

TECHNICAL SPECIFICATION

FOR

POLE PACKAGE (P01)

**Development of design, fabrication and prototype testing of Pole Structure for 765
KV D/C Transmission Lines**

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POLE STRUCTURE, SCOPE, DESIGN, FABRICATION AND TESTING for 765 KV D/C Transmission Lines

1.0 Transmission Line Pole structure, Scope and General information

1.0.1

A. Scope

This specification covers the following scope of work

● **PA**

- i. Design of pole structure for +0, +3, +6 & +9m extensions.
- ii. Development of design/drawing of Pole & its foundation (both Cassion & Open), development of structural drawing, BOM & shop drawings.
- iii. Fabrication and Galvanizing of Pole structure.
- iv. Horizontal proto assembly (PA+0).
- v. Transportation to test bed.
- vi. Full scale proto-type testing of PA+0.
- vii. Submission of final set of documents (Pole Design/ Clearance drawing/ Structural drawing/ BOM/ shop drawing of Pole with its extensions and foundation designs).

● **PD/ PE**

- i. Design of pole structure for +0, +3, +6 & +9m extensions.
- ii. Development of design/ drawing of Pole & its foundation (both Cassion & Open), development of structural drawing, BOM & shop drawings.
- iii. Fabrication and Galvanizing of Pole structure.
- iv. Horizontal proto assembly (PD/PE+9).
- v. Supply to POWERGRID store.
- vi. Submission of final set of documents (Pole Design/ Clearance drawing/ Structural drawing/ BOM/ shop drawing of Pole with its extensions and foundation designs).

B. Schedule

The entire scope of work mentioned above shall be completed as per the completion schedule attached at *Annexure-II*.

C. The Contractor shall also be required to develop anchor/ base plate drawing for all body extensions based on the design inputs provided by the Employer.

D. a). The provisional quantities are given in Bid Proposal Sheets (BPS).

b). The items of work are described very briefly in the BPS. The various items in the BPS shall be read in conjunction with the corresponding sections in the Technical Specification including amendments and additions, if any. The unit rates and price quoted by the Contractor shall be based on the description of items in the BPS and also 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 explicitly described in these documents but are essential for the satisfactory completion of the various works.

d). The unit rates quoted shall be inclusive of all plant, equipment, men, material, skilled & unskilled labour.

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

The transmission line pole steel structures are self-supporting hot dip galvanized structures, made up mainly of steel plates and designed to carry the line conductors with necessary insulators, earth wires and hardware fittings under all loading conditions. Outline diagram of pole structures are enclosed with the specification.

The pole structure shall be fabricated using mild steel or/and high tensile steel plates/sections as specified in this specification under various packages.

The Pole structure, **Suspension (PA+0)** designed and fabricated by Contractor shall be prototype tested by Contractor in presence of the Owner. The owner shall depute their representative at their own expenses to witness the tests. The responsibility for design and successful prototype testing shall solely lie with the Contractor. At the time of proto-assembly and/ or proto testing, if any modification is required to be carried out, the same shall be carried out by the Contractor. These modifications, if any, shall also be incorporated on the fabrication shop drawings and/ or on the structural drawings.

The Pole structure, **Tension/Dead End (PD/PE+9)** designed and fabricated by Contractor shall undergo horizontal proto assembly. The owner shall depute their representative at their own expenses to witness the horizontal proto assembly. At the time of proto-assembly, if any modification is required to be carried out, the same shall be carried out by the Contractor. These modifications, if any, shall also be incorporated on the fabrication shop drawings and/ or on the structural drawings.

After successful completion of testing (PA)/ proto-assembly (PD/PE), the revised structural drawings, bills of materials and shop drawings shall be submitted to the Owner within 15 days of completion of testing (PA)/proto-assembly (PD/PE) of poles for their approval. After approval, Contractor has to submit drawings/BOMs and shop drawings through DREAMS portal. The pole structure **Tension/Dead End (PD/PE+9)** after horizontal proto assembly along with X-arms, GW peak, base plate, anchor bolts for foundation with fasteners/step bolts, ladder, hanger/D-shackle as may be required shall be supplied by the contractor to POWERGRID site at identified store location of 765kV D/C LILO of **Fatehpur-Varanasi** T/L.

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 outlined by the Contractor and shall be finally accepted by the Employer after discussions before the award of Contract. 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 purchases 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 include 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 equipment's.
- 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 products 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 each item of supply.

The Quality Plan shall be mutually discussed and approved by the Employer's after incorporating necessary corrections by the Contractor as may be required.

1.0.2 Type of Pole structures & Design Parameters

1.0.1.1 The Pole structures for the transmission lines are classified as given below:

Type of Pole	Deviation Limit	Typical Use
Double circuit vertical configuration (765KV) (Hexa ACSR Zebra)		
PA(Std+9)	0-2 deg	To be designed for tangent /suspension Pole.
PD/PE(Std+9)	0-60 deg	To be designed for tension/section/Anti Cascading
		Dead End with 0 deg to 15 deg deviation both online side and sub-station side (slack span)
	0 deg	Complete Dead End

1.0.3 Extensions

1.0.3.1 The Double Circuit pole structure shall be designed so as to be suitable for adding 3M, 6M, 9M extensions for maintaining adequate ground clearances without reducing the specified factor of safety in any manner. Also tapering ratio of this extension shall be kept same as that of tested pole and the design factor of safety of non-tested extension shall not be less than the factor of safety of tested pole in any case. Base plates to be designed for all these extensions and **for Tension/ Dead End pole (PD/ PE+9)**, base plates for +9m pole to be supplied.

1.0.3.2 All above extensions provisions to pole structures shall be treated as part of normal structure only. The **Suspension Pole (PA+0)** shall be designed and tested for the Reliability level 2. For the **Tension/ Dead End pole (PD/ PE+9)**, since full scale prototype of pole structure may not be possible due to limitation of testing facility, the contractor will offer design with Reliability level 3.

1.0.4 Spans and Clearances

1.0.4.1 Normal Ruling Span

The Design Span or Normal ruling span for the line shall be as under:
 250 meters for double circuit 765KV with **(PA+9) Suspension Pole**
 200meters for double circuit 765KV with **(PD/PE+9) Tension/Dead end Pole.**

1.0.4.2 Wind Span

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

1.0.4.3 Weight Span

The weight span is the horizontal distance between the lowest points of the conductors on the two spans adjacent to a pole structure. For design of structures, maximum weight span limits given in table below shall be considered:

WEIGHT SPANS FOR 765 KV

Tower Type	Normal Condition		Broken wire condition	
	Maximum(m)	Minimum(m)	Maximum(m)	Minimum(m)
PA	375	125	225	50
PD	300	0	180	(-)300
Dead End condition for PD	150	0	30	(-)300
Dead End with Slack Span condition for PD	250	0	170	(-)300

1.0.5 Electrical Clearances

1.0.5.1 Ground Clearance

The minimum ground clearance from the bottom conductor at maximum sag conditions i.e. at max. operating temperature and still air shall be less than 18000 mm for 765KV D/C line.

1.0.5.2 An allowance of 150mm shall be provided to account for sag errors.

1.0.5.3 Live Metal Clearance

The minimum live metal clearance to be provided between the live parts and steel work of pole structure shall be as given in the table below:

Wind pressure Condition	Minimum electrical clearance
A. For "I" Suspension Insulator Strings	
1. 0° Swing	6100 mm (For D/C)
2. 25°Swing	4400 mm
3. 55°Swing	1300 mm
B. For Jumpers in tension insulator strings (with or without Pilot)	
1. 0° Swing	6100 mm (For D/C)
2. 25° Swing	4400 mm
3. 55° Swing	1300 mm

Note: Maximum two (2) nos of pilot insulator string to be used per phase (only on davit/cross arm where conductor/ jumper is coming closer to pole body) for PD pole only.

1.0.5.4 Bidder shall adopt same cross arm design where jumper is projecting outside of cross-arm for PD type pole structure to be used as dead end and angle pole structure.

1.0.5.5 For computing the live metal clearances, the dimensions of insulator strings as indicated in technical specifications shall be considered. The design of the pole structure shall be such that it should satisfy all the above conditions when clearances are measured from any live point of the strings.

1.0.5.6 Cross arm projections for Dead end pole structures shall be fixed in such a way that it can accommodate a condition of 15deg deviation of conductors towards pole structure at both Left and Right-side cross arms on slack span side and 0-15 degrees deviation online side.

1.0.5.7 For Dead End Tower design conditions, following wind span is to be considered:

Wind Span for Dead End

Tower Type	Normal Condition	Broken wire condition
Dead End	100	20
Dead End with Slack Span	200	120

1.0.5.8 Angle of Shielding

The angle of shielding is defined as the angle formed by the line joining the centre lines of the earth wire/OPGW and outer power conductor, in still air, at pole structure supports, to the vertical line through the centre line of the earth wire/OPGW. Bidders shall design the pole structure in such a way that the angle of shielding does not exceed 10 deg for 765KV D/C Transmission Lines. For estimating the minimum angle of protection, the drop of earth wire suspension clamp along with shackle shall be taken as 150mm.

1.0.5.9 Mid Span Clearance

The minimum vertical mid span clearance between the earth wire/OPGW and the nearest power conductor shall not be less than 9000 mm for 765KV D/C Hexa ACSR Zebra line which shall mean the vertical clearance between earth wire /OPGW and the nearest conductor under all temperatures and still air condition in the normal ruling span. Further, the tensions of the earth wire/OPGW and power conductors shall be so coordinated that the sag of earth wire/OPGW shall be at least 10% less than that of power conductors sag under all temperature loading conditions.

1.0.5.10 Phase to Phase Spacing

The phase to phase spacing for conductors shall be governed by the live metal clearances to be maintained as per the specifications and dimensions of the structures/ components. However, the minimum phase to phase clearance shall be as follows:

	Minimum phase to phase clearance (mm)	765KV D/C
1.	Vertical	15000
2.	Horizontal	15000

1.0.5.11 DETAILS OF LINE MATERIALS

a) Following are the Conductor / Earth Wire/OPGW Properties to be used for loading calculation:

Detail of Conductor & Earthwire

	<u>Hexa ACSR Zebra(765KV)</u>	<u>Earth Wire (7/3.66)</u>	<u>OPGW-48 Fibre</u>
Overall diameter (cm)	2.862	1.098	1.2
Cross Sectional Area (sqcm)	4.845	0.7365	0.584
Unit Weight (kg/m)	1.621	0.583	0.451
Ultimate Tensile strength (kg)	13289.0	6934	9500
Coeff. Of thermal expansion (/degC)	19.3E-06	11.5E-06	13.8E-06
Modulus of Elasticity (kg/sqcm)	0.703600E+06	1.9361E+06	1.44+06

Conductor per phase	6	NA	NA
Spacing between conductor of same phase(sub conductor spacing)(mm)	457	NA	NA

Maximum of EW and OPGW loading (i.e. Transverse, Longitudinal) and maximum/minimum vertical load of EW/OPGW shall be taken for design of pole structure.

b) Details of insulator strings

Insulator string details have been attached at *Annexure-I*.

1.0.6 Design of Pole structures

The following clauses specify the minimum requirements for design of pole structures:

1.0.6.1 Design Criteria

- a) The pole structure shall be designed to meet design requirements & design criteria stipulated in IS 802:2015, ASCE Manuals and reports on Engineering practice No. 72 and ASCE-48-19 “Design of Steel Transmission Pole Structures”, & CBIP Manual as applicable except otherwise specified in this specification. Wind Zone to be considered for the design of pole structure is **IV** (47m/s).
- b) Terrain category shall be considered as 2.
- c) Under broken wire condition, pole shall be designed considering transverse load based on maximum angle of deviation and longitudinal load based on minimum angle of deviation.
- d) Reliability level shall be considered as 2 for double circuit 765 KV poles with hexa bundle sub-conductors per phase if full scale prototype testing can be done.
- e) For 765kV (D/C), bidders may offer pole structures as Single for Suspension (PA) & Twin for Tension (PD/PE) poles. These structures shall be designed and tested for Reliability level 2. If the full scale prototype of pole structure could not be tested due to limitation of testing facility, the contractor may offer design with Reliability level 3.
- f) Contractor shall offer pole/ foundation design considering the type of conductor and the earthwire & OPGW properties mentioned above.
- g) Deflection Criteria: 5% of height of pole @ultimate load condition and 2% of the height of pole @ everyday loading condition.

1.0.6.2 Design Temperatures

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

- i) Minimum temperature : 0 deg.C
- ii) Everyday temperature : 32 deg.C
- iii) Max. temperature of
 - a) Conductor : 85 deg.C
 - b) Earthwire / OPGW exposed to sun : 53 deg.C

1.0.6.3 Conductor and Earthwire Configuration

Double circuit pole structures shall be in vertical formation. The phase to phase spacing shall not be less than the values specified as per 1.0.5.10. Poles with two peaks shall be provided with one OPGW and one EW.

Indicative Single Line Diagram has been attached at *Annexure-III*.

1.0.6.4 Maximum Tension

Maximum tension shall be based on either

- a) at Minimum temperature with 36% full wind pressure, or
- b) at 32 deg C with full wind pressure whichever is more stringent.

Sag tension calculations are to be carried out by the contractor considering conductor & earthwire/ OPGW parameters & specified conditions and spans. As per Clause 15 of IS 802:2015 the initial tension at 32°C and without wind shall not exceed 22% of the ultimate tensile strength for the conductor and 20% of the ultimate tensile strength for the earthwire/ OPGW.

For normal poles, the value of final unloaded tension of conductor at everyday temperature considered for Pole Design under Safety Condition and Anticascading condition, shall not be less than 22% of the ultimate tensile strength of conductor.

At ruling span, the final unloaded tension of conductor at everyday temperature of upper phase shall not be less than that of conductor in lower phase so as to maintain the phase-to-phase spacing.

The maximum tension of conductor and earth wire shall not exceed 70 per cent of the ultimate tensile strengths. Similarly, the maximum tension of OPGW shall not exceed 45 per cent of the ultimate tensile strengths.

As per Clause 12.1.2.1 (b) (2) of IS 802:2015, Under security condition for tension and dead end poles, the transverse loads due to line deviation shall be the component of 100 percent mechanical tension of conductor and groundwire/ OPGW corresponding to 100% of design wind pressure at everyday temperature or 36% design wind pressure at minimum temperature after accounting for drag coefficient and gust response factor. Drag coefficient for wind on the pole body shall be as per following table: -

Member Shape	Drag Coefficient
16-sided Polygonal	0.9
12-sided Polygonal	1.0
8-sided Polygonal	1.4
6-sided Polygonal	1.4
Square, Rectangle	2.0

The cross section and polygon of the structure shall be so selected that it offers optimum weight of the structure using specified materials and also ease of fabrication and erection. For cross arms also, Polygonal Sections shall be used.

1.0.7 Loading Conditions

The Contractor shall calculate loads at structure, conductor & earthwire/ OPGW points under different loading conditions viz. Reliability Conditions (Normal Condition), Security Conditions (Broken Wire Condition), Safety Conditions, Anti-

cascading condition etc. as per IS-802:2015 considering various combinations of design temperatures, wind loads and prepare loading trees/diagrams/charts. The loading trees/diagrams/charts shall be submitted to Employer for approval. The pole structure designs shall be developed by the contractor as per the approved loading trees/charts/diagram.

1.1 Design and Drawings

1.1.1 The following design calculations and drawings are required to be furnished to the Employer:

A) ALONGWITH THE BID:

Detailed design calculations and drawings for PA+0m (Suspension) and PD+0/PE+0 (60deg. Tension/ Dead end) type pole structure along with foundation (both open & caisson).

B) AFTER AWARD OF CONTRACT:

The Contractor shall submit detailed design of pole structures with all extensions along with foundation design (both open & caisson) /drawings of all type of pole structures for soil type as per Clause 1.9. The pole structure design shall be submitted along with the stress diagram / computer output together with sample calculations etc., Anchor Bolt templates and loading / rigging arrangement of pole structure testing (if applicable) to enable the Employer to make a preliminary check regarding structural stability of pole structure before fabrication.

1.1.2 After design and testing (if applicable) of pole structures and subsequent approval of design, drawings and bill of materials the Contractor shall furnish further copies to the Employer for necessary distribution:

- a) Detailed design calculation and drawing for pole structures and foundations (both open & caisson).
- 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 pole structure accessories.

1.1.3 As the pole structure being designed for specific loading requirements (viz. wind zone, spans, angle of deviations, extensions etc.) shall also be used in other wind zones as well as for other spans, angle of deviation, extensions; the contractor shall also submit spotting data limits for use of extensions in various designed and tested pole structure in other cases along with supporting detailed design calculations.

1.1.4 The contractor shall also submit foundation designs & drawings (along with detailed design calculation) of both raft type and caisson type foundations for the pole structures considering standard soil conditions (refer Clause 1.9).

1.1.5 All the drawings shall have a proper name plate clearly displaying the name of EMPLOYER/ OWNER on right hand bottom corner. The exact format of the nameplate shall be handed over to the successful bidder for incorporation of the

same on all the drawings. Also, all the drawings shall carry the following statement and shall be displayed conspicuously on the drawing.

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

- 1.1.6 The Contractor is required to submit the drawings in DREAMS PORTAL for Employer's approval. While submitting the structural drawings, bill of materials, shop drawings and any other drawings pertaining to the subject poles, the Contractor shall clearly indicate on each drawing POWERGRID Specification No., Name of the specific Pole type, letter reference no. and date on which the submission are made.
- 1.1.7 The pole structure accessories drawings like Number plate, Danger plate, phase plate, Circuit Plate, Step Bolt, Anti-climbing device, pole plate and Earthing Arrangement Bird Guard, D-shackle etc. shall be prepared by the Contractor and shall be submitted to the Employer for approval.
- 1.1.8 The drawings submitted by the Contractor shall be approved /commented by the Employer as the case may be within fifteen (15) days of submission in DREAMS portal. If the designs/drawings are commented by the Employer, the Contractor shall submit revised design/drawings duly incorporating all comments within fifteen (15) days of date of issue of comments.
- 1.1.9 Other than the items indicated above, some other drawings and documents, such as BOM, Shop drawings, structural drawings for pole structures/extensions, which are required for the project, shall also be developed by the Contractor. However, no extra cost on this account shall be payable to the Contractor.

1.2 Materials

1.2.1 Pole structure Steel Sections

Steel of tested quality in conformity with IS: 2062:2011 are to be used in pole structures. Not more than two grades of steel shall be permitted for use. The quality of steel shall be BR/BO. The Contractor can use other equivalent grade of steel plates conforming to latest International Standards. However, use of steel grade having designated yield strength more than that of IS:2062 grade E450 BR/ EN 10025 grade S450 JO / ASTM 572 grade 65 (designated yield strength 450 MPa) is not permitted, unless otherwise indicated in this specification.

Steel plates below 6mm size exclusively used for packing plates/packing washers produced as per IS: 1079 (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 IIS:2062 or equivalent standard meeting mechanical strength/metallurgical properties corresponding to selected grade Flats of equivalent grade meeting mechanical strength/ metallurgical properties may also be used in place of plates for packing plates/ packing washers.

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.

1.2.2 Fasteners: Bolts, Nuts and Washers.

- 1.2.2.1 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 galvanized as per IS:1367 (Part-13)/IS:2629.
- 1.2.2.2 The bolt shall be of 16/24/30/36 mm diameter and of property class 5.6 or 8.8 as specified in IS:1367 (Part-III) and matching nut of property class as specified in IS:1367 (Part-VI).
- 1.2.2.3 Bolts up to M16 and having length up to 10 times the diameter of the bolt should be manufactured by cold forging and thread rolling process to obtain good and reliable mechanical properties and effective dimensional control. The shear strength of bolts shall be as per applicable standard. Bolts should be provided with washer face in accordance with IS:1363 (Part-I) to ensure proper bearing.
- 1.2.2.4 Nuts for hexagonal bolts should be double chamfered as per the requirement of IS:1363 Part-III. It should be ensured by the manufacturer that nuts should not be over tapped beyond 0.4mm oversize on effective diameter for size up to M16.
- 1.2.2.5 Fully threaded bolts shall not be used. The length of bolts shall be such that the threaded portion will not extend into the place of contact of the members.
- 1.2.2.6 All bolts shall be threaded to take the full depth of the nuts and threaded for enough to permit firm gripping of the members, but not further. It shall be ensured that the threaded portion of each bolt protrudes not less than 3mm and not more than 8mm when fully tightened. All nuts shall fit tight to the point where the shank of the bolt connects to the head.
- 1.2.2.7 Flat and tapered washers shall be provided wherever necessary. Spring washers shall be provided for insertion under all nuts. These washers shall be steel electro-galvanised, positive lock type and 3.5mm in thickness for 16mm diameter bolt and 4.5mm for 24mm bolt.
- 1.2.2.8 To avoid bending stress in bolts or to reduce it to minimum, no bolt shall connect aggregate thickness of members more than three (3) times its diameter.
- 1.2.2.9 The bolt positions in assembled pole structures shall be as per structural drawing.
- 1.2.2.10 Bolts at the joints shall be so staggered that nuts shall be tightened with spanners without fouling.
- 1.2.2.11 To ensure effective in-process Quality control it is desirable that the manufacturer should have in house testing facility for all tests like weight of zinc coating, shear strength and other tests etc. The manufacturer should also have proper Quality Assurance System which should be in line with the requirement of this specification and IS: 9001 series Quality System Standard.
- 1.2.2.12 **Anchor bolts**
Anchor bolts shall generally conform to IS: 5624. The size, grade & numbers of anchor bolts and its thread and nuts selection should be compatible with the required strength as per design.

1.3 Pole structure Accessories

Arrangement shall be provided for fixing of all pole structure accessories to the pole structure at a height between 2.5 meters and 3.5 meters above the ground level. To prevent birds perching immediately above the suspension insulator strings (I type) and fouling the same with dropping, suitable bird guards shall be provided on all

suspension poles. In case of I string Bird Guard as per IS 5613 shall be provided at cross arm tips. Suitable provision to be provided on Suspension pole structure facilitating installation of bird guard.

1.3.1 Step Bolts & Ladders

Each pole structure shall be provided with step bolts as per drawing enclosed in the section of drawing. The step bolts conforming to IS:10238 of not less than 16mm diameter and 175mm long shall be provided, spaced not more than 450mm apart and extending from 2.5 meters above the ground level to the top of the pole structure. However, the head diameter shall be 35mm as indicated in the enclosed drawing. The step bolt shall be fixed on two sides of polygon of the pole structures in alternate step arrangement. Each step bolt shall be provided with two nuts on one end to fasten the bolt securely to the pole structure 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. As an alternate to step bolts, ladders of suitable design may also be provided by the contractor. For horizontal access on cross arms, suitable designed hooks shall also be provided. Detailing for providing step bolts/hooks/ladders etc. shall be done so that all parts of pole structures are accessible and installation & maintenance of insulators, hardware assemblies, conductors etc. is possible.

1.3.2 Insulator Strings and Earth wire Clamps Attachments

- a) For the attachment of suspension Insulator string, if required a suitable dimensioned swinging hanger on the pole structure 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 shall be of same rating/strength as that of corresponding rating/ Ultimate tensile Strength of Insulator string. The design and supply (for tension pole) of hanger, D-shackles, strain plate, extension link etc. are also in the scope of Contractor.
- b) At tension pole structures, 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 provision for the same shall be provided by the Contractor. These items shall be of same rating/strength as that of corresponding rating/ Ultimate tensile Strength of Insulator string.
- c) D shackles, if required for attachment of Insulator strings (for tension Pole), shall be supplied by the contractor from the identified and approved sub-vendor/supplier of Hardware fittings.

1.4 Pole structure Fabrication

- 1.4.1 The Pole Structure along with cross arms, earth wire peaks, base plate and joints shall be fabricated by the Contractor as per the design prepared by the contractor and approved by the by the Employer. The fabrication of Pole structure shall be in conformity with the following:
- 1.4.2 Except where hereinafter modified, details of fabrication shall conform to industry practices and relevant standards.
- 1.4.3 Joints shall be so designed and fabricated that eccentricity is avoided as far as possible. In case of connections by means of slip joints, minimum overlap shall be as per applicable ASCE standard.

- 1.4.4 The cross arms shall be connected to the pole by means of suitable flanges welded on the body and cross arms.
- 1.4.5 The Pole structures shall be accurately fabricated to connect together easily without any undue strain on the structure.
- 1.4.6 No sharp/rough edges shall be permitted in the entire structure.
- 1.4.7 On slip-in joints, diameter of the inner and outer part of the pole shall be controlled to ensure smooth assembly of the pole structure and its correct height after erection.
- 1.4.8 The structure shall be designed so that all parts shall be accessible for inspection and cleaning. Drain holes shall be provided at all points where pockets of depression are likely to hold water. The top end of the pole, earth wire peaks and cross arms shall be suitably sealed with cover plate welded to the structure.
- 1.4.9 The length of any individual segment shall be such that it can be easily transported and erected. All similar parts shall be made strictly inter-changeable. Pole segments, as far as possible, shall be fabricated in single piece. Higher diameter pole segments may be fabricated in two or more parts and kept minimum. The maximum permissible parts shall be as follows:

Sr No.	Maximum diameter(D) of segment (mm)	Outer pole	Max permissible no of fabricated parts per pole segment/seams
1	$D < 600$		1
2	$600 \leq D < 1200$		2
3	$1200 \leq D < 1800$		3
4	$D \geq 1800$		4

- 1.4.10 Suitable provisions shall be kept in the design and detailing of pole structures for easy erection at site using conventional as well as mechanized methods.
- 1.4.11 Design and detailing for providing step bolts/hooks/ladders etc. shall be done so that on provision of these, all parts of pole structures are accessible and installation & maintenance of insulators, hardware assemblies, conductors etc. is possible. Design detailing for provision of other accessories viz., Anti-climbing device, Danger plate, Number, Phase plate etc. shall also be done. Ladder for the Tension/Dead End pole (PD/PE+9) also has to be supplied along with the proto assembled pole.

1.4.12 **Material Cutting, Forming & Bending**

- 1.4.12.1 The required material cutting, forming and bending operations shall be carried out generally in accordance with the relevant sections of ASCE Manuals and reports on Engineering practice No. 72 and ASCE-48-11 “Design of Steel transmission Pole Structures”.
- 1.4.12.2 Before any cutting work is started, all steel shall be carefully straightened and trued by pressure and not by hammering. They shall again be trued after cutting & welding etc.

1.4.13 **Drilling and Punching**

- 1.4.13.1 Holes for bolts shall be drilled or punched with a jig but drilled holes shall be preferred. The tolerances regarding punch holes are as follows:

- a) Holes must be perfectly circular and no tolerance in this respect is 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 hole should not exceed 0.8mm on diameter.
 - c) Holes must be square with the plates or angles and have their walls parallel.
- 1.4.13.2 All burrs left by drills or punch shall be removed completely. When the pole structure members are in position the holes shall be truly opposite to each other. Drilling or reaming to enlarge holes shall not be permitted.
- 1.4.14 **Welding**
- 1.4.14.1 All welding shall be in accordance with the latest revision of American Welding Society Structural Welding Code (ANSI/AWS D1.1) or other equivalent National/International standards. Welding terms and symbols should comply with the AWS definitions and symbols.
- 1.4.14.2 Care should be exercised with respect to welding procedures, qualification of welders, operators and procedures, electrodes, preheat, notch toughness and minimum yield of the electrodes to ensure conformance with the requirements of the ANSI/AWS D1.1 code. Preheating shall be done according to the ANSI/AWS code or the steel producers' recommendations, or both.
- 1.4.15 **Erection mark**
- 1.4.15.1 Each individual member shall have erection mark conforming to the component number given to it in the fabrication drawings. The mark numbers shall be marked with marking dies of 16mm size before galvanising and shall be legible after galvanising,
- 1.4.15.2 Erection Mark shall be A-BB-CC-DDD
- A = Employer's code assigned to the Contractors- Alphabet
- BB = Contractor's Mark-Numerical
- CC = Pole structure 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"

1.5 Unit Rate, Quantities and weights.

1.5.1

- a). The provisional quantities are given in Bid Proposal Sheets (BPS).
- b). The items of work are described very briefly in the BPS. The various items in the BPS shall be read in conjunction with the corresponding sections in the Technical Specification including amendments and additions, if any. The unit rates and price quoted by the Contractor shall be based on the description of items in the BPS and also 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 explicitly described in these documents but are essential for the satisfactory completion of the various works.

d). The unit rates quoted shall be inclusive of all plant, equipment, men, material, skilled & unskilled labour.

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

1) **Design and development of drawings of Pole Structure** shall include charge for: Development of structural/shop drawing/Bill of material of standard pole including all body/leg extensions, base plate, anchor bolts and development of open type & caisson type foundation design/drawing for tower type PA & PD/PE. Development of Revised drawing/BOM/Shop drawing.

2) **Fabrication and horizontal Proto assembly of Pole Structure** shall include charge for:

(i) For Pole PA

a. Fabrication and horizontal Proto assembly of Pole Structure, Galvanizing, complete with base plate, anchor bolts, step bolts/ladder, bolts & nuts etc. but excluding pole accessories such as danger plates, number plates, phase plate, anti-climbing devices.

b. Re fabrication of pole structure members if any on account of changes suggested during horizontal proto assembly.

(ii) For Pole PD/PE

a. Item under above head include rate/charges for Fabrication and horizontal Proto assembly of Pole Structure, Galvanizing, complete with base plate, anchor bolts, step bolts/ladder, bolts & nuts etc. but excluding pole accessories such as danger plates, number plates, phase plate, anti-climbing devices.

b. Supply of Pole structure along with all accessories to identified store location of 765kV D/C LILO of *Fatehpur-Varanasi* T/L

3) **Proto Type Testing of Pole Structure PA** shall include charge for

a. Transportation of Pole to be tested to the test bed along with bolts & nuts, spring washers and necessary Pole accessories required for Pole testing.

b. Erection of Pole at test bed

c. Full scale proto testing of pole type PA to the full design loads including charges for bolt slip test and additional loads as specified for verification of overall capacity of Pole upto Destruction. In case of failure of Pole during testing, some of the testing cases may have to be repeated, charges for which is also deemed to be included in the rate quoted by contractor in price schedule

d. Re fabrication of pole structure members if any on account of failure/changes suggested during testing.

e. Dismantling of test Pole in the event of failure/changes proposed by POWERGRID.

Though fully galvanized pole structure parts are to be supplied, the weight of pole structure shall mean the weight of pole structure calculated by using the black sectional (i.e. ungalvanised) weight of steel members of the size indicated in the approved fabrication drawings and bill of materials, without taking into consideration the reduction in weights due to holes, notches and bevel cuts etc. but taking into consideration the weight of the D shackles, hangers, strain plates, pack plates, gusset plates, extension link/plates and pack washers etc. The weight of strain plates, pack plates, extension link and gusset plates shall

mean the weight of its circumscribing rectangle, without taking into consideration the reductions in weight due to holes, notches etc. The weight of D-shackles, hangers and pack washers shall be net actual weight taking into consideration reduction due to holes. For bolts and nuts along with spring washers and step bolts, the weight per pole structure shall be calculated from the bolt schedule applicable to each type of pole structure and body extensions as approved by the Employer. The rate quoted by the bidder for pole structure/pole structure parts supply, is deemed to be inclusive of galvanizing charges including the cost of zinc.

1.5.2 Payment of the pole structures shall be made on per structure basis as per the unit rates in the contract irrespective of any change in weight of structure estimated by the bidder at the time of the bidding vis-à-vis weight of structure as per actual tested and approved design.

1.6 Galvanising

1.6.1 Fabricated Pole structure Parts

The pole structure parts 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 pole structure parts shall have a minimum overall Zinc coating of 610 gms per sq. m of surface area except for plates & sections below 5mm which shall have Zinc coating of 460 gms per sq. m of surface area. The average zinc coating for all sections and plates 5mm & above shall be maintained as 87 microns and that for plates & sections below 5mm shall be maintained as 65 microns.

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

The surface preparation for fabricated pole structure parts for hot dip galvanizing shall be carried out as indicated herein below:

- (i) **Degreasing& Cleaning of Surface:** Degreasing and cleaning of surface, wherever required, shall be carried out in accordance with clause 4.1 of IS 2629-1985. After degreasing the article shall be thoroughly rinsed. However, if acidic degreasers are used rinsing is not required.
- (ii) **Pickling:** Pickling shall be done using either hydrochloric or sulphuric acid as recommended at clause 4.3 of IS 2629 -1985. The actual concentration of the acids and the time duration of immersion shall be determined by the Contractor depending on the nature of material to be pickled. Suitable inhibitors also shall be used with the acids to avoid over pickling. The acid concentration, inhibitors used, and maximum allowable iron content shall form part of plant standard to be formulated and submitted to employer along with Quality Assurance Program.
- (iii) **Rinsing:** After pickling, the material shall be rinsed, preferably in running water to remove acid traces, iron particles or any other impurities from the surface. Two rinse tanks are preferable, with water cascading from the second tank to the first to ensure thorough cleaning. Wherever single tank is employed, the water shall be periodically changed to avoid acid contamination, and removal of other residue from the tank.

- (iv) Fluxing: The rinsed article shall be dipped in a solution of Zinc ammonium chloride. The concentration and temperature of the flux solution shall be standardized by the contractor depending on the article to be galvanized and individual circumstances. These shall form part of plant standard to be formulated and submitted to employer along with Quality Assurance Program. The specific gravity of the flux solution shall be periodically monitored and controlled by adding required quantity of flux crystals to compensate for drag-out losses. Free acid content of the flux solution also shall be periodically checked and when it is more than two (2) grams of free acid per litre of the solution, it shall be neutralized. Alternatively, Ph value should be monitored periodically and maintained between 5.0 to 5.5.
- (v) Drying: When dry galvanizing is adopted the article shall be thoroughly dried after fluxing. For the purpose of drying, the contractor may use hot plate, air oven or any other proven method ensuring complete drying of the article after fluxing and prior to dipping in the molten zinc bath. The drying process shall be such that the article shall not attain a temperature at which the flux shall get decomposed. The article thus dried shall be galvanized before the flux coating picks up moisture from the atmosphere or the flux layer gets damaged or removed from the surface. The drying procedure, time duration, temperature limits, time lag between fluxing, drying, galvanizing etc. shall form part of plant standard to be formulated and submitted to employer along with Quality Assurance Program.
- (vi) Quality of Zinc: Any one or combination of the grades of zinc specified in IS 209 or IS 13229 or other comparable international standard shall be used for galvanizing. The contractor shall declare the grade(s) of zinc proposed to be used by them for galvanizing. The molten metal in the zinc bath shall contain minimum 98.5 % zinc by mass. It shall be periodically measured and recorded. Zinc aluminum alloy shall be added as per IS 2629.
- (vii) Dipping Process: The temperature of the galvanizing bath shall be continuously monitored and controlled. The working temperature of the galvanizing bath shall be maintained at 450 ± 10 degree C. The article should be immersed in the bath as rapidly as possible without compromising on safety aspects. The galvanizing bath temperature, immersion angle & time, time duration of immersion, rate of withdrawal etc shall be monitored and controlled depending upon the size, shape, thickness and chemical composition of the article such that the mass of zinc coating and its uniformity meets the specified requirements and the galvanized surface is free from imperfections and galvanizing defects.
- (viii) Post Treatment: The article shall be quenched in water. The quench water is to be changed / drained periodically to prevent corrosive salts from accumulating in it. If water quenching is not done, then necessary cooling arrangements should be made. The galvanized articles shall be dipped in chromating solution containing sodium dichromate and sulphuric acid or chromic acid base additive at a predetermined concentration and kept at room temperature to retard white rust attack. The temperature of the chromate solution shall not exceed 65 degree C. The articles shall not be stacked immediately after quenching and dichromating. It shall be ensured that the articles are dry before any further handling operation.
- (ix) Storing, Packing and Handling: In order to prevent white rust formation sufficient care should be exercised while storing handling and transporting galvanized products. The articles shall be stored in an adequately ventilated area. The articles shall be stored with spacers in between them and kept at an inclination to facilitate easy drainage of any water collected on the articles. Similar care is to be taken while transporting and storing the articles at site.

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

In case of restriction due to the size of hot dip galvanising bath, pole segments having outer diameter more than 1m and upto 2.5m may be galvanized in two halves and then seamlessly welded. For pole segments having outer diameter more than 2.5m galvanizing shall be carried out in maximum four parts, and then seamlessly welded. After seamless welding of above parts, surface of the welded portion shall be cleansed and prepared. These welded portions shall be galvanized by metallizing using molten zinc technique. For metallizing, the process as per ANSI/AWS WCZ/D19.0-72 or other National/ International standard/Guidelines shall be followed. The thickness of zinc coating by metallizing shall not be less than the minimum specified for hot dip galvanizing.

1.6.2 **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.

1.6.3 **Inspection and Tests**

1.6.3.1 General

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

1.6.3.2 Inspection

In addition to the provision of Clause 20 of GCC, the following shall also apply:

- 1.6.3.2.1 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 Pole 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.
- 1.6.3.2.2 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 specifications.
- 1.6.3.2.3 Should any member of the structure be found not to comply with the approved 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.
- 1.6.3.2.4 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.
- 1.6.3.2.5 All gauges and templates necessary to satisfy the Employer shall be supplied by the Contractor.

1.6.3.2.6 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 Testing of Pole Structure

1.7.1 The scope of work covers the proto-type testing of following pole structures:

- i) 765KV D/C (Hexa ACSR Zebra) Suspension PA Std+0m extension.

For design of other extensions of pole structures, the factor of safety in the design shall not be less than the factor of safety considered in the design of above proto tested pole structures.

1.7.2 The Pole structures shall be prototype tested with +0m extension by the contractor at any testing station having facilities to test the structures. The prototype pole structures after inspection by employer shall be transported to the test bed by the Contractor. Testing of Pole structure shall generally conform to IS:802 (Part-III). The employer shall depute their representative at their own expense to witness the tests. The responsibility for design and successful prototype testing shall solely lie with the Contractor. At the time of proto-assembly and/ or proto testing, if any modification is required to be carried out, the same shall be carried out by the Contractor without financial implication to employer. These modifications, if any, shall also be incorporated on the fabrication shop drawings and/ or on the structural drawings.

1.7.3 A galvanized pole structure of each type complete with specified extension shall be subjected to design and destruction tests by first applying test loads applied in a manner approved by the Employer. The pole structure shall withstand these tests without showing any sign of failure or permanent distortion in any part. Thereafter, the pole structure shall be subjected to destruction by increasing the loads further in an approved manner. The pole structure shall be tested for all specified loading conditions as approved by employer. The Contractor shall submit to the Employer, for approval, the detailed programme and proposal for testing the pole structures showing the methods of carrying out the tests and manner of applying the loads. After the Employer has approved the test procedures and programs 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. The Contractor shall submit one set of shop drawings along with the bill of materials at the time of prototype pole structure testing for checking the pole structure material. Further at the time of submission of test report on successful completion of testing, the contractor has to submit the final structural drawings, 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 pole structure.

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

- 1.7.5 Each type of pole structure to be tested shall be a full scale prototype galvanized pole structure and shall be erected vertically on rigid foundation. The pole structure erected on test bed shall not be out of plumb by more than 1 in 360.
- 1.7.6 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 pole structure upto the maximum anticipated loads to be applied during testing.
- 1.7.7 The sequence of testing shall be decided by the Employer at the time of approving the rigging chart / test data sheet.
- 1.7.8 The Employer may decide to carry out the tensile test, bend test etc. as per the relevant IS/DIN on few members of the test pole structure 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.
- 1.7.9 Prefix 'T' shall be marked on all members of test pole structure in addition to the Mark No. already provided.
- 1.7.10 During the testing, depending on facilities available in the test bed, Employer may decide to install strain gauges at selected structural members on test pole for monitoring loads on the members. The strain gauge readings shall be recorded and attached with the test report. In such cases, payments for use of strain gauges shall be made separately.

1.7.11 **Method of Load Application**

- 1.7.11.1 Loads shall be applied according to the approved rigging arrangement through normal wire attachments angles on bent plates.
- 1.7.11.2 The various types of loads, transverse, vertical and longitudinal shall be applied in such a way that there is no impact loading on the pole structure due to jerks from the winches.
- 1.7.11.3 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.

1.7.12 **Pole structure Testing Procedure**

The procedure for conducting the pole structure test shall be as follows:

1.7.12.1 **Bolt Slip & Joint adjustment 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.

1.7.12.2 **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

1.7.12.3 **Observation Periods**

Under normal and broken wire load tests, the pole structure 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 upto and including 95 percent of full design loads.

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

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

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. 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 constituent parts.

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

Further, for pole the maximum deflection during testing shall not exceed 8% of the height of the pole being tested for test load cases

1.7.12.4 **Recording**

The deflections of the pole structure 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 metre long with marking upto 5 mm accuracy.

1.7.12.5 **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 sheet be intimated to the contractor at the time of approving rigging chart / test data.

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 till the load value reaches as specified in approved rigging chart or pole fails (whichever is earlier)

1.8 Standards

- 1.8.1 The design, fabrication, galvanizing and testing of pole structures 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.
- 1.8.2 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.

Sl. No.	Indian Standard	Title	International Standard
1.	IS:209-1992	Specification for Zinc	ISO/R/752 ASTM B6
2.	IS 800-1991	Code of practice for General Building Construction of Steel	CSA S16.1
3	(a)IS:802(Part 1) Sec 1-2015 Sec 2-2016	Code of Practice for use of Structural Steel in Overhead Transmission Line Towers: Materials, loads and Permissible Stresses Section 1 Materials and loads Section 2 Permissible stresses.	ASCE 52 IEC 826 BS 8100
	b)IS:802-1990 (Part 2)	Code of Practice for use of structural steel in overhead Transmission Line: Fabrication, Galvanizing, Inspection and Packing	ASCE 52
	c)IS:802-1990 (Part 3)	Code of practice for use of Structural Steel in Overload Transmission Line Towers & Testing	ASCE 52 IEC 652
4.	IS:808-2021	Dimensions for Hot Rolled Steel Beam, Column, Channel and Angle Sections.	
5.	IS:875-1992	Code of Practice for Design Loads (other than Earthquakes) for Buildings and Structures.	
6.	IS:1363-1992	Hexagon Nuts (size range M5 to M36)	
7.	IS:1367-1992	Technical Supply Conditions for Threaded Steel/ Fasteners	
8.	IS 1477:1990	Code of practice for Painting of Ferrous Metals in Buildings: Part-I: Pre-treatment Part-II: Painting	
9.	IS:1573-1991	Electro-Plated Coatings of zinc on iron and Steel	
10.	IS:1852-1993	Rolling and Cutting Tolerances of Hot	

Sl. No.	Indian Standard	Title	International Standard
		Rolled Steel Products	
11.	IS-1893-1991	Criteria for Earthquake Resistant Design of Structures	IEEE 693
12.	IS:2016-1992	Plain Washers	ISO/R887 ANSI B18-22.1
13.	IS:2062-1992	Steel for general structural purposes	
14.	IS:2074-1992	Ready Mixed Paint, Air Drying, Oxide. Zinc Chrome, Priming Specification.	
15.	IS:2551-1990	Danger Notice Plates	
16.	IS:2629-1990	Recommended Practice for Hot Dip Galvanizing of iron and steel.	ASTM A123 CSA G 164
17.	IS:2633-1992	Method of Testing Uniformity of Coating of Zinc Coated Articles	ASTM A123 CSA G164
18.	IS:3043-1991	Code of Practice for Earthing	
19.	IS:3063-1994	Single coil Rectangular section Spring Washers for Bolts, Nuts Screws	DIN-127
20.	IS:3757-1992	High Strength Structural Bolts	
21.	IS:4759-1990	Specification for Hot zinc coatings on structural steel and other Allied products	
22.	IS:5369-1991	General Requirements for Plain Washers	
23.	IS:5613-1993	Code of Practice for Design installation and Maintenance of Overhead Power Lines Section-1: Design Part 2, Section-2: Installation and Maintenance	
24.	IS:6610-1991	Specification for Heavy Washers for Steel structures.	
25.	IS:6623-1992	High Strength Structural Nuts	
26.	IS:6639-1990	Hexagon Bolts for Steel Structure.	ASTM A394 CSA B334
27.	IS:6745-1990	Method for Determination of weight of Zinc coated iron and Steel Articles.	ASTM A90
28.	IS:8500-1992	Specification for Weldable Structural Steel (Medium & High Strength Qualities)	
29.	IS:10238-1989	Step Bolts for Steel Structures	
30.	IS:12427-1988	Bolts for Transmission Line Poles	
31.	Publication No.19(N)/700	Regulation for Electrical Crossing of Railway Tracks.	
32.		Design of Steel Transmission Pole Structures.	ASCE 48-11

Sl. No.	Indian Standard	Title	International Standard
33.		Design of Steel Transmission Pole Structures.	ASCE Manuals and reports on Engineering practice No. 72

The standards mentioned above are available from

Reference Abbreviation	Name and Address
BIS/IS	Beureau Of Indian Standards. Manak Bhavan, 9, Bahadur Shah Zafar Marg, New Delhi - 110001. INDIA
ISO	International Organisation for Standardization. Danish Board of Standardization Danish Standardizing Sraat, Aurehoegvej-12 DK-2900, Heelestrup, DENMARK.
CSA	Canadian Standard Association 178, Rexdale Boulevard, 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
ASCE	American Society of civil Engineers 345 East 47 th 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,

1.9 Foundations

1.9.1 Type of Foundations

The foundation shall be designed for both open cast type and Caisson type.

Open type of foundation shall be designed for various soil types as per definition given in the following clause and for caisson type of foundation parameters shall be intimated to the contractor during detailed engineering stage.

1.9.1.1 Classifications of Open Cast Foundations

Classification 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:

- a) **Normal dry**
Are 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.
- b) **Sandy Dry Soil**
Are 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.
- c) **Wet**
Are 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.
- d) **Wet Cultivated**
Are 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 department.
- e) **Partially Submerged**
Are used at locations where sub-soil water table is met between 0.75 meter and 1.5 metre below the ground level.
- f) **Fully Submerged**
Are used at locations where sub-soil water table is met at less than 0.75 meter below the ground level.
- g) **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.
- h) **Fissured Rock**
Are used at locations where decomposed or fissured rock, hard gravel, kankar, limestone, laterite 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 are adopted. Where fissured rock is encountered with subsoil water table less than 1.5 meter below ground level, submerged fissured rock foundations are adopted. In case of dry locations dry fissured rock foundations are adopted.

1.9.1.2 Design Parameters for Open Cast Foundations

Design of foundations for all pole structures and pole structures with extensions shall be developed by the contractor based on the typical soil properties as indicated below in the table.

Soil Properties for open Cast type foundation

Sl. No	Properties of Soil	Ultimate Bearing Capacity in KN/M ² (Kg/M ²)	Angle of Repose (Degree)
1	For Normal Soil (UP, Uttarakhand, Haryana, Delhi, Bihar, Jharkhand, WB, MP, Chhattisgarh, Kerala, J&K, Ladakh, Assam, Andhra Pradesh, Telangana, Tamil Nadu)		
	Normal Dry Soil	268 (27350)	30
	Wet Soil Due to Presence of Subsoil/ Surface Water	134 (13675)/ 268(27350)	15
	Black cotton Soil Due to Presence of Subsoil/Surface water and dry condition	134 (13675)	0
	Sandy Soil	268 (27350)	20
2	Fissured Rock		
	a) Fissured rock in dry portion	613 (62500)	20
	b) Fissured rock in presence of water	613 (62500)	10
3	Weight of earth for normal soil and black cotton soil		UNIT
	a) Dry	KN/M ³ (Kg/M ³)	14.12 (1440)
	b) In presence of Surface Water	KN/M ³ (Kg/M ³)	14.12 (1440)
	c) In presence of Subsoil Water	KN/M ³ (Kg/M ³)	9.22 (940)
	4 Weight of Fissured Rock		
	a) Dry	KN/M ³ (Kg/M ³)	14.12 (1440)
	b) In presence of Subsoil Water	KN/M ³ (Kg/M ³)	9.22 (940)

1.9.2 Loads on Foundations

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

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

- a) Max. Tension or uplift loads.
- b) Max. Compression or down-thrust loads.
- c) Max. Horizontal shear or side thrust.
- d) Max. Bending moment/ Overturning moment

1.9.2.3 Overload factor for Foundation loads:

The overload factor for foundation loads shall be considered as 1.1 i.e. all the reactions (compression, tension and side thrust) on the foundations shall be increased by 10 percent for development of foundation design.

1.9.2.4 Stability analysis

1.9.2.4.1 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.

1.9.2.4.2 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 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-impose each other, the earth frustum will be assumed truncated by a vertical plane passing through the centre line of the tower base. In case of foundation with undercut, resistance provided by weight of earth in an inverted frustum of a conical pyramid shall be increased by 25 %. This shall also be applicable for stability analysis check for over turning in case of foundation with undercut.

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* below

Weight of Concrete Type of concrete	Weight of dry region KN/m³ (Kg/m³)	Weight in presence of sub- soil water KN/m³ (Kg/m³)
Plain Concrete	21.96 (2240)	12.16 (1240)
Reinforced Concrete	23.54 (2400)	13.73 (1400)

1.9.3 Design Criteria

1.9.3.1 As per IS 456: 2002 Partial safety factor shall be considered 1.5 for concrete and 1.15 for steel.

1.9.3.2 The thickness of concrete in the chimney portion of the tower footing shall be provided with minimum cover of not less than 100 mm from any part of the pole 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 locations, the chimney should have all around clearance of 150 mm from any part of pole limiting the minimum section of chimney to 450 mm square.

1.9.3.3 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. Effective length of 1.5 times the unsupported length shall be considered for evaluating the slenderness ratio of chimney.

1.9.3.4 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.

1.9.3.5 In case of RCC type foundations, the frustum can be single or multi stepped. The thickness of bottom slab (including slopped slab portion) should not be less than 300 mm. The bottom portion of minimum 100 mm thickness of the slab shall have vertical sides and balance portion shall have 45° slope as indicated in drawing enclosed in the bidding documents. In case of sloped pad/haunch foundation, If the total thickness of sloped pad/haunch is more than 750mm, minimum reinforcement of 0.1% of cross section area of haunch shall be provided perpendicular to the slope at both faces of haunch (0.05% in each face). Further 4 bars of minimum 10 mm diameter along the slope of haunch shall also be provided in addition to the minimum reinforcement in haunch as stated above.

1.9.3.6 The total depth of open type foundations below the ground level (including lean concrete pad) shall not be less than 1.5 meters and more than 5.0 meters.

1.9.3.7 The anchor bolts and base plate shall be designed to take full down-thrust or uplift loads. The Contractor shall furnish the calculation for anchor bolts and base plate design along with the foundation design.

1.9.3.8 In case of R.C.C. foundations having steel reinforcement in base slab, at least 50 mm. thick pad of lean concrete corresponding to 1:3:6 nominal mix shall be provided below the bottom slab.

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

1.9.3.10 The additional weight of concrete in the footing below ground level over the earth weight & 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.

1.9.4 Design of Foundations

1.9.4.1 Structural design of foundation shall be done by limit state method as per IS-456: 2010.

1.9.4.2 Pier type foundation, proposed to be adopted by bidder, shall be designed & constructed as per IS-456, IS-491 and prudent utility practices and applicable national/international standards/ practices so as to withstand all loads/ reactions due to pole structures. The soil strength factor shall be considered as 0.7.

1.9.4.3 The construction drawings/ working drawings along with design calculation of foundations shall be submitted by the contractor for approval.

1.9.4.4 **Properties of Concrete**

For open cast type foundations:

The cement concrete used for the foundations shall generally be of grade of M20. 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.

For Pier/ Pile type foundations:

Concrete for Pile/ Pier type foundation shall be M25 grade design mix as per IS 456.

1.9.4.5 Reinforcement shall conform to IS 1786 for high strength steel bars (Fe 500/ Fe500D).