



VOLUME-II

SECTION – 2.2

TOWERS & ACCESSORIES



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SECTION – 2.2

TOWERS & ACCESSORIES

1.0.0 INTENT OF SPECIFICATION

This specification is intended to cover the requirements of engineering, manufacture, assembly, testing at manufacturer's works, proper packing for transportation, loading at shop, transportation to site, erection, testing and commissioning of complete 400 kV Double Circuit (D/C) Transmission Line Towers & Accessories including 500 meter (approximately) Multi Circuit (M/C) Transmission Line Towers & Accessories (near CTU Khavda-II Substation end) and one nos. Gantry Towers with One no. Beam/Girder Structures & Accessories.

2.0.0 SCOPE OF WORK

2.1.0 The scope of work shall include the Design, Engineering, Manufacturing, Fabrication, Proto Type Test, Supply & delivery of:

- a) 9.5 km (approximately), 400kV Single Circuit (S/C) Transmission Line from PSS-1 to KPS-2 on double circuit Towers and their required body extensions as per CBIP-3223 (2014 with latest amendment) and IS-802 (2015 with latest amendment), including stubs, stub setting templates, bolts, nuts and washers, anti-theft type bolts & nuts, hangers, D-shackles, U-Bolts, bird guards and all types of tower accessories like phase plates, number plates, danger plates, circuit plates, anti-climbing devices for all types of towers & their body extensions, design & supply of extensions and special tower if any.
- b)
- c) 14.5 km (approximately), 400kV Single Circuit (S/C) Transmission Line from PSS-2 to KPS-2 on double circuit Towers and their required body extensions as per CBIP-3223 (2014 with latest amendment) and IS-802 (2015 with latest amendment), including stubs, stub setting templates, bolts, nuts and washers, anti-theft type bolts & nuts, hangers, D-shackles, U-Bolts, bird guards and all types of tower accessories like phase plates, number plates, danger plates, circuit plates, anti-climbing devices for all types of towers & their body extensions, design & supply of extensions and special tower if any.
- d)
- e) 5 km (approximately), 400kV Single Circuit (S/C) Transmission Line from PSS-1 to PSS-2 on double circuit Towers and their required body extensions as per CBIP-3223 (2014 with latest amendment) and IS-802 (2015 with latest amendment), including stubs, stub setting templates, bolts, nuts and washers, anti-theft type bolts & nuts, hangers, D-shackles, U-Bolts, bird guards and all types of tower accessories like phase plates, number plates, danger plates, circuit plates, anti-climbing devices for all types of towers & their body extensions, design & supply of extensions and special tower if any. The connected take-off D/C Tower near PSS-1 may be considered with Auxiliary Cross-arm as an alternate to two numbers of double circuit tower. (Bidder shall refer attached drawings)
- f)
- g) 0.5 km (approximately) , 400kV Multi Circuit (M/C)) Transmission Line Towers and their required body extensions as per CBIP-3223 (2014 with latest amendment) and IS-802 (2015 with latest amendment), including stubs, stub setting templates, bolts, nuts and washers, anti-theft type bolts & nuts, hangers, D-shackles, U-Bolts, bird guards and all types of tower



accessories like phase plates, number plates, danger plates, circuit plates, anti-climbing devices for all types of towers & their body extensions, design & supply of extensions.

- h) One nos. 400kV Gantry Towers and One no. required Girder / beam as per CBIP-3223 (2014 with latest amendment) and IS-802 (2015 with latest amendment), including foundation bolts, bolts, nuts and washers, anti-theft type bolts & nuts, U-Bolts and all types of tower accessories for inter-connection between GIPCL PSS-1 & 2 at a later stage.
- i) The chimney of the foundation shall at least be 300 mm square providing a minimum clear concrete cover of not less than 100 mm over any part of the stub angle in case of dry foundations and at least 450 mm square with minimum clear concrete cover of not less than 150 mm over any part of the stub angle in case of wet, partially submerged and fully submerged foundations
- j) The Chimney top must be at least 1500 mm above ground level and also the coping shall be extended up to lower most joint level between the bottom lattices and main corner legs of the tower

2.2.0 For this package, the towers shall be designed for Wind Zone – IV (47m/s), Seismic Zone- V and Corrosion Zone C5-M (as per ISO 12944).

2.3.0 The towers structures to be supplied shall be type tested for the above condition or, the designs shall be of standard approved designs of PGCIL/CTU for the above environment conditions.

3.0.0 CODES AND STANDARDS

3.1.0 The design, manufacturing, fabrication, galvanizing, 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.

3.2.0 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.

3.3.0 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.

Sl. No.	Indian Standard	Title	International Standard
1.	IS: 209	Specification for Zinc	ISO/R/752 ASTM B6
2.	IS: 278	Galvanized Steel Barbed Wire	ASTM A131 ASTM A121

3.	IS: 800-1984	Code of Practice for General Building construction in Steel	CSA 6.1 CSA STEAM 16.1
4.	IS: 802 (Part 1)	Code of Practice for General Building Construction in Steel in Overhead Transmission Line Tower: Materials, loads and Permissible Stress Section- 1: Materials and loads Section-2: Permissible stresses.	ASCE 52 IEC60826 BS 8100
6.	IS: 802 (Part 2)	Code of Practice for use of structural steel in Overhead Transmission Line: Fabrication, Galvanizing, inspection & Packing	ASCE 52
7.	IS: 808	Dimensions for Hot Rolled Steel Beam, Column, Channel and Angle Sections.	
8.	IS: 875	Code of Practice for Design Loads (other than Earthquakes) for Buildings and Structures.	
9.	IS: 1363	Hexagon Nuts (size range M5 to M36)	
10.	IS: 1367	Technical Supply Conditions for Threaded Steel Fasteners	
11.	IS: 1852	Rolling and Cutting Tolerances of Hot Rolled Steel Product	
12.	IS: 1893	Criteria for Earthquake Resistant Design of Structures	IEEE 693
13.	IS:2016	Plain Washers	ISO/R887 ANSI B18-22.1
14.	IS:2062	Steel for general structural purposes	ISO/R/6F30-1967 CAN/CSA G40.21, BS 4360
15.	IS:2551	Danger Notice Plates	
16.	ISO 12944	Corrosion protection of steel structures by protective paint systems	
17.	IS 406	Method of Chemical Analysis of Slab Zinc	
18.	IS 1573-1976	Electroplated coating of Zinc on iron & Steel	
19.	IS 2629	Recommended practice for Hot Dip Galvanizing of iron & Steel	ASTM A 123, CAN/CSA G 164 ISO:1461(E)
20.	IS 2633	Method of Testing Uniformity of Coating of Zinc coated articles	
21.	IS 3043	Code of Practice for Earthing with Amendments 1 & 2	
22.	IS 6745	Methods for determination of weight of Zinc coated iron and Steel articles	ASTM A 90 BS:443-1969 ISO 1460-1973
23.	IS:8500- 1991	Specification for weldable structural steel (Medium and High strength qualities).	BS : 4360

4.0.0 TECHNICAL REQUIREMENTS

- 4.1.0 The basic drawings for all the towers and their extensions shall be provided by Tower Manufacturer and the same design shall be Type tested for the WZ-4, Seismic Zone-V, which shall include structural drawings/erection drawings and / or shop fabrication drawings, Bill of Materials for all the towers and their extensions as well as construction drawings for

foundations. Bidder shall include in their offer the following:

- Design, Proto Fabrication, Assembly and Type Testing (non-destructive type) of new 400kV Double Circuit towers. Bidder may also offer already designed & type-tested tower meeting the above requirement.
- Design, Proto Fabrication, Assembly and Type Testing (non-destructive type) of new 400kV Double Circuit tower with Auxiliary Cross Arm (for tower/s near PSS-1, if opted by the bidder). Bidder may also offer already designed & type-tested tower meeting the above requirement.
- Design, Proto Fabrication, Assembly and Type Testing (non-destructive type) of new 400kV Multi Circuit towers. Bidder may also offer already designed & type-tested tower meeting the above requirement.
- Design, Proto Fabrication, Assembly and Type Testing (non-destructive type) of new 400kV Gantry tower with Girder/ Beam at PSS-1 (for interconnecting transmission line between PSS-1 & 2). Bidder may also offer already designed & type-tested tower meeting the above requirement.
- Bidder shall provide 3D drawings of Tower, accessories, with soft copy and compatible 3D viewer.
- For Type tested towers bidder shall furnish documentary evidences for transmission line tower structures along with foundation design.

- 4.2.0 The tower members can be directly fabricated from the structural/erection drawings wherever the required fabrication details are provided on the same or shop fabrication drawings. Before taking up mass fabrication, the Contractor shall arrange for one number proto-assembly for each type of tower and extensions which shall be inspected by Owner / Owners' representative. After assembly inspection, the Contractor shall incorporate revisions in the drawings. The revised drawings shall be submitted in 3 (three) copies for final approval from the Owner.
- 4.3.0 All the drawings shall have a proper name plate clearly displaying the name of GIPCL on right hand bottom corner. The exact format of the nameplate shall be handed over to the successful bidder for incorporation of the same on all the drawings.
- 4.4.0 While submitting the structural drawings, bill of materials, shop drawings and anyother drawings pertaining to the subject transmission line, the Contractor shall clearly indicate on each drawing GIPCL Specification No., Name of the specific Transmission line and project, letter reference no. and date on which the submission are made. The same practice is also to be followed while submitting distribution copies.
- 4.5.0 The bidder shall submit the tower accessories drawings like number plate, phaseplate, Danger plate, bird guard, circuit plate, step bolt, earthing, etc. after endorsing the name of the project. Also drawing of anti-climbing device, D-shackle etc. shall be prepared by the Contractor and shall be submitted to the Owner / GIPCL, in three (3) copies for approval. These drawings shall be prepared in A4 size only.
- 4.6.0 The drawings prepared and submitted by the Contractor shall be approved / commented by the Owner as the case may be, within Ten (10) days of receipt of drawings in his office. If the designs/drawings are commented by the Owner / GIPCL, the Contractor shall submit revised design/drawings duly incorporating all comments within Ten (10) days of date of issue of comments. The Contractor shall submit three (03) copies of all approved structural drawings and BOM for tower extensions as well as for tower accessories for further distribution.
- 4.7.0 The mass fabrication shall be taken up from the approved shop drawings. The overall responsibility of fabricating tower members correctly lies with the Contractor only and the



Contractor shall ensure that all the tower members can be assembled / fitted while erecting without any undue strain on them.

- 4.8.0 The testing of the towers shall be carried out at Bidder's own test bed or a suitable test bed, where adequate facilities are available. The scope of this specification also provides for development of structural drawings and fabrication shop drawings, Bill of Materials including bolts/nuts and spring washers, section wise steel requirement chart, fabrication and supply of prototype tower and its assembly, inspection, transportation of prototype tower material to the test bed along with bolts/nuts & spring washer and necessary tower accessories required for tower testing, erection of the tower at the test bed and testing the same to the full design load and additional loads as specified for verification of overall capacity of the tower.
- 4.9.0 The Contractor shall also be required to develop stub and stub setting template drawings for all body extensions based on the final approved tower schedule.
- 4.10.0 In addition to the above, the design carried out shall be the most optimum as per the best practices prevailing in the market. The design calculations shall be submitted to GIPCL / Owner for their approval. All subsequent activities shall be governed by clauses stated above.
- 4.11.0 Broken wire condition

The Loads for broken wire conditions shall be considered as per relevant clause of IS 802 (Part1/Sec1):2015. The tower type DD shall be considered as large angle tension tower/Dead end tower

4.12.0 Redundant Design

All redundancy in the towers are to be triangulated. Redundant having an angle of 15 deg or less with horizontal are to be designed for a concentric vertical ultimate load of 1.5KN acting at centre of the unsupported length. The contractor has to furnish the calculation for the same. The redundant shall also be designed for 2.5% of maximum axial load of connecting member (i.e leg members, bracing member, etc,)

4.13.0 Tower Testing procedure

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

i) 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 codesign 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.

ii) Normal Broken Wire Load Tests All the loads, for a particular load-combination test, shall be applied gradually upto 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.

iii) 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

5.0.0 MATERIALS

5.1.0 Tower Steel Sections

- 5.1.1 IS Steel Sections of tested quality of conformity with IS: 2062:2006 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. The Contractor can use other equivalent grade of structural steel angle sections and plates conforming to latest International Standards. However, use of steel grade having designated yield strength more than that of EN 10025 grade S355 JR/JO (Designated yield strength 355 MPa) is not permitted, unless otherwise indicated in this specification.
- 5.1.2 Steel plates below 6mm size exclusively used for packing plates/packing washers produced as per IS 1079 -1994 (Grade -0) are also acceptable. However, if below 6mm size plate are used as load bearing plates viz gusset plates, joint splices etc. the same shall conform to IS : 2062 / or equivalent standard meeting mechanical strength/ metallurgical properties corresponding to grade E250 or grade E350 (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 2062:2006 – grade 350, 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 2062:2006 – grade 350.
- 5.1.3 For designing of towers, preferably rationalized steel sections have been used. During execution of the project, if any particular section is not available, the same shall be substituted by higher section. Any cost on account of the same shall be borne by the Contractor. However, design approval for such substitution shall be obtained from the Board before any substitution and records of such substitutions shall be maintained by the Contractor.
- 5.1.4 All the Towers structure parts (including but not limited to bolts, nuts washer etc.) shall be galvanized considering the corrosion zone of C5-M. The minimum thickness of zinc coating shall not be less than 910 gm/sq. m. (minimum 126 microns, at any point of the structure, Averaging shall not be allowed).

5.2.0 Fasteners: Bolts, Nuts and Washers

- 5.2.1 All tower members shall be joined together with Bolts and nuts. The joints shall be connected with hexagonal bolts and nuts. All hexagonal bolts and nuts shall conform to IS-12427. They shall have hexagonal head and nuts, the heads being forged out of the solid, truly concentric, and square with the shank, which must be perfectly straight. Anti-theft bolts and nuts shall have round tapered heads with hexagonal shear nuts. They shall confirm to IS: 12427 and IS:

1367 for property class 5.6/5 except for dimensions. All bolts and nuts shall be galvanised as per IS: 1367 (Part-13)/IS: 2629. Galvanization shall be considering corrosion zone C5-M.

- 5.2.2 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).
- 5.2.3 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.
- 5.2.4 Nuts for hexagonal bolts shall 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 M 16.
- 5.2.5 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.
- 5.2.6 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.
- 5.2.7 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 3.5 mm in thickness for 16 mm dia bolt and 4.5 mm for 24 mm bolt.
- 5.2.8 **SPACING OF BOLT AND EDGE DISTANCES** : The minimum spacing of bolts and edge distances shall be as given below:

Bolt Diameter (mm)	Hole Diameter (mm)	Minimum Bolt (mm)	Minimum edge hole centre to rolled or swan edge (mm)	Distance of Hole Centre to sheared or flame cut edge
16	17.5	40	20	23
20	21.5	48	25	28

- 5.2.9 **LOCKING DEVICES** : Electro-galvanized spring washers of type B of thickness indicated below corresponding to bolt diameter shall be provided for insertion under all nuts

Bolt Diameter (mm)	Thickness of spring washer (mm)
16	3.5
20	4

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

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

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

6.0.0 TOWER ACCESSORIES

6.1.0 Step Bolts & Ladders

- 6.1.1 Each tower shall be provided with step bolts as per specification drawings.
- 6.1.2 The contractor shall submit distribution copies of the same endorsing the package details (i.e. line name, LOI No. etc.).
- 6.1.3 The step bolts conforming to IS: 10238 of not less than 16mm diameter and 175mm long spaced not more than 450mm apart and extending from 2.5 meters above the ground level to the top of the tower. However, the head diameter shall be 50mm. For Double circuit tower the step bolt shall be fixed on two diagonally opposite legs up to top of the towers.
- 6.1.4 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.
- 6.1.5 The step bolts shall be capable of withstanding a vertical load not less than 1.5 KN.
- 6.1.6 For special towers, where the height of the super structure exceeds 50 meters, ladders along with protection rings, as per OWNER approved design shall be provided in continuation of the step bolts on one face of the tower from 30 meters above ground level to the top of the special structure. In this case the bidder shall supply the relevant drawings of the ladder to OWNER for approval. From 2.5 m to 30m height of super structure step bolts shall be provided.
- 6.1.7 Suitable platform using 6 mm 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.
- 6.1.8 The platform shall be fixed on tower by using counter-sunk bolts.

6.2.0 Insulator Strings and Earth wire Clamps Attachments

- 6.2.1 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.
- 6.2.2 The hanger, extensions links, D-shackles etc. as required and considered in the design of the tower shall have minimum ultimate tensile strength of 120 kN for single suspension string and 160 kN for double suspension string for 400 KV suspension towers.
- 6.2.3 The design and supply of hanger, D-shackles, strain plate, extension link etc. are also in the scope of Contractor.
- 6.2.4 At tension towers, strain plates of suitable dimensions under each cross-arm tip, shall be provided for taking the hooks or D-shackles of the tension insulator strings. Full details of the

attachments shall be provided to the contractor. To achieve requisite clearances, if the design calls for providing extra D-shackles, link plate etc. before connecting the insulator string the same shall be supplied by the Contractor.

6.2.5 Earth wire Clamps Attachments

1) Suspension Clamp

Wherever required, the Contractor shall supply U – bolts, D – Shackles, copper bond etc. for attachment of Suspension clamp to the tower and take OWNER's approval for details of the attachments before the mass fabrication.

2) Tension Clamps

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

6.3.0 Anti-climbing Device & Bird Guard

6.3.1 Barbed wire type anti climbing device shall be provided and installed by the Contractor for all towers. The barbed wire shall conform to IS-278 (size designation A1). The barbed wires shall be hot dip galvanized for C5-M specifications and as per procedure laid down in IS: 4826. The drawings of ACD shall be approved by Owner.

6.3.2 The bird guards for suspension towers shall be made of galvanized (C5-M specifications) iron sheet and shall conform to IS: 5613 (Part-2/Section-1)-1985. Necessary holes shall be provided on the cross arm of the suspension towers for fixing the bird guards. The height of the anti-climbing device shall be provided approximately 2.5 to 3.5 meter above ground level.

6.4.0 Danger, Number, Circuit and Phase plate

6.4.1 Danger Plates, Phase Plates and Number plates shall be provided and installed by the Contractor. Further Circuit plates also shall be provided and installed by the contractor for the Double circuit towers. These Danger/Number/Phase/ circuit Plate shall be as per the drawing enclosed in the section of drawing. The contractor shall submit distribution copies of the same endorsing the package details (i.e. line name, LOI No. etc) and installed by the Contractor. Plates shall be of SS-304 material, letters shall be engraved and shall be visible from at least 3 meter distance.

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

6.4.3 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.

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

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

7.0.0 TOWER FABRICATION

7.1.0 The tower members shall be fabricated in accordance with IS: 802(Part –II) - 1978 with the



latest revision.

- 7.2.0 All parts of towers shall be fabricated in accordance with the shop drawings prepared from approved detailed assembly drawings.
- 7.3.0 Towers shall have bolted connection. Welding shall not be permitted at any point unless otherwise approved by the Owner/GIPCL.
- 7.4.0 The tower members shall be accurately fabricated, so that these could be bolted together easily at site without undue strain on the bolts or members.
- 7.5.0 No angle member shall have the two leg flanges brought together by closing the angle.
- 7.6.0 The structure shall be such that all parts are accessible for inspection and cleaning. Drain holes shall be provided at all points where pockets of depression are likely to hold water. It will be ensured that the stressed members will not have any blank hole after final assembly, except for holes on account of step bolts or, planned holes in stubs.
- 7.7.0 Fabrication of towers shall be carried out in conformity with the latest practice employed in the manufacture of transmission line towers by using power driven cropping, punching, shearing and drilling machines. The extent of various operations shall be governed by relevant Indian standards or any other approved standard specifications and standard practice followed by such operations.
- 7.8.0 All sections before any work is done on them, shall be carefully levelled, straightened and made true to detailed drawing by methods which will not injure the material so that when assembled, the adjacent matching surface are in clear contact throughout. The steel sections shall be straightened and trued by pressure and not by hammering. No rough edge shall be permitted anywhere in the entire structure. The flanges of the angle sections at the ends of members shall be properly chamfered, if there are even slight chances of its fouling with other members or if they cause difficulty in proper tightening of bolts. All clippings, back cuts, grindings, bends, holes etc. shall be as per the detailed drawings and free from burrs.
- 7.9.0 Full interchangeability shall be guaranteed.
- 7.10.0 No welding, filling or plugging shall be permitted unless previously approved. Welding of two or more pieces to obtain length of members specified will not be permitted.
- 7.11.0 All sections, plates and bars, before any work is done on them, shall be straightened, free from twists, carefully levelled and made true to detailed drawings by methods, which will not injure the materials so that when assembled, the adjacent surfaces are in close contact throughout. Hammering shall not be permitted for straightening or flattening of members.
- 7.12.0 Cuttings of members shall be affected by shearing, cropping, flame cutting or sawing. Members preferably over 10 mm thickness shall be sawn, or flame cut followed by grinding. The surface so cut shall be clean, smooth, reasonably square and free from any distortion.
- 7.13.0 Members shall be bent hot, but in case of small bends, the cold bending may be done with the prior approval of the Engineer, provided no fracture of materials occurs. All the bending operations shall be done by pressure. No bending of members shall be done for slope above 450.
- 7.14.0 When members are spliced by a lap joint, heel of inside angles shall be rounded to the minimum possible radius consistent with proper fit with the fillet of the outside angle. The thickness of the ground heel shall not be less than that of leg. Flat heeling will not be allowed.

7.15.0 The fabrication tolerances shall be as per IS: 7215-1974.

8.0.0 DRILLING AND PUNCHING

8.1.0 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.

8.2.0 Holes in the members shall be either punched or drilled with the help of jigs and fixtures. Drilled holes will be preferred. However, members up to 12 mm thickness may be punched. Members over 12 mm thickness shall be drilled. All burrs left after drilling or punching should be removed completely. Holes adjacent to the bend shall be drilled or punched after bending. Tolerances regarding punch holes are as follows: -

- i. Holes must be perfectly circular and no tolerances in this respect are permissible.
- ii. 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 hole should not exceed 0.8mm on diameter.
- iii. Holes must be square with the plates or angles and have their walls parallel.
- iv. Holes for bolts shall be circular. Oval or lobbed forms of holes shall not be permitted. The diameter of holes shall be 1.5 mm more than diameter of bolts.
- v. The accuracy of location of holes shall be such that for any group when assembled, it shall admit the bolt at right angles to the plane of connection.
- vi. All burrs left by drills or punch shall be removed completely. When the tower members are in position the holes shall be truly concentric / matching to each other. Drilling or reaming to enlarge holes shall not be permitted.
- vii. Drilling, punching or other similar process is not permitted after galvanizing.

9.0.0 ERECTION MARK

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

9.2.0 Erection Mark shall be A – BB – CC – DDD

A = GIPCL code assigned to the Contractors –Alphabet

BB = Contractor's Mark-Numerical

CC = Tower Type Alphabet.

DDD = Number mark to be assigned by Contractor in consultation with owner– Numerical.

Erection mark for high tensile steel members shall be prefixed by the letter "H"

10.0.0 EARTHING

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

The drawings and standards for pipe & counterpoise type earthing shall be as per CBIP manual. Additional earthing shall be provided on every 7 to 8 kms distance at tension tower (exact quantity & location to be decided by Site In-charge) for direct earthing of both shield wires.



11.1.0 Pipe Type Earthing

Each earthing arrangement will consist of not less than 50 mm diameter, not less than 3000 mm long heavy-duty G.I. pipe driven at least 3650mm away from the nearest leg of the tower so that the same is outside earthing zone of the tower itself. 50x6 mm G.S. strip 4650 mm long and placed 600 mm below the ground level shall be used to connect the tower with the pipe. Bolt holes of the leg members joining the bottom most bracing shall be used for connecting the G.S. strip. The quoted rates will include the supply of these earthing materials complete with necessary bolts and nuts required for connection of strip with pipe and of the strip with tower. Galvanization shall be of 910 gm/m² or minimum 126 micron at any point. (averaging is not permitted). Negative tolerance is not permitted for dimensions of cross-sectional area.

11.2.0 Counterpoise Type Earthing

Where necessary, because of difficulties in grounding pipes in rocks or to control excessively high footing resistance, counterpoise earth shall be provided by the contractor. The counterpoise earth will be of size not less than 7/9 SWG (3.67 mm) galvanized steel wire having suitable galvanized steel lugs forged at its one end. The length of each counterpoise earth will not be less than 30 meters. Galvanized steel wire shall be galvanized considering corrosion zone C5-M.

The contractor shall furnish full details of counterpoise earth and the supply is also included under the scope of the contractor.

11.0.0 EXTENSIONS

The towers are designed with 9m body extension so as to be suitable for adding 3m, 6m and 9m body extensions/leg extensions for maintaining adequate ground clearances without reducing the specified factor of safety in any manner. If required the bidder can design the towers for suitable extensions of 12m, 15m and 18m subject to approval of Owner / GIPCL, PGCIL / CTUIL and especially from BSF or, Defense Authorities of INDIA.

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

12.0.0 SPAN AND CLEARANCES

13.1.0 Normal Span

Ampacity of Transmission line system at various ambient temp, wind speed shall be provided with calculations in excel

The normal ruling span of the line is 400m for 400kV Transmission Line.

I. Wind Span

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

II. Weight span

The weight span is the horizontal distance between the lowest points of the conductors on the

two spans adjacent to the tower. For spotting of structures, the span limits given in following table shall prevail: -

Item	Particulars	400kV	
Span	i) Normal span	400 m	
	ii) Wind span	400 m	
	iii) Weight span, both span (total)	Suspension (m)	Tension (m)
	a) Maximum	600	600
	b) Minimum	200	0
	iv) Weight span, broken wire condition	Suspension (m)	Tension (m)
	a) Maximum	360	360
	b) Minimum	100	-300 (DD) / -200 (DB,DC)
Wind Speed	Zone as per IS: 875	IV (47m/s)	
Corrosion	Zone as per ISO 12944	C5-M	
Seismic	Zone as per IS: 1893	V	
Conductor		AL59 equivalent to Moose (Quad configuration)	
Ground wire		OPGW	

For all crossing spans such as major road crossings, power line crossings, etc the span shall not exceed 80% of Design span. An individual span shall be as near to the normal design span as far 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 in certain standard body extension designed for the purpose according to technical specification.

13.2.0 CLEARANCES

I) GROUND CLEARANCES

The minimum ground clearance from the bottom conductor shall not be less than 8840 mm for 400kV lines at the maximum sag conditions and still air. Suitable margin from ground is to be maintained in addition of ground clearance as per IE rules for man/animal/vehicle movement under the line

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

II) Conductor creep shall be compensated by over tensioning the conductor at a temperature of 32°C lower than the stringing temperature for AL59 MOOSE equivalent conductor.

III) Phase 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 8000mm for 400kV vertically.

IV) LIVE METAL CLEARANCES

The minimum live metal clearance to be provided between the live parts and steel work of superstructure shall be as per IS 5613 and given in Table

400 kV Nominal System Voltage	
For Single Suspension Insulator Strings	
0° - 22° Swing	3050 mm
22° - 44° Swing	1860 mm
For Jumpers in tension insulator strings	
0° - 20° Swing	3050 mm

The pilot insulator strings are to be used for DO/DE towers only.

The bidder is permitted to adopt separate cross arm for 'DO' type towers under dead end conditions provided adequate live metal clearance is available with at least 15° angle on both line side and slack span side, and also provided that all the specified conditions of the specifications are fulfilled.

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

Additional Jumpers required to test tie line to be included suitably. (To be installed and removed after testing). EPC Contractor shall provide required drawing showing clearances and location for the same.

For computing the live metal clearances, the dimensions of, Double Suspension, Single Suspension Pilot, Single Tension and Quad 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.

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.

13.0.0 ROAD CROSSING

At all important road crossings, the towers shall be fitted with double tension insulator strings depending on the type of tower but the ground clearance at the roads under maximum temperature and still air shall be such that even with conductor broken in adjacent span, ground clearance of the conductor from the road surfaces shall be in line with IE rules. At all national highway crossings tension towers shall be used.

14.0.0 ANGLE OF SHIELDING

The angle of shielding is defined as the angle formed by the line joining the centerlines of the earthwire/OPGW and outer power conductor in still air at tower supports, to the vertical line through the center line of the earthwire. Bidders shall design the tower in such a way that the angle of shielding does not exceed 20° for 400 KV. The drop of the earthwire clamp equal to 150 mm should be considered while calculating the minimum angle of protection.

15.0.0 MID SPAN CLEARANCES

The minimum vertical mid span clearance between the earthwire and the nearest power conductor shall not be less than 9000 mm for 400 KV, 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/ OPGW and power conductor, shall be so coordinated that the sag of earthwire shall be at least 10% less than that of power conductors under all temperature loading conditions.

16.0.0 TOWER LOADING CONDITIONS

The design of towers shall be carried out by the Contractor as per IS 802 (Part 1/section1) 2015 considering wind zone 4. However, for Drag coefficient calculation to be followed as per IS802 (P1/S1:1995)

- Terrain category shall be considered as 2
- Reliability level shall be considered as 2 for 400 kV lines.

SLENDERNESS RATIOS

Compression Members- The Slenderness ratios of compression members shall be determined as below.

Sr	TYPE OF MEMBERS	VALUE OF KL/r
1	Leg sections or joints members bolted in both faces at connections for $0 < L/r \leq 120$.	L/r
2	Members with concentric loading at both ends of the unsupported panel connections for $0 < L/r < 120$.	L/r
3	Members with concentric loading at one end and normal framing eccentricity at the other end of the unsupported panel for $0 < L/r < 120$.	$30 + 0.75 L/r$
4	Members with normal framing eccentricities at both ends of the unsupported panel for $0 < L/r$	$60 + 0.50 L/r$
5	Members unrestrained against rotation at both ends of the unsupported panel for $120 < L/r \leq 200$.	L/r
6	Members partially restrained against rotation at one end of the unsupported panel for $120 \leq L/r \leq 225$	$28.6 + 0.762 L/r$
7	Members partially restrained against rotation at both ends of the unsupported panel for $120 \leq L/r \leq 250$.	$46.2 + 0.615 L/r$
8	Redundant Members for $0 < L/r < 250$	L/r

Drag Coefficient of the tower shall be as follows: -

Solidity Ratio	Drag Coefficient
Upto 0.05	3.6
0.1	3.4
0.2	2.9
0.3	2.5
0.4	2.2
0.5 and above	2.0



17.0.0 SERVICE CONDITION

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

Maximum ambient temperature (Degree Celsius)	50°C
Minimum ambient temperature (Degree Celsius)	9.5°C
Relative humidity (% range)	95%
Maximum annual rainfall & snowfall (Cm)	As per published Meteorological/ climatological data
Maximum altitude above mean sea level (Meter)	<10 m
Isokeraunic level (days/years)	82/Year
Wind Zone	IV (47m/s)
Seismic Zone	V
Corrosion Zone	C5-M

Note: Climate varies from moderately hot and humid tropical climate to cold climate.