<td>Beureau Of Indian Standards. Manak Bhavan, 9, Bahadur Shah Zafar Marg, New Delhi - 110001. INDIA</td>
</tr>
<tr>
<td>ISO</td>
<td>International Organisation for Standardization. Danish Board of Standardization Danish Standardizing Sraat, Aurehoegvej-12 DK-2900, Heeleprup, DENMARK.</td>
</tr>
<tr>
<td>NEMA</td>
<td>National Electric Manufacture Association, 155, East 44th Street. New York, NY 10017 U.S.A.</td>
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</table>
1.0 **Tests on Complete Strings with Hardware Fittings**

1.1 **Voltage Distribution Test**

The voltage across each insulator unit shall be measured by sphere gap method. The result obtained shall be converted into percentage. The maximum voltage across any disc shall not exceed the values specified in the standard technical particulars.

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 that stipulated in the standard Technical particulars. There shall be no evidence of corona on any part of the sample. The test shall be carried out as per IEC:61284. The atmospheric condition during testing shall be recorded and the test results shall be accordingly corrected with suitable correction factor as stipulated in IEC:60060-1.

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 that stipulated in the standard Technical particulars. The test procedure shall be in accordance with IEC:61284.

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 sub conductors each tensioned at 25% of UTS 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 composite longrod/disc insulators after the vibration test.

The composite longrod insulators shall be subjected to the Mechanical performance test followed by mechanical strength test as per relevant standards.

The disc insulators shall be subjected to the following, tests as per relevant standards:

<table>
<thead>
<tr>
<th>Sl.No.</th>
<th>Test</th>
<th>Percentage of insulator units to be tested</th>
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</thead>
<tbody>
<tr>
<td>a)</td>
<td>Temperature cycle test followed by mechanical performance test</td>
<td>60</td>
</tr>
<tr>
<td>b)</td>
<td>Puncture test / steep wave front test (Only for glass insulators)</td>
<td>40</td>
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</table>

1.6 **Assembly Test**

This test shall be carried out to ensure that the cotter pins, bolts, clamps etc., fit freely and properly.

1.7 **Slip strength test for dead end assembly**

The test shall be carried out as per IS:2486 (Part-I) except that the load shall be steadily increased to 95% of minimum ultimate tensile strength of conductor/earthwire and retained for one minute at this load.

2.0 **Tests on Hardware Fittings**

2.1 **Magnetic Power Loss Test for Suspension Assembly**

An alternating current over the range of 800 amps to 1200 shall be passed through each tube. The reading of the wattmeter with and without suspension assemblies alongwith 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 1200 amperes shall be read off from the graph and the same shall be limited to the value guaranteed by the supplier.

2.2 **Galvanising/Electroplating Test**

The test shall be carried out as per Clause no. 5.9 of IS: 2486-(Part-1) except that both uniformity of zinc coating and standard preece 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 conductor shall be fixed in the clamp. The clamp slip strength at various tightening torques 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 centre type suspension clamp. For AG suspension clamp only clamp slip strength after assembly shall be found out. The clamp slip strength at the recommended tightening torque shall be as indicated in GTP

2.6 **Heating Cycle Test**

Heating cycle test shall be performed in accordance with IS 2486 (Part-I) with following modifications:

i) Temperature of conductor during each cycle: 40 deg. C above designed maximum operating temperature of the conductor.

ii) Number of cycle: 100

iii) Slip strength test shall also be carried out after heating cycle test.

2.7 **Ageing Test on Filler (if applicable)**

The test shall be done in accordance with Grease drop point test method. The specimen should be drop as a droplet when kept at a temperature 40 deg. C above designed maximum operating temperature of the conductor for 30 minutes. The temperature shall then be increase till one droplet drops and the temperature recorded.

2.8 **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.
2.9 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.

2.10 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.

2.11 Mechanical Strength Test for 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.

2.12 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 Accessories for Conductor and Earth wire Accessories

3.1 Mid Span Compression Joint for Conductor and Earth wire Accessories

(a) Slip Strength Test

The fitting compressed on conductor shall not be less than one metre in length. The test shall be carried out as per IS:2121 (Part-ii)-1981 clause 6-4 except that the load shall be steadily increased to 95% of minimum ultimate tensile strength of conductor and retained for one minute at this load. There shall be no movement of the conductor relative to the fittings and no failure of the fittings during this one minute period.
(b) Heating Cycle Test (for conductor accessories only)

Heating cycle test shall be performed in accordance with IS 2121 (Part-II-1981) with following modifications:

i) Temperature of conductor during each cycle: 40 deg. C above designed maximum operating temperature of the conductor.

ii) Number of cycle: 100

iii) Slip strength test shall also be carried out after heating cycle test.

3.2 Vibration Damper for Conductor and Earth wire Accessories

(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 0.18/d to 1.4/d where d is the diameter of conductor in metres. 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 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 0.191 f to 0.762 f Kgf/mm limits where f is frequency in Hz.

(iv) The above mean phase angle response curve shall be between 25o to 130o 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 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 done for twin conductor without armour rods as per the parameters given under this part of the Specification. The tension shall be taken from Sag & Tension calculation (0 deg. C & no wind condition and 350 m ruling span) for a span ranging from 100 m to 1100.

(ii) The self damping factor and flexural stiffness (EI) for conductor shall be calculated on the basis of experimental results. The details for 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 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 without damper, anti-node 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 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 shall be determined. In addition to above damper clamp vibration amplitude and anti-node 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 clamp 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 conductor shall be tensioned at tension corresponding to 0 deg. C & no wind condition and ruling span 350 m from sag –tension calculation 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 has been tensioned, clamps shall be installed to support the conductor 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. 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 for a minimum duration of one minute shall not slip i.e. the permanent displacement between conductor 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 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/\( \nu \) mm, where \( \nu \) 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 re-torquing 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 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 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.

3.3 Spacer/Spacer Damper

(a) Vibration Tests

The test set up shall be as per Clause No. 2.2(c) (i) of Annexure-A. The spacer/spacer damper 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 (Tension form sag-tension calculation at 0 deg. C & no wind condition and 350 m ruling span). The spacer/spacer damper 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 No 2.4 (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 25 mm 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 conductor bundle string at a tension of tension at 0 deg. C & No wind. In case of spacer for jumper, the. clamp of sample shall be tightened with a specified tightening torque. One of the sample clamps, when subjected to a longitudinal pull parallel to the conductor axis 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 the sample measured after removal of the load shall not exceed specified values. The minimum slip under longitudinal pull varies with clamp type according to the following table:

<table>
<thead>
<tr>
<th>Clamp Type</th>
<th>Longitudinal Load (kN)</th>
<th>Maximum Slip (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Metal-Metal bolted</td>
<td>6.5</td>
<td>1</td>
</tr>
<tr>
<td>Rubber loaded</td>
<td>2.5</td>
<td>2.5</td>
</tr>
<tr>
<td>Clamp using Preformed rods</td>
<td>2.5</td>
<td>12</td>
</tr>
</tbody>
</table>

c) Compressive and tensile test

This test shall be conducted on 3 (three) nos samples 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 centre 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) Dynamic Characteristic Test (for Spacer Damper only)

The purpose of this test is to obtain quantitative information regarding the dynamic characteristics of the spacer damper. The values obtained during this test will serve as references to evaluate the behaviour of the same spacer damper under the fatigue test.

The test will consist in the application of sinusoidal movement of the spacer-damper articulation and measuring the force (F), displacement (X) and phase angle (Ø) between these two, from these values, the stiffness (K) and the damping factor (n) will be calculated.

\[
\frac{F}{X} = \frac{\cos \theta}{\cos \theta}; \quad n = \frac{\tan \theta}{\sin \theta}
\]

The test frequency shall not be higher than 3 Hz. The test shall be performed at five different displacement amplitudes. The amplitudes shall be selected to reproduce 10, 20, 40, 60 and 90 percent of the maximum displacement permitted by the spacer-damper design.

The test shall be performed on three samples.

e) Fatigue Test (for Spacer Damper only)

The purpose of this test is to evaluate the capacity of the spacer damper to sustain without damage the cyclic movements which can be induced by vibrations.

The spacer damper articulation shall be subjected to cyclic motions for a total of 10 million cycles. The test frequency shall be between 2 and 3 Hz. The amplitude of motion shall be established on the following basis:

— the load applied on the spacer damper clamp shall not be less than ± 300 N.

— the clamp displacement under the applied load shall not be less than 60% of the maximum displacement permitted by the design.

— if the 300 N load generates movement exceeding the maximum permitted displacement, the load can be reduced to limit the movement to 95% of the maximum displacement.

— After the test, the sample shall be subjected to a second dynamic characteristic test. This test shall be performed at two amplitudes, 10% and 60% of the maximum displacement.
— The spacer damper shall show no signs of cracks or deterioration, loosening of bolts or abnormal wear.

The dynamic characteristics \((k\) and \(n))\ shall not be less than 60% of the values measured before the fatigue test. The test shall be performed on three samples.

f) Ozone Test

The 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 2x magnification.

h) Log Decrement test (for spacer damper only)

The spacer damper assembly shall be mounted on test span of conductor bundle at a tension of 0 deg. C & no wind and ruling span of 350 m. The test span shall be instrumented to continuously monitor and record the horizontal motion of the sub-conductor in the sub-span between suspension point and the first sample.

The log decrement test shall be made with an initial peak to peak amplitude of four to six times the conductor diameter in the middle of the sub-span being considered. The conductor shall be excited in a horizontal one loop per sub-span resonant mode with a slow and steady build up of amplitude that minimises harmonics and other distortions. After achieving a steady state motion, the conductor excitation shall be discontinued leaving the conductor undisturbed. The motion shall be recorded until it reduces to an amplitude of half of the conductor diameter. The logarithmic (log) decrement shall be the value for a minimum reduction of 80 % in amplitude. The minimum acceptable log decrement average for five or more excitation shall be 0.04 based upon the following formula for decay.

\[
\log_e \frac{A_n}{A_{n+1}} = \log_e \frac{A_0}{A} = 1/n
\]

Where \(A_0\) is the initial amplitude and \(A_n\) is the amplitude ‘\(n\)’ cycles later

3.4 Magnetic Power Loss Test for 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 1200 to 1800 amperes per sub-conductor the magnetic power loss at various currents should be specified in tabulated graphical form. The difference between the power losses without and with sample at room temperature shall be limited to value guaranteed by the supplier for 1574 amperes current (rms). The losses shall be determined by averaging the observations obtained from at least four samples.

3.5 Corona Extinction Voltage Test (Dry)
The sample when subjected to power frequency voltage shall have a corona extinction voltage of not less than 154 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 IS:731-1971.

3.6 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 microvolts at one MHz when subjected to 50 Hz AC voltage of 154 kV rms line to ground under dry condition. The test procedure shall be in accordance with IS:8263.

3.7 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.

3.8 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 as per the values stipulated in the Standard Technical Particulars.

(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.

3.9 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)

41 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 Owner 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 Owner in Quality Assurance Programme.
ANNEXURE-B

Acceptance Tests

1. Mid Span Compression Joint for Conductor & Earthwire
   (a) Hardness Test

   The Brinnel hardness at various points on the steel sleeve of conductor core and tension clamp shall be measured.

2. Vibration Damper for Conductor & 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 2.2 (c) (ii) 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 2.2 (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 messenger cable 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 cable. 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>
<thead>
<tr>
<th>Vibration Damper of</th>
<th>Conductor</th>
</tr>
</thead>
<tbody>
<tr>
<td>-</td>
<td>1 Sample for 1 000 Nos. &amp; below</td>
</tr>
<tr>
<td>-</td>
<td>3 Samples for lot above 1 000 &amp; upto 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.

(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.

3. Spacer Damper/ Spacer for jumper

(a) Dynamic characteristics Test

The test shall be carried out as per clause 3.5 (c) of 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 parallel to the conductor ± 50 mm

(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.
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Chapter-01
Specification for OPGW cabling & associated hardware & fittings

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2.0 Applicable Standards
Section-01
Specification for OPGW cabling and associated hardware & fittings

The broad scope of this specification include the survey, planning, design, engineering, manufacturing, supply, transportation, insurance, delivery at site, unloading, handling, storage, installation, splicing, termination, testing, demonstration for acceptance and commissioning and documentation for:

a) OPGW fibre optic cable including all associated hardware, accessories & fittings
b) Fibre Optic approach cable including installation material
c) Fibre Optic Distribution Panels (FODP) & Joint Box
d) Supply of spares
e) Supply of test equipments
f) All other associated work/items described in the technical specifications.

This section of the technical specification describes the functional and technical specifications of OPGW cabling and associated hardware and fittings.

1.0 Fibre Optic Cabling

In this section of the technical specification, the functional & technical specifications of OPGW cable, associated hardware & fittings for the requirements for G.652D Dual-window Single mode (DWSM) telecommunications grade fibre optic cable is mentioned. Bidders shall furnish with their bids, detailed descriptions of the fibres & cable(s) proposed.

All optical fibre cabling including fibre itself and all associated installation hardware shall have a minimum guaranteed design life span of 25 years. Documentary evidence in support of guaranteed life span of cable & fibre shall be submitted by the Contractor during detailed engineering.

1.1 Required Optical Fibre Characteristics

The optical fibre to be provided should have following characteristics:

1.1.1 Physical Characteristic

Dual-Window Single mode (DWSM), G.652D optical fibres shall be provided in the fibre optic cables. DWSM optical fibres shall meet the requirements defined in Table 1-1(a).

1.1.2 Attenuation

The attenuation coefficient for wavelengths between 1525 nm and 1575 nm shall not exceed the attenuation coefficient at 1550 nm by more than 0.05 dB/km. The attenuation coefficient between 1285 nm and 1330 nm shall not exceed the attenuation coefficient at 1310 nm by more than 0.05 dB/km. The attenuation of the fibre shall be distributed uniformly throughout its length such that there are no point discontinuities in excess of 0.10 dB. The fibre attenuation characteristics specified in table 1-1 (a) shall be “guaranteed” fibre attenuation of any & every fibre reel.

The overall optical fibre path attenuation shall not be more than calculated below:

Maximum attenuation @ 1550 nm : 0.21 dB/km x total km + 0.05 dB/splice x no. of splices + 0.5 dB/connector x no. of connectors.
Maximum attenuation @ 1310 nm : 0.35 dB/km x total km + 0.05 dB/splice x no. of splices + 0.5 dB/connector x no. of connectors.

Table 2-1(a)
DWSM Optical Fibre Characteristics

<table>
<thead>
<tr>
<th>Fibre Description:</th>
<th>Dual-Window Single-Mode</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mode Field Diameter:</td>
<td>8.6 to 9.5 μm (± 0.6μm )</td>
</tr>
<tr>
<td>Cladding Diameter:</td>
<td>125.0 μm ± 1 μm</td>
</tr>
<tr>
<td>Mode field concentricity error</td>
<td>≤ 0.6μm</td>
</tr>
<tr>
<td>Cladding non-circularity</td>
<td>≤ 1%</td>
</tr>
<tr>
<td>Cable Cut-off Wavelength λcc</td>
<td>≤ 1260 nm</td>
</tr>
<tr>
<td>1550 nm loss performance</td>
<td>As per G.652 D</td>
</tr>
<tr>
<td>Proof Test Level</td>
<td>≥ 0.69 Gpa</td>
</tr>
<tr>
<td>Attenuation Coefficient:</td>
<td></td>
</tr>
<tr>
<td>@ 1310 nm</td>
<td>≤ 0.35 dB/km</td>
</tr>
<tr>
<td>@ 1550 nm</td>
<td>≤ 0.21 dB/km</td>
</tr>
<tr>
<td>Chromatic Dispersion;</td>
<td></td>
</tr>
<tr>
<td>Maximum:</td>
<td>18 ps/(nm x km) @ 1550 nm</td>
</tr>
<tr>
<td></td>
<td>3.5 ps/(nm x km) 1288-1339nm</td>
</tr>
<tr>
<td></td>
<td>5.3 ps/(nm x km) 1271-1360nm</td>
</tr>
<tr>
<td>Zero Dispersion Wavelength</td>
<td>1300 to 1324 nm</td>
</tr>
<tr>
<td>Zero Dispersion Slope :</td>
<td>0.092 ps/(nm²xkm) maximum</td>
</tr>
<tr>
<td>Polarization mode dispersion</td>
<td>≤ 0.2 ps/km²½</td>
</tr>
<tr>
<td>coefficient</td>
<td></td>
</tr>
<tr>
<td>Temperature Dependence :</td>
<td>Induced attenuation ≤ 0.05 dB (-60°C - +85°C )</td>
</tr>
<tr>
<td>Bend Performance :</td>
<td></td>
</tr>
<tr>
<td>@ 1310 nm (75±2 mm dia Mandrel),</td>
<td>100 turns; Attenuation Rise ≤ 0.05 dB/km</td>
</tr>
<tr>
<td>@ 1550 nm (75±2 mm dia Mandrel),</td>
<td>100 turns; Attenuation Rise ≤ 0.10 dB/km</td>
</tr>
<tr>
<td>@ 1550 nm (32±0.5 mm dia Mandrel,</td>
<td>1 turn; Attenuation Rise ≤ 0.50 dB/km</td>
</tr>
</tbody>
</table>

1.2 Fibre Optic Cable Construction

The OPGW (Optical Ground Wire) cable is proposed to be installed on the new transmission lines alongside transmission line construction. The design of cable shall account for the varying operating and environmental conditions that the cable shall experience while in service. The OPGW cable to be supplied shall be designed to meet the overall requirements of all the transmission lines. The Tower span details shall be collected by the contractor during survey. To meet the overall requirement of the transmission line(s), the contractor may offer more than one design without any additional cost to Employer, in case single design is not meeting the requirement. OPGW cable to be designed to meet transmission line sag-tension parameters and other details to be provided by Transmission Line contractor. Any other details, as required for cable design etc. shall be collected by the Contractor during survey.
1.2.1 Optical Fibre Cable Link Lengths

The estimated optical fibre link lengths are provided in Appendices as transmission line route length. However, the Contractor shall supply the OPGW cable as required based on the tower schedule. The Contractor shall verify the transmission line route length during the survey and the Contract price shall be adjusted accordingly.

For the purpose of payment, the optical fibre link lengths are defined as transmission line route lengths from Gantry at one terminating station to the Gantry in the other terminating station. The actual cable lengths to be delivered shall take into account various factors such as sag, service loops, splicing, working lengths & wastage etc., and no additional payment shall be payable in this regard. The unit rate for FO cable quoted in the Bid price Schedules shall take into account all such factors.

1.2.2 Optical Fibre Identification

All optical fibres shall be individually coated. Individual optical fibres within a fibre unit and fibre units shall be identifiable in accordance with EIA/TIA 598 or IEC 60304 or Bellcore GR-20 colour-coding scheme.

Colouring utilized for colour coding optical fibres shall be integrated into the fibre coating and shall be homogenous. The colour shall not bleed from one fibre to another and shall not fade during fibre preparation for termination or splicing.

Each cable shall have traceability of each fibre back to the original fibre manufacturer's fibre number and parameters of the fibre. If more than the specified number of fibres is included in any cable, the spare fibres shall be tested by the cable manufacturer and any defective fibres shall be suitably bundled, tagged and identified at the factory by the vendor.

1.2.3 Buffer Tube

Loose tube construction shall be implemented. The individually coated optical fibre(s) shall be surrounded by a buffer for protection from physical damage during fabrication, installation and operation of the cable. The fibre coating and buffer shall be strippable for splicing and termination. Each fibre unit shall be individually identifiable utilizing colour coding. Buffer tubes shall be filled with a water-blocking gel.

1.2.4 Optical Fibre Strain & Sag-Tension chart

The OPGW cable shall be designed and installed such that the optical fibres experience no strain under all loading conditions of transmission lines. Zero fibre strain condition shall apply even after a 25 year cable creep.

For the purpose of this specification, the following definitions shall apply:

- **Maximum Working Tension (MWT)** is defined as the maximum cable tension at which there is no fibre strain.
- The **no fibre strain** condition is defined as fibre strain of less than or equal to 0.05%, as determined by direct measurements through IEC/ETSI (FOTP) specified optical reflectometry.
- The **Cable strain margin** is defined as the maximum cable strain at which there is no fibre strain.
• The cable **Maximum Allowable Tension (MAT)** is defined as the maximum tension experienced by the Cable under the worst case loading condition.

• The cable **max strain** is defined as the maximum strain experienced by the Cable under the worst case loading condition.

• The cable **Every Day Tension (EDT)** is defined as the maximum cable tension on any span under normal conditions.

• The **Ultimate /Rated Tensile Strength (UTS/ RTS/ breaking strength)** is defined as the maximum tensile load applied and held constant for one minute at which the specimen shall not break.

While preparing the Sag-tension charts for the OPGW cable the following conditions shall be met:

• The Max Allowable Tension (MAT) / max strain shall be less than or equal to the MWT/ Strain margin of the cable.

• The sag shall not exceed the earth wire sag in all conditions.

• The Max Allowable Tension shall also be less than or equal to 0.4 times the UTS.

• The 25 year creep at 25% of UTS (creep test as per IEEE 1138) shall be such that the 25 year creep plus the cable strain at Max Allowable Tension (MAT) is less than or equal to the cable strain margin.

• The everyday tension (EDT) shall not exceed 20% of the UTS for the OPGW cable.

The Sag-tension chart of OPGW cable indicating the maximum tension, cable strain and sag shall be calculated and submitted along with the bid under various conditions as per tower design of the transmission line.

The size of OPGW shall be selected such that max. tension and sag at specified temperature and wind condition remains within the limits of transmission line tower design.

### 1.2.5 Cable Materials

The materials used for optical fibre cable construction, shall meet the following requirements:

#### 1.2.5.1 Filling Materials

The interstices of the fibre optic unit and cable shall be filled with a suitable compound to prohibit any moisture ingress or any water longitudinal migration within the fibre optic unit or along the fibre optic cable. The water tightness of the cable shall meet or exceed the test performance criteria as per IEC 60794-1-F-5.

The filling compound used shall be a non-toxic homogenous waterproofing compound that is free of dirt and foreign matter, non-hygroscopic, electrically nonconductive and non-nutritive to fungus. The compound shall also be fully compatible with all cable components it may come in contact with and shall inhibit the generation of hydrogen within the cable.

The waterproofing filling materials shall not affect fibre coating, colour coding, or encapsulant commonly used in splice enclosures, shall be dermatologically safe, non-staining and easily removable with a non-toxic cleaning solvent.

#### 1.2.5.2 Metallic Members

When the fibre optic cable design incorporates metallic elements in its construction, all metallic elements shall be electrically continuous.
1.2.6 Marking, Packaging and Shipping

This section describes the requirements for marking, packaging and shipping the overhead fibre optic cable.

(a) Drum Markings: Each side of every reel of cable shall be permanently marked in white lettering with the vendors' address, the Purchaser’s destination address, cable part number and specification as to the type of cable, length, number of fibres, a unique drum number including the name of the transmission line & segment no., factory inspection stamp and date.

(b) Cable Drums: All optical fibre cabling shall be supplied on strong drums provided with lagging of adequate strength, constructed to protect the cabling against all damage and displacement during transit, storage and subsequent handling during installation. Both ends of the cable shall be sealed as to prevent the escape of filling compounds and dust & moisture ingress during shipment and handling. Spare cable caps shall be provided with each drum as required.

The spare cable shall be supplied on sturdy, corrosion resistant, steel drums suitable for long periods of storage and re-transport & handling.

There shall be no factory splices allowed within a continuous length of cable. Only one continuous cable length shall be provided on each drum. The lengths of cable to be supplied on each drum shall be determined by a "schedule" prepared by the Contractor and approved by the owner.

1.3. Optical Ground Wire (OPGW)

OPGW cable construction shall comply with IEEE-1138, 2009. The cable provided shall meet both the construction and performance requirements such that the ground wire function, the optical fibre integrity and optical transmission characteristics are suitable for the intended purpose. The cable shall consist of optical fibre units as defined in this specification. There shall be no factory splices within the cable structure of a continuous cable length.

The composite fibre optic overhead ground wire shall be made up of multiple buffer tubes embedded in a water tight aluminium/aluminium alloy protective central fibre optic unit surrounded by concentric-lay stranded metallic wires in single or multiple layers. Each buffer tube shall have maximum 12 no. of fibres. All fibres in single buffer tube or directly in central fibre optic unit is not acceptable. The dual purpose of the composite cable is to provide the electrical and physical characteristics of conventional overhead ground wire while providing the optical transmission properties of optical fibre.

1.3.1 Central Fibre Optic Unit

The central fibre optic unit shall be designed to house and protect multiple buffered optical fibre units from damage due to forces such as crushing, bending, twisting, tensile stress and moisture. The central fibre optic unit and the outer stranded metallic conductors shall serve together as an integral unit to protect the optical fibres from degradation due to vibration and galloping, wind and ice loadings, wide temperature variations, lightning and fault current, as well as environmental effects which may produce hydrogen.

The OPGW design of dissimilar materials for stranded wires and tubes are not allowed. Central fibre optic unit may be of aluminium / aluminium alloy tube. There shall be no exposed areas of tubing that can make electrical contact either directly or indirectly through moisture, contamination, protrusions, etc with the surrounding stranded wires. The tube may be fabricated as a seamless tube, seam welded, or a tube without a welded seam.
1.3.2 Basic Construction

The OPGW cable construction shall conform to the applicable requirements of this specification, applicable clauses of IEC 61089 related to stranded conductors and Table 1.2(a) OPGW Mechanical and Electrical Characteristics. In addition, the basic construction shall include bare concentric-lay-stranded metallic wires with the outer layer having left hand lay. The wires may be of multiple layers with a combination of various metallic wires within each layer. The direction of lay for each successive layer shall be reversed. The finished wires shall contain no joints or splices unless otherwise agreed to by the Employer and shall conform to all applicable clauses of IEC 61089 as they pertain to stranded conductors.

The wires shall be so stranded that when the complete OPGW is cut, the individual wires can be readily regrouped and then held in place by one hand.

1.3.3 Breaking Strength

The rated breaking strength of the completed OPGW shall be taken as no more than 90 percent of the sum of the rated breaking strengths of the individual wires, calculated from their nominal diameter and the specified minimum tensile strength.

The rated breaking strength shall not include the strength of the optical unit. The fibre optic unit shall not be considered a load bearing tension member when determining the total rated breaking strength of the composite conductor.

1.3.4 Electrical and Mechanical Requirements

Table 1-2(a) provides OPGW Electrical and Mechanical Requirements for the minimum performance characteristics. Additionally, the OPGW mechanical & electrical characteristics shall be similar to that of the earthwire being replaced such that there is no or minimal consequential increase in stresses on towers. OPGW installation sag & tension charts shall be as per transmission line requirement. For the OPGW cable design selection and preparation of sag tension charts, the limits specified in this section shall also be satisfied. The Bidder shall submit sag-tension charts for the above cases with their bids.

<table>
<thead>
<tr>
<th></th>
<th>Everyday Tension</th>
<th>≤ 20% of UTS of OPGW</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1)</td>
<td>D.C. Resistance at 20°C:</td>
<td>&lt; 1.0 ohm/Km or Employer provided values</td>
</tr>
<tr>
<td>(2)</td>
<td>Short Circuit Current</td>
<td>≥ 6.32 kA for 1.0 second or Employer provided values</td>
</tr>
</tbody>
</table>

Bidder may offer separate design for each short circuit rating however OPGW design with higher short circuit level shall be acceptable.

1.3.5 Operating conditions

Since OPGW shall be located at the top of the transmission line support structure, it will be subjected to Aeolian vibration, Galloping and Lightning strikes. It will also carry ground fault currents. Therefore, its electrical and mechanical properties shall be same or similar as those required of conventional ground conductors.
1.4 Installation Hardware

The scope of supply includes all required fittings and hardware such as Tension assembly, Suspension assembly, Vibration dampers, Reinforcing rods, Earthing clamps, Downlead clamps, splice enclosure etc. The Bidder shall provide documentation justifying the adequacy and suitability of the hardware supplied. The quantity of hardware & fittings to meet any eventuality during site installation minimum@ 1% shall also be provided as part of set/km for each transmission line without any additional cost to Employer.

The OPGW hardware fittings and accessories shall follow the general requirements regarding design, materials, dimensions & tolerances, protection against corrosion and markings as specified in clause 4.0 of EN 61284: 1997 (IEC 61284). The shear strength of all bolts shall be at least 1.5 times the maximum installation torque. The OPGW hardware & accessories drawing & Data Requirement Sheets (DRS) document shall consist of three parts: (1) A technical particulars sheet (2) An assembly drawing i.e. level 1 drawing and (3) Component level drawings i.e. level 2 & lower drawings. All component reference numbers, dimensions and tolerances, bolt tightening torques & shear strength and ratings such as UTS, slip strength etc shall be marked on the drawings.

The fittings and accessories described herein are indicative of installation hardware typically used for OPGW installations and shall not necessarily be limited to the following:

(a) **Suspension Assemblies**: Preformed armour grip suspension clamps and aluminium alloy armour rods/reinforcing rods shall be used. The suspension clamps shall be designed to carry a vertical load of not less than 25 KN. The suspension clamps slippage shall occur between 12kN and 17 kN as measured.

The Contractor shall supply all the components of the suspension assembly including shackles, bolts, nuts, washers, split pins, etc. The total drop of the suspension assembly shall not exceed 150 mm (measured from the centre point of attachment to the centre point of the OPGW). The design of the assembly shall be such that the direction of run of the OPGW shall be the same as that of the conductor.

(b) **Dead End Clamp Assemblies**: All dead end clamp assemblies shall preferably be of performed armoured grip type and shall include all necessary hardware for attaching the assembly to the tower strain plates. Dead end clamps shall allow the OPGW to pass through continuously without cable cutting. The slip strength shall be rated not less than 95% of the rated tensile strength of the OPGW.

(c) **Clamp Assembly Earthing Wire**: Earthing wire consisting of a 1500 mm length of aluminium or aluminium alloy conductor equivalent in size to the OPGW shall be used to earth suspension and dead end clamp assemblies to the tower structure. The earthing wire shall be permanently fitted with lugs at each end. The lugs shall be attached to the clamp assembly at one end and the tower structure at the other.

(d) **Structure Attachment Clamp Assemblies**: Clamp assemblies used to attach the OPGW to the structures, shall have two parallel grooves for the OPGW, one on either side of the connecting bolt. The clamps shall be such that clamping characteristics do not alter adversely when only one OPGW is installed. The tower attachment plates shall locate the OPGW on the inside of the tower and shall be attached directly to the tower legs/cross-members without drilling or any other structural modifications.

(e) **Vibration Dampers**: Vibration dampers type 4R Stockbridge or equivalent, having four (4)
different frequencies spread within the Aeolian frequency bandwidth corresponding to wind speed of 1 m/s to 7 m/s, shall be used for suspension and tension points in each span. The Contractor shall determine the exact numbers and placement(s) of vibration dampers through a detailed vibration analysis as specified in technical specifications.

One damper minimum on each side per OPGW cable for suspension points and two dampers minimum on each side per OPGW cable for tension points shall be used for nominal design span of 400 meters. For all other ruling spans, the number of vibration damper shall be based on vibration analysis.

The clamp of the vibration damper shall be made of high strength aluminum 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 OPGW cable without damaging the strands or causing premature fatigue failure of the OPGW cable under the clamp. The clamp groove shall be in uniform contact with the OPGW cable 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 OPGW cable 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.

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.

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.

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.

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 OPGW cable shall not cause excessive stress concentration on the OPGW cable leading to permanent deformation of the OPGW strands and premature fatigue failure in operation.

The vibration analysis of the system, with and without damper and dynamic characteristics of the damper as detailed in Technical Specification, shall have to be submitted. The technical particulars for vibration analysis and damping design of the system are as follows:
### Sl. No. | Description | Technical Particulars
---|---|---
1 | Span Length in meters | 400 meters |
   | (i) Ruling design span: | 400 meters |
   | (ii) Maximum span: | 1100 meters |
   | (iii) Minimum Span: | 100 meters |
2 | Configuration: | As per Specifications |
3 | Tensile load in each: | As per sag tension calculations |
4 | Armour rods used: | Standard preformed armour rods/AGS |
5 | Maximum permissible dynamic strain: | +/- 150 micro strains |

The damper placement chart for spans ranging from 100m to 1100m shall be submitted by the Contractor. Placement charts should be duly supported with relevant technical documents and sample calculations.

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 OPGW cable 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

#### 1.5 Fibre Optic Splice Enclosures (Joint Box)

All splices shall be encased in Fibre Optic Splice Enclosures. Suitable splice enclosures shall be provided to encase the optical cable splices in protective, moisture and dust free environment. Splice enclosures shall comply with ingress protection class IP 66 or better. The splice enclosures shall be designed for the storage and protection of required number of optical fibre splices and equipped with sufficient number of splice trays for splicing all fibres in the cable. No more than 12 fibres shall be terminated in a single splice tray. They shall be filled with suitable encapsulate that is easily removable should re-entry be required into the enclosures.

Splice enclosures shall be suitable for outdoor use with each of the cable types provided under this contract. Splice enclosures shall be appropriate for mounting on transmission line towers above anti-climb guard levels at about 10 metres from top of the tower and shall accommodate pass-through splicing. The actual mounting height and location shall be finalised after Survey. Contractor shall be responsible for splicing of fibres and installation of splice enclosures.

#### 1.5.1 Optical Fibre Splices
Splicing of the optical fibre cabling shall be minimized through careful Contractor planning. There shall be no mid-span splices allowed. All required splices shall be planned to occur on tower structures. All optical fibre splicing shall comply with the following:

(a) All fibre splices shall be accomplished through fusion splicing.

(b) Each fibre splice shall be fitted with a splice protection sheath fitted over the final splice.

(c) All splices and bare fibre shall be neatly installed in covered splice trays.

(d) For each link, bi-directional attenuation of single mode fusion splices, shall not average more than 0.05 dB and no single splice loss shall exceed 0.1 dB when measured at 1550 nm.

(e) For splicing, fibre optic cable service loops of adequate length shall be provided so that all splices occurring at tower structures can be performed at ground level.

1.6 Fibre Optic Approach Cables

For purposes of this specification, a fibre optic approach cable is defined as the Armoured underground fibre optic cable required to connect Overhead Fibre Optic Cable (OPGW) between the final in line splice enclosure on the gantry / tower forming the termination of the fibre cable on the power line and the Fibre Optic Distribution Panel (FODP) installed within the building. The estimated fibre optic approach cabling length requirements are indicated in the appendices. However, the Contractor shall supply & install the optical fibre approach cable as required based on detailed site survey to be carried out by the Contractor during the project execution and the Contract price shall be adjusted accordingly.

1.6.1 Basic Construction

The cable shall be suitable for direct burial, laying in trenches & PVC/Hume ducts, laying under false flooring and on indoor or outdoor cable raceways.

1.6.2 Jacket Construction & Material

The Approach Cable shall be a UV resistant, rodent proof, armoured cable with metallic type of armouring. The outer cable jacket for approach cable shall consist of carbon black polyethylene resin to prevent damage from exposure to ultra-violet light, weathering and high levels of pollution. The jacket shall conform to ASTM D1248 for density.

1.6.3 Optical, Electrical and Mechanical Requirements

Approach cable shall contain fibres with identical optical/ physical characteristics as those in the OPGW cables. The cable core shall comprise of tensile strength member(s), fibre support/bedding structure, core wrap/bedding, and an overall impervious jacket.

1.7 Fibre Optic Distribution Panel

Fibre Optic Distribution Panels is required for each location for termination of fibres in a manner consistent with the following:

(a) FODPs shall be suitable for use with each of the cable types provided as part of this contract. FODPs shall accommodate pass-through splicing and fibre terminations.
(b) FODPs for indoor use shall be supplied in suitable cabinets/racks with locking arrangement

(c) All FODPs shall be of corrosion resistant, robust construction and shall allow both top or bottom entry for access to the splice trays. Ground lugs shall be provided on all FODPs and the Contractor shall ensure that all FODPs are properly grounded. The FODP shall meet or exceed ingress protection class IP55 specifications.

1.7.1 Optical Fibre Connectors

Optical fibres shall be connectorised with FC-PC type connectors preferably. Alternatively connector with matching patch cord shall also be acceptable. Fibre optic couplings supplied with FODPs shall be appropriate for the fibre connectors to be supported. There shall be no adapters.

1.8 Service Loops

For purposes of this specification, cable and fibre service loops are defined as slack (extra) cable and fibre provided for facilitating the installation, maintenance and repair of the optical fibre cable plant.

(a) **Outdoor Cable Service Loops:** In-line splice enclosures installed outdoors and mounted on the utility towers shall be installed with sufficient fibre optic cable service loops such that the recommended minimum bend radius is maintained while allowing for installation or maintenance of the cable to be performed in a controlled environment at ground level.

(b) **Indoor Cable Service Loops:** FODPs shall provide at least three (3) metres of cable service loop. Service loops shall be neatly secured and stored, coiled such that the minimum recommended bend radius' are maintained.

(c) **Fibre Units Service Loops:** For all fibre optic cable splicing, the cable shall be stripped back a sufficient length such that the fan-out of fibre units shall provide for at least one (1) metre of fibre unit service loop between the stripped cable and the bare fibre fan-out.

(d) **Pigtail Service Loops:** Connectorised pigtails spliced to bare fibres shall provide at least 1 metre of service loop installed in the FODP fibre organizer and at least one (1) metre of service loop to the couplings neatly stored behind the FODP coupling panels.

(e) **Fibre Service Loops:** At least 0.5 metre of bare fibre service loop shall be provided on each side of all fibre splices. The bare fibre service loops shall be neatly and safely installed inside covered splice trays.

1.9 Test Equipment

The table 1.3 below provides mandatory test equipment requirements, to be provided as applicable as per BoQ. The parameters / features of the mandatory equipments are enumerated as follows:

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Test Equipment</th>
<th>Parameter</th>
</tr>
</thead>
<tbody>
<tr>
<td>A.</td>
<td>Test Equipments for OPGW cable</td>
<td>Equivalent to Anritsu MW9076B1 or better.</td>
</tr>
<tr>
<td>1</td>
<td>OTDR (Optical Time Domain Reflectometer) for 1310/1550 nm with laser source.</td>
<td></td>
</tr>
</tbody>
</table>
In case the offered make/model of test equipment has multiple options for the parameters, the option of higher range shall be acceptable. The supplied test equipment shall be suitable for use in the high EMI/EMC environment. The Contractor shall submit performance certificate for offered test equipment from at least one customer. The Contractor shall offer only reputed make test equipment such as Acterna (JDSU)/Anritsu/Sumitomo/Agilent/EXFO etc.

### 2.0 Applicable Standards

The following standards and codes shall be generally applicable to the equipment and works supplied for OPGW and associated items:

1. **American Society for Testing and Materials ASTM**
   
   **ASTM-B415**  
   Standard Specification for Hard-Drawn Aluminium-Clad Steel Wire

2. **Bell Communication Research**
   
   **GR-20**  
   Generic requirements for optical fibre and optical fibre cable

3. **ITU-T/CCITT Recommendations**
   
   **G.650**  
   Definitions and test methods for the relevant parameters of single-mode fibres

   **G.652**  
   Characteristics of a single-mode optical fibre cable

4. **IEEE**
   
   **IEEE-1138**  
   IEEE Standard Construction of Composite Fibre Optic Ground Wire (OPGW) for Use on Electric Utility power Lines

5. **Telecommunication Industry Association EIA/TIA**
   
   **EIA/TIA-455-3**  
   Procedure to Measure Temperature Cycling Effects on Optical

<p>| | |</p>
<table>
<thead>
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<th></th>
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</thead>
<tbody>
<tr>
<td>2</td>
<td>Optical Attenuators (variable 1310/1550nm). Equivalent to JDSU OLA55 or better.</td>
</tr>
<tr>
<td>3</td>
<td>Optical Power meter (1310/1550nm) Equivalent to JDSU OLP55 or better.</td>
</tr>
<tr>
<td>4</td>
<td>Optical Talk set Equivalent to JDSU OTS55 or better.</td>
</tr>
<tr>
<td>5</td>
<td>Optical Fibre Fusion Splicer incl. Fibre cleaver Equivalent to Sumitomo T-39-SE or better.</td>
</tr>
<tr>
<td>6</td>
<td>Calibrated Fibre</td>
</tr>
<tr>
<td>7</td>
<td>Connectorization kit FIS – FI-0053-FC-INST or equivalent</td>
</tr>
<tr>
<td>8</td>
<td>Splice kit FIS – FI-0053-FF or equivalent</td>
</tr>
<tr>
<td>9</td>
<td>Optical test accessory kit including all necessary connectors, adaptors, cables, terminations and other items required for testing FIS – FI-0053-TS-ST or equivalent</td>
</tr>
</tbody>
</table>
Fibres, Optical Cable, and Other Passive Fiber Optic Components

Salt Spray (Corrosion) Test for Fibre Optic Components

Measurement of Change in Optical Transmittance

Repeated Impact Testing of Fibre Optic Cables and Cable Assemblies

Fibre Optic Circuit Discontinuities

Fibre Optic Cable Tensile Loading and Bending Test

Compressive Loading Resistance of Fibre Optic Cables

Measurement of Fibre Point Defects Using an OTDR

Measurement of Optical Fibre Macrobend Attenuation

Spectral Attenuation Cutback Measurement for Single-Mode Optical Fibres

Measurement of Cut-Off Wavelength of Single-Mode Fibre by Transmitted Power

Compound Flow (Drip) Test for Filled Fibre Optic Cable

Fluid Penetration Test for Fluid-Blocked Fibre optic Cable

Fibre Optic Cable Twist-Bend Test

Single-Mode Fibre, Measurement of Mode Field Diameter by Far-Field Scanning

Mode Field Diameter Measurement, Variable Aperture Method in the Far-Field

Chromatic Dispersion Measurement of Multimode Graded Index and Single-Mode Optical Fibres by Spectral Group Delay Measurement in the Time Domain

Chromatic Dispersion Measurement of Single-Mode Optical Fibres by the Phase-Shift Method

Cable Cut-off Wavelength of Single-Mode Fibre by Transmitted Power

Mode Field Diameter Measurement

Chromatic Dispersion Measurement of Single-Mode Optical Fibres by the Differential Phase-Shift Method

Method of Measuring Optical Fibre Cross-Sectional Geometry by Automated Grey-Scale Analysis

Optical Fibre Cable Colour Coding

(6) International Electrotechnical Commission IEC standards

IEC-60793-1 series Optical fibres – Generic & product specifications, measurement methods & test procedures specification

IEC-60794-1-1 Optical fibre cables – Generic specification

IEC-60794-1-2 Optical fibre cables – Basic optical cable test procedure

IEC-60794-3 Optical fibre cables – Duct, buried and aerial cables – sectional specification

IEC-60794-4 Optical fibre cables – Overhead cables

IEC-61089 Round wire concentric lay overhead electrical stranded conductors

IEC-61232 Aluminium-clad steel wires for electrical purposes

IEC-61284 Overhead lines-Requirements and tests for fittings

IEC-61395 Overhead electrical conductors – Creep test procedures for stranded conductors

Specifications and codes shall be the latest version, inclusive of revisions, which are in force at the
date of the contract award. Where new specifications, codes, and revisions are issued during the period of the contract, the Contractor shall attempt to comply with such, provided that no additional expenses are charged to the Employer without Employer’s written consent.

In the event the Contractor offers to supply material and/or equipment in compliance to any standard other than Standards listed herein, the Contractor shall include with their proposal, full salient characteristics of the new standard for comparison.

In case values indicated for certain parameters in the specifications are more stringent than those specified by the standards, the specification shall override the standards.

I.10 References

(1) CIGRE Guide for Planning of Power Utility Digital Communications Networks
(2) CIGRE Optical Fibre Planning Guide for Power Utilities
(3) CIGRE New Opportunities for Optical Fibre Technology in Electricity Utilities
(4) CIGRE guide to fittings for Optical Cables on Transmission Lines

End of this Section
Chapter - 02
Inspection & Testing Requirement

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All materials furnished and all work performed under this Contract shall be inspected and tested. Deliverables shall not be shipped until all required inspections and tests have been completed, and all deficiencies have been corrected to comply with this Specification and approved for shipment by the Employer.

Except where otherwise specified, the Contractor shall provide all manpower and materials for tests, including testing facilities, logistics, power and instrumentation, and replacement of damaged parts. The costs shall be borne by the Contractor and shall be deemed to be included in the contract price.

The entire cost of testing for factory, production tests and other test during manufacture specified herein shall be treated as included in the quoted unit price of materials, except for the expenses of Inspector/Employer’s representative.

Acceptance or waiver of tests shall not relieve the Contractor from the responsibility to furnish material in accordance with the specifications.

All tests shall be witnessed by the Employer and/or its authorized representative (hereinafter referred to as the Employer) unless the Employer authorizes testing to proceed without witness. The Employer representative shall sign the test form indicating approval of successful tests.

Should any inspections or tests indicate that specific item does not meet Specification requirements, the appropriate items shall be replaced, upgraded, or added by the Contractor as necessary to correct the noted deficiencies at no cost to the Employer. After correction of a deficiency, all necessary retests shall be performed to verify the effectiveness of the corrective action.

The Employer reserves the right to require the Contractor to perform, at the Employer's expense, any other reasonable test(s) at the Contractor's premises, on site, or elsewhere in addition to the specified Type, Acceptance, Routine, or Manufacturing tests to assure the Employer of specification compliance.

2.1 Testing Requirements

Following are the requirements of testing:

1. Type Testing
2. Factory Acceptance Testing
3. Site Acceptance Testing

2.3.1 Type Testing

"Type Tests" shall be defined as those tests which are to be carried out to prove the design, process of manufacture and general conformity of the materials to this Specification. Type Testing shall comply with the following:
(a) All cable & equipment being supplied shall conform to type tests as per technical specification.

(b) The test reports submitted shall be of the tests conducted within last seven (7) years for OPGW cable prior to the date of proposal/offer submitted. In case the test reports are older than seven (7) years for OPGW cable on the date of proposal/offer, the Contractor shall repeat these tests at no extra cost to the Employer.

(c) The Contractor shall submit, within 30 days of Contract Award, copies of test reports for all of the Type Tests that are specified in the specifications and that have previously (before Contract award) been performed. These reports may be accepted by the Employer only if they apply to materials and equipment that are essentially identical to those due to be delivered under the Contract and only if test procedures and parameter values are identical to those specified in this specifications carried out at accredited labs and witnessed by third party / customer’s representatives.

In the event of any discrepancy in the test reports or any type tests not carried out, same shall be carried out by Contractor without any additional cost implication to the Employer.

In case the Type Test is required to be carried out, then following shall be applicable:-

(d) Type Tests shall be certified or performed by reputed laboratories using material and equipment data sheets and test procedures that have been approved by the Employer. The test procedures shall be formatted as defined in the technical specifications and shall include a complete list of the applicable reference standards and submitted for Employer approval at least four (4) weeks before commencement of test(s). The Contractor shall provide the Employer at least 30 days written notice of the planned commencement of each type test.

(e) The Contractor shall provide a detailed schedule for performing all specified type tests. These tests shall be performed in the presence of a representative of the Employer.

(f) The Contractor shall ensure that all type tests can be completed within the time schedule offered in his Technical Proposal.

(g) In case of failure during any type test, the Supplier is either required to manufacture a fresh sample lot and repeat all type tests successfully or repeat that particular type test(s) at least three times successfully on the samples selected from the already manufactured lot at his own expenses. In case a fresh lot is manufactured for testing then the lot already manufactured shall be rejected.

2.1.1 Type Test Samples

The Contractor shall supply equipment/material for sample selection only after the Quality Assurance Plan has been approved by the Employer. The sample material shall be manufactured strictly in accordance with the approved Quality Assurance Plan. The Contractor shall submit for Employer approval, the type test sample selection procedure. The
selection process for conducting the type tests shall ensure that samples are selected at random. For optical fibres/ Fibre Optic cables, at least three reels/ drums of each type of fibre/cable proposed shall be offered for selection. For FO cable installation hardware & fittings at least ten (10) samples shall be offered for selection. For Splice enclosures at least three samples shall be offered for selection.

2.1.2 List of Type Tests

The type testing shall be conducted on the following items

(a) Optical fibres
(b) OPGW Cable
(c) OPGW Cable fittings
(d) Vibration Damper
(e) Splice Enclosure (Joint Box)
(f) Approach Cable

2.1.2.1 Type Tests for Optical Fibres

The type tests listed below in table 2-1 shall be conducted on DWSM fibres to be supplied as part of overhead cables. The tests specific to the cable type are listed in subsequent sections.

Table 2-1
Type Tests For Optical Fibres

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Test Name</th>
<th>Acceptance Criteria</th>
<th>Test procedure</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Attenuation</td>
<td>As per Section-01 of TS</td>
<td>IEC 60793-1-40 Or EIA/TIA 455-78A</td>
</tr>
<tr>
<td>2</td>
<td>Attenuation Variation with Wavelength</td>
<td>As per Section-01 of TS</td>
<td>IEC 60793-1-40 Or EIA/TIA 455-78A</td>
</tr>
<tr>
<td>3</td>
<td>Attenuation at Water Peak</td>
<td>As per Section-01 of TS</td>
<td>IEC 60793-1-40 Or EIA/TIA 455-78A</td>
</tr>
<tr>
<td>4</td>
<td>Temp. Cycling (Temp dependence of Attenuation)</td>
<td>As per Section-01 of TS</td>
<td>IEC 60793-1-52 Or EIA/TIA 455-3A, 2 cycles</td>
</tr>
<tr>
<td>5</td>
<td>Attenuation With Bending (Bend Performance)</td>
<td>As per Section-01 of TS</td>
<td>IEC 60793-1-47 Or EIA/TIA 455-62A</td>
</tr>
<tr>
<td>6</td>
<td>Mode Field dia.</td>
<td>As per Section-01 of TS</td>
<td>IEC 60793-1-45 Or EIA/TIA 455-164A/167A/174</td>
</tr>
<tr>
<td>7</td>
<td>Chromatic Dispersion</td>
<td>As per Section-01 of TS</td>
<td>IEC 60793-1-42 Or EIA/TIA 455-168A/169A/175A</td>
</tr>
<tr>
<td>8</td>
<td>Cladding Diameter</td>
<td>As per Section-01 of TS</td>
<td>IEC 60793-1-20 Or EIA/TIA 455-176</td>
</tr>
<tr>
<td>9</td>
<td>Point Discontinuities of attenuation</td>
<td>As per Section-01 of TS</td>
<td>IEC 60793-1-40 Or EIA/TIA 455-59</td>
</tr>
</tbody>
</table>
Table 2-1
Type Tests For Optical Fibres

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Test Name</th>
<th>Acceptance Criteria</th>
<th>Test procedure</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>Core -Clad concentricity error</td>
<td>As per Section-01 of TS</td>
<td>IEC 60793-1-20 Or EIA/TIA 455-176</td>
</tr>
<tr>
<td>11</td>
<td>Fibre Tensile Proof Testing</td>
<td>As per Section-01 of TS</td>
<td>IEC 60793-1-30 Or EIA/TIA 455-31B</td>
</tr>
</tbody>
</table>

-End Of Table-

2.1.2.2 Type Tests for OPGW Cables

The type tests to be conducted on the OPGW cable are listed in Table 2-2 Type Tests for OPGW Cables. Unless specified otherwise in the technical specifications or the referenced standards, the optical attenuation of the specimen, measured during or after the test as applicable, shall not increase by more than 0.05 dB/Km.

Table 2-2
Type tests for OPGW Cable

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Test Name</th>
<th>Test Description</th>
<th>Test Procedure</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Water Ingress Test</td>
<td>IEEE 1138-2009</td>
<td>IEEE 1138-2009 (IEC 60794-1-2 Method F5 or EIA/TIA 455-82B) Test duration: 24 hours</td>
</tr>
<tr>
<td>3</td>
<td>Short Circuit Test</td>
<td>IEEE 1138-2009</td>
<td>IEEE 1138-2009 Fibre attenuation shall be continuously monitored and recorded through a digital data logging system or equivalent means. A suitable temperature sensor such as thermocouple shall be used to monitor and record the temperature inside the OPGW tube in addition to monitoring &amp; recording the temperatures between the strands and between optical tube and the strand as required by IEEE 1138. Test shall be conducted with the tension clamps proposed to be supplied. The cable and the clamps shall be visually inspected for mechanical damage and photographed after the test.</td>
</tr>
</tbody>
</table>
### Table 2-2
Type tests for OPGW Cable

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Test Name</th>
<th>Test Description</th>
<th>Test Procedure</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Or IEC60794-4-10 / IEC 60794-1-2 (2003) Method H1</td>
<td>Initial temperature during the test shall be greater than or equal to ambient field temperature.</td>
</tr>
<tr>
<td>4</td>
<td>Aeolian Vibration Test</td>
<td>IEEE 1138-2009</td>
<td>IEEE 1138-2009 Fibre attenuation shall be continuously monitored and recorded through a digital data logging system or equivalent means. The vibration frequency and amplitude shall be monitored and recorded continuously. All fibres of the test cable sample shall be spliced together in serial for attenuation monitoring. Test shall be conducted with the tension/suspension clamps proposed to be supplied. The cable and the clamps shall be visually inspected for mechanical damage and photographed after the test.</td>
</tr>
<tr>
<td>5</td>
<td>Galloping test</td>
<td>IEEE 1138-2009</td>
<td>IEEE 1138-2009 Test shall be conducted with the tension/suspension clamps proposed to be supplied. The cable and clamps shall be visually inspected for mechanical damage and photographed after the test. All fibres of the test cable sample shall be spliced together in serial for attenuation monitoring.</td>
</tr>
<tr>
<td>6</td>
<td>Cable Bend Test</td>
<td>Procedure 2 in IEC 60794-1-2 Method E11</td>
<td>The short-term and long-term bend tests shall be conducted in accordance with Procedure 2 in IEC 60794-1-2 E11 to determine the minimum acceptable radius of bending without any increase in attenuation or any other damage to the fibre optic cable core such as bird caging, deformation, kinking and crimping.</td>
</tr>
<tr>
<td>7</td>
<td>Sheave Test</td>
<td>IEEE 1138-2009</td>
<td>IEEE 1138-2009 Fibre attenuation shall be continuously monitored and recorded through a digital</td>
</tr>
<tr>
<td>S. No.</td>
<td>Test Name</td>
<td>Test Description</td>
<td>Test Procedure</td>
</tr>
<tr>
<td>-------</td>
<td>-------------</td>
<td>---------------------------------------</td>
<td>-----------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td></td>
<td></td>
<td>OR</td>
<td>data logging system or equivalent means. The Sheave dia. shall be based on the pulling angle and the minimum pulley dia employed during installation. All fibres of the test cable sample shall be spliced together in serial for attenuation monitoring.</td>
</tr>
<tr>
<td>8</td>
<td>Crush Test</td>
<td>IEEE 1138-2009 (IEC 60794-1-2, Method E3/ EIA/TIA 455-41B)</td>
<td>The crush test shall be carried out on a sample of approximately one (1) metre long in accordance with IEC 60794-1-2 E3. A load equal to 1.3 times the weight of a 400-metre length of fibre optic cable shall be applied for a period of 10 minutes. A permanent or temporarily increase in optical attenuation value greater than 0.1 dB change in sample shall constitute failure. The load shall be further increased in small increments until the measured attenuation of the optical waveguide fibres increases and the failure load recorded along with results.</td>
</tr>
<tr>
<td>9</td>
<td>Impact Test</td>
<td>IEEE 1138-2009 (IEC 60794-1-2, Method E4/ EIA/TIA 455-25B)</td>
<td>The impact test shall be carried out in accordance with IEC 60794-1-2 E4. Five separate impacts of 0.1-0.3kgm shall be applied. The radius of the intermediate piece shall be the reel drum radius ± 10%. A permanent or temporary increase in optical attenuation value greater than 0.1 dB/km change in sample shall constitute failure.</td>
</tr>
<tr>
<td>10</td>
<td>Creep Test</td>
<td>IEEE 1138-2009</td>
<td>As per Aluminium Association Method, the best-fit straight line shall be fitted to the recorded creep data and shall be extrapolated to 25 years. The strain margin of the cable at the end of 25 years shall be calculated. The time when...</td>
</tr>
</tbody>
</table>
### Table 2-2
Type tests for OPGW Cable

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Test Name</th>
<th>Test Description</th>
<th>Test Procedure</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>the creep shall achieve the strain margin limits shall also be calculated.</td>
</tr>
<tr>
<td>12</td>
<td>Strain Margin Test</td>
<td>IEEE 1138-2009</td>
<td>IEEE 1138-2009</td>
</tr>
<tr>
<td>13</td>
<td>Stress strain Test</td>
<td>IEEE 1138-2009</td>
<td>IEEE 1138-2009</td>
</tr>
<tr>
<td>15</td>
<td>Temperature Cycling Test</td>
<td>IEEE 1138-2009</td>
<td>IEEE 1138-2009 Or IEC 60794-1-2, Method F1</td>
</tr>
<tr>
<td>16</td>
<td>Corrosion (Salt Spray) Test</td>
<td>EIA/TIA 455-16A</td>
<td></td>
</tr>
<tr>
<td>17</td>
<td>Tensile Performance Test</td>
<td>IEC 60794-1-2 E1 / EIA/TIA 455-33B</td>
<td>The test shall be conducted on a sample of sufficient length in accordance with IEC 60794-1-2 E1. The attenuation variation shall not exceed 0.05 dB/Km up to 90% of RTS of fibre optic cable. The load shall be increased at a steady rate up to rated tensile strength and held for one (1) minute. The fibre optic cable sample shall not fail during the period. The applied load shall then be increased until the failing load is reached and the value recorded.</td>
</tr>
<tr>
<td>18</td>
<td>Lightning Test</td>
<td>IEC 60794-4-10 / IEC 60794-1-2 (2003)</td>
<td>The OPGW cable construction shall be tested in accordance with IEC 60794-1-2, Method H2 for Class 1.</td>
</tr>
<tr>
<td>19</td>
<td>DC Resistance Test</td>
<td>IEC 60228</td>
<td>On a fibre optic cable sample of minimum 1 metre 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 zero metre and subsequently one metre apart.</td>
</tr>
</tbody>
</table>
### Table 2-2
**Type tests for OPGW Cable**

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Test Name</th>
<th>Test Description</th>
<th>Test Procedure</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>The tests shall be repeated at least five times and the average value recorded after correcting at 20°C.</td>
<td>-End Of Table-</td>
</tr>
</tbody>
</table>

#### 2.1.2.3 Type Test on OPGW Cable Fittings

The type tests to be conducted on the OPGW Cable fittings and accessories are listed below:

(i) **Mechanical Strength Test for Suspension/Tension Assembly**


   **Suspension Assembly**

   The armour rods /reinforcement rods are assembled on to the approved OPGW using the Installation Instructions to check that the assembly is correctly fitted and is the same that will be carried out during installations.

   **Part 1:**

   The suspension assembly shall be increased at a constant rate up to a load equal to 50% of the specified minimum Failure Load increased and held for one minute for the test rig to stabilise. The load shall then be increased at a steady rate to 67% of the minimum Failure Load and held for five minutes. The angle between the cable, the Suspension Assembly and the horizontal shall not exceed 16°. This load shall then be removed in a controlled manner and the Protection Splice disassembled. Examination of all the components shall be made and any evidence of visual deformation shall be documented.

   **Part 2:**

   The Suspension clamp shall then be placed in the testing machine. The tensile load shall gradually be increased up to 50% of the specified Minimum Failure Load of the Suspension Assembly and held for one minute for the Test Rig to stabilise and the load shall be further increased at a steady rate until the specified minimum Failure Load 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 shall be documented.

   **Tension Assembly**

   The Tension Assembly is correctly fitted and is the same that will be carried out during installations.

   **Part 1:**

   The tension assembly (excluding tension clamp) shall be increased at a constant rate up to a load equal to 50% of the specified minimum Failure Load increased at a constant rate and held for one minute for the test rig to stabilise. The load shall then be increased at a steady rate to 67% of the minimum Failure Load and held for five minutes. This load shall then remove in a controlled manner and the Tension Assembly disassembled. Examination of the Tension Dead-End and associated components shall be made and any evidence of visual deformation shall be documented.
Part 2:
The Tension Dead-End and associated components shall then be reassembled and bolts tightened as before. The tensile load shall gradually be increased up shall gradually be increased up to 50% of the specified Minimum Failure Load of the Tension Assembly and held for one minute for the Test Rig to stabilise and the load shall be further increased at a steady rate until the specified minimum Failure Load 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 shall be documented.

Acceptance Criteria for Tension/Suspension Assembly:

- No evidence of binding of the Nuts or Deformation of components at end of Part 1 of Test.
- No evidence of Fracture at the end of one minute at the minimum failure load during Part 2 of the Test.

Any result outside these parameters shall constitute a failure.

(ii) Clamp Slip Strength Test for Suspension Assembly

The suspension assembly shall be vertically suspended by means of a flexible attachment. A suitable length fibre optical cable shall be fixed in the clamps. Once the Suspension Clamp has been assembled, the test rig is tensioned to 1 kN and the position scale on the recorder ‘zeroed’. The test rig is then tensioned to 2.5 kN and the relative positions of the Reinforcing Rods, Armour Rods and Suspension Clamp shall be marked by a suitable means to confirm any slippage after the test has been completed. The relative positions of the helical Armour Rods and associated Reinforcing Rods at each end shall be marked and also 2 mm relative position between clamp body and Armour Rods shall be marked on one side. The load shall be increased to 12 kN at a loading rate of 3 kN/min and held for one minute. At the end of this one minute period, the relative displacement between clamp body and the armour rods shall be observed. If the slippage is 2 mm or above, the test shall be terminated. Otherwise, at the end of one minute the position of the clamp body and 2 mm. relative positions between clamp body and armour rods shall be marked on the other side. After the one minute pause, the load shall be further increased at a loading rate of 3 kN/min, and recording of load and displacement shall continue until either the relative Position displacement between clamp body and armour rods reaches more than 2 mm or the load reaches the maximum slip load of 17 kN. On reaching either of the above values the test is terminated. Visual examination of all paint marks shall be recorded, and a measurement of any displacement recorded in the Table of Results.

Acceptance Criteria:
The Suspension Clamp has passed the Slip Test if the following conditions are met:

- No slippage* shall occur at or below the specified minimum slip load.

  * Definition of no slippage in accordance with IEC 61284, 1997:- Any relative movement less than 2 mm is accepted. The possible couplings or elongations produced by the cable as a result of the test itself are not regarded as slippage.

- Slippage shall occur between the specified maximum and minimum slip load of 12 - 17 kN.

- There shall be no slippage of the Reinforcing Rods over the cable, and no slippage of the Armour Rods over the Reinforcing Rods.
• The relative movement (i.e. more than 2 mm between Armour Rods & Clamp body) between minimum 12 kN and maximum slip 17 kN, shall be considered as slip.

• The Armour Rods shall not be displaced from their original lay or damaged**.

** Definition of no damage in accordance with convention expressed in IEC 61284: 1997 no damage, other than surface flattening of the strands shall occur.

Any result outside these parameters is a failure.

(iii) Slip Strength Test of Tension Clamp

Tension clamps shall be fitted on an 8 m length of fibre optic cable 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 shall gradually be applied up to 20% of the RTS of OPGW. Displacement transducers shall be installed to measure the relative movement between the OPGW relative to the Reinforcing Rods and Tension Dead -End relative to Reinforcing Rods. In addition, suitable marking shall be made on the OPGW and Dead-End to confirm grip. The load shall be gradually increased at a constant rate up to 50% of the UTS and the position scale of the recorder is zeroed. The load shall then gradually increased up to 95% of the UTS and maintained for one minute. After one minute pause, the load shall be slowly released to zero and the marking examined and measured for any relative movement.

Acceptance Criteria:

- No movement* shall occur between the OPGW and the Reinforcing Rods, or between the Reinforcing Rods and the Dead-End assembly.
- No failure or damage or disturbance to the lay of the Tension Dead-End, Reinforcing Rods or OPGW.

* Definition of no movement as defined in IEC 61284: Any relative movement less than 2 mm is accepted. The possible couplings or elongations produced by the conductor as a result of the test itself are not regarded as slippage.

Any result outside these parameters shall constitute a failure.

(iv) Grounding Clamp and Structure Mounting Clamp Fit Test

For structure mounting clamp, one series of tests shall be conducted with two fibre optic cables installed, one series of tests with one fibre optic cable installed in one groove, and one series of tests with one fibre optic cable in the other groove. Each clamp shall be installed including clamping compound as required on the fibre optic cable. The nut shall be tightened on to the bolt by using torque wrench with a torque of 5.5 kgm or supplier's recommended torque and the tightened clamp shall be held for 10 minutes. After the test remove the fibre optic cable and examine all its components for distortion, crushing or breaking. Also the fibre optic cable shall be checked to ensure free movement within the core using dial callipers to measure the diameter of the core tube. The material shall be defined as failed if any visible distortion, crushing, cracking or breaking of the core tube is observed or the fibre optic cable within the core tube is not free to move, or when the diameter of the core tube as measured at any location in the clamped area is more than 0.5 mm larger or smaller of the core diameter.
as measured outside the clamped area.

(v) **Structure Mounting Clamp Strength Test**

The clamp and mounting assembly shall be assembled on a vertical 200 mm x 200 mm angle and a short length of fibre optic cable installed. A vertical load of 200 kg shall be applied at the end of the mounting clamp and held for 5 minutes. Subsequently, the load shall be increased to 400 kg and held for 30 seconds. Any visible distortion, slipping or breaking of any component of the mounting clamp or assembly shall constitute failure.

### 2.1.2.4 Type Test on Vibration Damper

The testing standard of vibration damper for OPGW shall be as per applicable international standard i.e. IEC 61897.

(a) **Dynamic Characteristic 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 Critical Aeolian Vibration frequency band ranging from 0.18/d to 1.4/d – where d is the OPGW cable diameter in meters. The damper assembly shall be vibrated vertically with a ±1 mm amplitude from 5 to 15 Hz frequency and beyond 15 Hz at 0.5 mm 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 fibre optic cable 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:

\[ V.D. \text{ for OPGW} - 0.060 f \text{ to } 0.357 f \text{ kgf/mm}^* \]

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 fibre optic cable 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 done for single fibre optic cable without armour rods. The tension shall be taken as 25% of RTS of fibre optic cable for a span ranging from 100 m to 1100 m.

(ii) The self damping factor and flexural stiffness (EI) for fibre optic cable shall be calculated on the basis of experimental results. The details to experimental analysis with these data shall be furnished.

(iii) The power dissipation curve obtained from Damper Characteristics Test shall be used for analysis with damper.

(iv) Examine the Aeolian Vibration level of the fibre optic cable 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 fibre optic cable 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 fibre optic cable with damper(s) installed at the recommended location, the dynamic strain level at the clamped span extremities, damper attachment point and the antinodes on the fibre optic cable shall be determined. In addition to above damper clamp vibration amplitude and antinodes vibration amplitudes shall also be examined.

The dynamic strain levels at damper attachment point, clamped span extremities and antinodes shall not exceed the specified limits. The damper clamp vibration amplitude shall not be more than that of the specified fatigue limits.

(c) Fatigue Tests

(i) Test Set Up

The fatigue tests shall be conducted on a laboratory set up with a minimum effective span length of 30m. The fibre optic cable shall be tensioned at 25% of RTS of fibre optic cable 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 fibre optic cable has been tensioned, clamps shall be installed to support the fibre optic cable 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 fibre optic
Design, Supply, Installation and Commissioning of Kushma-New Butwal 220 kV Transmission Line

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 step less speed control as well as step less 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) 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 herein shall be repeated after fatigue tests 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 fibre optic cable and subjected to dynamic characteristics test. There shall not be any major deterioration in the characteristics 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 fibre optic cable under clamp shall also be free from any damage.

For purposes of acceptance, the following criteria shall be applied:

1. There shall not be any resonant frequency shift before and after the test by more than ±20%
2. The power dissipation of the damper before and after test at the individual resonant frequencies do not differ by more than ±20%

Besides above tests, the type tests listed below in the table shall also be conducted on Vibration Damper

<table>
<thead>
<tr>
<th>Sl No.</th>
<th>Test Name</th>
<th>Test Procedure</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Visual examination &amp; Dimensional and material verification</td>
<td>IEC 61897 Clause 7.1 &amp; 7.2</td>
</tr>
<tr>
<td>2</td>
<td>Clamp Slip test</td>
<td>IEC 61897 Clause 7.5</td>
</tr>
<tr>
<td>3</td>
<td>Clamp bolt tightening test</td>
<td>IEC 61897 Clause 7.7</td>
</tr>
<tr>
<td>4</td>
<td>Attachments of weights to messenger</td>
<td>IEC 61897 Clause 7.8</td>
</tr>
</tbody>
</table>
### 2.1.2.5 Type Tests for Splice Enclosures (Joint Box)

Following Type tests shall be demonstrated on the Splice Enclosure(s) (Splice Enclosure/Box). For certain tests, lengths of the fibre optic cable shall be installed in the splice box, and the fibres must be spliced and looped in order to simulate conditions of use. The attenuation of the fibres shall be measured, during certain tests, by relevant Fibre Optic Test Procedures (EIA/TIA 455 or IEC 60794-1 procedures).

(i) **Temperature Cycling Test**

FO cable is installed in the splice enclosure and optical fibres spliced and looped. The box must be subjected to 5 cycles of temperature variations of -40°C to +65°C with a dwell time of at least 2 hours on each extreme.

Fibre loop attenuation shall be measured in accordance with EIA 455-20/IEC 60794-1-C10. The variation in attenuation shall be less than ±0.05dB. The final humidity level, inside the box, shall not exceed the initial level, at the closing of the box.

(ii) **Humid Heat test**

The sealed splice enclosure, with fibres spliced and looped inside, must be subjected to a temperature of +55°C ±2°C with a relative humidity rate of between 90% and 95% for 5 days. The attenuation variation of the fibres during the duration of the test shall be less than ±0.05dB, and the internal humidity rate measured, less than 2%.

(iii) **Rain Withstand Test / Water Immersion test**

The splice enclosure with optical fibres cable installed and fibres spliced fixed, shall be subjected to 24 hours of simulated rain in accordance with IEC 60060 testing requirements. No water seepage or moisture shall be detected in the splice enclosure. The attenuation variation of the fibres after the test shall be less than ±0.05dB.

(iv) **Vibration Test**

The splice enclosure, with fibres united inside, shall be subjected to vibrations on two axes with a frequency scanning of 5 to 50 Hz. The amplitude of the vibrations shall be constant at 0.450mm, peak to peak, for 2 hours, for each of the vibrations' axes. The variation in attenuation, of the fibres, shall be less than ±0.05dB. The splice enclosure shall be examined for any defects or deformation. There shall be no loosening or visible damage of the FO cable at the entry point.

(v) **Bending and Torsion test**

The splice enclosure, with fibres spliced inside, shall be firmly held in place and be subjected to the following sequence of mechanical stresses on the cable:

<table>
<thead>
<tr>
<th>5</th>
<th>Attachment of clamps to messenger cable</th>
<th>IEC 61897 Clause 7.8</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>Damper effectiveness evaluation</td>
<td>IEC 61897 Clause 7.11.3.2</td>
</tr>
</tbody>
</table>
a) 3 torsion cycles of ±180° shall be exercised on the cable. Each cycle shall be less than one minute.

b) 3 flexure cycles of the cable, of ±180° with one cycle less than one minute.

The variation in the attenuation, of the fibres, shall be less than ±0.05dB. The cables connection ring shall remain securely fixed to the box with the connection maintained firmly. No defects/fissures shall be noted on the joint ring or on the splice enclosure

(vi) Tensile test

The splice enclosure with cable fixed to the boxes shall be subjected to a minimum tension of 448 N for a period of two minutes. No fissure shall be noted in the connections or on the box.

(vii) Drop Test

With 2 lengths of 11 metres of cable fixed to the box, it shall be dropped five times from a height of 10 metres. There shall be no fissure, at all, of the box, and the connections shall remain tight. The test surface shall be carried out in accordance with IEC 60068-2-32.

2.1.2.6 Type Tests for Fibre Optic Approach Cable

The type tests to be conducted on the Fibre Optic Approach cable are listed in Table 2-3: Type Tests for Fibre Optic Approach Cable. Unless specified otherwise in the technical specifications or the referenced standards, the optical attenuation of the specimen, measured during or after the test as applicable, shall not increase by more than 0.05 dB/Km.

<table>
<thead>
<tr>
<th>S.NO.</th>
<th>Test Name</th>
<th>Test Procedure</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Water Ingress Test</td>
<td>(IEC 60794-1-F5 / EIA 455-82B) Test duration : 24 hours</td>
</tr>
<tr>
<td>2</td>
<td>Seepage of filling compound</td>
<td>(EIA 455-81A) Preconditioning : 72 hours, Test duration : 24 hours.</td>
</tr>
<tr>
<td>3</td>
<td>Crush Test</td>
<td>(IEC 60794-1-E3/ EIA 455-41)</td>
</tr>
<tr>
<td>4</td>
<td>Impact Test</td>
<td>(IEC-60794-1-E4/ EIA 455-25A)</td>
</tr>
<tr>
<td>5</td>
<td>Stress strain Test</td>
<td>(EIA 455-33A)</td>
</tr>
<tr>
<td>6</td>
<td>Cable Cut-off wavelength Test</td>
<td>(EIA 455-170)</td>
</tr>
<tr>
<td>7</td>
<td>Temperature Cycling Test</td>
<td>(IEC60794-1-F1/EIA-455-3A) – 2 cycles</td>
</tr>
</tbody>
</table>

-End Of Table-

2.1.2.6.1 Impact Test
The Impact test shall be carried out in accordance with IEC:60794-1-E4. Five separate impacts of 2.0 kg shall be applied at different locations. The radius of the intermediate piece shall be the reel drum radius ± 10%. A permanent or temporary increase in optical attenuation value greater than 0.05 dB/km shall constitute failure.

2.2 Factory Acceptance Tests

Factory acceptance tests shall be conducted on randomly selected final assemblies of all equipment to be supplied. Factory acceptance testing shall be carried out on OPGW Cable and associated hardware & fittings, Approach Cable, Joint Box, FODP etc. and all other items for which price has been identified separately in the Bid Price Schedules.

Material shall not be shipped to the Employer until required factory tests are completed satisfactorily, all variances are resolved, full test documentation has been delivered to the Employer, and the Employer has issued Material Inspection & Clearance Certificate (MICC). Successful completion of the factory tests and the Employer approval to ship, shall in no way constitute final acceptance of the system or any portion thereof. These tests shall be carried out in the presence of the Employer’s authorised representatives unless waiver for witnessing by Employer’s representatives is intimated to the contractor.

Factory acceptance tests shall not proceed without the prior delivery to and approval of all test documentation by the Employer.

The factory acceptance tests for the supplied items shall be proposed by the Contractor in accordance with technical specifications and Contractor's (including Sub-Contractor's / supplier's) standard FAT testing program. In general the FAT for other items shall include at least: Physical verification, demonstration of technical characteristics, various operational modes, functional interfaces etc.

For Test equipment FAT shall include supply of proper calibration certificates, demonstration of satisfactory performance, evidence of correct equipment configuration and manufacturer’s final inspection certificate/ report.

2.2.1 Sampling for FAT

From each batch of equipment presented by the Contractor for Factory acceptance testing, the Employer shall select random sample(s) to be tested for acceptance. Unless otherwise agreed, all required FAT tests in the approved FAT procedures, shall be performed on all samples. The Sampling rate for the Factory acceptance tests shall be minimum 10% of the batch size (minimum 1) for all items. The physical verification shall be carried out on 100% of the offered quantities as per the approved FAT procedure. In case any of the selected samples fail, the failed sample is rejected and additional 20% samples shall be selected randomly and tested. In case any sample from the additional 20% also fails the entire batch may be rejected.

For the OPGW cable hardware fittings & accessories, the minimum sampling rate, and batch acceptance criteria shall be as defined in IS 2486.
The Sampling rate for the Factory acceptance tests shall be 10% of the batch size (minimum 2) for FO cable drums, FODPs, Joint box and other similar items.

Since FAT testing provides a measure of assurance that the Quality Control objectives are being met during all phases of production, the Employer reserves the right to require the Contractor to investigate and report on the cause of FAT failures and to suspend further testing/approvals until such a report is made and remedial actions taken, as applicable.

### 2.2.2 Production Testing

Production testing shall mean those tests which are to be carried out during the process of production by the Contractor to ensure the desired quality of end product to be supplied by him. The production tests to be carried out at each stage of production shall be based on the Contractor’s standard quality assurance procedures. The production tests to be carried out shall be listed in the Manufacturing Quality Plan (MQP), along with information such as sampling frequency, applicable standards, acceptance criteria etc.

The production tests would normally not be witnessed by the Employer. However, the Employer reserves the right to do so or inspect the production testing records in accordance with Inspection rights specified for this contract.

### 2.2.3 Factory Acceptance Tests on Optical Fibre to be supplied with OPGW

The factory acceptance tests listed in the table below are applicable for the Optical fibres to be supplied. The listed tests follow testing requirements set forth in IEEE standard 1138/IEC 60794. The referenced sections specify the detailed test description. The acceptance norm shall be as specified in the above mentioned IEEE standards unless specified otherwise in the technical specifications.

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Test Name</th>
<th>Acceptance Criteria</th>
<th>Test procedure</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Attenuation Coefficient</td>
<td>TS, Table 1-1(a)</td>
<td>EIA/TIA 455-78A</td>
</tr>
<tr>
<td>2</td>
<td>Point Discontinuities of attenuation</td>
<td>TS, Section 1.1.2</td>
<td>EIA/TIA 455-59</td>
</tr>
<tr>
<td>3</td>
<td>Attenuation at Water Peak</td>
<td>TS, Table 2-1(a)</td>
<td>EIA/TIA 455-78A</td>
</tr>
<tr>
<td>4</td>
<td>Chromatic Dispersion</td>
<td></td>
<td>EIA/TIA 455-168A/169A/175A</td>
</tr>
<tr>
<td>5</td>
<td>Core – Clad Concentricity Error</td>
<td></td>
<td>EIA/TIA 455-176</td>
</tr>
<tr>
<td>6</td>
<td>Cladding diameter</td>
<td></td>
<td>EIA/TIA 455-176</td>
</tr>
<tr>
<td>7</td>
<td>Fibre Tensile Proof Testing</td>
<td></td>
<td>EIA/TIA 455-31B</td>
</tr>
</tbody>
</table>

The test report for the above tests for the fibers carried out by the Fiber Manufacturer and used in the OPGW cables shall be shown to the inspector during OPGW cable FAT and shall be submitted along with the OPGW cable FAT report.
2.2.4 Factory Acceptance Test on OPGW Cable

The factory acceptance tests for OPGW cable specified below in Table follow the requirements set forth in IEEE standard 1138 / IEC 60794. The FAT shall be carried out on 10% of offered drums in each lot as specified in technical specifications and the optical tests shall be carried out in all fibres of the selected sample drums. The Rated Tensile Strength test shall be carried out on one sample in each lot.

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Factory Acceptance Test on Manufactured OPGW</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Attenuation Co-efficient at 1310 nm and 1550 nm</td>
</tr>
<tr>
<td>2</td>
<td>Point discontinuities of attenuation</td>
</tr>
<tr>
<td>3</td>
<td>Visual Material verification and dimensional checks as per approved DRS/Drawings</td>
</tr>
<tr>
<td>4</td>
<td>Rated Tensile Strength</td>
</tr>
<tr>
<td>5</td>
<td>Lay Length Measurements</td>
</tr>
</tbody>
</table>

2.2.5 Factory Acceptance Test on OPGW Fittings

The factory acceptance tests for OPGW Fittings as specified below in Table 2-6. The sampling plan shall be as per relevant standard:

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Factory Acceptance Test On OPGW Fittings</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><strong>Suspension Assembly</strong></td>
</tr>
<tr>
<td>1</td>
<td>UTS/Mechanical Strength of the assembly</td>
</tr>
<tr>
<td>2</td>
<td>Clamp Slip Test</td>
</tr>
<tr>
<td>3</td>
<td>Visual Material verification and dimensional checks as per approved DRS/Drawings</td>
</tr>
<tr>
<td>4</td>
<td>Mechanical strength of each component</td>
</tr>
<tr>
<td>5</td>
<td>Galvanising test</td>
</tr>
<tr>
<td></td>
<td><strong>Tension Assembly</strong></td>
</tr>
<tr>
<td>6</td>
<td>Clamp Slip Strength test</td>
</tr>
<tr>
<td>7</td>
<td>Visual Material verification and dimensional checks as per approved DRS/Drawings</td>
</tr>
<tr>
<td>8</td>
<td>Mechanical strength of each component</td>
</tr>
<tr>
<td>9</td>
<td>Galvanising Test</td>
</tr>
</tbody>
</table>
Table 2-6
Factory Acceptance Tests On OPGW Fittings

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Factory Acceptance Test</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><strong>Vibration Damper</strong></td>
</tr>
<tr>
<td>10</td>
<td>Galvanising test on damper, masses and messenger wires</td>
</tr>
<tr>
<td>11</td>
<td>Damper response (resonant frequencies)</td>
</tr>
<tr>
<td>12</td>
<td>Clamp Slip test</td>
</tr>
<tr>
<td>13</td>
<td>Strength of messenger wires</td>
</tr>
<tr>
<td>14</td>
<td>Attachments of weights to messenger cable</td>
</tr>
<tr>
<td>15</td>
<td>Attachments of clamps to messenger cable</td>
</tr>
<tr>
<td>16</td>
<td>Clamp bolt tightening test</td>
</tr>
<tr>
<td>17</td>
<td>Clamp bolt torque test</td>
</tr>
<tr>
<td>18</td>
<td>Dynamic characteristic test.</td>
</tr>
<tr>
<td>19</td>
<td>Visual Material verification and dimensional checks as per approved DRS/Drawings</td>
</tr>
<tr>
<td></td>
<td><strong>Structure Mounting Clamp</strong></td>
</tr>
<tr>
<td>20</td>
<td>Clamp fit test</td>
</tr>
<tr>
<td>21</td>
<td>Clamp Strength test</td>
</tr>
<tr>
<td>22</td>
<td>Visual Material verification and dimensional checks as per approved DRS/Drawings</td>
</tr>
</tbody>
</table>

End of Table

2.2.6 Factory Acceptance Test on Approach Cable

The factory acceptance tests for Approach Cable specified below in Table 2-7:

Table 2-7
Factory Acceptance Tests On Approach Cable

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Factory Acceptance Test</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Attenuation Co-efficient at 1310 nm and 1550 nm</td>
</tr>
<tr>
<td>2</td>
<td>Point discontinuities of attenuation</td>
</tr>
<tr>
<td>3</td>
<td>Visual Material verification and dimensional checks as per approved DRS/Drawings</td>
</tr>
</tbody>
</table>
2.2.7 Factory Acceptance Test on Splice Enclosure (Joint Box) /FODP

The factory acceptance tests for Splice Enclosures/FODP as specified below in Table: 2-8

Table 2-8
Factory Acceptance Tests on Splice Enclosures (Joint Box)/FODP

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Factory Acceptance Test</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Visual check of Quantities and Specific Component Number for each component of Splice Enclosure/FODP and dimensional checks against the approved drawings.</td>
</tr>
</tbody>
</table>

2.2.8 Factory Acceptance Test on Test Equipment & other items

As per technical specification and approved DRS/Documents.

2.3 Site Acceptance Tests

The Contractor shall be responsible for the submission of all material & test equipment supplied in this contract for site tests and inspection as required by the Employer. All equipment shall be tested on site under the conditions in which it will normally operate.

The tests shall be exhaustive and shall demonstrate that the overall performance of the contract works satisfies every requirement specified. At a minimum Site Acceptance Testing requirement for FO cable etc. is outlined in following section. This testing shall be supplemented by the Contractor's standard installation testing program, which shall be in accordance with his quality plan(s) for FO installation.

During the course of installation, the Employer shall have full access for inspection and verification of the progress of the work and for checking workmanship and accuracy, as may be required. On completion of the work prior to commissioning, all equipment shall be tested to the satisfaction of the Employer to demonstrate that it is entirely suitable for commercial operation.

2.3.1 Minimum Site Acceptance Testing Requirement for FO Cabling

Prior to installation, every spooled fibre optic cable segment shall be tested for compliance with the Pre-shipment data previously received from the manufacturer. This requirement will preclude the installation of out of specification cable segments that may have been damaged during shipment.

2.3.1.1 Phases of Site Acceptance Testing

SAT shall be carried out link by link from FODP to FODP. SAT may be performed in parts in case of long links.
The tests, checks, adjustments etc conducted by the Contractor prior to offering the equipment for SAT shall be called Pre-SAT activities. The Pre-SAT activities shall be described in the installation manuals and Field Quality Plan documents.

Sag and tension of OPGW shall generally be as per approved sag-tension chart and during installation, sag and tension of OPGW shall be documented. Upon completion of a continuous cable path, all fibres within the cable path shall be demonstrated for acceptance of the cable path. Fibre Optic cable site testing minimum requirements are provided in Table 2-9(a) through 2-9(c) below:

**Table 2-9(a)**
Fibre Optic Cable Pre-Installation Testing

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Physical Inspection of the cable assembly for damage</td>
</tr>
<tr>
<td>2.</td>
<td>Optical fibre continuity and fibre attenuation with OTDR at 1550 nm</td>
</tr>
<tr>
<td>3.</td>
<td>Fibre Optic Cable length measurement using OTDR</td>
</tr>
</tbody>
</table>

**Table 2-9(b)**
Fibre Optic Cable Splicing Testing

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Per splice bi-directional average attenuation with OTDR</td>
</tr>
<tr>
<td>2.</td>
<td>Physical inspection of splice box/enclosure for proper fibre / cable routing techniques</td>
</tr>
<tr>
<td>3.</td>
<td>Physical inspection of sealing techniques, weatherproofing, etc.</td>
</tr>
</tbody>
</table>

**Table 2-9(c)**
Fibre Optic Cable Commissioning Testing

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>End to End (FODP to FODP) bi-directional average attenuation of each fibre at 1310 nm and 1550 nm by OTDR.</td>
</tr>
<tr>
<td>2.</td>
<td>End to End (FODP to FODP) bi-directional average attenuation of each fibre at 1310 nm and 1550 nm by Power meter.</td>
</tr>
<tr>
<td>3.</td>
<td>Bi-directional average splice loss by OTDR of each splice as well as for all splices in the link (including at FODP also).</td>
</tr>
<tr>
<td>4.</td>
<td>Proper termination and labelling of fibres &amp; fibre optic cables at FODP as per approved labelling plan.</td>
</tr>
</tbody>
</table>
Chapter-03

Installation for OPGW Cabling

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3.2 Installation of Approach cable ............................................................ 2
3.3 Optical fibre termination and splicing .................................................. 3
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3.5 Methodology for installation and termination ....................................... 3
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3.1 Installation requirements

The OPGW cable shall be installed at the top of the tower in place of earthwire (only one of the earthwire peaks in case of 400kV & above lines, if applicable) for under construction transmission lines as envisaged.

The OPGW cable sections shall normally be terminated & spliced only on tension towers. In exceptional circumstances, and on Employer specific approval, cable may be terminated on suspension towers, but in this case tower strength shall be examined to ensure that tower loads are within safe limits and if required, necessary tower strengthening shall be carried out by the Contractor.

For OPGW Cable to be installed on new line transmission line, the stringing shall be carried by the Transmission Line Contractor as per the stringing chart/procedure submitted by them and approved by Employer. The Contractor shall install OPGW as per approved stringing procedure.

The Contractor shall follow precautions including proper location of drum site, installation of stringing blocks/pulleys, proper sagging, proper installation of hardware, proper tension as per Sag-Tension chart, provision of service loops of OPGW in jointing locations etc.

3.1.1 Installation of OPGW cable

The OPGW cable sections shall normally be terminated & spliced only on tension towers. In exceptional circumstances and on Employer specific approval, cable may be terminated on Suspension towers, but in this case tower strength shall be examined to ensure that tower loads are within safe limits and if required, necessary tower strengthening shall be carried out by the Contractor. In such a case, the jointing of OPGW on suspension tower if required, shall be acceptable subject to its suitability.

3.1.2 Installation Hardware Fittings

All required hardware fittings shall be installed alongwith OPGW Cable.

3.2 Installation of Approach Cable

The existing cable trenches/ cable raceways proposed to be used shall be identified in the survey report. The Contractor shall make its best effort to route the cable through the existing available cable trenches. Where suitable existing cable trenches are not available, suitable alternatives shall be provided after Employer approval. However, the approach cable shall be laid in the HDPE pipe in all condition.

Suitable provisions shall be made by the Contractor to ensure adequate safety earthing and insulated protection for the approach cable.
All required fittings, supports, accessories, ducts, inner ducts, conduits, risers and any item not specially mentioned but required for laying and installation of approach cables shall be supplied and installed by the Contractor.

### 3.3 Optical Fibre Termination and Splicing

Optical fibre terminations shall be installed in Fibre Optic Distribution Panels (FODP) designed to provide protection for fibre splicing of preconnectorized pigtails and to accommodate connectorized termination and coupling of the fibre cables. The Contractor shall provide rack/wall mounted Fibre Optic Distribution Panels (FODPs) sized as indicated in the appendices and shall terminate the fibre optic cabling up to the FODPs. The location of FODP rack shall be fixed by the Contractor, with the Employer’s approval.

### 3.4 Fibre Optic Distribution Panel

At each location requiring the termination of at least one fibre within a cable, all fibres within that cable shall be connectorized and terminated in Fibre Optic Distribution Panels in a manner consistent with the following:

(a) All fibre optic terminations shall be housed using FODPs provisioned with splice organizers and splice trays. All fibres within a cable shall be fusion spliced to pre-connectorized pigtails and fitted to the "Back-side" of the provided fibre optic couplings.

(b) Flexible protection shall be provided to the patch cord bunches going out from FODP to other equipment.

### 3.5 Methodology for Installation and Termination

All optical fibre cable termination, installation, stringing and handling plans, guides and procedures, and engineering analysis (e.g. tension, sag, vibration etc.) shall be submitted to the Employer for review and approval in the engineering/design phase of the project, prior to establishing the final cable lengths for manufacture. Installation procedures including details of personnel and time required shall be documented in detail and submitted to Employer for approval. All installation practices shall be field proven and ISO accredited.

All cable segments shall include service loops as specified in this specification. The maximum allowable stringing tension, maximum allowable torsional shear stress, crush strength and other physical parameters of the cable shall not be exceeded. The preventative measures to be taken shall be documented in detail and submitted to Employer in advance of installation.

Optical fibre attenuation shall be measured after installation and before splicing. Any increase in attenuation or step discontinuity in attenuation shall not be acceptable and shall constitute a cable segment failure. In the event of cable damage or any fibre damage, the complete section (tension location to tension location) shall be replaced as mid-span joints are not acceptable.

Any or all additional steel work or modifications required to attach the fibre cabling to the overhead transmission/distribution line towers shall also be carried out by the Contractor. It shall be the Contractor’s responsibility to provide adequate communications among all crew members and support staff to ensure safe and successful installations.
3.6 Cable Raceways

To the extent possible, existing cable raceways shall be utilised. The Contractor is required to provide and install any additional indoor cable raceways which may be required for proper implementation of the fibre optic cabling system. This requirement shall be finalised during survey. The cable raceways shall conform to the following:

(a) All cable raceways shall be sized to support full loading requirements plus at least a 200% safety loading factor.

(b) Indoor cable raceways shall be fabricated from construction grade aluminium, galvanized iron or anodized sheet metal or any other suitable material approved by the Employer. Suitable anti-corrosion measures shall be provided. Steel fabricated raceways shall be finished inside and out, treated to resist rust and to form a metal-to-paint bond.

(c) Mechanical construction drawings of the cable raceways shall be submitted for Employer’s information & review.

……………………………………End of this Section………………………………………
APPENDIX – A

General Requirements
### Table A-1
Typical Transmission line details

<table>
<thead>
<tr>
<th>Line Voltage</th>
<th>S/C or D/C</th>
<th>Nominal Span (E/W &amp; Conductors in mtrs.)</th>
<th>Wind Zone as per IS 802</th>
<th>Design Tension at Every Day Temp (32°C) and full wind condition – Earthwire) in kg for Wind Zone</th>
<th>Wind Pressure (kg/Sq-m) considering gust factor</th>
<th>Max Sag – Ground Wire at 53°C (in mtrs)</th>
<th>UTS – Earthwire (in Kg)</th>
<th>Weight – Earth wire (in Kg/km)</th>
<th>Minimum Clearance in mtrs.</th>
</tr>
</thead>
<tbody>
<tr>
<td>220 kV</td>
<td>D/C</td>
<td>350</td>
<td>IV</td>
<td>200</td>
<td>7.83</td>
<td>6230</td>
<td>483</td>
<td>4.8</td>
<td>7.5</td>
</tr>
</tbody>
</table>

A1 Minimum clearance between conductor and ground (in meters)
B1 Minimum clearance between two phase conductors (in meters) – vertical in case of D/C towers and horizontal in case of S/C towers.
C1 Minimum clearance between conductor and earth wire (in meters)
Appendix-B

Data Requirement Sheets
Appendix-B

Data Requirement Sheets

The following sets of Data Requirement Sheets are required to be filled up by the bidders to aid in the evaluation process. The response shall be brief and to the point and shall be supported by the printed product description and other literature. The DRS duly filled and the relevant drawings shall also be submitted during the detailed engineering along with the relevant technical brochures.
DRS Form 1

DATA REQUIREMENTS SHEETS for
OVERHEAD FIBRE OPTIC CABLE

OPTICAL GROUND WIRE (OPGW) – 24 Fibre:
(if applicable)

Manufacturer: _________________________________
Part #: _________________________________
Configuration: _________________________________

<table>
<thead>
<tr>
<th>Seq</th>
<th>Parameter:</th>
<th>As per Technical Specification</th>
<th>As per Bidder Offering</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>No. of Fibres Dual Window Single-Mode:</td>
<td>24</td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td>Buffer Type:</td>
<td>Loose Tube</td>
<td></td>
</tr>
<tr>
<td>3.</td>
<td>Buffer Tube material</td>
<td>Non-metallic</td>
<td></td>
</tr>
<tr>
<td>4.</td>
<td>No. of Buffer Tubes:</td>
<td>Minimum Two (2)</td>
<td></td>
</tr>
<tr>
<td>5.</td>
<td>No. of Fibers per buffer Tube:</td>
<td>Maximum Twelve (12)</td>
<td></td>
</tr>
<tr>
<td>6.</td>
<td>Expected Cable Life:</td>
<td>25 Year</td>
<td></td>
</tr>
</tbody>
</table>
# DATA REQUIREMENTS SHEETS for OPTICAL FIBRE
## DUAL-WINDOW SINGLE MODE (DW-SM)

## OPTICAL PARAMETERS

<table>
<thead>
<tr>
<th>Seq</th>
<th>Parameter:</th>
<th>As per Technical Specification</th>
<th>As per Bidder offering</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Fiber manufacturer(s) / Type:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td>Attenuation Coefficient @ 1310 nm: @ 1550 nm:</td>
<td>≤ 0.35 dB/km</td>
<td>≤ 0.21 dB/km</td>
</tr>
<tr>
<td>3.</td>
<td>Point discontinuity @ 1310nm: @ 1550nm:</td>
<td>≤ 0.05 dB</td>
<td>≤ 0.05 dB</td>
</tr>
<tr>
<td>4.</td>
<td>Nominal Mode Field Diameter @ 1310 nm: @ 1550 nm:</td>
<td>8.6 to 9.5 µm (± 0.6 µm)</td>
<td></td>
</tr>
<tr>
<td>5.</td>
<td>Chromatic Dispersion Coefficient @ 1310 (1288-1339) nm: @ 1310 (1271-1360) nm: @ 1550 nm:</td>
<td>3.5 ps/(nm×km)</td>
<td>5.3 ps/(nm×km)</td>
</tr>
<tr>
<td>6.</td>
<td>Zero dispersion wavelength:</td>
<td>1300 to 1324 nm</td>
<td></td>
</tr>
<tr>
<td>7.</td>
<td>Cutoff wavelength:</td>
<td>≤ 1260 nm</td>
<td></td>
</tr>
</tbody>
</table>

### Physical and Mechanical Properties

| 8.  | Bend Performance: | | |
|     | (37.5 mm radius, 100 turns) @1310 nm | ≤ 0.05 dB | |
|     | (30 mm radius, 100 turn) @1550 nm | ≤ 0.05 dB | |
|     | (16mm radius, 1 turn) @ 1550nm | ≤ 0.50 dB | |
| 9.  | Cladding Diameter (nominal ± deviation): | 125.0 µm ± 1 µm | |
| 10. | Polarisation mode dispersion coefficient | ≤ 0.2 ps/km$^{1/2}$ | |
| 11. | Proof test level | ≥ 0.69 Gpa | |

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End of the Appendix

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Section-IX-APPENDIX-B

Volume II
SECTION-X

PILE FOUNDATION
SECTION-X

CONTENTS

PART-I GENERAL INFORMATION & SCOPE FOR LATTICE TOWER LOCATIONS
PART-II BORED CAST-IN-SITU PILE FOUNDATION
PART-III RATES AND MEASUREMENTS
PART-IV TESTING AND ACCEPTANCE CRITERIA
PART-V M. S. LINER
PART-VI STANDARD AND ANNEXURES
PART-VII SFQP TRANSMISSION LINE PILE
SECTION-X (Part-I)

GENERAL INFORMATION & SCOPE FOR LATTICE TOWER LOCATIONS
## SECTION – X (Part-I)

GENERAL INFORMATION & SCOPE

### CONTENTS

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<th>DESCRIPTION</th>
<th>PAGE NO.</th>
</tr>
</thead>
<tbody>
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<td>1</td>
</tr>
<tr>
<td>2.0</td>
<td>Scope</td>
<td>1</td>
</tr>
<tr>
<td>3.0</td>
<td>Sub soil data</td>
<td>2</td>
</tr>
<tr>
<td>4.0</td>
<td>Design and Drawings</td>
<td>2</td>
</tr>
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<td>5.0</td>
<td>Table of Compliance</td>
<td>2</td>
</tr>
</tbody>
</table>
SECTION-X (PART – I)

1.0 GENERAL

1.1 This section covers the specification for pile foundation work envisaged in Kusma – New Butwal 220 kV D/C transmission line

Pile foundations are envisaged for tower locations under the river crossing portion.

2.0 SCOPE

2.1 The work to be performed under this specification consists of boring in all kinds of soil including weathered rock, fissured rock, hard rock, shale etc., providing and installation of cast-in-situ RCC vertical bored piles of 1200mm diameter, providing all labour, materials, supervision, dewatering, scaffolding, platforms, boring and construction equipments & machineries, tools, tackles and plants, supplies, power, fuel, transportation on land and water, all incidental items not shown or specified but reasonably implied or necessary for successful and timely completion of work including Contractor's supervision in strict accordance with IS Codes, drawings and specifications. The nature of work shall generally involve construction/installation of cast-in-situ RCC vertical bored piles of specified diameter, pile caps, pedestals, tie beam (if required) etc. as per the Purchaser's construction drawings and also co-ordination with tower erection contractor for setting of stubs / fixing of anchor bolts (as the case may be) for River crossing locations

2.2 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.

2.3 The Bidder's offer should be based on the mobilization of at least one no. piling rig for each tower location together with all associated working gangs, tool & tackles etc. (including at least one no. of Rotary Hydraulic drilling rig capable of boring minimum 1200mm diameter piles up-to 40m depth below existing Ground Level with necessary tools/accessories for boring) However, if extra rigs are required to be deployed by the Contractor to match with the project construction schedule, the same shall be deployed without any additional cost to the Purchaser. The contractor has to execute the complete job as per soil strata actually encountered at the time of construction.

2.4 The Contractor shall be responsible for the soundness of the above pile foundations installed / constructed by them.

2.5 After completion of installation / construction of piles, pile integrity test shall be conducted for each pile by the contractor, in presence of Purchaser’s representative, to establish its soundness. The procedure for conducting of pile integrity test is given briefly at Part – IV of this Specification. The tentative quantity of tests to be carried out are
given in BPS. Bidder has to quote the price accordingly.

2.6 The setting of stub/fixing of foundation anchor bolts (as indicated in the drawing) shall be the responsibility of the Contractor.

2.7 The Bidder shall quote based on the provisional Bill Of Quantities (BOQ) furnished in the Bid Proposal Sheet (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 as per Purchaser/Purchaser’s design & drawing based on the unit rates for items quoted.

3.0 SUB-SOIL DATA

3.1 The detailed soil investigation for the locations where pile foundations are envisaged shall be carried out by the Contractor. The contractor has to execute the complete job as per the soil strata actually encountered at the time of construction which may have some variations of reasonable nature from the soil investigation report. Any extra claim whatsoever on account of such variations shall not be entertained.

4.0 DESIGN AND DRAWINGS

4.1 Purchaser shall develop the pile foundation design based on the soil investigation report for the particular location. The construction drawings required for execution of pile foundations shall be given to the contractor as per site requirement during execution stage.

5.0 TABLE OF COMPLIANCE

Bidder shall use one copy of “Technical Specifications” to indicate compliance status. Within the right hand margin, Bidder shall indicate compliance status to each paragraph along with a cross-reference to its proposal and an index key for any explanation or comment.

In addition, The Bidder shall annotate the Table of contents of the above stated volume to provide a high level summary of compliance status. In both cases, the following symbols, and no others, shall be used:

C- Bid complies with all requirements in the adjacent paragraph
A- Bid is not compliant with the requirements in the adjacent paragraph, but a functional alternative is proposed.
X- Bid takes exception to the requirements of the adjacent paragraph and no functional alternative is proposed.
Only one symbol shall be assigned to a paragraph and shall indicate the worst case level of compliance for that paragraph. The annotation may be hand written.

Bidder shall underline, on the compliance copy, all requirements to which exceptions have been taken (X) or to which alternatives have been proposed (A).

Each alternative shall be clearly and explicitly described. Such descriptions shall use the same paragraph numbering as the bid document sections addressed by the alternatives. All alternative descriptions shall be in one contiguous section of the Bidder’s proposal, preferably in the same volume, and titled “Alternatives”. A separate section titled “Exceptions” should be provided containing any discussion or explanation Bidder chooses to provide concerning exceptions taken.

Alternatives which do not substantially comply with the intent of the bid documents will be considered exceptions.

The Purchaser will assess the merits of each alternative and exception and will be the sole judge as to their acceptance.
SECTION X (Part-II)

BORED CAST-IN-SITU PILE FOUNDATION
<table>
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<th>SL.NO.</th>
<th>DESCRIPTION</th>
<th>PAGE NO.</th>
</tr>
</thead>
<tbody>
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<td>1</td>
</tr>
<tr>
<td>2.0</td>
<td>Layout and levels</td>
<td>2</td>
</tr>
<tr>
<td>3.0</td>
<td>Site preparation</td>
<td>2</td>
</tr>
<tr>
<td>4.0</td>
<td>Properties of construction material</td>
<td>2</td>
</tr>
<tr>
<td>5.0</td>
<td>Storage and handling of construction material</td>
<td>5</td>
</tr>
<tr>
<td>6.0</td>
<td>Cement concrete</td>
<td>6</td>
</tr>
<tr>
<td>7.0</td>
<td>Reinforcement Steel</td>
<td>10</td>
</tr>
<tr>
<td>8.0</td>
<td>Construction of Pile cap, pedestal, tie beam etc.</td>
<td>13</td>
</tr>
<tr>
<td>9.0</td>
<td>Pile Installation</td>
<td>19</td>
</tr>
<tr>
<td>10.0</td>
<td>Erection of Steel embedded parts</td>
<td>26</td>
</tr>
<tr>
<td>11.0</td>
<td>Installation</td>
<td>27</td>
</tr>
<tr>
<td>12.0</td>
<td>Protection against damage in transit</td>
<td>27</td>
</tr>
<tr>
<td>13.0</td>
<td>Foundation bolts</td>
<td>28</td>
</tr>
<tr>
<td>14.0</td>
<td>Stability of Structure</td>
<td>28</td>
</tr>
<tr>
<td>15.0</td>
<td>Grouting and under Pinning</td>
<td>29</td>
</tr>
<tr>
<td>16.0</td>
<td>Bar Grips</td>
<td>31</td>
</tr>
<tr>
<td>17.0</td>
<td>Splicing</td>
<td>31</td>
</tr>
<tr>
<td>18.0</td>
<td>MS Liner</td>
<td>32</td>
</tr>
</tbody>
</table>
SECTION –X (Part-II)

1.0 CONSTRUCTION OF BOARD CAST IN-SITU-PILE FOUNDATION

1.1 General Requirement

1.1.1 The specification 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 Employer in accordance with the Technical Specifications and conform to location, lines, grades and cross sections shown on the construction drawing or as directed by the Employer. The specifications are not, however, intended to cover all the minute details and the work shall be executed according to the specified Indian Codes. In absence of the Codes, work shall be executed according to the best prevailing local Public Works Department practice or to the recommendations of the relevant International Standards or to the instructions of the Employer. This specification shall have precedence in case anything contrary to this is stated anywhere in this Bid Document. In case of conflict between the Specification and Codes, the former shall prevail.

1.1.2 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 capacity of some key equipments are listed below. However, bidder has to furnish informations regarding the equipments they intend to deploy for the project as per proforma 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>3 T 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</td>
<td>2.5 inch</td>
</tr>
<tr>
<td></td>
<td>for bentonite</td>
<td></td>
</tr>
<tr>
<td>6.</td>
<td>Rotary drilling rig</td>
<td>Minimum torque 12T</td>
</tr>
<tr>
<td></td>
<td>(Hydraulic) alongwith all accessories</td>
<td></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 EMPLOYER.

2.0 Layout and Levels
2.1 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 Employer. 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 Employer. 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 Employer for verification of the detailed layout and correctness of the layout and levels to the satisfaction of the Employer so that the work can be carried out accurately according to specifications and approved drawings. The contractor shall be solely responsible for the correctness of layout and levels.

3.0 Site Preparation

This section of the specification covers site preparation of the areas as indicated in the drawings.

3.1 Reference Points and Bench Marks

3.1.1 Void

3.1.2 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 Employer.

4.0 Properties of Construction Materials

This clause specifies the properties of common building materials unless otherwise mentioned in the drawings or schedule of items.

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, except for lean concrete.

4.1 Coarse aggregates/Stone
4.1.1 All coarse aggregates shall be as per IS:383 consisting of hard, strong, compact grained and durable pieces of crushed stone having uniform in texture and colour and free from decay, flaws, veins, cracks and sand holes. Coarse aggregates should be of angular shape & rectangular surface and shall be free from organic or clay coatings and other impurities like disintegrated stones, soft flaky particles, adherent coatings, clinkers, slag, mica and any other materials liable to affect the strength, durability or appearance of concrete. The surface of a freshly broken stone shall be bright, clean, and free from any dull, chalky or earthy appearance. Coarse aggregates with round surface shall not be used. Coarse aggregates shall not absorb more than 5% of its weight of water after 24 hours immersion. Samples shall be submitted by the Contractor and approved samples shall be retained by the Employer for comparison of bulk supply.

4.1.2 Sieving and washing of aggregates by approved method shall be carried out wherever required.

4.1.3 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.

4.1.4 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.

4.2 Cement

Cement used shall generally be ordinary Portland Cement conforming to the latest Indian Standard Code IS:8112 or IS:12269. Alternatively, other varieties of cement other than ordinary Portland Cement such as Portland Pozzolana Cement conforming to IS:1489 or Portland Slag Cement conforming to IS:455 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 and as mentioned in the construction drawing. No additional payment shall be
made for using Sulphate Resistant Cement.

### 4.3 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, alkalis, salts, coal, mica, shale or other laminated materials, in such forms or quantities as to affect adversely the hardening, strength, durability or appearance of concrete or to cause corrosions to any metal in contact with such 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 Employer all sand shall pass through IS Sieve no. 2.36mm. Sand for concrete shall conform to IS:383.

### 4.4 Water

Water shall be clean, fresh and free from organic matters, acids or soluble salts and other deleterious substances which may cause corrosion, discoloration, efflorescence etc. 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 at least three 15 cm. cubes of concrete prepared with proposed water shall not be less than 90% of average strength of three similar cubes prepared with distilled water. PH of water shall generally be not less than 6.

### 4.5 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. Reinforcement shall conform to IS:1786 for deform and cold twisted bars (Fe 500). If mentioned in the BPS, epoxy coated reinforcement shall conform to IS:13620. Thermo Mechanically Treated (TMT) bars (equivalent grade) in place of cold twisted bars are also accepted. Hard drawn steel wire shall conform to IS:432. Hard drawn steel wire fabric shall conform to IS:1566. All steel bars including and above 6mm diameter shall be of tested for quality. Substitution of reinforcement, other than those mentioned above, shall not be permitted without the prior approval of the Employer. 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. Spacers, chairs, stays, hangers and annealed steel wire for bending etc. as may be necessary, should be used for proper completion of foundation job. Spacers or chairs should be placed at a maximum spacing of 1 m and closer spacing shall be provided wherever necessary.

In area near nala or where subsoil strata is attacking in nature Epoxy coated reinforcement and ready mix concrete shall be used. Such area may involve
continuous dewatering also for casting of foundation. Portland Pozzolona cement or Slag cement shall be used for such locations. For concreting under water, Slump of concrete shall be 100 -150 mm recorded by suitable method

5.0 Storage & Handling of construction Materials

All materials shall be stored by the Contractor in a manner aiding convenient access for identification and inspection at all times. The storage arrangements shall be subject to the approval of the Employer. Storage of materials shall be as described in IS:4082.

All materials shall be so stored as to prevent deterioration or intrusion of foreign matter and to ensure the preservation of their quality and fitness for the work. Any material which has deteriorated or has been damaged or is otherwise considered defective by the Employer shall not be used for concrete, and shall be removed from site immediately, failing which, the Employer will get the materials removed and the cost thereof shall be recovered from contract price. The Contractor shall maintain up to date accounts of receipt, issue and balance (stock wise) of all materials.

5.1 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.

5.2 Coarse Aggregates and Sand

All coarse aggregates & sand shall be stored on brick 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 Employer, aggregates from different sources shall be stacked separately with proper care to prevent intermixing.

5.3 Reinforcement

Reinforcement steel shall be stored consignment wise and size wise, off the ground and under cover. It shall be protected from rusting, oil grease and distortions. If directed by the Employer, the reinforcement steel may have to be coated with cement wash before stacking, to prevent scale and rust at no extra cost to the Employer. The stacks shall be easily measurable. Only steel needed for immediate use shall be removed from
Fabricated reinforcement shall be carefully stored to prevent damage, distortion, corrosion & deterioration.

6.0 Cement Concrete

6.1 General

6.1.1 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.

6.1.2 The provisions of IS:456 shall be complied with, unless permitted otherwise. Any other Indian Standard Code shall form the part of the specification to the extent it has been referred to or applicable within this specification.

6.1.3 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.

6.2 Admixtures

6.2.1 The admixtures in concrete for promoting workability, improving strength or for any other purpose, shall be used only after the written permission from the Employer. The Admixtures shall conform to IS:9103.

6.2.2 Admixtures should not impair durability of concrete nor combined with the constituent to form harmful compounds nor increase the risk of corrosion of reinforcement.

6.2.3 Addition of admixtures should not reduce the specified strength of concrete in any case. The workability, compressive strength and the slump loss of concrete with and without the use of admixtures shall be established during the trial mixes before use of admixtures.

6.2.4 The chloride content of admixtures shall be independently tested for each batch before acceptance.

6.2.5 If two or more admixtures are used simultaneously in the same concrete mix, data shall be provided to assess their interaction and to ensure their compatibility.

6.2.6 In case admixtures are used in the concrete for any structure, fresh mix design be done considering the admixture with the specific approval from Employer. No extra payment shall be made to the Contractor on this account.
6.3 Grades of Concrete

6.3.1 The minimum grade of concrete to be used for piling shall be M-25 with minimum cement content 400 kg/m$^3$ and maximum water cement ratio of 0.5. Concrete shall conform to the controlled design mix as specified in IS:456. In addition, nominal mixes of 1:3:6 and 1:4:8 (with aggregates of nominal size 40mm maximum, by weight converted to equivalent volume shall also be used as per field quality plan. The concrete in aggressive surroundings due to presence of sulphate, etc., shall confirm to IS:456. The slump of concrete shall be maintained between 150 to 200 mm.

6.3.2 The Contractor shall carry out concrete mix design in accordance with IS:10262 and submit mix design calculations and get them approved from the Employer well in advance of installation of pile foundations. 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(i.e.slump).

6.4 Workmanship

All workmanship shall be according to the current Industry standard and best practices.

Before starting a pour the Contractor shall obtain the approval of the Employer 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.

6.4 Mixing of Concrete

6.4.1 All design mix concrete shall be mixed in mechanically operated mixer of an approved size and type capable of ensuring a uniform distribution on the materials through the mass. However, contractor can also use central batching plant situated within the area allocated for the Contractor's particular use.

6.4.2 The proportions of sand, coarse aggregate, cement and water shall be as determined by the mix design. However, in case of nominal mix concrete (for lean concrete only) the proportions of fine sand, and coarse aggregate, cement and water shall be fixed. The proportions, as determined for design mix concrete and shall always be approved by the Employer. The quantities of the cement, sand and coarse aggregates shall be determined by weight. However, for a faster progress at site, quantities of the cement, sand and coarse aggregates can be converted to
equivalent volume. 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.

6.4.3 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 at least 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 Employer. Mixers shall not be loaded above their rated capacity as it prevents thorough mixing. If there is segregation after unloading from the mixer the concrete should be remixed.

6.4.3 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 Employer to allow for loss in the drum.

6.5 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 Employer, concrete shall be transported in deep containers, having mortar leak proof, which will reduce the rate of 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.

6.6 Placing of Concrete

a) Formwork and placement of reinforcement shall be approved in writing by the Employer before concrete is placed. The forms shall be well wetted and oil 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 Employer. As far as possible, concrete shall be placed in the formwork by means approved by the Employer and shall not be dropped from a height or handled in a manner which may cause segregation. Any drop over 1800 mm shall have to be approved by the Employer. 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 spread 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 case may be allowed subject to the approval of the Employer. 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. Tie beams, pile caps, footings shall be poured in one operation normally, in special circumstances with the approval of the Employer these can be poured in horizontal layers not exceeding 500 mm 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.

6.7 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 position 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 no extra payment shall be made on this account.

6.8 Blockouts

Blockouts in concrete as indicated in the drawing or as directed by the Employer shall be provided wherever required. No extra payment shall be made to the Contractor on this account.

6.9 Repairs and Finishes of Concrete

All concrete surfaces shall have even and clean finish, free from honeycombs, 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 Employer.

The unit rate of concrete work shall be inclusive of the cost of cleaning and finishing exposed surface as mentioned above.

7.0 Reinforcement Steel

This section of the specification shall cover providing reinforcement steel and its 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.

7.1 General Requirements

7.1.1 Reinforcement steel of same type & grade shall be used for structural reinforcement work as detailed in the drawing released by the Employer. No work shall be commenced without proper verification with the bar-bending schedule provided in the drawing.

7.1.2 Contractor shall supply, fabricate and place reinforcement to shapes and dimensions as indicated on the drawings and as per specifications. The reinforcement shall be either plain or deformed steel bars or welded wire fabric conforming to relevant IS specifications.

7.1.3 Any adjustment in reinforcement to suit field conditions and construction joints other than shown on drawings shall be subjected to the approval of Employer.

7.2 Bending

7.2.1 Unless otherwise specified, reinforcement steel shall be bent in accordance with procedure specified in IS:2502. 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.

7.2.2 No reinforcement shall be bent when in position in the work without approval of the Employer, 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 Employer. 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.

7.3 Placing in position

7.3.1 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 contact, 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 contact 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.

7.3.2 The placing of reinforcements shall be completed well in advance of concrete pouring. Immediately before pouring, the reinforcement shall be checked by the Employer 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 Employer. 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 at least (7) days. The sizes and locations of the concrete blocks shall be approved by the Employer.

7.3.3 Longitudinal reinforcement in pile shall be high yield strength cold twisted deformed steel bars conforming to IS:1786. Thermo mechanically Treated (TMT) bars (equivalent grade) in place of Cold twisted deformed steel bars are also accepted. Lateral reinforcement in pile shall be of tor steel conforming to IS:432 Part-I.

7.3.4 The longitudinal reinforcement shall project 52 times its diameter above cut-off level unless otherwise indicated in the drawing.

7.3.5 The minimum diameter of the links or spirals bar shall be 8mm 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.

7.3.6 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.

7.3.7 The minimum clear distance between the two adjacent main reinforcement bars shall normally be 100mm for the full depth of cage, unless otherwise specified.

7.3.8 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.

7.3.9 Laps shall be staggered as far as practicable and as directed by the Employer. 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 (Center to Center).

7.3.10 Proper cover and central placement of the reinforcement cage in the pile bore shall be ensured by use of suitable concrete spacers or rollers, as required, without any additional cost to the Employer.

7.3.11 Minimum clear cover to the reinforcement shall be 75mm unless otherwise mentioned.

7.3.12 Unless otherwise specified by the Employer reinforcement shall be placed within the following tolerance as specified in IS:456:2000.

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.

7.3.13 Welding of reinforcement bars shall be avoided. However, welding may be done in specific case subject to prior permission from the Employer.

8.0 Construction of Pile Cap, Pedestal, Tie Beam etc.

The Contractor shall deploy all labour, equipment, tools & tackles and materials required for complete execution of the work in accordance with the drawings and as described herein.
8.1 Excavation

8.1.1 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.

8.1.2 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.

8.1.3 Side and bottoms of excavation shall be cut sharp and true, undercutting shall not be permitted. Each side of excavation shall be used in lieu of formwork for placement of concrete unless authorised, in special cases, by the Employer, where limitation of space for larger excavation necessitate such decision.

8.1.4 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.

8.1.5 Suitability for bearing of the bottoms of excavations shall be determined by the Employer.

8.1.6 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 filling with lean concrete 1:4:8 mix, with aggregate of 40mm maximum nominal size at no additional cost to the Employer.

8.1.7 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. 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 Employer.

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.

8.1.8 Excavations for foundations specified shall be carried out at least 75mm 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.

8.1.9 When excavation requires coffer dams, sheet piling, bracing, sheeting, shoring, draining, dewatering etc. the Contractor shall have to provide the same as required and the cost there of shall be included in the unit rate quoted for the item of excavation and contractor shall submit necessary drawings showing arrangement and details of proposed installation and shall not proceed until he has received approval from the Employer.

8.1.10 The Contractor shall have to constantly pump out the water collected in pits due to rain water, springs, seepage etc. and maintain dry working conditions at no extra cost to the Employer.

8.1.11 For the purpose of excavation in earthwork, all types of soil including kankar, morum, shingle and boulders up to 150mm size are included and no separate payment shall be made for different type of soils encountered.

8.4 Form work

8.4.1 General

8.4.1.1 If it is so desired by the Employer, the Contractor shall prepare, before commencement of the actual work, design and drawings for form work and centering and get them approved by the Employer. The form work shall conform to the shape, alignment and dimensions as shown in the drawings.

Form work shall be composed of steel and/or best quality shuttering wood of non-absorbent type or plywood. 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. Struts 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 Employer in specified cases.

Supports or props should not be supported on an unpropped lower suspended floor or beam unless calculations are submitted to the Employer to confirm the strength of the lower floor or beam and no propping shall be taken out until the Employer approval has been given.

8.4.1.2 The form work 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 well as working load. Where the concrete is vibrated, the formwork shall be strong enough to withstand the effects of vibration, without appreciable deflection, bulging, distortion or loosening 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 Employer 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 Employer 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.

8.4.1.3 Temporary openings for cleaning, inspection and for pouring concrete may be provided at the base of vertical forms and as may be directed by the Employer. The temporary openings shall be so formed that they can be conveniently closed when required and must not leave any mark on the concrete.

8.4.2 Cleaning and Treatment of Forms

8.4.2.1 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. Along with wire brushes, brooms, etc. compressed air jet and/or water jet shall be kept handy for cleaning, if directed by the Employer.

8.4.2.2 Before shuttering is placed in position the form surface in contact with concrete shall be treated with approved non-standing oil or composition of other material approved by the Employer. 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.

8.4.2.3 If formwork for pedestal/chimney 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.

8.4.3 Removal of Forms

8.4.3.1 The Contractor shall begin the removal of formwork only after approval of Employer. 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 there from. This record shall be checked and countersigned by the Employer. The Contractor shall be responsible for the safe removal of
formwork but the Employer may delay the time of removal if he considers it necessary. Any work showing signs of damage through premature removal of formwork or loading shall be entirely reconstructed without any extra cost to Employer.

8.4.3.2 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 Employer.

8.4.3.3 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 Employer.

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.

8.4.4 Re-use of Forms

Before re-use, all forms shall be thoroughly scrapped cleaned and joints, etc. shall be examined, and when necessary repaired and inside surface treated as specified. Formwork shall not be used/re-used, if declared unfit or unserviceable by the Employer.

8.5 Back Filling

8.5.1 General Requirement

8.5.1.1 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 Employer.

8.5.1.2 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 Employer.

8.5.1.3 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 Employer. The soil may have to be brought from a distance up to 2 km. By the shortest haulage route as approved by the Employer. If directed by the Employer, the excavated earth from the adjoining areas (which is to be disposed off up to a distance of 500 meters by manual labour) shall be used as for back filling purpose.
8.5.1.4  Back filling shall not be dropped directly upon or against any structure where there is danger of displacement or damage.

8.5.1.5  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 Employer. Pushing of earth for back filling shall not be adopted under any circumstances.

8.5.1.6  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 Employer. Finished surface shall be free of irregularities and depressions and shall be within 50mm of the specified level.

8.5.1.7  Any additional quantity of back filling, if required, beyond the excavation payment line shall be done by the contractor at his own expense.

8.6  Construction Joints

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 Employer 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 Employer, 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 soffit of the beams framing into it.

   ii) Concrete in tie 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 Employer.

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 Employer. 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 construction joints.

8.6 Curing and Protection of Concrete

Newly placed concrete shall be protected by approved means from rain, sun & wind. Concrete placed below ground level shall be protected from falling earth during and 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 three days or as otherwise instructed by the Employer after placing of concrete. 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 Employer, 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 Hessian or similar absorbent 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 Employer. 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, floatation etc. that may impair the strength and durability of the concrete. Approved curing compound can be used with the permission of the Employer. Such compound shall be applied to all exposed surfaces of the concrete as soon as possible after the concrete has set.

9.0 Pile Installation

Installation of piles shall be carried out as per pile layout drawings, installation criteria, technical specifications and the directions of the Employer.

9.1 Equipment and Accessories
9.1.1 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 Employer.

9.1.2 The capacity of the rig shall be adequate so as to reach the specified founding level.

9.1.3 Provision shall be kept for chiseling within the pile bore, as specified in this specification. Chiseling shall be carried out only with the approval of Employer. The contractor must have the provision of equipment/accessories which can bore in the hard rock strata if required, without any additional cost implication to the Employer.

9.2 Installation Criteria

9.2.1 The Contractor while boring the pile bores, shall constantly collect the bore spoils and these shall be compared with the layer wise 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 Employer.

9.2.2 Whenever the rock strata is encountered in the pile bore, the Contractor shall immediately report the matter to the Employer and shall take up the work of rock chiseling or any other suitable method only after the certification/approval of the Employer. Since the piles are required to be terminated in the firm/hard strata and as stipulated in the construction drawing the Contractor shall demonstrate such founding strata and seek approval of the Employer before terminating the piles.

9.2.3 The pile should be socketed and founded in good rock only. Whenever rock strata is encountered at any pile bore and the level of good rock (i.e. rock strata is not highly fractured and weathered and core recovery is not less than 80% with RQD 70%) is different than that is given in the Geotechnical Investigation report, in that case to establish the level of good rock, core drilling is necessary to be carried out at least upto 5m depth in rock strata encountered by the contractor without any additional cost implication to EMPLOYER and no time extension will be permitted on this account.

9.2.4 In order to verify the terminating depth, where rock strata is met with, the rock samples obtained from the bore spoils of pile shall also 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 zone shall be done with prior approval of the Employer.

9.3 Control of position and alignment

Piles shall be installed vertically as accurately as possible as per the construction drawing. The permissible limits for deviation with respect to
position and inclination/alignment shall conform to IS-2911 (Part I/Sec.2), as reproduced below.

9.3.1 Maximum permissible deviation in alignment is 1.5%. Piles should not deviate more than 75mm or D/10 which ever is less from their positions at the working level. In case of piles deviating beyond these limits, the piles should be replaced or supplemented by one or more additional piles including the revised cap size (as the situation may be) at no additional cost to the Employer. Any extra claim whatsoever from the contractor on this account shall not be entertained.

9.4 Boring

9.4.1 Boring operations shall be done by rotary or percussion type drilling rigs using Direct Mud Circulation (DMC), Reverse Mud Circulation (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 cohesion less 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 along with their bid, complete details regarding the installation of piles and the method by which they wish to install the piles.

9.4.2 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 Employer at no extra cost to the Employer.

9.4.3 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 center line of guide casing shall be checked before continuing further boring. Guide casing shall be minimum 2.0m length. Additional length of guide casing shall be used depending on the conditions of the strata, ground water level etc. as required by the Employer without any additional cost to the Employer.

9.4.4 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.
9.4.5 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 re-circulated back to the boring. The bentonite slurry mixing and re-circulation plant shall be suitably designed and installed.

9.4.6 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.

9.4.7 The size of cutting tools shall not be less than the diameter of the pile as specified in the drawing and not more than 75mm.

9.5 Chiseling

9.5.1 Chiseling, if required, may be resorted to with the permission of the Employer below the socketing horizon. The chiseling tool or bit shall be of adequate size and weight so as to reach the desired depth.

9.6 Cleaning of Pile bore

9.6.1 After completion the pile bore up to 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.

9.6.2 Pile bore shall be cleaned by fresh drilling mud through tremie pipe before start of concreting and after placing reinforcement.

9.6.3 Pile bore spoil along with used drilling mud shall be disposed off from site up to 2 Km. or as directed by the Employer.

9.7 Adjacent Structures

9.7.1 When working near existing structures care shall be taken to avoid any damage to such structures.

9.8 Concreting

9.8.1 Concreting shall not be done until the Employer is satisfied that the bearing strata (soil/rock) met with the termination level of pile, satisfied the installation criteria/approved founding depth.

9.8.2 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 Employer 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.

9.8.3 Pile bore bottom shall be thoroughly cleaned to make it free from sludge
or any foreign matter before and after placing the reinforcement cage.

9.8.4 Proper placement of the reinforcement cage to its full length shall be ensured before concreting.

9.8.5 Entire concreting in pile bores 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.

9.8.6 Concreting operations shall not proceed if the contaminated drilling mud at the bottom of the pile bore possess 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 Employer thereafter.

9.8.7 Consistency of the drilling mud suspension shall be controlled throughout concreting operations in order to keep the bore stabilised as well as to prevent concrete getting mixed up with the thicker suspension of the mud.

9.8.8 It shall be ensured that volume of concrete poured is at least equal to the theoretically computed volume of pile shaft being cast.

9.8.9 The temporary guide casing shall be entirely withdrawn cautiously, after concreting is done up to the required level. While withdrawing the casing concrete shall not be disturbed.

9.8.10 Tests on concrete cubes shall be carried out as specified in this section of the Specifications.

9.9 Cut-off-level (COL)

9.9.1 Cut-off-level of piles shall be as indicated in approved construction drawings or as directed by the Engineer-in-Charge.

9.9.2 The top of concrete in pile shall be brought above the COL to remove all laitance and weak concrete and to ensure good concrete at COL for proper embedment into pile cap.

9.9.3 When the pile cut off level is less than 1.0 meter below the working level, concrete shall be cast up to the piling platform level to permit overflow of concrete for visual inspection. In case COL of pile is more than 1.0 meter below working level then concrete shall be cast to minimum of one meter above COL.

9.9.4 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 Employer.

9.10 Sequence of Piling

9.10.1 Each pile shall be identified with a reference number and date wise proper record of construction shall be maintained by the Contractor.

9.10.2 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.

9.11 Building up of Piles

9.11.1 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 of concrete with minimum cement content 400kg/m³, ensuring proper continuity with the existing concrete and to the satisfaction of the Employer. 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.

9.12 Breaking off of Piles

9.12.1 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 Employer. No extra payment shall be made on this account.

9.13 Preparation of Pile head

9.13.1 The soil surrounding the piles shall be excavated up to the bottom of the lean concrete below the pile cap with provision for working space sufficient enough to place shuttering, reinforcement, concreting and any other related operations.

9.13.2 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.

9.13.3 The projected reinforcement above COL shall be properly cleaned and bent to the required shape and level to be anchored into the pile cap as shown in the drawing.

9.13.4 The pile top shall be embedded into the pile cap by minimum 50mm or clear cover to reinforcement, whichever is higher.
9.13.5 All loose material on the top of pile head after chipping to the desired level shall be removed and disposed off up to a lead of 2km or as directed by the Employer.

9.14 Rejection and Replacement of Defective Piles

9.14.1 The Employer reserve the right to reject any pile which in his opinion is defective with reference to technical specification & construction drawings 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 Employer without affecting the performance of adjacent piles. The Contractor shall install additional piles to substitute the defective piles as per the directions of the Employer at no extra cost to the Employer.

9.14.2 During execution of pile foundation work, if the bore holes need to be abandoned due to any reason and pile position to be shifted or realigned, other than for any design requirement by the Employer, fresh bore holes are to be executed at a suitable new position, which may vary from 2D to 3D (where, D is diameter of pile) as decided by the Employer, which may demand for resizing of pile cap including possible increase in reinforcement quantity due to resizing of pile cap. In all such cases the abandoned bore holes are to be filled up with plain cement concrete (1:3:6) so that no cavity remain in the bore hole of the abandoned pile. Any extra claim whatsoever from the contractor on account of abandoned bore hole, filling up of abandoned bore hole with concrete and any extra cost due to resizing of pile cap including increase in reinforcement quantity shall not be entertained by the Employer & the same have to be born by the contractor.

9.15 CRITERIA FOR TERMINATING THE PILES

9.15.1 The piles can be terminated at a depth based on design developed by the Employer, where loads on 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 construction drawing.

9.15.2 Standard penetration test (SPT) shall be carried out starting from 1.0 M above the specified pile termination depth and there after @ 1m. up to the pile termination depth.

9.15.3 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 borehole by means of a 650 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 blows shall be recorded for every 150 mm 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 25 mm 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.

9.16 Recording of Piling Data

9.16.1 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 Employer within two days of completion of concreting of the pile.

9.17 Check for Pile bore

9.17.1 On completion of boring and cleaning the bottom of each pile bore shall be checked by the methods as approved by the Employer, 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 Employer.

9.17.2 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.

9.18 Properties of drilling mud

9.18.1 Properties of drilling mud shall be checked as per requirements indicated in Annexure ‘C’ prior to the commencement of piling work and thereafter at least once in a week or as found necessary by the Employer, one sample consisting of 3 specimens shall be tested.

9.18.2 Density and sand content of the drilling mud shall be checked in each pile.
10.0 Erection of Steel Embedded Parts

10.1 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 drawings.

10.2 The supply of embedded steel parts like ladders, steel pieces set in concrete inserts, dowel bars required for construction joints etc. are in the scope of the Contractor. However, supply of anchor bolts/stubs, as the case may be, will be supplied by tower contractor.

10.3 Embedded steel parts shall include items such as foundation anchor bolts, stubs, ladders, steel pieces set in concrete inserts, dowel bars for concrete work, etc. shown on the drawing or as required by the Employer. Material shall also include setting in forms for connecting in place and grouting as required. The grouting operations, if required, shall be performed as per the direction of Employer.

10.4 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 : 816.

10.5 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 Employer. The threads of holding down bolts shall be greased and protected with water proof tape.

11.0 Installation

11.1 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.

11.2 Groups of holding down bolts shall be set in such a manner that the tolerance of whole group is not more than 3mm from its true position in plan at the top of the bolt 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 more than 1:500.

12.0 Protection Against Damage in Transit
12.1 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 Employer. Distorted reinforcement bars or plates 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 Employer 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 Employer 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.

13.0 Foundations Bolts

13.1 The foundation bolts / stubs, as required, for the tower structures shall be supplied by the respective tower contractor. These shall be embedded in concrete while the foundation is cast. The Contractor shall ensure the proper alignment of these bolts to match the holes in the base plate and also co-ordinate with the respective tower contractor for its correctness. 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 shall include the cost of above adjustments, grouting, and skins etc. required for this purpose.

13.2 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.

13.3 Before erection of towers, by tower contractor, on the 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 piling 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 cost for any such work or material. No steel structures shall be erected on their foundations unless such foundations have been certified fit for
erection by the Employer. Adequate number of air release holes and inspection holes shall be provided in the base plate.

14.0 Stability of Structure

14.1 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 guy ing to ensure adequate resistance to wind and also to loads due to erection equipment and their operations. Guying and bracing shall be done for 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 guy ing, the Contractor shall not use other structures in the vicinity which are likely to be damaged by the guy.

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.

15.0 Grouting and under Pinning

15.1 General requirement

15.1.1 Furnishing of all labour materials and equipment and performance of all operations necessary to complete the work of grouting of block outs 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.

15.1.2 Grouting shall be adopted for filling the block outs, pockets below foundation bolt holes. The block out and bolt holes which have to be grouted shall be cleaned thoroughly by use of compressed air immediately before taking up the grouting operations.

15.1.3 Cement and alluminium 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. Admixture should be according to IS:9103.

15.1.4 The quantity of aluminum 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 block outs, 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
block out 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.

15.1.5 Under pinning 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 cement 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 Employer. 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 aggregate and water in proportion of 1:1.25:2:0.4 by weight. In all cases minimum 28 days cube strength should not be less than 25N/mm².

Shims provided for the alignment of 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.

15.1.6 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.

15.1.7 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.

15.1.8 When it is clear that the center of base has been properly filled, the mortar outside the base plate shall be briefly rammed to ensure compaction below the edges. Any mortar which has been mixed for a period longer than half an hour, shall not be used in the work.

15.2 Materials
15.2.1 Cement shall conform to the stipulations contained in IS:8112 and shall have a fineness (specific surface of cement) not less than 225 sq.m./kg when tested for fineness by Blaine’s air permeability method as per IS:4031.

15.2.2 Sand shall conform to the stipulations contained in IS:383.

15.2.3 Water shall be clean and fresh and shall be of potable quality.

15.2.4 Aluminium powder or anti-shrinkage admixture like ‘Groutex’ CRS-NS grout or its equivalent shall be of standard brand from reputed manufacturer and shall be approved by the Employer prior to its use for work.

15.3 CURING

The work shall be cured for a period of 7 days commencing 24 hours after the completion of the grouting and under pinning operations. The curing shall be done by covering the surfaces with wet gunny bags.

16.0 Bar Grips

16.1 This covers the technical requirement for furnishing and installation of bar grips complete including all labour materials, equipments, staging, etc.

16.2 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 Employer.

17.0 Splicing

17.1 a) The reinforcement bars are to be joined 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 in situ.

17.2 The joints shall be staggered as far as possible. Necessary staging arrangements are to be made by the Contractor.
17.3 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 Employer.

17.4 The length of the sleeve should be adequate, that it is safe under the pull out loading conditions.

17.5 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.

17.6 All bar grips installation shall be subject to inspection and approval by the Employer before concreting operation are performed. In case of any defect or joint being not up to mark, the same shall be replaced by the Contractor at no extra cost.

18.0 **MS Liner**

MS liner shall be provided wherever included in the construction drawings released by the Employer and/or otherwise required by the Employer. For MS liner the technical specifications stipulated at Part-V shall apply.
SECTION-X (Part-III)

RATES AND MEASUREMENTS
### SECTION – X (Part-III)

**RATES AND MEASUREMENTS**

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SECTION – X (Part-III)

RATES & MEASUREMENT

1.0 Excavation

1.1 The unit rate for excavation shall be quoted by the Bidder in the respective schedule of BPS for Lattice tower locations and is included in other items indicated at pole locations. The unit rate quoted shall hold good for excavation (other than boring) for all depth and size in all types of soil including sheet piling, sheeting, shoring, bracing, draining, dewatering, cofferdams etc. as required for successful completion of job. The excavation shall be carried out in accordance with stipulations in Part-II of this Specification.

1.2 The unit of measurement shall be in cu.m. The design excavation volume shall be calculated considering dimension of pile cap plus 150mm on all sides of the pile cap and depth as shown in the drawing below the lean concrete level. The payment shall be made based on unit rate quoted, for excavation actually carried out or as per the design excavation volume as calculated above, whichever is less. No extra payment shall be admissible for excavations if required to be carried out in slope to maintain stability of pit.

1.3 The Contractor shall arrange to transport the excavated soil to a distance as directed by Employer and the rates quoted for excavation in Price schedule shall include all lead, lift, carriage etc.

2.0 Cement Concrete

2.1 Actual volume of work as executed or as per drawing issued, whichever is less, measured in cubic meter corrected up to second place of decimal shall be considered for payment as per unit rate quoted in BPS. Deductions for openings, conduits, pipes, ducts, pockets etc. shall only be made provided they are larger than 0.1 sq.m. in area (for each opening ).

2.2 No deduction shall be made for embedded fixtures including reinforcement, sleeves, anchor bolts and similar items.

2.3 The volume for structural concrete and lean concrete shall be measured separately.

3.0 Form Work

3.1 Formworks of different types / shapes shall be measured with reference to actual surface area in contact with the concrete and paid on area basis. The unit of measurement will be in sq.m. corrected upto second place of decimal.

3.2 No payments for formwork for construction joints shall be made.

3.3 Opening up to 0.1 sq.m. of boxing left for inserts etc. shall not be considered as if non-existent for the purpose of formwork measurement of surface in which the opening occur. If the cross-
sectional area of any openings exceeds 0.1 sq.m., area of such openings shall be measured and deducted from the area payable for the form work.

3.4 No payment shall be made for making the formwork water proof or for supports, scaffolding, centering, approaches, etc.

3.5 No separate payment shall be made for using fillets for rounding of chamfering junctions, corners, etc.

4.0 Back filling

The actual volume of backfilling shall be measured in cubic meter rounded off up to 2\textsuperscript{nd} place of decimal and the unit rate wherever applicable shall include all the necessary operations required to complete the work as per drawing & Part-II of this Specifications.

5.0 Reinforcement Steel

5.1 The unit rate for reinforcement steel shall include supply and placement of reinforcement steel of specific grade, stirrups, annealed wire for binding the reinforcement, chairs, hangers, spacers, welding, tack welding etc. as required to complete the RCC work in pile, pile cap, pedestal/chimney, tie beam (if required) including cleaning, straightening, cutting, bending, binding etc. The unit rate shall also include placement of reinforcement cage in pile shaft/bore and all other cost for tools, plants, materials, labour, transportation to site by appropriate means as required. The payment of reinforcement steel shall be made based on working drawing. Wastage, overlaps, spacer bars, chairs, stays, hangers, annealed steel wire shall not be measured for the payment and cost of these items shall be deemed to be included in the rates of reinforcement.

5.2 Standard hooks, cranks, bends, authorised laps, etc. shall be measured.

5.3 Separator pieces between two or more layers of steel shall not be measured.

5.4 No payment shall be made for supports, spacers, chairs, hangers, etc. of height/length of 300mm and less, required for keeping the steel in position. For supporting horizontal reinforcement at heights, drawings for supports, spacers, chairs, hangers, etc. larger than 300mm, shall be prepared by the Contractor and got it approved from Employer. Payment shall be made for these supports as approved by the Employer, or as actually provided, whichever is less, as per the unit rate quoted for reinforcement.

5.5 No extra payment shall be made for modification of already embedded reinforcement, if required due to faulty fabrication or placement.

5.6 Dowels as required for completion of the work shall be provided by the contractor which will not be separately calculated for payment.

6.0 Piling work
6.1 The items of work are briefly described in the BPS. The various items in the BPS shall be read in conjunction with the corresponding sections/parts in the Technical Specifications, including amendments, and additions, if any. The unit rate quoted for items shall include all the activities covered in the description of the item as well as all necessary operations described in the specification and any other specific requirements.

6.2 The unit rates wherever applicable shall also include all minor activities which are obviously and fairly intended, though may not have been clearly brought out in the description of items or in these documents, but are essential for the satisfactory completion of the work.

6.3 Unit rates shall also include for all safety measures as required by codal provisions, local regulations, acts, bye-laws, etc. and mobilization of all plant, equipment, scaffolding, materials, skilled and unskilled labour, de-mobilisation after completion of work, supervision, establishing level and coordinates at each location by carrying levels from one established bench mark and distances from one set of grid lines furnished by the Employer.

6.4 Unit rate wherever applicable on per meter length basis for a particular diameter of pile shall remain unchanged irrespective of the actual length/depth of individual piles executed at any location.

6.5 Unit rate wherever applicable for pile boring through all kind of soil, including weathered rocks, laterite, shell, hard rock shall be inclusive of cost of boring by approved method, bailing out all the pile bore spoils from the pile bore, keeping the bore hole free from bored material/debris etc. and disposing same along with the drilling mud up to 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 including necessary materials, equipment and manpower.

6.6 Unit rate wherever applicable quoted for pile boring through soil including weathered rocks, laterite, shell, hard rock shall include shifting of plant and equipment from one pile location to another location, providing temporary casing as required and removal of the same after completing concreting. 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.

6.8 Unit rate wherever applicable 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 up to 2 kms., flushing the pile bore by fresh bentonites before concreting, collection of samples from bottom of the pile bore, transporting to laboratory, testing and reporting of results.

6.9 Unit rate wherever applicable of pile boring shall include concreting in piles by tremie method only, cost of preparation of pile head and disposal of debris etc., resulting from breaking off of pile up to COL, up

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to a distance of 2 km.

6.11 Unit rates wherever applicable 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.

6.12 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 chiseling operations, and shall be inclusive of transportation to laboratory, testing and reporting of the results.

6.13 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 or ground level whichever is lower through soil/weathered rock up to termination/founding level as per drawing or actual length achieved of the pile in meters, up to second place of decimal.

7.0 Standard Penetration Test (SPT)

The actual quantity of SPT done shall be calculated in nos. and the unit rate wherever applicable quoted shall include all the necessary equipments, labour, materials, operations etc. required to complete the work as per Part-II of this Specifications.

8.0 MS LINER

8.1 The items of works are briefly described in the BPS for lattice tower locations. The various items in the BPS wherever applicable shall be read in conjunction with the Part-V of this Specifications. The unit rate wherever applicable quoted for items shall include all the activities covered in the description of the item as well as all necessary operations described in the specification and any other specific requirements.

8.2 The unit rates wherever applicable shall also include all minor activities which are obviously and fairly intended, though may not have been clearly brought out in the description of items or in these documents, but are essential for the satisfactory completion of the work.

8.3 The measurement for payments shall be made in Metric Tonne (MT) corrected upto third place of decimal based on the calculated weight of the M.S. liner as per construction drawing and with reference to the sectional weights of respective thickness of M.S. plate as per Indian Standards or M.S. liner actually provided, which ever is less. The unit rate quoted shall be inclusive of all wastage.

9.0 Pile Integrity Test

The actual quantity of pile integrity test done shall be calculated in nos. and the unit rate wherever applicable quoted shall be include all necessary equipments, manpower, labour, materials, operations etc. required to complete the work as per Part-IV of this Specification. The payment shall only be made after successful completion of the job and submission of complete report for each no. of test.
SECTION-X (Part-IV)

TESTING AND ACCEPTANCE CRITERIA
### TESTING AND ACCEPTANCE CRITERIA

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SECTION –X (Part-IV)

TESTING AND ACCEPTANCE CRITERIA

1.0 Construction Materials

1.1 Any material considered to be Sub-standard or not meeting the Specifications as described in Section – IX, Part-II, of this Specification and as declared/certified accordingly by the Purchaser shall not be used by the Contractor and shall be removed from the site immediately at no extra cost to the Purchaser.

2.0 Cement Concrete

2.1 Testing

2.1.1 The Contractor shall carry all sampling and testing in accordance with Standard Field Quality Plan (SFQP) as enclosed with this Specification, relevant Indian Standards and this Specification at his own cost in field and in a laboratory approved by the Purchaser. For the tests carried in the laboratory contractor shall the test results to the Purchaser in triplicate within 7(seven) days after completion of the test.

2.1.2 Facilities required for sampling and testing materials, concrete, etc. in field and in laboratory shall be provided by the Contractor. 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 Purchaser. Tests shall be done in the presence of the Purchaser or his authorised representative. In case the Purchaser requires additional test, the Contractor shall arrange to get these tests done and submit to the Purchaser the test results in triplicate within three days after completion of any test.

2.1.3 The Contractor shall maintain records of all inspection and testing, which shall be made available to the Purchaser, whenever required.

2.1.4 The testing apparatus/equipment installed in the field laboratory shall be calibrated / corrected by the qualified person as frequently as possible to give accurate testing results.

2.1.5 Frequency of sampling and testing, etc. and Acceptance Criteria should be as per SFQP. However, Purchaser 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 tables of Standard Field Quality Plan are for cross checking at site to ascertain the conformity of the materials to the Specifications.

2.1.6 One sample consisting of six test cubes shall be made from the
concrete used in each pile, three to be tested after 7 days and three after 28 days.

2.1.7 In preparation of test cubes/specimens vibrators shall not be used.

2.1.8 Concrete shall be tested for slump at every 1 hour interval.

2.2 Acceptance Criteria for Concrete

a) The acceptance criteria of concrete shall be in accordance with Standard Field Quality Plan (SFQP) and as per Section – IX, Part-II of this Specification.

b) 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 Purchaser.

c) 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>
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<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 Pedestal/chimney and for concrete to receive grouted plant or structural steel work</td>
<td>+5 -5</td>
</tr>
<tr>
<td>Alignment of tie beams, Pedestal/chimney, pile cap</td>
<td>+5 0</td>
</tr>
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<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</td>
<td>+10 -5</td>
</tr>
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</table>
Design, Supply, Installation and Commissioning of Kushma-New Butwal 220 kV Transmission Line

assemblies

Alignment of holding down bolts assemblies  
+5  -5

Centers of pockets or holes with greatest lateral dimensions not exceeding 150mm  
+5  -5

Centers of pockets or holes with greatest lateral dimension exceeding 150mm.  
+10  -5

2.3  Acceptance criteria of Finished Concrete

2.3.1  Finished concrete shall be true to shape, lines, levels plumb and dimensions as shown on drawings.

2.3.2  All embedded fixtures shall be of correct type and in correct position as shown in drawings.

2.3.3  Finished concrete surface shall be free from blemishes like honeycombs, air bubbles, fins, etc.

2.3.4  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 Purchaser.

2.3.5  The finished concrete shall be of a standard quality and equal to the accepted sample.

3.0  Reinforcement Steel

Reinforcement shall be checked for cleanliness, proper bending, binding, placing and securing in position with provision for proper cover. The reinforcement should conform to the requirement of Section – IX, Part-II of this Specification.

4.0  Testing for position and alignment

4.1  Each pile shall be checked for its position with respect to specified location. Each pile bore shall be checked for its alignment.

4.2  Permissible limits for deviation shall be as specified under SECTION-IX, Part-II of this Specification.

5.0  Properties of drilling mud

5.1  Properties of drilling mud shall be checked as per requirements indicated in Annexure ‘C’. Prior to the commencement of piling work and thereafter at least once in a week or as found necessary by the Purchaser, one sample consisting of 3 specimens shall be tested.

5.2  Density and sand content of the drilling mud shall be checked in each pile.
6.0 Check for Pile bore

6.1 On completion of boring and cleaning the bottom of each pile bore shall be checked by the methods as approved by the Purchaser, 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 Purchaser.

6.2 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.

7.0 Pile Integrity Test

7.1 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.

7.2 The equipments consists of a electronic control unit, a hand-held instrumented hammer and an accelerometer and computer.

7.3 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 lattiance. 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.

7.4 The results to be stored in a compact control unit and transferred to computer and detail analysis to be carried out.

7.5 The contractor is to submit a detailed report for the data specified in cl. 7.1 above and as required by the Purchaser.
SECTION-X (Part-V)

M. S. LINER
SECTION – X (Part-V)

M.S. LINER

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SECTION –X (Part-V)

M.S.LINER

1.0 Structural steel MS liner for R.C.C Vertical bored piles

1.1 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.

M.S. liner shall be provided to piles at locations, as directed by the Purchaser. The extent up to 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 Purchaser.

1.2 Drawings

1.2.1 Contractor shall submit calculations and fabrication details for connection/splice/joint for fabrication of liners and get these approved by the Purchaser 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.

1.2.2 Purchaser 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 Purchaser shall entertain no extra claim on this account. All revisions in the drawings should be highlighted in the drawing distinctly.

1.2.3 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.

1.2.4 In the case of variations in drawings and specifications, the decision of the Purchaser shall be final. In case Contractor in the execution of his work, find discrepancies in the information furnished by Purchaser, he shall refer such discrepancies to the Purchaser before proceeding with such work.

1.3 Fabrication

1.3.1 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 Purchaser.

1.4 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 Purchaser in writing.

1.5 **Welding**

1.5.1 Welding shall be in accordance with IS:816, IS:819, IS:1024, IS:1261, IS:1323, IS:4353 and IS:9595, as appropriate.

1.5.2 For welding of any particular type of joint, Contractor shall give evidence acceptable to the Purchaser of having satisfactorily completed appropriate tests as described in any of the Indian Standards - IS:817, IS:1393, IS:7307 (Part J), as relevant and as per the checklists given in the Annexure to this section of the specification.

1.5.3 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.

1.5.4 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 Purchaser 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.

1.5.5 “Open-Arc-Welding” process employing coated electrodes shall be employed for fabrication of other welded connections and field welding.

1.5.6 Wherever welding is done for assembling the components of liner, the job shall be so positioned that down hand welding is possible. In cases where such positioning of job is not possible other manual welding positions could be resorted to.

1.5.7 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.

1.5.8 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.
1.5.9 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 Purchaser. The edge form of weldments shall be prepared either by machines or by automatic gas cutting with surface rougher of the welding area not exceeding 50sq.mm. All edge cut by flame shall be ground before they are welded.

1.5.10 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.

1.5.11 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.

1.5.12 Specific approval of the Purchaser shall be taken by the Contractor for the various electrodes proposed to be used on the work before any welding is started.

1.5.13 Electrodes larger than 5mm diameter shall not be used for root-runs in butt-welds.

1.5.14 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.

1.5.15 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.

1.5.16 Prequalified 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 Purchaser for approval.
before start of welding. This shall include all details of welding procedures with references to provisions of IS:9595 and IS:4353. Approval of the welding procedure by Purchaser shall not relieve Contractor of his responsibility for correct and sound welding without undue distortion in the finished structure.

1.5.17 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.

1.5.18 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.

1.6 Pre-Heating Inter-run Temperature and Post Weld Heat Treatment.

i) Welding of mild steel shall not be undertaken when the plate temperature is $0^\circ C$ 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</td>
<td>IS:8500 or steel IS:2062 steel</td>
</tr>
<tr>
<td>Up to 20mm incl.</td>
<td>Welding by this electrode</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td></td>
<td>10 deg.C</td>
</tr>
</tbody>
</table>

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 $0^\circ C$, 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 inter-pass 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.

1.7 **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.

1.7.1 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.

1.7.2 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.

1.7.3 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 un-melted.

1.7.4 Pudding shall be sufficient to enable the gases to escape from the molten metal before it solidifies.

1.7.5 Non-uniform heating and cooling should be avoided to ensure the excessive stresses are not locked up resulting ultimately in cracks.

1.7.6 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.

1.7.7 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.

1.7.8 Intermittent welds shall not be permitted without the approval of the purchaser. These shall be permitted only when specifically approved in the fabrication drawings.

1.7.9 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 Purchaser.

1.7.10 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.

1.7.11 The correction of defective welds shall be carried out as directed by Purchaser 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 purchaser shall be used to ensure that the whole of the crack and material up to 25 mm beyond each end of the crack has been removed. Cost of all such test and operations incidental to correction shall be to Contractor’s account.

2.0 Inspection and Rectification

2.1 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.

2.2 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 re-welded. 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 Purchaser.

2.3 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.

2.3.1 Random die penetration tests shall be conducted after welding of M.S. liner plates.

3.0 ERECTION MARKS

3.1 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 purchaser well in advance of the erection.

3.2 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.

3.3 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 numerals in addition to the
common erection mark.

4.0 Errors

Any error in shop work which prevents proper assembling and fitting of parts in the field, moderate use of drift pins or moderate amount of reaming will be classified by Purchaser as defective workmanship. All charges incurred by Purchaser 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 purchaser chooses to reject the material because of poor workmanship the cost of all handling and returning the material to 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.

5.0 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 Purchaser. Distorted steel shall not be used in fabrication unless the distortion are minor which in the opinion of the Purchaser 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 Purchaser 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.

6.0 Anti Corrosive Treatment for Mild Steel Liners

6.1 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-250 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-250 microns. The physical properties of primer and top coat shall be as given below.
6.2 Technical data of Priming material

Binder content 45%  
Total Solids 45%  
Solvent 55%  
Viscosity 16 (Ford Cup No.4)  
Density 0.88  
Flash point +40°C  
Anti-porosity 80/99 in one and two layers, respectively  
Heat-resistance 170/220 continuously & short period strain.  
Contact angle 5° (Lorentzon & Westtress)  
Covering Capacity 12-20 Sq.m./litre  
Layer thickness 12/25 on glossy/coarse surface  
Homogeneity No sediment  
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 2 hrs for continuous penetration between layers  
Lustre Semi-glossy  
Colour Lightly yellowish  
YSAM group 2  
Injurious to health No  
Physiological condition No dangerous gas generation when welding  
Application Airless spray equipment or conventional painting with roll/brush.  
Cleaning of equipment White spirit
6.3 Technical particulars of final coat

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<thead>
<tr>
<th>Parameter</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>System</td>
<td>Two Components</td>
</tr>
<tr>
<td></td>
<td>Component A : Base Part</td>
</tr>
<tr>
<td></td>
<td>Component B : Accelerator Part</td>
</tr>
<tr>
<td>Colour</td>
<td>Black</td>
</tr>
<tr>
<td>Mixing Ratio</td>
<td>1:1 by Weight</td>
</tr>
<tr>
<td>% Solid by Weight</td>
<td>More than 95%</td>
</tr>
<tr>
<td>Pot Lift (Temp.27°C</td>
<td>2 hours</td>
</tr>
<tr>
<td>Relative humidity 65%)</td>
<td></td>
</tr>
<tr>
<td>Setting Time (At 22°C</td>
<td>4-5 hours</td>
</tr>
<tr>
<td>Relative humidity 65%)</td>
<td></td>
</tr>
<tr>
<td>Fully cured</td>
<td>7 days</td>
</tr>
<tr>
<td>Density of cured mass</td>
<td>1.35</td>
</tr>
<tr>
<td>Flash Pt. of blended product</td>
<td>40°C (104°F)</td>
</tr>
<tr>
<td>Hardness</td>
<td>75 Shore D</td>
</tr>
<tr>
<td>Finish</td>
<td>Semi glossy</td>
</tr>
<tr>
<td>Water absorption after 6 mths.</td>
<td>Negligible</td>
</tr>
<tr>
<td>Covering Capacity</td>
<td>1.5 sq.m./Kg (400 Microns thk.)</td>
</tr>
<tr>
<td>Storage Life</td>
<td>1 year in sealed condition.</td>
</tr>
</tbody>
</table>

7.0 Shop Connections

Surfaces to be permanently in contact shall receive a priming coat immediately at the works except where jointed by welding.
SECTION - X (Part-VI)

STANDARDS AND ANNEXURES
### SECTION – X(Part-VI)

**STANDARDS & ANNEXURES**

**CONTENTS**

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LIST OF INDIAN STANDARDS

The construction work of pile foundation shall conform to the following Indian 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 — earthwork.
- **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** Weld able 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.
<table>
<thead>
<tr>
<th>IS</th>
<th>Description</th>
</tr>
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<tbody>
<tr>
<td>IS : 3025</td>
<td>Methods of sampling and test (Physical and chemical) for water used in Industry.</td>
</tr>
<tr>
<td>IS : 3350</td>
<td>Methods of tests for routine control for water used in Industry.</td>
</tr>
<tr>
<td>IS : 3370</td>
<td>Code of Practice for concrete structure for the storage of liquids.</td>
</tr>
<tr>
<td>IS : 3613</td>
<td>Acceptance Tests for Wire Flux Combinations for submerged Arc welding of structural steels.</td>
</tr>
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<td>IS : 3658</td>
<td>Recommended Practice for Radiographic Examination of Fusion Welded Butt Joints in Steel Plates.</td>
</tr>
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<td>IS : 3764</td>
<td>Safety codes for Excavation work.</td>
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<tr>
<td>IS : 4353</td>
<td>Recommendations for Submerged Arc Welding of Mild Steel and Low Alloy Steels.</td>
</tr>
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<td>IS : 4656</td>
<td>Form vibrators for concrete.</td>
</tr>
<tr>
<td>IS : 4701</td>
<td>Code of practice for earth work on canals.</td>
</tr>
<tr>
<td>IS : 8500</td>
<td>Specification for weldable structural steel (medium and high strength qualities)</td>
</tr>
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<td>IS : 9103</td>
<td>Admixtures for concrete.</td>
</tr>
<tr>
<td>IS : 10262</td>
<td>Recommended guidelines for concrete mix design.</td>
</tr>
</tbody>
</table>
ANNEXURE - C

SPECIFICATION OF DRILLING MUD (BENTONITE SLURRY)

1.0 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 up to 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

PILE DATA SHEET

1. Reference No. Location (Co-ordinates)_______ 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

INSPECTION & TESTING FOR STRUCTURAL STEEL WORKS

1.0 GENERAL

Contractor shall carry out a comprehensive inspections and testing programme during fabrication and erection. An indicative programme of inspection/testing envisaged by Purchaser 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 Purchaser. 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 Purchaser.

d) If any rolling defect viz, laminations, cracks etc. are found in the steel during processing it 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.

c) 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 Purchaser.

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 thermo chalk 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) Butt welds 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.................................................................

Backing Strip use.................................Type........................................

Welding Process.................................................................

Current Conditions-Polarity.................................................................

Size of Electrode.................................................................

Amperage and Voltage.................................................................

Number of Electrodes used per run.................................

Cleaning method.................................................................

Remarks.................................................................

Engineer-in-Charge Power-Grid (Inspecting Authority)

Signature For and on behalf of Contractor Date:

D. FABRICATION CHECK LIST : ACCEPTANCE PROFORMA

No. _________________________
Design, Supply, Installation and Commissioning of Kushma-New Butwal 220 kV Transmission Line

Section-X- Part-VI
Volume II

ICB-PMD-KGTCP-072/73-04

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Characteristic</th>
<th>As per DRG/FCL</th>
<th>Actual</th>
<th>Accept/Reject</th>
<th>Remarks</th>
</tr>
</thead>
</table>

Power Grid Representative

Contractor’s Representative

Dt. ______________________

Project

Work

Sub-Assy

______________________________

______________________________

______________________________

______________________________

I hereby certify that the work has been carried out as per the specifications.

______________ ______________________

Project ________________________________

Work ________________________________

Sub-Assy ________________________________

______________________________

______________________________

______________________________

______________________________

______________________________

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 ‘’),
 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.