भारत सरकार
Government of India
विद्युत मंत्रालय
Ministry of Power
केन्द्रीय विद्युत प्राधिकरण
Central Electricity Authority
विद्युत प्रणाली अभियांत्रिकी एवं प्रौद्योगिकी विकास प्रभाग
Power System Engineering & Technology Development Division

To,

As per attached list.

विषय : **Invitation of comments on draft Standard Technical Specification for Steel Pole Structure-reg.**

महोदया /महोदय **,**

A standardisation technical committee has been constituted by CEA under the Chairmanship of Chief Engineer (PSETD), CEA comprising members from Pole manufacturers, CPRI, SERC, utilities etc. for preparation of Standard Technical Specification for Steel Pole Type Structures considering the vide acceptance of the steel tubular poles as an alternative to lattice structure by the Indian utilities, increased use of such structure in some areas due to its less foot print & Right of Way (RoW), better aesthetic & high reliability under extreme weather condition (smaller bending moment at the base under heavy load condition) and absence of any national standard covering erection and design of steel Pole type transmission towers.

The standardisation will help the utilities/Transmission Service Providers and manufacturer to get products of similar quality & reliability, the delivery will be faster and would establish uniform practices across the country. Based on the deliberations held in the meeting of the technical committee and inputs received from the various stakeholders, the draft Standard Technical Specification for Steel Pole Structure has been prepared and is attached herewith (in the Pdf & word file formats)

All stakeholders/utilities are requested to provide comments/valuable inputs on the draft Standard technical Specification by **9th May, 2021** by post or email : **[ce-psetd@gov.in]** so that the document can be finalized within the assigned timeframe. It is requested that if the comments are provided by editing the word file, the same may please be done in the track change mode.

Encl.: As above.

भवदीय,

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उप निदेशक

Copy to :

1. SA to Member (PS),CEA
2. Chief Engineer (IT division), CEA with a request to upload the document on CEA website for inviting comments from stake holders.

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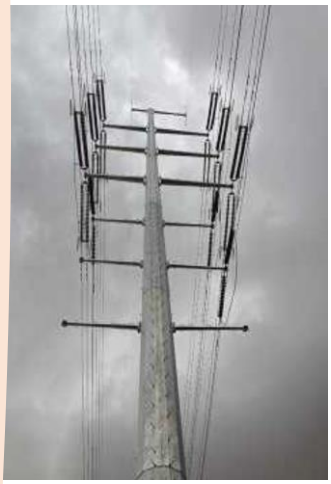

THE DRAFT STANDARD TECHNICAL SPECIFICATION FOR STEEL POLE STRUCTURE

GOVERNMENT OF INDIA
MINISTRY OF POWER
CENTRAL ELECTRICITY AUTHORITY

APRIL 2021

THE STANDARD TECHNICAL SPECIFICATION
FOR
STEEL POLE STRUCTURE

1.0 General

1.1 This specification covers design, engineering, manufacturing, supply, fabrication, galvanizing, proto assembly and testing, inspection before dispatch, delivery of various types of steel pole structures for Transmission Lines (as specified by the utility) at site, design of foundations, laying of foundations along with supply of complete foundation material, erection of steel pole structures with accessories for conductor & eartwire/OPGW and , hard ware fittings for insulators, complete stringing & sagging. The detailed survey of site, profiling, tower / steel pole structure spotting / optimization of tower location, soil resistivity measurement and geotechnical investigation shall also be in the scope of Bidder.

1.2 All the raw materials such as steel, zinc for galvanizing, reinforcement steel and cement for tower foundation, coke and salt for tower earthing etc. anchor bolts & their templates, bolts, nuts, washers, D-shackles, hangers, links, danger plates, phase plate, number plate, circuit plate, anti-climbing devices, Bird Guard etc. required for tower/ pole structure manufacture and erection shall be included in the bidder's scope of supply. Bidder shall clearly indicate in the offer, the sources from where he proposes to procure the raw materials and the components.

1.3 The entire stringing work of conductor and earth wire shall be carried out by standard stringing practice.

1.4 Some of the useful definitions **relating to** Pole structures are given at **Annexure- A**

1.5 The survey, and optimization of tower / steel pole structure locations are covered **in Annexure – B**

a) For survey, erection of towers, stringing of conductors and patrolling of transmission line in difficult and inaccessible terrains, use of helicopter or Unmanned Aerial Vehicle (UAV) may be considered. The required clearance from Director General Civil Aviation (DGCA) or any other competent authority shall be obtained before taking up such activity**.**

b) The route alignment and optimization of route of transmission line may be carried out on BHUVAN GIS platform of National Remote Sensing Centre (NRSC).

2.0 Applicable Standards

2.1 The design, manufacturing, fabrication, galvanizing, testing, erection procedure and materials used for manufacture and erection of towers / steel pole structure, design and construction of foundations shall conform to the Indian Standards (IS). In case, Indian Standards are not available, International Standards shall be followed. Standards shall be latest revisions, with amendments from time to time as given in **Annexure- C**, 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 or better to those specified. In case of award, salient features of comparison between the Standards proposed by the Contractor and those specified in this document will be provided by the Contractor to establish their equivalence.

3.0 Service and climatic conditions for installation

Following basic information shall be provided by the purchaser:

(a)	Nominal System Voltage	
(b)	Frequency	
(c)	Highest System voltage	
(d)	Conductor (Type, Diameter, Area etc.)	
(e)	No. of conductors per phase	
(f)	Earth Wire (Type, Diameter, Area etc.)	
(g)	OPGW (Type, Diameter, Area etc.)	
(h)	No. of circuits and voltage level of circuits (for Multi circuit & multi voltage pole structure)	
(i)	Configuration (vertical/horizontal)	
(j)	Terrain category	
(k)	Wind zone and corresponding basic wind speed	
(l)	Maximum ambient temperature	
(m)	Minimum ambient temperature	
(n)	Maximum daily average temperature	
(o)	Maximum relative humidity (in %)	
(p)	Maximum annual rain fall (in mm)	
(q)	Number of rainy days/year	
(r)	Average number of thunder storm (days per annum)	
(s)	Altitude above MSL	
(t)	Atmospheric condition & Pollution level	
(u)	Seismic zone	

(v)	Type of insulator (porcelain disc/longrod, polymer or glass)	
(w)	Insulator configuration for suspension and tension (single/double/triple/quadruple/ V-string)	
(x)	No. of discs / long rods in each string • Suspension • Tension	

In addition to above, any other input required for design of Steel pole structure may be provided by the purchaser during detailed engineering. The purchaser may also clearly indicate / specify any constraint likely to be faced during commissioning of the transmission line due to site conditions, particularly related to electrical clearances.

4.0 Steel Pole Structure for Transmission Lines

4.1 General Description

4.1.1 The steel pole structures can be Single circuit / Multi circuit (indicate the no. of circuits & voltage level) / Multi circuit & multi-voltage (Indicate no. of circuits at each voltage level) / any other configuration (indicate the configuration) and shall be used for entire line or a section of line or for few locations of the line.

4.1.2 The number of poles (dual / multiple poles) shall be decided based on voltage level, no. of conductors per phase and no. of circuits etc.

4.1.3 The pole Structures shall be self-supporting polygonal steel pole type, designed to carry the line conductors with necessary insulators, earth-wires / OPGW and all fittings under all loading conditions.

4.1.4 The pole structure shall be fully galvanized. The most efficient grade of structural steel and plates shall be used in order to yield the optimum cost of tower / pole structure and foundation. The type and grade of mild steel shall conform to latest applicable national/international standards.

4.1.5 For cross arms also, Polygonal Sections shall be used.

4.2 Type of Pole Structures

4.2.1 The towers are classified as given below:

Table-1

Type of Pole	Deviation Limit	Typical Use
Tangent Pole (say PA/DPA/MCPA/MVPA)	0 - 2 deg.	To be used as tangent/suspension pole with suspension insulator
Tension / Angle Pole	0 deg. - 15 deg. / 2 deg. -	a) Tension/Angle Pole

(say PB/DPB/MCPB/MVPB)	15 deg.	with tension insulator b) Tension pole for the uplift forces resulting from 100m uplift span due to broken wire condition c) To be designed for anti-cascading condition
Tension / Angle Tower (say PC/DPC/MCPC/MVPC)	0 deg. - 30 deg. / 15 deg. - 30 deg.	a) Tension/Angle pole with tension insulator b) Tension pole for the uplift forces resulting from 100 m uplift span due to broken wire condition c) To be designed for anti-cascading condition
Tension / Angle /Dead end Tower (say PD/DPD/MCPD/MVPD)	30 deg.- 90 deg.	a) Tension/Angle pole with tension insulator b) Tension pole for the uplift forces resulting from 100 m uplift span due to broken wire condition c) To be designed for anti-cascading condition d) Dead end with 0 deg to 15 deg deviation both on line and sub-station side (slack span) e) Complete dead end f) To be designed for 90 deg. Deviation with or without extra cross-arm

P: Single Circuit Pole Structure, DP: Double Circuit Pole Structure, MCP: Multi Circuit (more than 2 circuits) Pole Structure, MVP: Multi Circuit & Multi Voltage Pole Structure

Note: The above pole structures can also be used for longer span with smaller angle of deviations. The terminal towers / pole structures for section of suspension / tangent pole structures shall be tension / angle towers / pole structures and angle of deviation shall depend on site condition.

4.2.2 **Extensions**

4.2.2.1 The tower shall be designed for Normal tower with + 3m , + 6m , +9m body extensions for maintaining adequate ground clearances without reducing the specified factor of safety in any manner.

4.2.2.2 All above extension provision to pole structures shall be treated as part of normal tower only.

4.2.2.2 In addition to above, the provision of adding 12m, 18m, and 25m body extension to all tower type shall also be kept by the Contractor. For Power Line Crossing tower type shall be as specified in Clause No. ----- with required extension depending upon the merit of the prevailing site condition. Bidder shall indicate the span for the towers with 12m/18m/25m body extensions. However, this shall not be less than 125 meter. The 25m extension shall be designed in such a manner that the same can also be used for 18m extension to normal tower / pole structures, after removal of the bottom (Part) pole section.

4.3 Spans

4.3.1 Normal Design Span

The Route of transmission line (66kV and above voltage level) shall be clearly identified as normal section without constraint, section through forest area, and section through urban areas / populated area / approach section near substations and normal design span in these sections for various voltage level of transmission lines as indicated in the Table-2 below shall be adopted.

Table-2

AC Voltage (kV)	Normal design span (metres)		
	Normal route without constraint	Forest area	Urban area / Populated area / approach section near substation
765kV 400 kV	200m (angle tower / pole structures) and 250m (tangent tower / pole structures)		
230 kV 220 kV	300	250	200
110 kV 132 kV	300	200	150
66 kV	250	150	100

4.3.2 Wind Span

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

ruling span. For tower design maximum wind span 1.1 times normal ruling span shall be considered.

4.3.3 Weight Span

(a) The weight span is the horizontal distance between the lowest points of the conductors on the two spans adjacent to the pole structure. For design of structures, the maximum weight span limits given in Table-3 below shall be considered.

Table-3

Voltage Level (kV)	Pole Type	Normal Condition		Broken wire condition	
		Maximum (m)	Minimum (m)	Maximum (m)	Minimum (m)
66	PA/DPA/MCPA/MVPA	375	0	225	0
	(PB/DPB/MCPB/MVPB) or (PC/DPC/MCPC/MVPC) or (PD/DPD/MCPD/MVPD)	375	0	225	-100
110 / 132	PA/DPA/MCPA/MVPA	450	0	270	0
	(PB/DPB/MCPB/MVPB) or (PC/DPC/MCPC/MVPC) or (PD/DPD/MCPD/MVPD)	450	0	270	-100
220 / 230	PA/DPA/MCPA/MVPA	450	0	270	0
	(PB/DPB/MCPB/MVPB) or (PC/DPC/MCPC/MVPC) or (PD/DPD/MCPD/MVPD)	450	0	270	-100
400 / 765	PA/DPA/MCPA/MVPA	375	0	225	0
	(PB/DPB/MCPB/MVPB) or (PC/DPC/MCPC/MVPC) or (PD/DPD/MCPD/MVPD)	300	0	180	-100

(b) In case at certain locations, the actual spotting spans exceed the design spans and cross-arms of the towers are required to be modified/ reinforced. The modified/reinforced cross-arm shall have factor of safely not less than that of tested tower for increased loadings.

4.4 Electrical Clearance

4.4.1 Ground Clearance

Minimum ground clearance for conductor shall be maintained as per requirement of Central Electricity Authority (Measures relating to Safety and Electric Supply) Regulations. However, requirement of maintaining electrostatic & electromagnetic interference, radio interference voltage, audible noise etc. within acceptable limits becomes ruling condition specifically for transmission lines of 400 kV and above voltage class.

The minimum ground clearance from the bottom conductor shall not be less than the values indicated in the Table-4 below under maximum sag conditions i.e. at maximum temperature for conventional ACSR / AAAC conductor or at temperature as specified for High Temperature Low Sag (HTLS) conductor and still air.

Table-4

Voltage Level	Minimum Ground Clearance
66kV	6100mm
110/132kV	6100mm
220/230kV	7015mm
400kV	8840mm
765kV	18000mm

However, to achieve the above clearance the height of tower shall be increased in the following manner:

a) An allowance of 150mm shall be provided to account for errors in stringing.
b) Conductor creep shall be compensated by over tensioning the conductor at a temperature of 26°C, lower than the stringing temperature for conventional ACSR / AAAC conductor.

4.4.2 Live metal Clearance

The minimum live metal clearance to be provided between the live parts and steel work of polygonal pole structure shall be as per IS: 5613 as given in Table-5 below.

Table-5

Voltage level	Suspension Insulator		Jumper		Tension Insulator
	Swing Angle	Clearance	Swing Angle	Clearance	Clearance
66kV	0^0	915 mm	0^0	915 mm	915 mm
	15^0	915 mm	10^0	915 mm	
	30^0	760 mm	20^0	610 mm	

	45^0	610 mm	30^0	610 mm	
	60^0	610 mm	-	-	
110/132kV	0^0	1530 mm	0^0	1530 mm	1530 mm
	15^0	1530 mm	10^0	1530 mm	
	30^0	1370 mm	20^0	1220 mm	
	45^0	1220 mm	30^0	1070 mm	
	60^0	1070 mm	-		
220/230kV	0^0	2130 mm	0^0	2130 mm	2130 mm
	15^0	1980 mm	10^0	2130 mm	
	30^0	1830 mm	20^0	1675 mm	
	45^0	1675 mm	-	-	
400kV	0^0	3050 mm	0	3050 mm	3050 mm
	22^0	3050 mm	25^0	3050 mm	
	44^0	1860 mm	-	-	
765kV	0^0	5600 mm (S/C) / 6100mm (D/C)	0^0	5600 mm (S/C) / 6100mm (D/C)	
	25^0	4400 mm	25^0	4400 mm	
	55^0	5500 mm	55^0	5500 mm	

For computing the live metal clearances the dimensions and configuration of Suspension / Tension insulators which shall actually be used shall be considered as per requirement. 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.

4.4.3 Phase to Phase Clearance

The minimum phase to phase vertical and horizontal clearance shall be governed by the tower design / geometrical configuration as well as minimum live metal clearances required under different insulator swing angles. The following values are generally adopted:

Table-6

Voltage level of Line (kV)	Minimum electrical clearance between conductors (Meters)	
	Vertical	Horizontal
66	2.0	3.5
110	3.2	5.5
132	3.9	6.8
220	4.9	8.4
400	8.0	13 to 16 (Approx.)
800	14.0	25.0

The staggering of conductor (s), if required, shall be as per IS: 5613.

4.4.4 Mid Span Clearance

The minimum vertical mid span clearance between the earth-wire / OPGW and the nearest power conductor shall not be less than the values mentioned in the Table-6 below 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-wires and power conductors shall be so coordinated that the sag of earth-wires / OPGW shall be at least 10% less than that of power conductors under all temperature loading conditions.

Table-6

Voltage Level	Mid Span Clearance
66 kV	3000 mm
110 kV	4500 mm
132kV	6100 mm
220 kV / 230 kV	8500 mm
400 kV	9000 mm
765 kV	9000 mm

4.5 Crossings

(a) Railway Crossing

All the railway crossings coming enroute the transmission line shall be identified by the Contractor and provisions of the regulation of Railways Authorities shall be followed. Approval from Railway Authorities shall be obtained before proceeding with work of railway crossing.

(b) Power line Crossing

Where one power line is to cross over another power line, poles with suitable extensions may be used, depending upon the merit of the prevailing site condition.

For crossing of power line of 400kV or above voltage class, large angle poles of deviation angle of 30-60 degree & designed for dead end condition, with required body extension, shall be used on either sides of the power line.,

For crossing of power line of 110 kV, 132 kV, 220 kV and 230 kV voltage class, the tension poles with required body extension shall be used on either sides of the power line and the crossing of power lines of 66kV class shall be done with any type of poles (suspension /or tension) with required body extension.

In case of crossing with tension poles proper guying shall be provided to facilitate stringing of the power line crossing sections separately on obtaining line shutdowns.

Clearance between lines crossing each other shall be kept in accordance with the Central Electricity Authority (Measures Relating to Safety and Electric Supply) Regulations. In order to reduce the height of the crossing towers, it may be advantageous to remove the ground-wire of the line to be crossed (if this is possible and permitted by the owner of the line to be crossed)

(c) Telecommunication Line Crossings

For crossing of telecommunication lines, Central Electricity Authority (Measures Relating to Safety and Electric Supply) Regulations and guidelines of Power and Telecommunication Co-ordination Committee (PTCC) shall be followed.

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

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

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

(d) Road Crossing & river crossing:

At all important road crossings, the tower shall generally be fitted with normal tension insulator but the ground clearance at the roads under maximum temperature and in still air shall be such that even with conductor broken in adjacent span, ground clearance of the conductor from the road surfaces will not be less than minimum ground clearances specified in Central Electricity Authority (Measures Relating to Safety and Electric Supply) Regulations. At all national / state highways, tension type towers (with deviation angle of 30-60 deg.) with tension insulator strings shall be used and crossing span shall not be more than 250 meters, unless higher span is permitted by national highways authority in case of highways having more lanes. Regulations of Highway Authorities shall be followed.

(e) River Crossings

In case of major river crossing, river crossing towers shall be of suspension type along with anchor towers of tension type tower (with deviation angle of 30-60 deg.) on either side of the main river crossing. Alternately on the basis of economics and / or site / execution constraints crossing of rivers using normal extended angle towers

(+18/+25/+30M Extns.) also shall be considered. For navigable rivers, clearance required by navigation authority shall be provided. For non-navigable river, clearance shall be reckoned with respect to highest flood level (HFL).

(f) For river crossings or power line crossings (66kV or above), railways or road crossings (express way, national highway & state highway) minimum two sets of long rod insulators or two sets of disc insulator strings per phase shall be used.

(g) Bidder shall adopt same cross arm design where jumper is projecting outside of cross arm for PD/DPD/MCPD/MVPD type tower to be used as dead end angle tower.

(h) The staggering of conductor (s), if required, shall be as per IS: 5613.

4.6 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 tower / pole structure supports, to the vertical line through the centre line of the earth-wire / OPGW. Bidders shall design the tower in such a way that the angle of shielding does not exceed 30 deg. for 66kV/110kV/132kV/220kV/230kV lines, 20 deg. for 400kV & 765kV (S/C) line and 10 deg. For 765kV (D/C) lines.

The drop of the earth-wire clamp should be considered while calculating the minimum angle of protection. For estimating the minimum angle of protection the drop of earth wire suspension clamp along with shackle shall be taken as 150 mm.

4.7 Design of Pole Structure

Pole structure shall be designed as per following minimum requirement:

4.7.1 Design Criteria

The pole structure shall be designed to meet design requirements & design criteria stipulated in latest versions of IS: 802 and ASCE standard 48 as applicable except otherwise specified in this specification.

4.7.2 Design Temperature

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

a) Minimum temperature (deg C): To be specified by utility as per site requirement

b) Every day temperature of conductor: 32 deg C
c) Max. temperature of
   i) Conductor (deg C): As per Conductor used (85 deg C, 95 deg. C for ACSR & AAAC conductor respectively)
   ii) Earth-wire exposed to sun: 53 deg C

4.7.3 Normal Loading Conditions

4.7.3.1 The 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. shall be calculated as per latest version of IS-802 considering various combinations of design temperatures, wind loads and prepare loading trees/diagrams/charts. However, Reliability level as per following Table-7 shall be considered for design of pole structure of transmission lines:

Table-7

66 kV to 400 kV Transmission lines with one / two circuits and one / two conductors per phase	Reliability level 1 corresponding to 50 years return period
(a) 66 kV to 400 kV Transmission lines with more than 2 circuits; (b) 400 kV Transmission lines with more than two conductors per phase; (c) 765 kV and 1150 kV transmission lines	Reliability level 2 corresponding to 150 years return period
(a)Special type pole structures; (b)Tall River crossing pole structures; (c) Multi-circuit pole structures whose full scale prototype cannot be tested due to limitation of testing facility	Reliability level 3 corresponding to 500 years return period

4.7.3.2 Any other loading condition/design criteria proposed by the Standing Committee of experts for investigation of transmission tower failure or any other task force constituted by the Government shall also be considered for designing of pole structure.

4.7.3.3 The loading trees/diagrams/charts shall be submitted to purchaser for approval. The pole structure designs shall be developed by the contractor as per the approved loading trees/charts/diagram.

4.7.3.4 The pole structure shall also be designed for narrow front wind load (considered to be acting on pole structure and conductor) corresponding to wind zone at site acting in any direction, i.e. 0, 45 or 90 deg.

4.7.3.5 For calculating vertical loads on the pole structure, the weight of suspension insulator and tension insulator shall also be considered for each phase conductor depending on the requirement.

4.7.3.6 **The towers / pole structures shall also be designed to suit for circuits strung on one side of the structure, if structure is designed for symmetrical configuration.**

4.7.4 Maximum Tension

4.7.4.1 Max tension shall be based on either

a) At 0 deg C (or at minimum temperature below 0 deg C if so specified by the utility) with 36% full wind pressure, or
b) at 32 deg C with full wind pressure whichever is more stringent.

4.7.4.2 Sag tensions calculations are to be carried out by the contractor considering conductor & earthwire/OPGW parameters & specified conditions and spans.

4.7.4.3 The initial tension at 32ºC and nil wind shall be 22% (for 400kV and above voltage level) / 25% (below 400kV) of the ultimate tensile strength for the conductor and less than 20% of the ultimate tensile strength for the earthwire/OPGW.

4.7.4.4 The ultimate 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 40 per cent of the ultimate tensile strengths.

4.8 Electro-mechanical strength of insulator

Electro-mechanical strength of insulator shall be selected such that:

a) under 100% design wind loading conditions, the load on insulator string shall not exceed 70 % of its electro-mechanical strength;
b) under everyday temperature and nil wind conditions, the load on insulator string shall not exceed 25% of its electro-mechanical strength.

4.9 Conductor and Earth-wire Configuration

4.9.1 Conductor configuration shall be as specified by the utility as per its requirement.

4.9.2 Single earthwire shall be used for transmission lines up to 220 kV and two earthwires shall be used for transmission lines of 400 kV and higher voltage classes.

4.9.3 The earthwire used in 66 kV voltage class lines shall be OPGW or galvanized stranded steel (GSS) or Aluminium Alloy Conductor Steel Reinforced (AACSR) type.

4.9.4 The earthwire used in 110 kV and above voltage class lines shall be OPGW and in case of 400kV and above voltage class lines, at least one out of two earthwires shall be OPGW and second earthwire shall be either of galvanized stranded steel (GSS) or Aluminium Alloy Conductor Steel Reinforced (AACSR)conductor type.

4.10 Deflection Criteria (for both suspension and tension Pole structure)

The deflection of 2% (under ultimate load condition) of the height of pole shall be considered in the design where the deflection of pole is restricted due to site requirement. Otherwise, the deflection of 5% to 8% (under ultimate load condition) of the height of pole shall be considered in the design where there is no such restriction at site. However, in any situation, the required electrical clearances has to be maintained as per Central Electricity Authority(Measures relating to safety and electric supply) Regulations.

4.11 D/T and W/T Ratio for Design of pole Structure

While designing the pole structure, the D/T ratio and W/T ratio (D: Diameter of section, W: Width of side, & T: Thickness of sheet) shall be maintained properly to avoid buckling under load and ovality of the individual sections of the pole structure.

5.0 Design Calculation and drawing

5.1 The detailed design calculation and drawings for different type of pole structure for the transmission line along with design of different type of foundation for the same are required to be furnished to the purchaser along with the bid. The line diagrams of pole structures are also to be furnished. The bidder shall also furnish basic assumptions and criteria of pole structure design so that design calculations could be checked even if computerized.

5.2 After award of contract, the Contractor shall submit detailed design of all polygonal pole structures with all extension along-with stress diagram/computer output together with sample calculations and foundation design and drawing etc., anchor bolt templates and loading/ rigging arrangement of tower testing to enable the purchaser to make a preliminary check regarding structural stability of tower before tests.

5.3 The Contractor should also submit one copy of reproducible of all drawings & Bill of Materials after final approval.

5.4 The drawings of accessories of pole structure like number plate, danger plate, phase plate, circuit plate, step bolt, anticlimbing device, pole plate and earthing arrangement, bird guard, D-shackle etc. shall be prepared by the contractor and shall be submitted to the purchaser, in soft copies for approval.

5.5 After approval of design by the Owner/Consultant, the Contractor shall develop structural drawings including all details of cross arms, joints and attachments based on approved design and furnish soft copies of the drawings for scrutiny at Owner's end. If the design/drawings are corrected by the purchaser, the Contractor shall submit revised designs/drawings within 15 (fifteen) days of issue of corrections. The contractor shall develop computer aided structural drawings and prepare bills of materials and shop drawings of Pole structure. After thorough scrutiny and upon satisfaction about the soundness/correctness of joints and the drawing as a whole, the Owner shall convey their acceptance to contractor.

5.6 Upon receiving the acceptance of structural drawing from the owner, the contractor shall develop shop drawings for Pole structure and fabricate them as per the drawings for the purpose of proto assembly and inspection. During proto - assembly inspection, Owner may depute their Engineer for checking the conformity. However, the overall responsibility of ensuring the correctness of the shop & structural drawings and the proto assembly shall lie with the contractor.

At this stage if any modification is required to be carried out on the fabrication shop drawings or on the structural drawings, the same shall be properly incorporated with prior intimation to the Owner.

5.7 Subsequent to the successful proto assembly of the Pole structure, the tower shall be tested as per IS-802 and as described by the Owner. The test shall be carried out in presence of Owner's and Contractor's representatives.

5.8 At the time of proto assembly and / or proto testing, if any modification are required to be carried out, the same shall be incorporated by the Contractor and the revised structural drawings, bills of materials and shop drawings shall be submitted to the Owner within 15 days of completion of testing of towers for approval. After approval, the Contractor shall submit copies of drawings/BOMs and 2 sets of shop drawings along with one set of RTF. Soft copies of Structural & Shop drawings and BOM's shall also be submitted in CD/DVD/Pen drive for computer use.

5.9 The right of design shall be with the Owner. All drawings therefore shall be duly marked with the following:

5.10 **Loading Trees:** Loading trees shall be prepared by the Contractor for design purposes. The loading trees shall summarize various aspects regarding loading and shall govern the design besides requirements stipulated in IS-802.

5.11 After successful testing of pole structure and subsequent approval of design, drawing and bill of materials, the Contractor shall furnish the soft copies of following design calculations, drawings and bill of material to the purchaser within fifteen (15) days of approval:

(a) Detailed design calculation and drawing for pole structure and foundations.
(b) Detailed structural drawings indicating section size, length of members, sizes of plate along with hole to hole distance, joint details etc.
(c) Bill of materials, indicating cutting and bending detail against each member.
(d) Shop drawings showing all details relevant to fabrication.
(e) All the drawings for the pole accessories.

5.12 While submitting the designs, structural drawings, bill of materials and any other drawings pertaining to the subject transmission line, the Contractor shall clearly indicate on each drawing Specification No., Name of the transmission line and project, Name of utility, letter reference No. and date on which the submission are made.

6.0 General Construction

6.1 Pole Structure

6.1.1 Steel of tested quality in conformity with IS: 2062 are to be used in, Pole structures, which includes pole shaft, cross arms & arm brackets, base plate etc.. Not more than two grades of steel shall be permitted for use. The quality of steel shall be BR/B0. ~~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 permitted, unless otherwise indicated in this specification. Steel plates below 6 mm size exclusively used for packing plates/packing washers produced as per IS : 1079 (Grade-0) are also acceptable. However, if below 6 mm 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 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 410025 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 355MPa) / IS 2062: 2011 — grade E350.

6.1.2 The silicon content of plates used for pole shaft shall be limited to less than 0.06 % to have better quality of galvanizing.

6.1.3 Pole shall be continuously tapered from top to bottom with uniform slope.

6.1.4 Steel grade of weldable quality only shall be selected. The grades of steel shall be selected to meet the design requirements keeping in view the overall optimum weight of the pole structure and availability of material.

6.1.5 The sheets/plates of monopole shall be from primary steel producers such as TATA/SAIL/JSW/ESSAR/ RINL only.

6.1.6 Quality Control Order issued by Ministry of Steel shall be followed.

6.2 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. The anchor bolts for the pole shall be provided with top and bottom templates to form cage. This is to get a proper alignment of bolts during casting of foundation.

6.3 Fasteners: Bolts, Nuts and Washers

6.3.1 All bolts and nuts shall conform to IS-12427. All bolts and nuts shall be galvanized as per IS-1367 (Part-13)/IS- 2629 and shall have hexagonal head and nuts, the heads being forged out of the solid steel rods & shall be truly concentric, and square with the shank, which must be perfectly straight.

6.3.2 The bolt shall be of minimum 16mm / 24mm diameter and of property class 6.8 (for foundation bolts) and 8.8 (for connection bolts) specified in IS: 1367 (Part-III) and matching nut of property class as specified in IS: 1367 (Part-VI).

6.3.3 Bolts upto M16 and having length upto 10 times the diameter of the bolt should be manufactured by cold forging and thread rolling process to obtain in 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 in accordance with IS: 1363 (Part-I) to ensure proper bearing.

6.3.4 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.

6.3.5 All bolts shall be threaded to take the full depth of the nuts and threaded 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 and tight to the point where the shank of the bolt connects to the head.

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

6.3.7 The bolt positions in assembled pole structure shall be as per IS: 5613 (Part-II/Section-2).

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

6.3.9 Nuts should be double chamfered as per the requirement of IS: 1363 Part-III. It should be ensured by the manufacturer that nuts should not be overlapped beyond 0.4mm (To be checked for M24) oversize on effective diameter for size up-to M16 / M24. The nuts shall be forged and tapped after galvanizing and then lubricated.

6.3.10 The bolts and nuts shall be free from forging and threading defects such as cuts, splits, burrs, bulging, taper, eccentricity, loose fit etc.

6.3.11 Flat and tapered washers shall be provided wherever necessary.

6.3.12 Spring washers shall be provided for insertion under all nuts. These washers shall be of steel electro-galvanized, positive lock type and 3.5mm in thickness for 16mm dia bolt and 4.5mm for 24mm bolt.

6.3.13 The surface of the washers shall be free of scales and burrs. The washers shall be coiled without any kinks (except for the shape with turned-up ends). The ends of the washer shall be so served as to prevent tangling.

6.3.14 The spring washers after coiling shall be suitably heat treated so as to result in the finished washer having hardness 43 to 50 HRC when tested in accordance with IS 1586.

6.3.15 To ensure effective in-process Quality Control it is essential that the manufacturer should have all the testing facilities for tests like weight of zinc coating, shear strength, other testing facilities etc. in house. The manufacturer should also have proper Quality Assurance System which should be in line with the requirement of this specification and IS: 14000 series Quality System standard.

6.4 Pole Structure Accessories

6.4.1 Step Bolts & ladders

(a) Each tower shall be provided with step bolts conforming to IS: 10238 of not less than 16mm diameter and 175 mm long, spaced not more than 450 mm apart and extending from about 2.5 meters above the ground level to the top of the tower. The head diameter shall be 35mm. The step bolt shall be fixed on two sides of polygon of the pole structure in alternate step arrangement. Each step bolt shall be provided with two hexagon nuts on one end to fasten the bolt securely to the tower and button head at the other end to prevent the feet from slipping away. The step bolts shall be capable of withstanding a vertical load not less than 1.5 kN. As an alternate to step bolts, ladders of suitable design may also be provided by the contractor.

(b) For special structures, where the height of the super structure exceeds 30 Mtrs??, ladders along with protection rings as per Employer approved design shall be provided in continuation of the step bolts on one face of tower from 30 Mtrs above ground level to the top of the special structure. From 2.5 m to 30 m height of super structure step bolts shall be provided. Suitable platform using 6 mm thick perforated checkered plates along with suitable railings for access from step bolts to the ladder and from ladder to each cross-arm tip and the earth-wire support shall also be provided. The platform shall be fixed on tower by using countersunk bolts.

(c) For horizontal access on cross arms, suitable designed hooks can 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.

6.4.2 Insulator Strings and earth-wire Clamps Attachments

(a) Insulators assemblies as approved by the purchaser shall be used by the Contractor for Suspension and Tension pole structures.

(b) For the attachment of suspension insulator string, a suitable dimensioned swinging hanger on the pole, if required, shall be provided so as to obtain specified clearances under respective swinging conditions of the strings. The hanger, extension links, D-shackles etc. as required & considered in the design of the pole, shall be of same strength as that of corresponding electromechanical strength / ultimate tensile strength of insulator string. The design & supply of hanger, extension links, D-shackles are also in the scope of the Contractor.

(c) At tension pole structures strain plates of suitable dimensions on the underside of each cross-arm tip and at the top of earth-wire peak, suitable plate should be provided for taking the hooks or D-Shackle of the tension insulator strings or earth-wire tension clamps, as the case may be. Full details of the attachments shall be submitted by the contractor for Employer’s approval before starting the mass fabrication.

(d) In the design of tension towers, D-Shackle, extension links etc., if any required and considered with single and double tension strings to meet requisite clearances, the same shall have minimum electromechanical strength / ultimate tensile strength as specified. The supply of these D-shackles & extension links shall also be in the scope of the Contractor.

6.4.3 Earth-wire / OPGW Clamps

Suspension and tension clamps conforming to IS 5613 shall be provided by the contractor. For Suspension and tension clamp for attachment of earthwire/ OPGW wherever required, the Contractor shall supply U–bolts, D–Shackles etc. for attachment of clamp to the pole structure. These items shall be of same rating/ strength as that of corresponding rating/ Ultimate tensile Strength of earthwire suspension/tension clamp.

6.4.4 Anti-climbing Device

Barbed wire type anti-climbing device shall be provided and installed by the Contractor for all pole structures. The height of the anticlimbing device shall be provided approximately 3 m above ground level. The barbed wire shall conform to IS: 278 (size designation A1). The barbed wires shall be given chromating dip as per procedure laid down in IS: 1340.

6.4.5 Danger, Number, Circuit and Phase plate

(a) Each tower shall be fitted with a number plate, danger plate and a set of phase plates per circuit. The arrangement for fixing these accessories shall not be more than 4.5 m above the ground level.
(b) The letters, figures and the conventional skull and bones of danger plates shall conform to IS: 2551 and shall be in a signal red on the front of the plate.
(c) The corners of the number, danger and circuit plates plate shall be rounded off to remove sharp edges.
(d) The letters of number & circuit plates shall be red enameled with white enameled background.

6.4.6 Bird Guards

To prevent birds perching immediately above the suspension insulator strings (I-Type / V-Type) and fouling the same with droppings, suitable bird guards shall be provided at crossarm tips of all suspension towers. Saw type bird guard conforming to IS: 5613 shall be provided. The bird guard arrangement shall be such that it shall either prevent bird from perching in position where they are liable to cause damages or ensure that if birds do perch, droppings will fall clear of the insulator string. Suitable provision of cleat / plate to be provided on all Suspension towers facilitating installation of bird guard after stringing.

6.4.7 Bird Diverters and aviation Requirement

(a) The bird diverters, wherever required as per MoEFF &CC or WII's guidelines, shall be provided. Technical specifications for bird diverter available at Central Electricity Authority's website (www.cea.nic.in) shall be followed.

(b) The day and / or night visual aids and markers for denoting transmission line or structures as per requirements of Directorate of Flight Safety or International Civil Aviation Organization.

6.5 Pole Structure Fabrication

6.5.1 The Pole Structure along with cross arms, earth-wire peaks, base plate and joints shall be fabricated by the Contractor as per the design developed by the Contractor and approved by the Owner/Consultant.

6.5.2 The fabrication of Pole structure shall be in conformity with the following:

(a) Except where hereinafter modified, details of fabrication shall conform to industry practices and relevant standards.

(b) Joints shall be so designed and fabricated that eccentricity is avoided as far as possible. Connections by means of slip joints or flange plates are both acceptable.

(c) Pole section, if made with telescopic slip joints, shall be suitable for easy assembly either in air or on the ground at the construction site. Overlapping shall not be less than 1.5 times the largest inside diameter of the female section. The taper of each section at a slip joint should match the taper of the adjacent section.

(d) On slip-in joints, diameter of the inner and outer part of the pole structure shall be controlled to ensure smooth assembly of the monopole structure.

(e) The cross arms shall be connected to the monopole by means of suitable flanges welded on the body and cross arms.

(f) The Pole structures shall be accurately fabricated to connect together easily at Site without any undue strain on the structure.

(g) The diameter of the hole for bolts shall be equal to the diameter of bolt plus 1.5 mm.

(h) 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.

(i) Maximum size of individual fabricated/welded piece shall be so selected to facilitate easy handling transportation and erection of pole structure. Any other specific restriction on length due to site condition should be specified by the purchaser beforehand. The limits of weights & dimensions of individual components shall be finalized at the time of design development and approval.

(j) All similar parts shall be made strictly inter-changeable. All steel sections before any work is done on them, shall be carefully leveled, straightened and made true to detailed drawings by methods which will not injure the materials so that when assembled, the adjacent matching surfaces are in close contact throughout.

(k) In case of restriction due to size of hot dip galvanizing bath, pole segments having outer diameter more than 1 m shall be fabricated in two half and seamlessly welded.

(l) No sharp/rough edges shall be permitted in the entire structure.

(m) Suitable provisions shall be kept in design and detailing of pole structure for easy erection at site using conventional as well as mechanized methods. Detail erection procedure/manuals shall be prepared and submitted by the Contractor.

(n) Design and detailing for providing step bolts/hooks/ladders etc. shall be done so that such provision would facilitate accessibility to all parts of pole structures and installation & maintenance of insulators, hardware assemblies, conductors etc. can be done easily. Design detailing for provision of other accessories viz. Anticlimbing device, Danger plate, Number, Phase plate etc. shall also be done.

6.5.3 Material Cutting, Forming & Bending

(a) The required material cutting, forming and bending operations shall be carried out generally in accordance with ASCE standard 48 "Design of Steel transmission Pole Structures".

(b) 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.

6.5.4 Drilling and Punching

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 aspect is permissible.

(b) The max. 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.

(d) All burrs left by drills or punch shall be removed completely. When the tower / 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.

6.5.5 Welding

(a) Welding being the key process of pole manufacturing, the manufacturer should have ISO 3834-2 certification for quality of welding.

(b) All welding shall be in accordance with the latest revision of American Welding Society Structural Welding Code (ANSI/AWS D1.1). Welding terms and symbols should comply with the AWS definitions and symbols.

(c) 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 D 1.1 code. Preheating shall be done according to the ANSI/AWS code or the steel producer's recommendations, or both. The welding shall be done by the shield metal-arc, gas shielded flux core, gas shield metal arc or submerged-arc processes. The storage of welding consumables (welding wire, electrodes, fluxes and gases) shall be in accordance with AWS D1.1and as per manufacturer's recommendations. These details shall be included in MQP (Manufacturing Quality Plan) to be prepared and submitted by the Contractor.

(d) Circumferential and longitudinal welds within the slip joint area of pole sections should be ultrasonically inspected in accordance with AWS D1.1. Longitudinal welds in pole sections where visual inspection is not adequate, magnetic particle tests or dye penetration test should be conducted in accordance with AWS D1.1.

(e) Shaft-to-shaft, pole shaft-to-base plate, and pole shaft-to-flange shall be full penetration welds. Arm shaft-to-arm bracket shall be partial penetration groove weld with fillet overlay, sized to develop the full strength of the shaft.

6.5.6 Erection mark

(a) Each individual member shall have an erection mark conforming to the component number given to it in the fabrication drawings. This mark shall be made with marking dies of 16 mm size before galvanizing and shall be legible after galvanizing.

(b) Erection Mark shall be in the format: A-BB-CCCC-DDD

Where,

A = Purchaser's code assigned to the Contractors - Alphabet
BB = Contractor's Mark-Section ID
CCCC = Tower Type-Alphabet (maximum 4 alphabets)
DDD = Number mark to be assigned by Contractor - Numerical.

7.0 Quantities and weight

(a) The provisional quantities required (including provisional spare for pole structure quantity) shall be mentioned by the purchaser. Final quantities shall be determined after completion and approval of the detailed route survey. The final quantities of pole structure including spare pole structures shall be confirmed by the purchaser based on the requirement of quantities of various pole structures after completion of detailed survey.

(b) The purchaser reserves the right to order the final quantities including required quantities of spares.

(c) The rate quoted by the bidder for pole structure / structure parts supply, is deemed to be inclusive of galvanising charges & the cost of zinc.

(d) The contractor is to supply upto 2.5% extra fasteners to take care of losses during erection.

(e) The weight of pole structure shall mean the weight of successfully tested pole structure calculated by using the black (i.e. un-galvanized) weight of members indicated in the approved bill of materials without taking into consideration the reduction in weights due to holes, notches and cuts etc., but taking into consideration the weight of the D-shackles, hangers, bolts, nuts and spring 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 considerations 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 structures and body extensions as approved by the purchaser.

(f) The estimated unit weight of each type of pole structure, anchor bolts/stubs and extensions shall be furnished by the bidder. The estimated weights of pole structure & extensions etc. are the minimum guaranteed values.

(g) 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.

8.0 Galvanizing

8.1 The proto type fabricated by the Contractor shall be tested in black condition (Un-galvanized) / galvanized condition. The Contractor shall examine various industrial practices for galvanizing of Pole Structures and recommend suitable alternatives for galvanizing. The Contractor shall ensure that design & fabrication of the pole structure is such that the same can be galvanized in full or suitable parts as per relevant standards using the alternative selected by the owner.

8.2 Fully galvanized towers / pole structures and anchor bolts shall be used for the lines. Galvanizing of the tower / pole structure members shall conform to IS: 2629 and IS: 4759. All galvanized members shall withstand tests as per IS: 2633. For fasteners, the galvanizing shall conform to IS: 1367 (Part-13). The galvanizing shall be done after all fabrication work is completed, except that the nuts may be tapped or re-run after galvanizing. Threads of bolts and nuts shall have a neat fit and shall be such that they can be turned with finger throughout the length of threads of bolts and they shall be capable of developing full strength of the bolts. Spring washers shall be electro-galvanized as per clause 4 of IS: 1573.

8.3 All fabrication work on pole sections (including welding of base section with base plate) shall be completed in all respect before hot dip galvanization. No cutting, grinding, welding, fabrication etc. shall be allowed on any pole sections after hot dip galvanization is over.

8.4 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.

8.5 **The pole manufacturer has to submit in writing the suitability of its galvanizing facility / bath where the pole sections are to be galvanized.**

8.6 Cold galvanizing methods shall not be applied on any of the pole sections while manufacturing / galvanizing.

8.7 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 at 87 microns and that for plates & sections below 5mm shall be maintained at 65 microns.

8.8 Higher thickness of galvanisation on tower / pole structure members shall be done in coastal areas. For coastal areas, the fabricated tower parts and stubs shall have a minimum overall zinc coating of 900 gm/m2 of surface area except for plates and sections below 5 mm, which shall have a minimum overall zinc coating of 610 gm/m2 of surface area. The average thickness of zinc coating for all sections and plates of 5 mm and above shall be maintained at 127 microns and that for plates and sections below 5 mm shall be maintained at 87 microns.

8.9 **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.

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

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

(b) **Pickling:** Pickling shall be done using either hydrochloric or sulphuric acid as recommended in IS 2629. 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.

(c) **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.

(d) **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.

(e) **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.

(f) **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 aluminium alloy shall be added as per IS 2629.

(g) **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.

(h) **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 dichromate 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.

(i) **Storing, Packing and Handling:** In order to prevent white rust formation sufficient care should be exercised while storing handling and transporting galvanized products. The articles shall be stored in an adequately ventilated area. The articles shall be stored with spacers in between them and kept at an inclination to facilitate easy drainage of any water collected on the articles. Similar care is to be taken while transporting and storing the articles at site. The Contractor shall prepare a detailed galvanizing procedure including Flow Chart with control parameters and all plant standards as required above and submit to employer for approval as part of Quality Assurance Plan. In case, galvanizing of any portion of pole structures is permitted in two parts/halves, Zinc Metallizing / cold galvanizing or Zinc Rich Paint, (Pre- mixed type paint, based on organic/inorganic binders specially formulated for steel surfaces may be used after welding of parts/halves so as to have equivalent thickness of specified zinc coating. The dried film of Zinc Rich Paint should contain a minimum of 92 percent Zinc Dust by mass is allowed as per Section -11 of American Welding Society standard AWS WZC/D19.0-72

9.0 Pole structure Foundations

The type of foundation for pole structure shall be designed based on a geotechnical investigation of the soil.

9.1 Geotechnical Investigations

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

9.1.1 Scope

(a) The scope involves soil sampling and tests, the details of which vary according to tower location, in order to develop recommendations concerning foundation types regarding bearing capacity, uplift

resistance and settlement constraints, as described hereafter. Detailed soil investigation shall be carried out at various tower locations as shall be identified by the Employer. In addition, for other tower locations, Contractor shall bore trial holes or excavate a test pit to at least 3.5 meters depth and furnish bore log data including depth of the ground water table at each tower location. Based on the soil parameters, Contractor shall recommend the foundation type suitable for each location as qualified herein and as approved by the Employer. The Employer may modify the field exploration campaign both prior to and during the exploration process based on the actual findings.

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

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

(d) The field and laboratory data shall be recorded on the proforma recommended in relevant Indian Standards. Contractor shall submit to Employer copies of field bore logs (one copy each to Employer's site and Design Directorate) and all the field records (countersigned by the Employer) soon after the completion of each borehole/test.

(e) Whenever Contractor is unable to extract undisturbed samples, it shall immediately inform the Employer. Special care shall be taken for locations where marshy soils are encountered and Contractor in such

cases shall ensure that specified number of vane shear tests are performed and the results correlated with other soil parameters.

(f) The soft copy of all field records and laboratory test results shall be sent to Employer on regular basis. Employer may observe, at all times, the laboratory testing procedures.

(g) The Contractor shall interact with the Employer to get acquainted with the different types of structures envisaged and in assessing the load intensities on the foundation for the various types of towers in order to enable him to make specific recommendations for the depth, founding stratum, type of foundation and the allowable bearing pressure.

(h) After reviewing Contractor's geotechnical investigation report, Employer will discuss with Contractor's Geotechnical Engineer and finalize the report.

(i) Contractor shall carry out all work expressed and implied in Clause 9.1.1 of these specifications in accordance with requirements of the specification.

9.1.2 General Requirements

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

(b) Contractor shall make use of information gathered from nearby quarries, unlined wells, excavations, etc. Study of the general topography of the surrounding areas will often help in the delineation of different soil types.

(c) Contractor shall gather data regarding the removal of overburden in the project area either by performing test excavations, or by observing soil erosion or landslides in order to estimate reconsolidation of the soil strata. Similarly, data regarding recent landfills shall be studied to determine the characteristics of such landfills as well as the original soil strata.

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

(e) It is essential that equipment and instruments be properly calibrated at the time of commencement of the work. If the Employer so desires, Contractor shall arrange for having the instruments tested/ calibrated at an approved laboratory at its cost and shall submit the test reports to

the Employer. If the Employer desires to witness such tests, Contractor shall arrange for the same.

9.1.3 **Specific Requirements for Geotechnical Investigation at River Crossings.**

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

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

Geotechnical Report must furnish the following:

(i) Geotechnical investigation scheme;
(ii) Bore-logs indicating soil stratification, with IS classification, sampling details and SPI 'N' values.
(iii) Soil cross-sections along various boreholes in two orthogonal directions indicating soil stratification based on field and laboratory tests;
(iv) Grain size distribution curves.
(v) IS classification of soils.
(vi) Shear tests (UU) to be done on saturated soil samples;
(vii) Bearing capacity of soil at different levels;
(viii) Highest flood level (H.F.L.);
(ix) Maximum discharge, velocity etc. (from authenticated source such as CWC or appropriate State authorities)
(x) Recommendations regarding type of foundation to be adopted at the location.

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

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

Contractor shall make his own arrangements for locating the coordinates and position of boreholes in creek/river with respect to two grid-lines indicated by Employer.
Boring in creek or river shall be payable only below the bed level and no payment shall be made for lowering the casing in water.

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

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

9.1.4 Codes and Standards for Geotechnical investigations

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

(b) All work shall be carried out in accordance with the Indian Standards and codes (latest revisions) and as amended from time to time **[Refer Annexure-C]**.

9.2 Foundation Types

(a) The foundation shall generally be either open cast raft type or pier type or pile or screw pile type depending on economy and feasibility of construction at site and shall be in conformity with the present day practices followed in the country and the specifications laid herein. All the footings of individual towers with or without extension shall be similar, irrespective of down and uplift. Plain Cement concrete/Reinforced Cement concrete footing shall be used for all types of normal towers. Foundation classification has been mentioned in **Annexure-E** for reference.

(b) In addition to the classification of foundations given in **Annexure-E**, depending on the site conditions other types of foundations shall also be provided by the Contractor suitable for:

i) Intermediate conditions under the above classifications to effect more economy, or
ii) For locations where special foundations (well type or piles) are necessitated.

(c) The scope of work for foundation shall include design, supply of materials such as cement, sand aggregates, reinforcement steel as well as all items of work related to supply and installation of foundations such as form work, excavation, anchor bolt/stub setting, concreting, placement of reinforcement, shoring, shuttering, dewatering, stock piling, dressing, curing, backfilling with excavated/borrowed earth (irrespective of leads).

(d) Consolidation of earth, carriage of surplus earth to the suitable points of disposals required by the Owner or any other activity related to completion of foundation work.

(e) The proposal for these types of foundations shall be submitted by the Contractor based on the detailed soil investigation and approval for the same shall be obtained from the Employer.

(f) The bidder has to furnish along with the bid one sample calculation for each type of foundation offer for verification of correctness of, design procedure adopted by the bidder.

(g) The bidder is required to quote in the relevant schedules of Bid, the composite rate of foundation per tower for the foundations listed in the Bill of quantities. The composite rate quoted shall deem to include the complete scope of work as indicated above.

(h) The bidder is also required to furnish estimated foundation volumes and unit rates for excavation, concreting and reinforcement in the relevant schedules of Bid. The unit rates of excavation, concreting & reinforcement when multiplied with the corresponding estimated volumes shall match with the composite rate quoted for the foundations for the complete scope of work.

(i) However, if foundations of types/classifications other than those listed in Bill of Quantities, are required to be designed and installed at certain locations due to different soil conditions, the payment for such foundations shall be made based on the unit rates for excavation, concreting and reinforcement, which shall deem to include the complete scope of work as indicated above.

9.3 Loads on Foundations

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

9.3.2 The reactions on the footings shall be composed of the following type of loads for which these shall be required to be checked:
a) Max. tension or uplift ~~along the leg slope~~.
b) Max. compression or down-thrust ~~along the leg slope~~.
c) Max. horizontal shear or side thrust

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

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

9.4 Stability Analysis

9.4.1 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.

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

a) Resistance against uplift

The uplift loads will be assumed to be resisted by the weight of earth in an inverted frustum of a conical pyramid of earth as per formula detailed in the specification drawing 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.

b) Resistance against down-thrust

The following load combinations shall be resisted by the bearing strength of soil:
i) The down thrust loads combined with the additional weight of concrete above earth are assumed to be acting on the total area of the bottom of the footing.
ii) The moment due to side thrust forces at the bottom of the footing.
iii) Additional moments due to eccentricity of the loads The structural design of base slab shall be developed for the above load combination. In case of toe pressure calculation due to above load combination, allowable bearing pressure can be increased by 25%.

c) Resistance against side-thrust

The lateral load capacity of a chimney foundation shall be based on the chimney acting as cantilever aided by the passive earth resistance developed 500 mm below the ground level. The chimney shaft shall be designed as per limit state method for the combined action of axial forces, tension and compression and the associated max. bending moment. In these calculations, the tensile strength of the concrete shall be ignored. Similarly, since stub angle is embedded in the centre of chimney, its effectiveness in the reinforcement calculation is to be ignored.- **Is it Applicable to Pole Structure??**

9.5 Properties of Concrete & Reinforcement

9.5.1 The cement concrete used for the foundations shall be of minimum grade M-20/25 corresponding to 1:1.5:3 nominal mix ratios with 20mm coarse aggregate for chimney portion and 20 mm coarse aggregate for pyramid or slab portion. If required higher grade concrete may be used for casting of tower footings as per site conditions. All the properties of concrete regarding its strength under compression tension, shear, punching and bend etc. as well as workmanship will conform to IS: 456-1978.- **Is it Applicable to Pole Structure??**

9.5.2 Ready Mix concrete from batching plant can also be used. The ready mix concrete shall conform to IS:4926. The selection and use of Materials for the ready mix concrete shall be in accordance with IS:456. The concrete shall be of M25 grade design mix as per IS:456. The minimum cement content shall not be less than 330kg/m3. The transport of concrete and transportation time shall be as per IS:4926.

9.5.3 For foundation in creek or aggressive soil areas, Concrete of M30 Grade design Mix conforming to IS 456 and epoxy coated reinforcement as per IS 13620 shall be used . In addition, 02 (two) coats of bituminous painting of minimum 1.6 kg/m2 per coat shall be applied on all the exposed faces of the foundation (i.e pedestal & base slab).

9.5.4 The weight of concrete to be considered for design of foundations is given in
Table-8 below:

Table-8

Type of Concrete	Weight of Concrete	
	Weight of dry region KN/M^3 (Kg/M^3)	Weight in presence of sub-soil water KN/M^3 (Kg/M^3)
Plain Concrete	21.96 (2240)	12.16 (1240)
Reinforced	23.54 (2400)	13.73 (1400)

9.5.5 a) The Portland Cement used in concrete shall conform to IS: 269.
b) The Pozzolena cement used in concrete shall conform to IS: 1489. The curing time of Pozzolena cement will be decided at the time of execution of the contract.

9.5.6 Concrete aggregates shall conform to IS: 383.

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

9.5.8 Reinforcement shall conform to IS: 432 for M.S. bars and hard drawn steel wire and to IS: 1139 and IS: 1786 for deformed and cold twisted bars respectively. All reinforcement shall be clean and free from loose mill scales, dust, loose rust, and coats of paint, oil or other coatings, which may destroy or reduce bond. Contractor shall supply, fabricate and place reinforcement to shapes and dimensions as indicated or as required to carry out the intent of drawings and specifications. Only one type of steel shall be used for the design.

9.6 Design of Foundations

9.6.1 Structural design of the foundations shall be done by limit State Method.

9.6.2 Partial safety factor shall be considered 1.5 for concrete and 1.15 for steel as per IS: 456.

9.6.3 The physical properties of soil under various conditions are furnished in table 4.3 to be considered for the design of foundations. However, it may be noted that the soil properties furnished in table 4.3 are tentative in nature. After soil investigations, if it is found that the design of foundations based on above soil properties cannot be used at that location, new foundation design shall be developed based on properties furnished in soil report.

9.6.4 Particulars of the foundations, along with the estimated volumes of concrete and excavation volumes for the various types of towers shall be given in the bid.

9.6.5 The thickness of concrete in the chimney portion of the tower footing would be such that it provides minimum cover of not less than 100mm from any part of the anchor bolt/stub angle to the nearest outer surface of the concrete in respect of all dry locations limiting the minimum section of chimney to 300mm square. In respect of all wet, partially submerged & fully submerged locations, the chimney should have all around clearance of 150mm from any part of anchor bolt/stub angle limiting to 450mm sq. minimum.

9.6.6 The chimney top or muffing must be at least 225 mm above ground level and also the coping shall be extended upto lower most joint level between the bottom lattices of the tower.

9.6.7 The spread of concrete pyramid or slabs for both P.C.C. and R.C.C. type foundations shall be limited to 45 degree with respect to the vertical. The centroidal axis of the slab shall coincide with the axis of the chimney and pass through the centre of foundation base. The design of the foundations (base slab and its reinforcement) shall take into account the additional

stresses in the foundation resulting from the eccentricity introduced due to non-compliance of this requirement.

9.6.8 At least 100 mm thick pad of size equal to the base of pyramid with its sides vertical will be provided below the pyramid for P.C.C. type foundations and 150 mm for R.C.C. type foundation is to be provided. Also, at least 75 mm. thick lean concrete (1:3:6) pad shall be provided below bottom slab. The size of the lean concrete shall be 75 mm beyond base of bottom slab on all sides.

9.6.9 The thickness of base slab at centre i.e., at the point of maximum bending shall not be less than 300 min. in case of RCC type foundation.

9.6.10 The minimum distance between the lowest edge of the anchor bolt/stub angle and the bottom surface of concrete footing shall not be less than 100mm or more than 150 mm in case of dry locations and not less than 150 mm or more than 200 mm in case of wet locations.

9.6.11 The total depth of foundations except Hard Rock type below the ground level shall not be less than 1.5 meters and more than 3.5 meters. To maintain the interchangeability of stubs for all types of foundations, for each type of tower, almost the same depths of foundations shall be used for different types of foundations. However for pile type foundations, depth limitations, depth limitations are not applicable.

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

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

9.6.14 Pile foundation design shall be based on IS: 2911.

9.6.15 **Over Load Factor:** The overload factor for foundations shall be considered as 1.1 i.e. the reaction on foundations shall be increased by 10 per cent.

9.7 Construction of tower foundations

9.7.1 Testing of Soil

The Contractor shall be required to undertake testing of soil for the tower locations in the manner specified under relevant Clause of this

Specification and shall submit his report about the subsoil water table, type of soil encountered, bearing capacity of soil, possibility of submergence and other soil properties required for the design of foundations. The Contractor shall also furnish soil resistivity values to the Employer along the line alignment.

9.7.2 Excavation

9.7.2.1 Excavation work must not be started until the tower schedule and profile has been approved by the Employer.

9.7.2.2 Except as specifically otherwise provided, all excavation for footing shall be made to the lines and grades of the foundation. The excavation wall shall be vertical and the pit dimensions shall be such as to allow a clearance of 150 mm on all sides from the foundation pad. The Contractor should ensure clearance of 150 mm from the foundation pad for quality work. All excavation shall be protected so as to maintain a clean sub-grade, until the footing is placed, using timbering / shuttering, shoring etc., if necessary. Any sand, mud, silt or other undesirable materials which may accumulate in the excavated pit shall be removed by the Contractor before placing concrete.

9.7.2.3 The soil to be excavated for tower foundations shall be classified as under:

(a) **Normal Dry Soil**

Soil removable either manually, by means of an ordinary pick axe, spade and shovel or mechanically by poclains, excavators etc..

(b) **Wet Soil**

During the excavation, if wet soil / the subsoil water table is encountered within the range of foundation depth or/and where pumping or bailing out of water is required due to presence of surface water will be treated as wet soil.

(c) **Dry Fissured Rock**

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

(d) **Wet Fissured Rock**

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

(e) **Hard Rock**

Any rock excavation other than specified under fissured rock above for which blasting drilling, chiseling are required.

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

9.7.2.5 No extra charge shall be admissible for the removal of the fallen earth in the pit, when once excavated. Shoring and timbering/shuttering as approved by authorized representative of the Employer shall be provided by the Contractor when the soil condition is so bad that there is like hood of accident due to the falling of earth.

9.7.2.6 Where rock is encountered, the holes for tower footings shall preferably be drilled, but where blasting is to be resorted to as an economy measure, it shall be done with the utmost care to minimize the use of concrete for filling the blasted area.

9.7.2.7 Unnecessarily large quantities of excavation/ blasting resulting in placement of large volumes of concrete, payment of concrete should be avoided.

9.7.2.8 In case where drilling is done, the stubs may be shortened suitably with the approval of the Employer or his authorized representatives.

9.7.2.9 The Contractor shall supply requisite blasting materials and be responsible for the purpose of the storage and use of this material.

9.7.3 Setting of Anchor Bolts/Stubs

(a) The anchor bolts/stubs shall be set correctly in accordance with approved method at the exact location and alignment shall be precisely at correct levels with the help of anchor bolt/stub setting templates and leveling instrument. Anchor bolts/Stubs shall be set in the presence of Employer's representative available at site and for which adequate advance intimation shall be given to the Employer by the Contractor.

(b) Setting of anchor/bolts/stub at each location shall be approved by the Employer's representative.

9.7.4 Anchor Bolt/Stub Setting Templates

Anchor bolt/Stub setting templates shall be designed and arranged by the Contractor at no extra cost for all types of towers with or without extension and also for leg extension. Anchor bolt/Stub templates for standard towers and towers with extension upto 9 m shall be of adjustable type. The anchor bolt/stub templates shall be painted. The Contractor shall deploy suitable number of templates in each line to ensure timely completion of lines. One

set each of anchor bolt/stub template shall be supplied without any extra cost to the owner after completion of work.

9.7.5 Mixing, Placing and Compacting of concrete

(a) The concrete shall be mixed in a mechanical mixer. However, in case of difficult terrain, hand mixing may .be permitted at the discretion of Employer. The water for mixing concrete snail be fresh, dean and free from oil, acids and alkalies, Saltish or brackish water shall not be used.

(b) Mixing shall be continued until there is uniform distribution of material and the mix is uniform in colour and consistency, but in no case the mixing be done for less than two minutes. Normally mixing shall be done close to the foundation, but in case it is not possible the concrete may be mixed at the nearest convenient place. The concrete shall be transported from the place of mixing to the place of final deposit as rapidly as practicable by methods which shall prevent the segregation or loss of any ingredient. The concrete shall be placed and compacted before setting commences.

(c) Form boxes shall be used for casting all types of foundations. The concrete shall be laid down in 150 mm layers and consolidated well, so that the cement cream works up to the top and no honey-combing is left in the concrete. The mechanical vibrator shall be employed for compacting the concrete. However, in case of difficult, terrain, manual compaction may be permitted at the discretion of the Employer. After concreting the chimney portion to the required height, the top surface should be finished smooth with a slight slope towards the outer edge, to drain off any rain water falling on the coping.

(d) In wet locations, the site must be kept complete dewatered, both during the placing of the concrete and for 24 hours thereafter. There should be no disturbance of concrete by water during this period.

(e) After the form work has been removed if the concrete surface is found to be defective, the damage shall be repaired with rich cement and sand mortar to the satisfaction of the Employer's representative before the foundation pits are back filled.

9.7.6 Back Filling and Removal of Anchor bolt/Stub Template

(a) After opening of form work and removal of shoring and timbering, if any, backfilling shall be started, after repairs, if any, to the foundation concrete. Backfilling shall normally be done with the excavated soil, unless it consists of large boulders/stones, in which case the boulders shall be broken to a maximum size of 80 mm. At such locations where borrowed earth is required for backfilling, this shall be done by the Contractor at no extra cost, irrespective of lead.

(b) The backfilling materials should be clean and free from organic or other foreign materials. The earth shall be deposited in maximum 200 mm layers, leveled and wetted and tempered properly before another layer is deposited Care shall be taken that the backfilling is started from the foundation ends of the pits, towards the outer ends. After the pits have been backfilled to all depth, the anchor bolt/stub template may be removed.

(c) The backfilling and grading shall be carried to an elevation of about 75 mm above the finished ground level to drain out water. After backfilling 50 mm high earthen embankment (band) will be made along the sides of excavation pits and sufficient water will be poured in the backfilling earth for at least 24 hours.

9.7.7 Curing

The concrete after setting for 24 hours shall be cured by keeping the concrete wet continuously for a period of 10 days after laying. The pit may be back filled with selected earth sprinkled with necessary amount of water and well consolidated in layers not exceeding 200 mm of consolidated thickness after a minimum period of 24 hours and thereafter both the backfilled earth and exposed chimney top shall be kept wet for the remainder of the prescribed time of 10 days. The uncovered concrete chimney above the backfilled earth shall be kept wet by providing empty cement bags dipped in water fully wrapped around the concrete chimney for curing and ensuring that the bags are kept wet by the frequent pouring of water on them.

9.7.8 Benching

When the line passes through hilly/undulated terrain, for a few tower locations it may be required to level the ground for casting of tower footings on same elevation. All the activities related to make the required area of ground in same elevation for casting of foundation, shall be termed as benching work. Benching work shall include cutting of excess earth and removing the same to a suitable point of disposal as required by the Employer. Benching shall be resorted to only after getting specific approval from the Employer. Volume of the earth to be cut shall be measured before cutting and got approved from the Employer. This volume of earth shall be considered for the purpose of payment against the head of benching work.

9.7.9 Protection of tower footing

9.7.9.1 The work shall include all necessary stone revetments, concreting and earth filling above ground level and the clearance from stacking on the site of all surplus excavated soil, special measures for protection of foundation close to or in nallas, river bed hilly/undulated terrain etc. by providing suitable revetments or galvanized wire netting and meshing packed with boulders. The top seal cover of the stone revetments shall be done with M-

150 concrete (1:2:4 mix). The Contractor shall furnish recommendations for providing protection at these locations wherever required.

9.7.9.2 The quantity of excavated earth obtained from a particular location shall generally be utilized in back-filling work in protection of tower footing of same location, unless it is unsuitable for such purpose. In the later case, the backfilling shall be done with borrowed earth of suitable quality irrespective of lead. The consolidation of earth shall however be done after backfilling free of cost.

9.7.9.3 The provisional quantities for protection work to foundations, if required, are to be furnished by the employer.

10.0 Tower Erection, Stringing and installation of Line Materials

10.1 The details of the scope of erection work shall include the cost of labour, all tools and plants and all other incidental expenses in connection with erection and stringing work.

10.2 The Contractor shall be responsible for transportation of all the materials as per the scope of work to site, proper storage and preservation at their own cost till such time the erected line is taken over by the Employer. The Contractor shall be responsible for transportation, proper storage, safe custody, loss or damage of all supplied items for incorporation in the lines and shall maintain and render proper account for all such materials at all times.

10.3 Contractor shall set up required number of stores along the line and the exact location of such stores shall be discussed and agreed to between the Contractor and the Employer.

11.0 Earthing

11.1 Suitable provision shall be made for fixing of pipe type and counter poise earthing on the pole structure. For counterpoise type earthing, the earthing will vary depending on soil resistivity. For soil resistivity less than 1500 ohms-meter, earthing shall be established by providing 4 lengths of 30 m counterpoise wire. Otherwise, for soil resistivity greater than 1500 ohms meter earthing shall be established by providing 4 length of 70 m counterpoise wire.

11.2 The footing resistance and impedance of each tower / pole structure shall be measured by the Contractor in dry weather after tower erection but before the stringing of earth-wire. All the towers are to be earthed, however, in no case Tower Footing impedance shall not exceed 10 ohms. Pipe type or Counterpoise type earthing or multiple earthing or use of environmental friendly earth enhancement material shall be used for earthing of towers / pole structure to achieve specified tower footing impedance. If it becomes difficult to achieve required tower footing resistance & impedance, line

surge arresters, if required, shall be used on phase conductors, which will prevent back flashover. Pipe type earthing and counterpoise type earthing shall be provided in accordance with the stipulations made in IS: 3043 and IS: 5613 (Part-II/section-2). Additional earthing shall be provided on towers after every 7 to 8 kms distance for direct earthing of shield wires.

11.3 The details for pipe and counterpoise type earthing are given in drawing enclosed with the specification. – To be given

11.4 The provisional quantities for pipe type earthing and counterpoise earthing shall be furnished in Bill of Quantities. The bidder shall include fabrication, supply and installation of earthing material including supply of coke, salt, earth enhancement material etc.

12.0 Statuary regulation and Standards

12.1 The Contractor is required to follow local statutory provisions, stipulations if CEA Regulations & Electricity Act 2003 as amended from time to time and other local rules and regulations referred in these specifications.

12.2 The codes and/or standards referred to in specifications shall govern, in all cases wherever such references are made. In case of a conflict between such (codes and/or standards) and the specifications, latter shall govern. Such codes and/or standards, referred to shall mean the latest revisions and as amended from time to time.

12.3 Other internationally accepted standards which ensure equivalent or better performance than those specified shall also be accepted

13.0 Quality Assurance

13.1 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 organization structure for the management and implementation of the proposed quality assurance programme.
(b) Documentation control system.
(c) 'Qualification data for bidder's key personnel;
(d) The procedure for purchases of materials, parts/components and selection of sub-Conti actor's services including vendor analysis, source inspection, incoming raw material inspection, verification of material purchases etc.

(e) System for shop manufacturing including process controls and fabrication and assembly controls.
(f) Control of non-conforming items and system for corrective action.
(g) Control of calibration and testing of measuring and testing equipments.
(h) Inspector and test procedure for manufacture.
(i) System for indication and appraisal of inspection status.
(j) System for quality audits.
(k) System for authorizing release of manufactured product to the Employer.
(l) System for maintenance of records.
(m) System for handling storage and delivery.
(n) A quality plan detailing out the specific quality control procedure adopted for controlling the quality characteristics relevant to each item of supply.

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

13.3 **Quality Assurance Documents:** The Contractor shall be required to submit all the Quality Assurance Documents as stipulated in the Quality Plan at the time of Employer's inspection of material.

13.4 The Employer, through his duly authorized representatives, reserves the right to carry out Quality Audit and Quality Surveillance of the systems and procedures of the Contractor's/his sub-Contractor's Quality Management and Control Activities. A typical Manufacturing Quality Plan (MQP) is enclosed as **Annexure-D**

14.0 Inspection and Tests

14.1 The prototype of normal pole structures shall be tested as per relevant IS. However, it shall not be mandatory to test prototype of tall river crossing pole structures and other special type pole structures designed for reliability level - 3 (500 year return period).

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

14.3 The Contractor shall keep the Employer informed in advance about the time of starting and of the progress of manufacture and fabrication of various tower parts at various stages, so that arrangements can be made for inspection.

14.4 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.

14.5 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.

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

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

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

14.9 All gauges and templates necessary to satisfy the Employer shall be supplied by the Manufacturer.

14.10 The correct 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.

14.11 The Employer shall have the right to re-inspect at his expenses any material though previously inspected and approved by him at the Contractor's works, before and after the same are erected at Site.

14.12 Tower Load Tests

14.11.1 Testing of Pole Structure

(a) The Pole structure designed and supplied by Contractor shall be proto type tested by Contractor at tower testing station like SERC, Chennai /CPRI, Bangalore or any other suitable testing site equipped to test Pole structure of transmission line in India only. The proto type pole structure after inspection by Owner shall be transported to the test bed by the Contractor. The contractor shall also carryout erection of pole structure at the tower testing station and after successful completion of proto-type testing shall dismantle and take back.

(b) Testing of Pole structure shall generally conform to IS: 802 (Part-III) or IEC 60652. The Owner shall depute its representative to witness the tests. The responsibility for design and successful proto type 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.

(c) **An galvanized polygonal pole type tower** of each type complete with 9m extension shall be **subjected to design and non-destructive tests by** applying test loads in a manner approved by the Employer. The tower shall withstand these tests without showing any sign of failure or permanent distortion / deformation in any part.

(d) The tower shall be tested for all the conditions considered for the design of tower. The Contractor shall submit to the Employer, for approval, the detailed programme and proposal for testing the towers showing the methods of carrying out the tests and manner of applying the loads. After the Employer has approved the test procedures and programmes, the Contractors will intimate the Employer about carrying out the tests at least one week 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 tower / pole structure testing for checking the tower/ pole structure material. Further at the time of submitting test report, the Contractor has to submit the final tracings of shop drawings and Bill of materials and structural drawings of tower for Employer's reference and record.

(e) In case of any premature failure even during waiting period, the tower is to be retested and steel used in the earlier test shall not be used again. However, if the failures are major in nature and considerable portion of tower is to be re-erected, in such cases all the tests which has been carried out earlier are required to be re-conducted again in compliance with Specification.

(f) No part of any tower shall be allowed to be used on the line unless it has been subjected to test.

(g) The Contractor shall ensure that the specification of materials and workmanship of all towers actually supplied conform strictly to the towers which have successfully under gone the tests. In case any deviation is detected, the Contractor shall replace such defective towers free of cost to the Employer.

(h) Each type of tower to be tested shall be a full scale prototype galvanized / un-galvanized tower and shall be erected vertically on rigid foundation of the stub protruding above ground level as provided in the design/drawing between ground level and concrete level. This portion of the stub shall be kept un-braced while testing???. The tower erected on the bed shall not be out of plumb by more than 1 in 360.

(i) All the measuring instruments shall be calibrated in systematic/approved manner with the help of standard weight/device.

Calibration shall be done before commencing the test of each tower up-to the maximum anticipated loads to be applied during testing.

(j) The suspension tower is to be tested with an arrangement simulating the chosen insulators string.

(k) The tension tower is to be tested with strain plate as per approved design/drawings.

(l) The sequence of testing shall be as per relevant standard or as decided by the Employer at the time of approving the rigging chart/test data sheet.

(m) The Employer may decide to carry out the tensile test, bend test etc. as per relevant IS on few members of the test tower / pole structure after completion of the test or in case of any premature failure. The decision of the Employer's representative regarding choice and number of members to be tested is final & binding. The Contractor shall make suitable arrangement for the same without any extra cost to the Employer.

(n) Prefix T shall be marked on all members of test tower in addition to the mark no. already provided.

(o) Owner's liability is limited to witnessing testing of towers only once for each type of tower. Due to premature failure, if the testing of tower is to be repeated more than once for any type of tower, in such circumstances the Contractor has to bear all the expenses in respect of Owner's representative.

14.11.2 Method of Load Application

(a) Loads shall be applied according to the approved rigging arrangement through normal wire attachments, angles or bent plates.

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

(c) 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 standard weights and accounted for in the test loads.

14.11.3 T**ower Testing Procedure**

All the test procedures shall be approved prior to conducting the type tests as per IS: 802. The procedure for conducting the tower test shall be as follows:

(a) Bolt Slip test

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

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

(b) 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 percent,
90 percent,
95 percent and
100 percent

(c) Observation Periods

Under normal and broken wire load tests, the monopole 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 monopole 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 monopole structure shall be constantly watched, and if it shows any tendency of failure anywhere, the loading shall be immediately stopped, released and then entire monopole 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.
Ovalization of holes and permanent deformation of bolts shall not be considered as failure.

(d) Recording

The deflection of the tower / pole structure in transverse & 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 markings upto 5 mm accuracy.

(e) Destruction Test

The destruction test shall not be carried out. However, the load under normal condition or broken wire condition shall be increased in steps of five (5) percent after the full design loads have been reached upto 120% and any abnormality / permanent deformation would be observed. Any abnormality / permanent deformation observed during this period will not be considered as failure.

The non- destructed pole structure subjected to test shall be allowed to be used on the transmission line.

15.0 Packing

15.1 Polygonal steel pole structure and its parts shall be suitably packaged so as to avoid physical damages to pole and its galvanizing. Packing procedure for polygonal pole shall be submitted by Contractor for approval of the Employer.

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

15.3 Bolts, Nuts, washers and other attachments shall be packaged in double gunny bags accurately tagged in accordance with the contents.

15.4 The packings shall be properly done to avoid losses/damages during transit. Each bundle or package shall be appropriately marked.

16.0 Other Annexures

(a) Annexure-F: Bidder's / Contractor's Guaranteed data sheet
(b) Annexure-G: Assembly and Installation of Pole structures
(c) Annexure-H: Safety Guide Lines
(d) Annexure-I: Standard Field Quality Plan (FQP)
(e) Annexure-J: Pre-commissioning procedures for transmission lines
(f) Format for Bill of Quantity (BoQ) for different types of Towers / pole Structures and different types of foundations

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Annexure-A

Some useful definitions relating to Pole Structures

(a) **Aeolian Vibration:**High-frequency, low amplitude vibration generated by a low-velocity steady wind blowing across the conductor on structural member. (Fig. 2.1)

(b) **Anchor Bolt Cage:**A framework formed of anchor bolts with top and bottom templates so that they can be lowered as a unit into the foundation prior to pouring. (Fig. 2.5)

(c) **Anti-climbing Device:**Barbed type anti-climbing device shall be used, the height of anticlimbing device shall be approximately 3m above ground level. (Fig.2.2)

(d) **Arm End Plate:**This plate is located at the end of static wire and conductor cross arms to facilitate the connections of wires. (Fig.2.2)

(e) **Arm Mounting Bracket**: The part of a static wire or conductor arm assembly that attaches the arm to the main body of the structure. This usually consists of a plate formed into a “U” shape or three piece bracket and welded to the base of the arm shaft. The required bolt hole pattern is cut/drilled into each leg of the bracket prior to welding to the arm shaft. Assembly to the structure is accomplished by securing the bracket to the corresponding arm mounting vangs with bolts. (Fig.2.2)

(f) **Arm Mounting Vang:** The part of the structure that the static wire or conductor arm assembly is attached to. This usually consists of two through vangs set parallel to each other with a bolt hole pattern matching the corresponding arm mounting bracket. (Fig. 2.2)

(g) **Blast Cleaning:** Cleaning and descaling of a steel object using peening actin of shot, sand, or abrasive powder under high pressure.

(h) **Backfill:** Materials such as concrete, sand, crushed stone, or soil that are placed to fill an excavation and/or surrounding an embedded structure.

(i) **Back-Up ring:** A steel ring located inside a section and welded to the section to a base plate, flange plate, or another section. The ring acts as a backing to place weld material in the joint to achieve full penetration and allow for Ultra Sonic Testing. The ring is often 5 mm thick for Utility product fabrication, but is limited by AWS to be sufficient to prevent burn-thru during the welding process. The ring is formed to match the inside diameter of the member it is being placed inside. (Fig.2.3)

(j) **Base-plate:** A plate welded to the bottom of the structure for attachment to an anchor bolt foundation. The plate has bolt holes to accommodate the anchor bolt cage pattern.(Fig.2.3)

(k) **Bearing Plate:** A plate attached (welded/bolted) to the bottom of a direct embedded section for the distribution/transmission line structures.

(l) **Camber (or Pre-camber):** Pole curvature, induced in fabrication, used to counteract predetermined pole deflection, such that the pole will appear straight under a specified load conditions. Primarily used on angle poles structures, the process is accomplished by applying heat to the structure sections during manufacturing. (Fig. 2.4)

(m) **Complete Joint Penetration:** A penetration by weld metal for the full thickness of the base metal in a joint with a groove weld.

(n) **Cantilever Structure:** A self-supporting pole structure that has no other means of support (guy wires, bracing members, etc.).

(o) **Circumferential Weld:** A butt weld joining two pole sections together. This joint generally involves a full penetration groove weld with back-up ring and ultra-sonic inspection. This connection splice is often used when single piece shipment is required.

(p) **Conductor Arm:** A member of a structure that supports one or more conductors.

(q) **Deadend Vang:** A vang that resists the full tension of a conductor or static wire.

(r) **Embedded Section:** This is a type of structure foundation in which a section is placed in the ground to a specified depth and back filled with either concrete, crushed rock or some other material. A portion of the embedded section is left above grade for connection of the remainder of the structure by slip joint or flange. (Fig. 3.1)

(s) **Finish:** Usually refers to the surface protection of a structure. There are four basic types that are commonly used and they are

- **Hot Dip Galvanized:** The entire member is immersed in molten zinc. This coating provides protection to both the inside and outside of the member.

- **Weathering Steel:** Special type of steel that forms a protective oxidized coating when exposed to the elements. Special precautions must be taken when using this material to avoid corrosion failure.

- **Painted:** A wide variety of wet and powder primers and topcoats are available. Members to be painted must either be sand blasted or wheel abrated. Members that are painted are usually sealed so that the interior surfaces do not need to be coated.

- **Metalized:** This process sprays molten material on the exterior surface of the member. The types of materials that can be applied include

copper and tin with zinc being the most widely used. This process is used mainly for members too large to hot dip galvanize.

(t) **Full Penetration:** A weld with 100% fusion for the thickness of the parent metal (in those cases where too different thickness are welded together the thinnest is used).

(u) **Galloping Vibration:** Low-frequency, large-amplitude vibration that occurs when a steady wind of moderate velocity blows over a conductor covered by a layer of ice deposited by freezing rain, mist, or sleet.

(v) **Ground Sleeve (or Corrosion Collar):** A steel jacket that encapsulates a portion of a direct-embedded pole immediately above and below the ground line. This is primarily used on embedded structures to enhance the resistance to corrosion of the structure due to soil contact.

(w) **Guyed Pole Structure:** A pole that depends on the utilization of guy wires to be structurally adequate to resist the loading applied to it. (Fig. 3.1)

(x) **Guy Vang:** A plate welded to the pole for the attachment of guy wires.

(y) **Guy Wire:** A cable used to support a structure by transferring loads to anchors in the ground or another structure. (Fig. 3.1)

(z) **H-Frame Structure:** Any of a large variety of structure configurations, which use multiple members for framing action to increase the structural load carrying capacity. (Fig. 3.2)

(aa) **Lamellar Tearing:** Separation in highly restrained base metal caused by through-thickness strains induced by shrinkage of the adjacent weld metal.

(bb) **Longitudinal Weld:** The seam weld made to join one or more pieces of a pole section to form a tubular shape.

(cc) **Local Buckling:** Introduction of a series of waves or wrinkles in one or more elements of a column section or on the compressive side of a beam section because of the inability of the section to resist the compressive stress in its current geometric shape.

(dd) **Loosely Bolted:** Bolted connections in which the nuts are drawn into contact with the mating surface without being tightened with tools.

(ee) **Penetration:** In the welding process, the distance from the original surface of the base metal to that point at which fusion ceases.

(ff) **Pole Cap:** A cap to cover the top of a structure. This can either vented cap that is attached with a bolt, a vented cap that is welded on, or a non-vented cap that is welded on. The type of protective finish applied to the structure usually decides the type of cap.

(gg) **Rake:** The amount of horizontal pole top displacement created by installing a pole tilted out of plumb. It is used to counteract predetermined pole deflection such that the pole will appear plumb under a specified load condition. (Fig.2.4)

(hh) **Saddle:** A type of reinforcing used on pole areas where exterior welded vangs or high concentrated loads are applied. The saddle, welded to the pole, usually consists of a plate formed to the shape of a pole section but of a greater thickness. The attachment or vang is then welded to the saddle that distributes the load over a greater pole area.

(ii) **Section:** Term given to identify given vertical members of a structure. Letters starting with “A” being the bottom section, “B” the next section up, and so on identifies sections.

(jj) **Suspension Vang:** Usually referred to as an attachment which carries only vertical and horizontal loads created by its own weight and wind pressure on the conductor.

(kk) **Swing Bracket:** An attachment used to decrease tensions under a broken wire condition. The bracket swings providing more slack in the line.

(ll) **Snug-Tight:** Tightness obtained manually through the full effort of a worker using an ordinary spud wrench or as obtained through a few impacts of an impact wrench.

(mm) **Stability:** The ability of a structure or member to support a given load without experiencing a sudden change in configuration.

(nn) **Vang:** Any number of various attachments placed on a structure for attaching insulators, guy wires, static wires, etc. A vang has a minimum of one hole, which is used for an attaching point. The vang can extend through a section or member and be welded on both ends. This is referred to as a thru vang. A vang attached to the outside surface of a member is referred to as an exterior welded vang.

Annexure-B

Survey, Route marking, Profile Plotting and Tower Spotting

1.0 Route Alignment

1.1 The route Alignment shall be carried out by the contractor using Survey of India topographical maps. The bidder may take the assistance of employer to obtain the topographical map of Survey of India.

1.2 Requirement of Transmission Line Routing

(a) The routing and realignment, if any required, of the transmission line shall be most economical from the point of view of construction and maintenance. The contractor shall identify & examine alternative route alignments and suggest to the Employer the optimal route alignment.

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

(c) The number of angle points shall be kept to minimum.

(d) The distance between the terminal points specified shall be kept shortest possible, consistent with the terrain that is encountered.

(e) Marshy and low lying areas, river beds and earth slip zones shall be avoided to minimize risk to the foundations.

(f) It would be preferable to utilize level ground for the alignment.

(g) Crossing of power lines shall be minimum. Alignment of a transmission line with respect to existing line will be kept considering ROW and tower falling distance.

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

(i) Areas subjected to flooding such as nalah shall be avoided.

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

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

(l) Angle points during survey should be selected such that shifting of the point within 100 m radius is possible at the time of construction of the line.

(m) Routing of a transmission line shall avoid large habitations, densely populated areas, protected / reserved forest/ National Parks / Wild Life & Bird Sanctuaries, the habitant zones of Great Indian Bustard and other protected species, civil / military airfields and aircraft landing approaches, reserve coal belt areas, mining area, oil pipe line/underground inflammable pipe lines etc. to the extent possible.

(n) The areas requiring special foundations and those prone to flooding should be avoided.

1.3 For examination of the alternatives & identification of the most appropriate route, besides making use of information/data/details available/extracted through Survey of India Topographical maps, the contractor shall also carryout reconnaissance/preliminary survey as may be required for verification & collection of additional information /data /details.

1.4 The contractor shall submit his preliminary observations & suggestions along with various information/data /details collected**,** topographical map data marked with the alternative routes etc. The final evaluation of the alternative routes shall be conducted by the contractor in consultation with Employer's representatives and optimal route alignment shall be proposed by the contractor. Site visit and field verification shall be conducted by the contractor jointly with the Employer's representative for the proposed route alignment.

1.5 Final route alignment drawing with latest topographical and other details/features including all rivers, railway lines, canals, roads etc. up to 8 kms on both sides of selected route alignment shall be submitted by the contractor for Employer's approval along with report containing other information/details as mentioned above.

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

2.0. Detailed Survey

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

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

2.3 **Route Marking**

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

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

2.3.3. At the starting point of the commencement of route survey a suitable peg/spike shall be driven firmly into the ground to indicate location of the survey instrument. The co-ordinates of the location of the survey instrument shall also be recorded. Further, the co-ordinates at prominent position at intervals of not more than 750 meter along the transmission line to be surveyed up to the next angle point shall also be recorded. Wooden peg of 50 x 50 x 650mm size shall also be driven at prominent position at intervals of not more than 750 metre along the transmission line to be surveyed up to the next angle point. Wire nails of 50 mm length should be fixed on the top of these pegs to show the location of instrument. The pegs shall be driven firmly into the ground to project 100mm only above ground level. Wherever the line alignment crosses the EHT line, Railway line, P&T line or roads, the contractor shall record co-ordinates on the points of crossing. Wherever line route alignment passes over permanent land marks such as rock, boulders, culverts etc. suitable white paint marks with directional and utility markings shall be made and co-ordinates recorded. At angle positions stone / concrete pillars of 150 x 150 x 1000mm in size with name of utility marked on them shall be embedded into the ground for easy identification.

2.4 **Profiling**

2.4.1. The complete profiling along the route shall be carried out using modern surveying equipment viz. total stations. Reference levels at every 20 metres along the route are to be recorded. R/Ls at other undulations along the route as well as in the route plan and other enroute details viz. crossings, building & structures, trees & other infrastructure etc. shall also be recorded. Areas along the route, which in the view of the contractor, are not suitable for tower spotting, shall also be marked in profile. Any undulation keeping conductor location as reference may also be indicated as dotted line in profile.

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

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

2.5 **Optimisation of Tower Location / Tower Spotting**

2.5.1. Optimisation of tower locations including profiling shall be done by the contractor using computer-aided tower spotting software - PLSCADD and shall furnish sample calculations and manual tower spotting drawings for some typical sections.

2.5.2. Necessary data in respect of conductor, earth-wire and insulator are to be collected from the Employer. On the basis of these, the Contractor shall prepare the sag template drawing and tower spotting data and submit the same along with sag tension calculations for the approval of the Employer. Sag template prepared based on the approved sag-template curve drawing shall only be used for tower spotting on the profiles. Approved templates, prepared on rigid transparent plastic sheet, shall be provided by the Contractor to the Employer for the purpose of checking the tower spotting. The templates shall be on the same scale as that of the profile.

2.5.4. **Tower Spotting**

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

a) Span

The number of consecutive spans between the section points shall not exceed 15 spans or 5 Km in plain terrain and 10 spans or 3km in hilly terrain or in coastal areas. A section point shall comprise of tension point with tension type towers (with deviation angle 0-15 deg. / 2-15 deg. / 0-30 deg. /15-30 deg./ 30-60 deg.) as applicable.

b) Extension/Truncation

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

c) Loading

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

d) Road Crossing

At all important road crossings, the tower shall generally be fitted with normal tension insulator strings but the ground clearance at the roads under maximum temperature and in still air shall be such that even with conductor broken in adjacent span, ground clearance of the conductor from the road surfaces will not be less than specified minimum ground clearances. At all national / state highways, tension type towers (with deviation angle of 30-60 deg.) with tension insulator strings shall be used and crossing span will not be more than 250 meters, unless higher span is permitted by national highways authority in case of highways having more lanes.

e) Railway Crossings

All the railway crossings coming-enroute the transmission line shall be identified by the Contractor. At the time of detailed survey, the railway crossings shall be finalised based on the following and also confirming to the regulation laid down by the Railway Authorities.

i) The crossings shall be supported on tension type tower (with deviation angle of 30-60 deg.) on either side.
ii) The crossing shall normally be at right angle to the railway track.
iii) The minimum horizontal distance measured at right angles from the centre of nearest track to any part of a structure (all structures shall be rigid and well founded), carrying electrical conductors crossing a railway shall be equal to the height of the structure in meters above normal ground level plus 6 meters.

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

v) The crossing span will be limited to 300 meters or 80 % of the normal span for which the structure are designed whichever is less.

vi) Minimum ground clearance between crossing conductor under condition of maximum sag and railway line shall maximum of following:

Voltage Level	Minimum clearances from Rail Level (For Electrified Section)		Minimum clearances from Rail Level (For Non-Electrified Section)	Minimum clearances between Highest Traction Conductor & Lowest Crossing Conductor
	At OHE Structures	At Mid OHE Span		
Above 66 kV & upto 132 kV	15.56 m	12.994 m	15.56 m	3.05 m
Above 132 kV & upto 220 kV	16.46 m	14.524 m	16.46 m	4.58 m
Above 220 kV & upto 400 kV	18.26 m	15.534 m	18.26 m	5.49 m
Above 400 kV & upto 500 kV	19.16 m	17.884 m	19.16 m	7.94 m
Above 500 kV & upto 800 kV	21.86 m	17.884 m	21.86 m	7.94 m

The approval for crossing railway track shall be obtained by the Employer from the Railway Authority.

f) River Crossings

In case of major river crossing, river crossing towers shall be of suspension type along with anchor towers of tension type tower (with deviation angle of 30-60 deg.)

on either side of the main river crossing. Alternately on the basis of economics and / or site / execution constraints crossing of rivers using normal extended angle towers (+18/+25/+30M Extns.) also shall be considered. For navigable rivers, clearance required by navigation authority shall be provided. For non-navigable river, clearance shall be reckoned with respect to highest flood level (HFL).

g) Power line Crossings

Where the line is to cross over another line, towers with suitable extensions may be used, depending upon the merit of the prevailing site condition.

For crossing of power line of 400kV or above voltage class, large angle towers of deviation angle of 30-60 degree & designed for dead end condition, with required body extension, shall be used on either sides of the power line.,

For crossing of power line of 110 kV, 132 kV, 220 kV and 230 kV voltage class, the tension towers with required body extension shall be used on either sides of the power line and the crossing of power lines of 66kV class shall be done with any type of towers (suspension /or tension) with required body extension.

In case of crossing with tension towers proper guying shall be provided to facilitate stringing of the power line crossing sections separately on obtaining line shutdowns.

Clearance between lines crossing each other shall be kept in accordance with the CEA (Measures Relating to Safety and Electric Supply) Regulations, 2010 and as amended up-to-date. In order to reduce the height of the crossing towers, it may be advantageous to remove the ground-wire of the line to be crossed (if this is possible and permitted by the Employer of the line to be crossed)

Minimum clearance in metres between lines when crossing each other:

Nominal System Voltage (kV)	11-66kV	110-132kV	220kV	400kV	765kV	+/-500kV HVDC	+/-800kV HVDC	1150kV
Low & Medium voltage	2.44	3.05	4.58	5.49	7.94			10.44
11-66	2.44	3.05	4.58	5.49	7.94			10.44
110-132	3.05	3.05	4.58	5.49	7.94	6.86	9.04	10.44
220-230	4.58	4.58	4.58	5.49	7.94	6.86	9.04	10.44
400	5.49	5.49	5.49	5.49	7.94	6.86	9.04	10.44
765	7.94	7.94	7.94	7.94	7.94	7.94	9.04	10.44
+/-500kV HVDC		6.86	6.86	6.86	6.86	7.94	9.04	10.44
+/-800kV HVDC		9.04	9.04	9.04	9.04	9.04	9.04	10.44
1150	10.44	10.44	10.44	10.44	10.44	10.44	10.44	10.44

h) Telecommunication Line Crossings

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

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

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

i) Oil Pipe-Line Crossings

Wherever transmission line crosses an oil/gas pipeline, the angle of crossing shall be as near to 90 degree possible. Further, a minimum separation of 3m should be maintained between pipe line and transmission line footings & pipe/counterpoise earthing.

j) Details Enroute

All topographical details, permanent features, such as trees, building etc. 44.5m (1200 kV S/C), 33.5m (765kV D/C), 32m (765kV S/C Delta), 42.5m (765kV S/C Horz.), 34.5m (+/- 800kV HVDC), 26m (400kV S/C), 23m (400KV D/C), 26m (+/- 500kV HVDC), 17.5m (220KV), 13.5m (132 KV) on either side of the alignment shall be detailed on the profile plan.

2.6 **Clearance from Ground, Building, Trees etc.**

Clearance from ground, buildings, trees and telephone lines shall be provided in conformity with the CEA (Measures relating to Safety and Electric Supply) Regulations 2010 and as amended from time to time.

2.6.1. The Contractor shall count, mark and put proper numbers with suitable quality of paint at his own cost on all the trees that are to be cut by the Employer at the time of actual execution of the work as detailed below. Any compensation for any loss or damage to the properties or for tree cutting will be the responsibility of the Contractor.

2.6.2. To evaluate and tabulate the trees and bushes coming within 44.5m (1200 kV S/C), 33.5m (765kV D/C), 32m (765kV S/C Delta), 42.5m (765kV S/C Horz.), 34.5m (+/- 800kV HVDC), 26m (400kV S/C), 23m (400KV D/C), 26m (+/- 500kV HVDC), 17.5m (220KV), 13.5m (132 KV) on either side of the central line alignment, the trees will be numbered and marked with quality paint serially from angle point 1 (I) onwards and the corresponding number will be painted on the stem of trees at a height of 1 meter from ground level. The trees list should contain the following:

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

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

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

d) The bushy and under growth encountered within the 89m (1200 kV S/C) , 67m (765kV D/C), 64m (765kV S/C Delta), 85m (765kV S/C Horz.), 69m (+/- 800kV HVDC), 52m (400kV S/C), 46m (400KV D/C), 52m (+/- 500kV HVDC), 35m (220KV), 27m (132 KV) line should also be evaluated with its type, height, girth and area in square meters, clearly indicating the growth in the tree/bush statement.

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

2.6.3.1 The contractor shall also collect data/details of ownership of land within the line corridor and tower base from the concerned revenue/local authorities and submit the same to employer.

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

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

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

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

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

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

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

2.6.5 The Contractor shall finalize the forest clearance proposal on the prescribed format, as per requirements of the state / MOE & F, duly completed in all respects for submission by the Employer to the Forest Department.

2.7 **Preliminary Schedule**

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

2.8 **Check Survey of Tower Locations**

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

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

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

2.9 **Contouring at hilly/undulated locations**

2.9.1. The levels up or down of each pit centre with respect to centre of tower location shall be recorded at intervals of 2m using total stations/GPS/digital theodolite and digitized contour plans shall be made. Based on the digitized elevation plans, the quantities of benching & protection work vis-à-vis possible unequal leg extensions(if applicable) shall be optimized using suitable computer-aided techniques/softwares or manual method.

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

2.11 **Survey Methodology & Precision**

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

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

2.11.3. In the absence of suitable benchmarks the leveling shall be done by two independent leveling parties working in opposite directions along the same line. The difference in elevations between the two surveys shall not exceed the precision required for 3rd order surveys as stated above.

2.11.4. All important objects and features along the transmission line centerline (railways, highways, roads, canals, rivers, transmission lines, distribution lines, telephone lines etc.) shall be surveyed and located with a positional accuracy of 1:2000 between points of known horizontal position.

2.12 **Survey Report**

2.12.1. Complete BOQ of the transmission lines as per format at Annexure- shall be furnished in the survey report.

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

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

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

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

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

2.12.3.4. Suggestions regarding location for setting up stores during line construction in consultation with Employer’s representative shall also be provided by the contractor.

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

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

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

2.12.5. The contractor shall also collect & report (as per Formats enclosed at B) details pertaining to pollution levels envisaged along the transmission line.

2.12.6. The soft copies of survey reports shall be furnished by the contractor to the Employer.

Annexure-C

RELEVANT INDIAN STANDARD / INTERNATIONAL STANDARD

S. No.	Indian Standard	Title	International Standard
1.	IS 209	Specification for Zinc	ISO/R/752 ASTM B6
2.	IS 278	Galvanized Steel Barbed wire for fencing - Specification	ASTM A131
3.	IS 800	Code of Practice for General Building Construction in Steel	CSA 6.1
4.	IS 802 (Part 1) Sec 1 Sec 2	Use of structural steel in Overhead Transmission Line Tower- Code of Practice for General Building Construction in Materials, loads and Permis sible Stress/ design strength Section- 1: Materials and loads Section-2 : Permissible stresses.	ASCE 52 IEC 826 BS 8100
5.	IS 802(Part 2)	Code of Practice for use of structural steel in Over head Transmission Line : Fabrication, Galv anizing, inspection & Packing	ASCE 52
6.	IS 802 (Part 3	Code of Practice for use of structural steel in Overload Transmission L ine: Tower testing	ASCE 52 ASCE 10 IEC 652
7.	IS 808	Dimensions for Hot Rolled Steel Beam, Column, Channel and Angle Sections.	
8.	IS 875 - Part-1,2,4	Code of Practice for Design Loads (other than Earthquakes) for Buildings and Structures.	
9.	IS 875 - Part-3	Code of Practices Design Loads (other than Earthquakes) for Buildings and Structures.	
10.	IS 1363 Part-1,2,3	Hexagon head bolts, Screws and Nuts (size range M5 to M36)	
11.	IS 1367	Technical Supply Conditions for Threaded Steel Fasteners	
12.	IS 1477	Code of practice for Painting of Ferrous Metals in Buildings: Part-I: Pre-treatment Part-II: Painting	
13.	IS 1573	Electro-Plated Coatings of zinc on iron and Steel	
14.	IS 1852	Rolling and Cutting Tolerances of Hot Rolled Steel Products	
15.	IS 1893	Criteria for Earthquake Resistant	IEEE 693

	Part-1,2,3,4	Design of Structures	
16.	IS 2016	Specification for Plain Washers	ISO/R887 ANSIB18-22.1
17.	IS 2062	Steel for General Structural purpose Hot Rolled Medium and High tensile Structural steel	BS EN 10025 / ASTM A572
18.	IS 2074	Ready Mixed Paint. Air Drying, Oxide. Zinc Chrome, Priming Specification	
19.	IS 2551	Danger Notice Plates	
20.	IS 2629	Recommended Practice for Hot Dip Galvanizing of iron and steel.	
21.	IS 2633	Method of Testing Uniformity of Coating of Zinc Coated Articles	ASTM A123 / ASTM 123M CSA G164
22.	IS 3043	Code of Practice for Earthing	
23.	IS 3063	Fastener- Single coil Rectangular section Spring lock Washers for Bolts, Nuts Screws	DIN-127
24.	IS 3757	High Strength Structural Bolts	
25.	IS 4759	Specification for Hot zinc coatings on structural steel and other Allied products	
26.	IS 5369	General Requirements for Plain Washers and lock washers	
27.	IS 5613 – Part-1	Code of Practice for Design installation and Maintenance of Overhead Power Lines: Lines upto and including 11kV Section-1: Design Section-2: Installation and Maintenance	
28.	IS 5613 – Part-2	Code of Practice for Design installation and Maintenance of Overhead Power Lines: Lines above11kV and upto & including 220kV Section-1: Design Section 2: Installation and Maintenance	
29.	IS 5613 – Part-2	Code of Practice for Design installation and Maintenance of Overhead Power Lines: 400kV lines Section-1: Design Section 2: Installation and Maintenance	
30.	IS 6610	Specification for Heavy Washers for Steel structures	
31.	IS 6623	High Strength Structural Nuts	
32.	IS 6639	Hexagon Bolts for Steel Structure	ASTM A394 ASTM A90 / A90M
33.	IS 8500	Specification for Weldable Structural Steel (Medium & High Strength Qualities)	
34.	IS 10238	Fasteners- Threaded Steel Fasteners - Step Bolts for Steel Structures	

35.	IS 12427	Fasteners- Threaded Steel Fasteners – Hexagon Head Transmission Line Tower Bolts	
36.	Publication No. 19(N) / 700	Regulation for Electrical Crossing of Railwa y Tracks	
37.		Design of Steel Transmission Pole Structures	ASCE 48-19 / ASCE Manuals and reports on Engineering practice No. 72
38.		Welding of Zinc coated steel	AWS 19.0-72
Codes and Standards for Geotechnical investigations			
1.	IS 1080	Codes of Practice for Design and Construction of Shallow foundations on Soils (other than Raft, Ring & Shell)	
2.	IS 1498	Classification and Identification of soils for General Engineering Purposes	ASTM D 2487 ASTM D 2488
3.	IS 1892	Codes for Practice for Subsurface Investigation for Foundation	
4.	IS 1904	Codes for Practice for Design and Construction of Foundation in Soil: General Requirements	
5.	IS 2131	Method of Standard Penetration test for Soils	ASTM D 1586
6.	IS 2220	Codes for Practice for Thin Walled Tube sampling of Soils	ASTM D 1587
7.	IS 2720 (Part-1-39)	Method of Test for Soils (Relevant Parts)	ASTM D 420
8.	IS 2809	Glossary of Terms and Symbols Relating to Soil Engineering	ASTM D 653-14
9.	IS 2911- Part I-VI	Code of Practice for Design and Construction of Pile Foundations (Relevant Parts)	
10.	IS 3025	Methods of Sampling and Testing (Physical and Chemical) for Water Used in Industry	
11.	IS 3043	Code of Practice for Earthing	
12.	IS 4078	Code of Practice for Indexing and Storage of Drill Cores	
13.	IS 4091	Code of Practice for Design and Construction of Foundations for Transmission Line Towers and Poles	
14.	IS 4434	Code of Practice for In-situ Vane Shear Test for Soils	ASTM D 2573 (M) -15 ASTM d 4648(M)-16
15.	IS 4453	Code of Practice for sub-surface Exploration by Pits, Trenches, Drifts and Shafts	ASTM D 4648
16.	IS 4464	Code of Practice for Presentation of Drilling	

		Information and Core Description in Foundation Investigation	
17.	IS 4968 (Part-II)	Method for Subsurface Sounding for Soils, Dynamic Method Using Cone and Bentonite Slurry	
18.	IS 5313	Guide for Core Drilling Observations	
19.	IS 6403	Code of Practice for Determination of Allowable Bearing Pressure on Shallow Foundation	ASTM D 194
20.	IS 6926	Code of Practice for Diamond Core Drilling for Site Investigation for River Valley Projects	
21.	IS 6935	Method of Determination of Water Level in a Bore Hole	
22.	IS 7422	Symbols and Abbreviations for Use in Geological Maps, sections and Subsurface Exploratory Logs (Relevant parts)	
23.	IS 8009 (Part-I)	Code of Practice for Calculation of Settlements of Foundations (Shallow Foundations Subjected to Symmetrical Vertical Loads)	
24.	IS 8764	Method for Determination of Point Load Strength Index of Rocks	
25.	IS 9143	Method for Determination of Unconfined Compressive Strength of Rock Materials	ASTM D 2938
26.	IS 9179	Method of Preparation of Rock Specimen for Laboratory Testing	ASTM D 4543
27.	IS 9259	Specification for Liquid Limit Apparatus	ASTM D 4318-17
28.	IS 9640	Specification for Split Spoon Sampler	ASTM D 1586-11
29.	IS 10050	Method of Determination of Slake Durability Index of Rocks	ASTM D 4644-16
30.	IS 11315 (Part-II)	Description of Discontinuities in Rock Mass-Core Recovery and Rock Quality	
31.	IS 398 Part-I	Specification for Aluminum Conductors for Overhead Transmission Purposes	IEC:1089 BS:215
32.	IS 398 Part-II	Aluminum Conductor Galvanised Steel Reinforced	BS;215 IEC:1089
33.	IS 398 Part-V	Aluminum Conductor Galvanised Steel Reinforced For Extra High Voltage (400 KV) and above	IEC:1089 BS:215
34.	IS 1778	Reels and Drums for Bare Conductors	BS:1559
35.	IS 1521	Method of Tensile Testing of Steel Wire	ISO 6892
36.	IS 2629	Recommended Practice for Hot Dip Galvanising of Iron and Steel	
37.	IS 2633	Method of Testing Uniformity of Coating on Zinc Coated Articles	
38.	IS 4826	Galvanised Coating on Round Steel Wires	IEC : 888

			BS:443
39.	IS 6745	Methods of Determination of Weight of Zinc Coating of Zinc Coated Iron and Steel Articles	BS:433 ISO 1460 ASTM A90
40.	IS 826	Method of Radio Interference Tests on High Voltage Insulators	IEC:437 NEMA:107 CISPR
41.		Zinc Coated steel wires for stranded Conductors	IEC : 888
42.		Hard drawn Aluminium wire for overhead line conductors	IEC : 889
43.	IS 209	Specification for Zinc	BS:3436
44.	IS 406	Method of Chemical analysis of slab zinc	IEC:1089 BS:215
45.	IS 731	Porcelain insulators for overhead Power lines with a nominal voltage greater than 1000 V	BS: 137 (I & II)
46.	IS 2071 Part-I Part-II Part-III	Methods of High Voltage Testing	IEC: 383
47.	IS 2486 Part-I Part-II Part-III	Specification for insulator fittings for Overhead Power lines with a nominal voltage greater than 1000 V General Requirements and Tests Dimensional Requirements Locking Devices	BS:3288 IEC: 120 IEC: 372
48.	IS 2629	Recommended Practice for Hot Dip Galvanising of Iron and Steel	ISO- 1461 (E)
49.	IS 2633	Method of Testing Uniformity of Coating on Zinc Coated Articles	
50.	IS 3188	Dimensions for Disc Insulators	IEC : 305
51.	IS 6745	Methods of Determination of Weight of Zinc Coating of Zinc Coated Iron and Steel Articles	BS:433 ISO 1460
52.	IS 8263	Method of Radio Interference Tests on High Voltage Insulators	IEC:437 NEMA:107 CISPR
53.	IS 8269	Methods for switching impulse test on HV insulators	IEC: 506
54.		Thermal mechanical Performance test and mechanical performance test on string insulator units	IEC: 575

55.		Salt Fog Pollution Voltage Withstand Test	IEC: 507
56.		Residual Strength of String Insulator units of Glass or Ceramic Material for Overhead Lines after mechanical Damage of the Dielectric	IEC: 797
57.		Guide for the selection of insulators in respect of polluted conditions	IEC: 815
58.		Tests on insulators of ceramic material or glass for overhead lines with a nominal voltage greater than 1000 V	IEC : 383
59.	IS 2121 (Part-II)	Specification for Conductor and Earthwire Accessories for Overhead Power lines:Mid-span Joints and Repair Sleeves for Conductors	
60.		Ozone test on Elastomer	ASTM- D1 171
61.		Tests on insulators of Ceramic material or glass for overhead lines with a nominal voltage greater than 1000V	IEC:383
62.	IS 6639	Hexagonal Bolts for Steel Structures	ISO/R-272
63.	IS 9708	Specification for Stock	
64.	IS 10162	Specification for Spacers Dampers for Twin Horizontal Bundle Conductors	

ISO	International Organization for Standardization
CSA	Canadian Standard Association
DIN	Deutsches Institute fiir Normung
ASTM	American Society for testing and Material
ASCE	American Society for Civil Engineers
IEEE	Institute of Electrical and Electronics Engineers
IEC	International Electro technical Commission

Manufacturer Quality Plan (MQP)

Sr. No.	Item/Components & Description of Test	Type of Check / List of Tests	Quantum of Check / Sampling rate	Reference Document / Standard	Acceptance Norms	Category of Responsibility*		
						Sub-Vendor	Manufacturer	Customer
A	**Raw Material & Components**							
1.1	**Structural Steel (Sections & Plates)** **Pole Shaft & Cross Arms** **Base Plate, Anchor Plate, Template Anchor Bolt**							
1.1.1	Mechanical Properties	(a) Test for Ultimate Tensile Strength	2-Samples for cast / heat size upto 100MT 3-Samples for cast / heat size between 100- 200 MT 4-Samples for cast / heat size over 200MT as per IS 2062	IS 2062 Grade E250A Utility Specification IS 2062 Grade E350A Utility Specification ASTM A572 Grade 65 BSEN 10025 S-355	410 N/sq. mm (Minimum) 490 N/sq. mm (Minimum)	P	V	W/V
		(b) Yield Stress		IS 2062 Grade E250A Utility Specification IS 2062 Grade E350A Utility Specification ASTM A572 Grade 65 BSEN 10025 S-355	(i) Below 20mm thick: 250 N/sq.mm (Minimum) (ii) 20mm – 40mm thick: 240 N/sq.mm (Minimum) (iii) Above 40mm: 230 N/sq.mm (Minimum) (i) Below 20mm: 350 N/sq.mm (Minimum) (ii) 20mm – 40mm: 330 N/sq.mm (Minimum) (iii) Above 40mm: 320 N/sq.mm (Minimum)	P	V	W/V

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Manufacturer Quality Plan (MQP)

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						Sub-Vendor	Manufacturer	Customer
		(c) Percentage Elongation at 5.65 xSQRT(Area)		IS 2062 Grade E250A Utility Specification IS 2062 Grade E350A Utility Specification ASTM A572 Grade 65 BSEN 10025 S-355 IS 7404 IS 13730	23% (Minimum) 22% (Minimum)	P	V	W/V
		(d) Bend Test	One Sample for 50MT per Section per cast or part thereof as per IS 2062	IS 2062 Grade E250A Utility Specification	Piece at room temperature shall withstand bending through 180 degree to an internal dia (i) Not greater t for 25mm (ii) 3t for >25mm with both side parallel without	P	V	W/V

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Sr. No.	Item/Components & Description of Test	Type of Check / List of Tests	Quantum of Check / Sampling rate	Reference Document / Standard	Acceptance Norms	Category of Responsibility*		
						Sub-Vendor	Manufacturer	Customer
				IS 2062 Grade E350A Utility Specification ASTM A572 Grade 65 BSEN 10025 S-355	cracking Piece at room temperature shall withstand bending through 180 degree to an internal dia not greater 2t			
1.1.2	Chemical Composition	Chemical Analysis	2-Samples for cast size upto 100MT 3-Samples for cast size between 100 - 200 MT 4-Samples for cast size over 200MT as per IS 2062	As per Chemistry / Chemical composition enclosed	As per Chemistry / Chemical composition enclosed	P	V	W/V
1.1.3.	Visual Inspection	Visual	One Sample for 50MT / Section or part thereof	IS 2062 Utility Spec. & as per Approved Drawings	Material to be free from surface defects like laminations, rough / jagged and imperfect edges, cracks, rounded apex, deep roll marks, pipy and any harmful defects	P	V	W
1.1.4.	Dimensional Inspection	Measurement	One sample for 50MT / Section or part thereof	IS 808 / IS 1730 / IS 1852 Utility Spec.		P	V	W
	Angle Section							
	(a) Tolerances for Leg length of Angles Equal /		One sample for 50MT / Section or	IS 808 / IS 1852	**Equal:** (i) Upto 45mm Leg length: +/- 1.5mm	P	V	W

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Manufacturer Quality Plan (MQP)

Sr. No.	Item/Components & Description of Test	Type of Check / List of Tests	Quantum of Check / Sampling rate	Reference Document / Standard	Acceptance Norms	Category of Responsibility*		
						Sub-Vendor	Manufacturer	Customer
	Unequal		part thereof		(ii) >45 to 100mm Leg length : +/- 2mm (iii) >100 mm Leg length: +/-2% of Leg length Diffreence between Leg length Equal Angles shall be limited to 75% of total Tolerance (+/-) **Unequal:** Tolerance as per IS			
	(b) Out of Squareness	Measurement	One sample for 50MT / Section or part thereof	IS 1852 Utility Spec.	+/- 1 degree	P	V	W
	(c) Camber	Measurement	One sample for 50MT / Section or part thereof	IS 1852	(i) For Flenge Less than 100mm: Reasonably Straight (ii) For Flenge 100mm and above: 0.2% of Length (Maximum)	P	V	W/V
	(d) Root Radius	Measurement	One sample for 50MT / Section or part thereof	IS 808	IS 808	P	V	W/V
	(e) Weight Tolerance for Angle Section	Unit weight test	One sample for 50MT / Section or part thereof	IS 808 / IS 1852	(i) Upto 3mm thick: +/- 5% (ii) >3 mm thick: +5% to -3% Over weights specified in IS 808	P	V	W/V
	Plate							
	(a) Weight Tolerance	Unit Weight test	One sample for 50MT / Section or part thereof	IS 1852 / IS 1730	+5% to -2.5% Over weights specified in IS 1730	P	V	W/V
	(b) Thickness Tolerance	Measurement	One sample for 50MT / Section or part thereof	IS 206, IS 1730 / IS 1852	(i) For < 8mm thick: +12.5% to -5% (ii) 8mm to 12mm: +7.5% to -5% (iii) Over 12mm: +/-5%	P	V	W/V
1.2	**Zinc (To be procured from Utility's approved source)**							
	Chemical Composition	Chemical Analysis	Every Consignment	IS 209 / IS 13229 ASTM B6	IS 209 / IS 13229 ASTM B6	P	V	W/V
	Chemical Composition	Chemical Analysis	One sample for 100MT or part thereof	IS 209 / IS 13229 ASTM B6	IS 209 / IS 13229 ASTM B6	P	V	W/V
	Chemical Composition	Chemical Analysis	One sample of	IS 209 / IS 13229	Minimum Zinc Purity 98.5%	P	V	W/V

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						Sub-Vendor	Manufacturer	Customer
			molten zinc taken from bath per quarter	ASTM B6				
		(a)						
B	**In Process Inspection**							
2.0	Fabrication of Tower Parts			IS 802 Part II/ IS 7215/ Utility's approved Drawing, Shop sketches				
(a)	Strengthening	Visual	100%			P	V	W
(b)	Cropping (Cutting)	Dimensional	1st piece and every 50th piece		Length : Tolerance +/- 2mm The cut surface to be clean, reasonable square & free from deterioration Letter size as per Utility Specification	P	V	W
(c)	Stamping	Visual	1st piece and every 50th piece		Letter size as per Utility Specification/ Manufacturer's norm	P	V	W
(d)	Punching / Drilling	Dimensional	1st piece and every 50th piece		Holes for bolts shall be punched with a jig but drilled holes shall be preferred. The punching may be adopted for thickness upto 12mm Tolerances regarding punch holes should be as follows: (a) Holes must be perfectly circular and no tolerance in this respect are possible (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.	P	V	W
(e)	Edge Security	Dimensional	1st piece and every 50th piece	IS 802 Part II/ IS 7215/ Utility's approved Drawing,		P	V	W/V

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Sr. No.	Item/Components & Description of Test	Type of Check / List of Tests	Quantum of Check / Sampling rate	Reference Document / Standard	Acceptance Norms	Category of Responsibility*		
						Sub-Vendor	Manufacturer	Customer
				Shop sketches				
	(i) For13.5 mm Dia Hole				Sheared 20mm (Minimum) Rolled 16mm (Minimum)			
	(ii) For17.5 mm Dia Hole				Sheared 23mm (Minimum) Rolled 20mm (Minimum)			
	(iii) For 21.5 mm Dia Hole				Sheared 28mm (Minimum) Rolled 25mm (Minimum)			
	(iv) For 25 mm & 25.5mm Dia Hole				As per approved Drawing			
(f)	Drilling & Punching Hole to Hole Distance		1st piece and every 50th piece		Tolerance cumulative and between consecutive holes shall be within +/- 2mm and +/-1 mm respectively	P	V	W/V
(g)	Notching Flange Cut Corner Cut Bevel Cut		1st piece and every 50th piece		+ 5mm on specified length of cut operationally shearing upto 12mm thick by gas cutting for material above 12mm thick	P	V	W/V
(h)	Heel Cutting	Dimensional	1st piece and every 50th piece	Utility Approved Drawings / Shop sketches	For members > 12mm thick, gas cutting to be adopted followed by grinding / macine cutting Tolerance on head cutting length : +10mm	P	V	W/V
(i)	Bending		100% Pieces	IS 802 (Part II)/ IS 7215/ Utility's approved drawing / Shop sketches	(1) HT sections / Plates All sections & all plates to be hot bent (2) MS Section • Cold – Section upto 75x75x6 – Angle upto 10 degree • Cold - Section upto 100x100x8 – Angle upto 5 degree • Hot - Section above 75x75x6 – Angle upto 10 degree • Hot - Section above 100x100x8 – Angle upto 5 degree (3) M S Plates • Cold upto 12mm thick upto 15 degree • Hot-Others	P	V	W/V
(j)	Welding	(a) WPS Approval (Welding		As per Technical		P	V	W/V

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Sr. No.	Item/Components & Description of Test	Type of Check / List of Tests	Quantum of Check / Sampling rate	Reference Document / Standard	Acceptance Norms	Category of Responsibility*		
						Sub-Vendor	Manufacturer	Customer
		Procedure Specification) (b) PQR / WQR Approval (Procedure / Welder qualification record)		spec./ approved Drawing/ Utility approved welding procedure & welder's qualification AWS D1.1				
	Welding	(1) DP Test (2) Dimensional & Visual for welded tower parts	Random basis	As per Technical spec./ approved Drawing/ Utility approved welding procedure & welder's qualification AWS D1.1		P	V	W/V
(k)	Final Inspection of fabricated Parts		Random basis	All parameters from (a) to (j) above are checked and record maintained before releasing the materials for galvanizing		P	V	W/V
(l)	Foundation Bolts Cutting & Shearing Chamfering Threading	Physical	1st piece & every 50th piece	IS 802/ Utility technical spec. / approved drawing		P	V	W/V
3.0	Galvanizing (Surface Preparation Procedure)							
3.1	Degreasing	Chemical	One Sample daily	IS 2629	Manufacturer's Plant Standard / IS	P	V	W/V
3.2	Pickling	Chemical	One Sample daily	IS 2629	Manufacturer's Plant Standard / IS Iron contents 100 to 120gram /liter (Max.)	P	V	W/V
3.3	Rinsing	Chemical	One Sample daily	IS 2629	Manufacturer's Plant Standard / IS	P	V	W/V
3.4	Pre-fluxing	Chemical	One Sample daily	IS 2629	IS 2629	P	V	W/V
3.5	Pre-heating	Measurement	One Sample	IS 2629	IS 2629	P	V	W/V

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Sr. No.	Item/Components & Description of Test	Type of Check / List of Tests	Quantum of Check / Sampling rate	Reference Document / Standard	Acceptance Norms	Category of Responsibility*		
						Sub-Vendor	Manufacturer	Customer
			daily					
3.6	Dipping					P	V	W/V
	Zinc Bath Temperature		Hourly Check	IS 2629	450 +/- 10 Degree C	P	V	W/V
	Immersion & Withdrawal Time			IS 2629	IS 2629	P	V	W/V
3.7	Quenching in Running water			IS 2629	IS 2629	P	V	W/V
3.8	Dichromating		One sample daily	IS 2629	IS 2629	P	V	W/V
4.0	Galvanizing Checking							
	Visual Checking	Visual	100%	IS 2629	Surface to be free from defects like bare / black spots(except when small and suitable for patching) heavy ash & flux inclusions, lumps, pimples, runs etc.	P	V	W
	Thickness of Zinc Coating	Measurement	8 samples per shift	IS 4759	The minimum average zinc coating for all section shall be 87microns for thickness >= 5mm & 65microns for thickness < 5mm and for plates	P	V	W
	Weight of Zinc coating	Measurement	3 samples per shift	IS 4759/ IS 6745	(a) For thickness below 5mm, but not less than 2mm and for plates – Average mass of coating : 460 gm/sq.m (b) For thickness 5mm and above – Average mass of coating : 610 gm/sq.m	P	V	W
	Uniformity of Zinc coating	Measurement	3 samples per shift	IS 2633	Material to withstand 4 dips of one minute each without showing signs of copper deposits	P	V	W
	Adhesion Tests of Zinc Coating	Pivoted Hammer Test	3 samples per shift	IS 2629	No removal or lifting of coating in areas between hammer impressions	P	V	W
5.0	**Final Inspection & Testing**	(m)						
	Visual & Dimensional Inspection For fabrication (as per approved drawing) & Galvanizing	Visual & Measurement	One sample for every 50MT / Section or part thereof	Please refer to Sr. No. 2(a) to 2(j) and Cl. No. 4(a)	Please refer to Sr. No. 2(a) to 2(j) and Cl. No. 4(a)	P	V	W
	Mechanical Property	(i) UTS test	One sample for	Please refer (for	Please refer (for test values) to Sr. No. 1.1..1 (a), (b),	P	V	W

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Manufacturer Quality Plan (MQP)

Sr. No.	Item/Components & Description of Test	Type of Check / List of Tests	Quantum of Check / Sampling rate	Reference Document / Standard	Acceptance Norms	Category of Responsibility*		
						Sub-Vendor	Manufacturer	Customer
		(ii) Yield Stress Test (iii) Percentage Elongation Test (iv) Bend Test	every 50MT / Section or part thereof	test values) to Sr. No. 1.1..1 (a), (b), (c), (d)	(c), (d)			
	Chemical Properties	Spectra Analysis	One sample for every 50MT / Section or part thereof	IS 2062	Chemistry / Chemical composition needs to be comparable with raw material supplier	P	V	W
	Galvanizing Tests	(i) Thickness of Zinc coating (ii) Weight of Zinc coating (iii) Uniformity of Zinc coating (iv) Adhesion Test of Zinc Coating	One sample for every 50MT / Section or part thereof	IS 2629/ IS 4759 / IS 6745 / IS 2633		P	V	W
	For foundation Bolt (a) Dimensional test	Measurement	Sampling as per IS 1367 / 2500	Approved Drawing	As per approved drawing	P	V	W
	(b) Mechanical Test UTS, Yield & Elongation	Mechanical	2 sample per heat / cast / lot of 100MT	As per IS 2062 / SAE 1018	As per IS 2062 / SAE 1018	P	V	W
	(c) Chemical Test	Spectra Analysis	2 sample per heat / cast / lot or part thereof	As per IS 2062 / SAE 1018	Chemistry / Chemical composition needs to be comparable with raw material supplier	P	V	W
6.0	Packing, Storing, Bundling and Handling	100%			IS 802/ Utility Spec./ Packing list to be submitted along with dispatch document.	P	V	W

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Chemical Composition of Steel

Element (%)	C18 HMn-HT (E350)	C20 HMn-HT (E350)	C18 MMn-For MS (E250)	C20 MMn-For MS (E250)
C	0.15 - 0.2	0.15 - 0.23	0.15 - 0.21	0.16 - 0.25
Mn	0.15 - 0.2	1.20 – 1.50	0.60 – 1.00	0.60 – 1.05
Si	0.15 - 0.2	0.15 – 0.35	0.10 - 0.40	0.10 - 0.40
P	0.047 Max.	0.035 Max.	0.04 Max.	0.047 Max.
S	0.047 Max.	0.035 Max.	0.04 Max.	0.047 Max.
Cr	0.2 Max.	0.05 Max.	0.10 Max.	0.2 Max.
Al	0.015 - 0.06	0.015 - 0.035	0.010 - 0.035	0.04 Max.
Ni	0.10 Max.	0.05 Max.	0.07 Max.	0.08 Max.
Cu	0.10 Max.	0.05 Max.	0.10 Max.	0.10 Max.
Mo	0.07 Max.	0.05 Max.	0.07 Max.	0.07 Max.
V	0.03 Min.	0.030 Min.	-	0.01 Min.
Ti	0.01 Max.	0.010 Max.	0.010 Max.	0.01 Max.
V + Nb + Ti	0.25 Max.	0.15 Max.	0.25 Max.	0.25 Max.
CE	0.47 Max.	0.44 Max.	0.42 Max.	0.42 Max.
Sn (Optional)	0.015 Max	0.10 Max	-	0.015 Max
B(Optional)	0.05 Max.	-	-	0.05 x.

1. Welding procedure and welder's performance qualification approval by Utility is required in case welding is involved at any stage of fabrication / erection.
2. All bent pieces shall be checked at the process of bending by a bend gauge made as per bend ratio/degree shown in the sketch of the item / mark no. On the stand one piece is thoroughly checked with bend gauge and all other pieces are checked by comparison method and pieces are cleared for further process. If the holes are to be made near the bend line, the same shall be done after bending.
3. Grades of steel used and the standards to which they conform shall be as approved by the utility and shall be indicated in the approved Drawings / BoM / offer list at the time of inspection
4. The manufacturer shall maintain proper co-relation of test certificate with respect to the material from raw material stage to finished material stage.
5. In case of any contradiction between Technical Specification / Approved Drawing and MQP, the details mentioned in the Technical Specification / Approved Drawing shall be final.
6. The manufacturer should progressively align their Quality System and sub-vendors Quality System to the requirements of ISO 9000 series Quality Standards and in due course of time should get their quality system certified to ISO 9001.
7. The manufacturer to ensure that all measuring & testing equipment is having valid calibration certificate issued by NABL accredited testing agency only.
8. Damage to galvanization coating to be avoided while handling.
9. The fabricator to ensure sequential supplies and other details as per Utility's Technical specification.
10. All relevant Standards shall be read along with latest amendments.

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Annexure-E

Classifications of Foundations

The foundation designs shall depend upon the type of soil, sub-soil water level and the presence of surface water which have been classified as follows:

(a) **Normal dry**

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

(b) **Sandy Dry Soil**

To be used for locations where cohesion less pure sand or sand with clay content less than 10% met in dry condition. If the clay content is more than 10 % met in dry condition, the foundation shall be classified as Normal Dry.

(c) **Wet**

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

(d) **Wet Cultivated**

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

(e) **Partially Submerged**

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

(f) **Fully Submerged**

To be 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**

To be 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 shall be adopted. Where fissured rock is encountered with subsoil water table less than 1.5 meter below ground level, submerged fissured rock foundations shall be adopted. In case of dry locations dry fissured rock foundations shall be adopted.

(i) **Hard Rock**

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

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

(k) Where soil is of composite in nature, classification of foundation shall be according to the type of soil predominant in the foundation pit**.**

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

Annexure-F

BIDDER'S / CONTRACTOR'S GUARANTEED DATA SHEET

BIDDER'S / CONTRACTOR'S GUARANTEED DATA	**Unit**	**Data offered for poles**
General		
Highest system voltage for equipment/power frequency	kV/Hz	
Nominal voltage	kV	
Rated lighting impulse withstand voltage (peak)	kV, peak	
Rated short duration power frequency withstand voltage	kV, r.m.s	
System neutral	-	
System short-circuit level & duration	kA (sec)	
Short circuit current for thermal stability check of the OPGW (1s)	kA	
Specific creepage distance based on highest system phase to phase (minimum)	mm/kV	
Radio Interference Voltage level	dB above 1µV	
Corrosion protection measures		
Average weight (gm / sq.m) and thickness (microns) of Zinc coating Poe Structure & Parts		
(a) Plates & Section below 5mm		
(b) Plates & Section above 5mm		
Galvanizing of bolts, nuts & washers	µm	
Conductor Details [Type of conductor, no. of sub-conductors per phase, Overall Diameter, stranding & wire diameter for Al/Al alloy & steel, weight per km, UTS, resistance per km, modulus of Elasticity, coefficient of linear expansion]	-	
Earthwire & OPGW details [Overall Diameter, stranding & wire diameter, weight per km, UTS, resistance per km, modulus of Elasticity, coefficient of linear expansion]	-	
Main Design Parameters		
Maximum ambient air temperature	^{0}C	
Minimum ambient air temperature	^{0}C	
Maximum conductor operating temperature to be considered for design (for sag tension calculation)	^{0}C	
	^{0}C	
Every day temperature	^{0}C	
Temperature with maximum wind	^{0}C	
Wind Zone and basic Design wind speed	m/s	
Terrain Category		

Reliability level		
Lines Data		
Number of circuits	-	
Number of conductors per phase	-	
Number of OPGW	-	
Number of earthwire	-	
Types of Poles		
Normal Suspension		
Angle of deviation		
Type of Insulator sets		
Wind Span	m	
Weight span	m	
Light Angle Tension		
Angle of deviation		
Type of insulator sets		
Wind Span		
Weight Span		
Main Design Data		
Minimum partial factors		
Partial factors for actions		
Deadweight		
Wind for normal conditions		
Conductor tension for normal conditions		
Conductor tension for exceptional conditions		
Erection/maintenance loads		
Partial material factors(M)		
Steel poles cross section areas		
Steel poles net section areas at bolt holes		
Support bolts		
Reinforcing steel for concrete foundations		
Foundation in-situ concrete structure		
Soil property		
Conductors for maximum wind load		
Conductors for everyday conditions		
Insulators for normal conditions		
Insulators for exceptional conditions		
Fittings for normal conditions		
Fittings for exceptional conditions		
Clearances		
Minimum vertical clearances (Minimum vertical clearances from the line conductors at maximum sag ground or for various crossings)		
Normal ground	m	
Ground in populated areas	m	
Roads and streets	m	
Trees which cannot be climbed	m	
Trees which can be climbed	m	
To residential or other buildings	m	

To roofs of non-residential buildings which can be climbed	m	
To roofs of non-residential buildings which cannot be climbed	m	
Minimum Horizontal clearances		
Roadside (sidewalk of paved roads)	m	
Roadside of unpaved roads- depending on area	m	
Railway track axis	m	
Parallel running power lines (lattice steel structure)	m	
Parallel running power lines (poles)	m	
Pipelines	m	
Mid-span clearances		
Mid-span phase to phase clearance for horizontal phase arrangement	m	
Mid-span phase to phase clearance for quasi-vertical phase arrangement	m	
Mid-span phase to phase clearance for quasi-vertical wire phase arrangement	m	
Minimum clearances between conductors/live fittings and tower steel structure		
Between conductors under still air condition	m	
Clearance between live parts and earthed tower parts in still air	m	
Clearance between live parts and earthed tower parts for 3 years wind (58% of maximum wind on conductor)	m	
Clearance under swung insulator string due to maximum wind on conductor	m	
Clearance condition for earthwire / OPGW		
EW/OPGW sag, compared to the conductor sag at every day temperature for the nominal span	-	
Shielding angle		
Foundations		
Soil Data (for Bidding only) The foundations will be designed on the basis of the soil investigations performed by the Contractor. As soil investigations is not complete, the bid shall be based on the soil characteristics given below		
Class 1 - Hard rock		
Density	kN/m^3	
Soil pressure	kN/m^3	
Shear friction resistance	kN/m^3	
Class 2 - Soft rock		
Density	kN/m^3	
Soil pressure	kN/m^3	
Angle of frustum		
Class 3 - Good Soil		
Density	kN/m^3	
Soil pressure	kN/m^3	
Angle of frustum		
Class 4 - Poor Soil, no Water		
Density	kN/m^3	
Soil pressure	kN/m^3	
Angle of frustum		

Class 5 - Poor Soil, with Water (submerged)		
Density without groundwater	kN/m^3	
Density with groundwater		
Soil pressure	kN/m^3	
Angle of frustum		
Class 6 - Very Poor Soil, with Water (submerged)		
Density	kN/m^3	
Soil pressure	kN/m^3	
Angle of frustum		
Backfill (good soil)		
Density (compacted)	kN/m^3	
Angle of frustum		
Poles General information and data		
Material used for all tower parts		
Bolts and nuts standard for poles		
Bolts and nuts qualities for poles		
Step bolt diameter (min.)	mm	
Permissible stresses of structural members, bolts and nuts correspond with	-	
Bolt connections secured with washers and spring washers		
All tower steel parts hot dip galvanized	-	
Zinc coat for steel sections for bolts and nuts	µm	
Quality and tests correspond with		
Wielding qualification	-	
Wielding quality	-	
Min. diameter and number of bolts at stressed member connections		
Bolt diameter	mm	
Maximum slenderness ratio (L/r)		
Main leg, stub and main compression members in crossarm	-	
All other members having computed stresses	-	
Redundant members without computed stressed	-	
Tension members only	-	
Minimum thickness and size of steel members of towers shall be as follows		
Main leg, stub and main compression members in crossarm	mm	
All other members having computed stresses	mm	
Redundant members without computed stressed	mm	
Gusset plates	mm	
Minimum angle bars for equal angle sections		
Minimum angle bars for unequal angle sections		
Maximum length of structural member	m	
Tolerances of finished members of lattice towers		
Max. lateral variations of actual length between points of lateral supports		
Finished members without ends finished for contact bearing		
Members upto 3m length	mm	
Members of 3m to 6m length	mm	

Members greater than 6m length	mm	
Tolerances for poles	-	
Double circuit normal suspension tower		
Design span	m	
Wind span	m	
Weight span (maximum)	m	
Maximum span	m	
Minimum ratio weight to wind span for clearance check	-	
Total weight of tower structures including 4 legs and 4 stubs for following tower configurations		
Basic/normal height tower ± 0	kg	
Double circuit Light Angle Tension tower		
Design span & Line angle	m	
Wind span	m	
Weight span	m	
Maximum span	m	
Line angle		
Double circuit normal suspension Pole		
Wind span	m	
Weight span max	m	
Maximum span	m	
Total weight of pole for following tower configurations		
Basic/normal height tower ± 0	kg	
Double circuit Light Angle Tension Pole		
Wind span	m	
Weight span	m	
Maximum span	m	
Line angle		
Total weight of pole for following tower configurations		
Basic/normal height tower ± 0	kg	

Annexure-G

Assembly and Installation of Pole structures

The installation contractor is ultimately responsible for the proper assembly and installation of pole structures. The contractor shall provide storage and handling instructions to minimize damage to painted or galvanized surface. Care must be taken during installation to avoid structural damage which could weaken the members and prevent them from supporting the intended loads.

1. Identification of components:

Each major component should include an identification tag. The assembly and component drawings should show:

(a) The location of each tag;
(b) The identification number on each tag;
(c) A list of all parts required for each structure or assembly.

2. Anchorage:

(a) An evaluation of local soil conditions should be made by a foundation designer. The foundation size and reinforcing must be adequate to withstand the maximum reactions which might be applied by the pole base.
(b) Concrete foundations should be installed well ahead of the installation of the poles. Standard concrete requires about 28 days to develop its full design strength.
(c) In designing and installing the foundation, consideration should be given to the possible need for underground wiring and grounding.
(d) Projection of the anchor bolts should allow for the thickness of the base plate, nuts (including the leveling nuts), and raking if required.
(e) Orientation of the anchor bolts in relation to the direction of the transmission line must be checked carefully using data from the Manufacturer's drawings and the utility's plans and specifications. The anchor bolts must also be vertical. This is typically checked by leveling the top cage template.
(f) Prior to installing the anchor bolt cage, the following assembly checks should be made:
    (i) Verify the part number on the cage assembly with the part number listed on the erection ("Z") drawing.
    (ii) Inspect the cage assembly for shipping or handling damage. Verify the anchor bolt cage assembly and the anchor bolt circle roundness against the assembly drawing. A four way measurement of the anchor bolt assembly across the 45 degree orientation is recommended. This check will avoid an out-of-round anchor bolt cage not fitting the structure base plate. If the anchor bolt cage is found to be out-of-round, contact the Manufacturer / its representative.
(g) Reinforcing steel for the foundation must not be welded to the anchor bolts.
(h) Care must be taken not to disturb the position of the anchor bolts while pouring concrete.

(i) After the concrete sets, the top cage template should be removed and the nuts should be retained for installation of the structure.

(j) Leveling nuts should be adjusted before installing the pole. Typically, they should be in a horizontal plane. However, they can be used to obtain a desired rake. The bottom of the base plate should be no more than 2 times the diameter of the anchor bolt (4.5 inches for a 2.25 inch diameter anchor bolt) above the top of the concrete foundation.

(k) In the case of structures which utilize embedded base installation, typically the bottom (embedded) section of the pole is installed in the ground first. The specified embedment depth should be shown on the manufacturer's erection drawing.

3. Assembly:

(a) General

(i) Assembly of pole sections at site shall in general be conducted using hydraulic jacking devices and / or suitable chain pulley blocks to achieve proper jacking force.

(ii) Where space near the foundation and lifting capabilities permit, it is preferable to assemble the complete structure on the ground and erect it as a unit. The sections of the pole should be aligned on the ground and supported, typically with wood blocks, in such a manner that they will readily fit together. Care should be taken to prevent dirt, stones, etc. from being trapped between the mating surfaces.

(iii) Proper alignment of the pole sections is facilitated by the location of the identification tags. These are positioned on the pole sections so that aligning them on the same side for the entire pole length will assure proper orientation of all conductor attachment points, arms attachments, camber, etc.

(iv) If the structure is assembled vertically, extra care may be needed to assure that all joints are properly assembled as indicated in the following paragraphs.

(b) Slipover Joints

(i) To facilitate the assembly, mating surfaces may be lubricated. Care should be taken not to use a lubricant that will later leak from the joint and stain the pole. Soapy water can also be used successfully for this purpose.

(ii) Each identification tag is positioned to indicate maximum splice. The mating section should never exceed this position. In addition, this tag can be used to determine if minimum splice has been achieved.

(iii) A sound slip joint depends on the application of the necessary force to achieve a tight joint. Although the method selected may depend upon the size of the pole sections, the type of pole design and the equipment available to the contractor. It

is recommended to use a hydraulic jacking device. Alternatively, two ratchet chain hoists or similar devices on opposite sides of the pole tube may be used providing adequate assembly forces can be achieved. Equal forces must be applied by the devices simultaneously. If the jacking nuts are used, forces must be applied no more than 1.5 inches from the surface of the pole and the forces must be distributed equally to all the nuts at each joint.

(iv) A tight, sound slip joint is dependent on meeting all of the following:

- The force used in assembly is at least the minimum value specified on the manufacturer's drawings.
- Any additional force applied to the joint does not result in additional movement of the joint.
- The overlap length is not less than the minimum length specified and is not more than the maximum length specified on the manufacturer's drawings.
- The joint shows no more than small gaps (which can be caused by slight mismatch in the shapes of the mating sections).

(v) Forces should be applied in a slow steady pull and the assembly be facilitated by oscillating the advancing section with the supporting crane or by striking the pole in the area of the joint with a hammer using a cushioning block of wood.

(c) Bolted Joints

Any bolting instructions specifically provided on manufacturer's drawings will supersede these general guidelines.

(i) **Multiple-bolt, moment connections (e.g. arm-to-pole connections, flange connections):** Threads may need to be lubricated in the field in order to achieve bolt tension in accordance with AISC recommendations.

(ii) **Single-bolt, pinned connections (e.g. swing brackets, cross-bracing, pinned crossarms):** The bolt head and the nut are snug against the outer plates and the locking device or nut is fully engaged. All plates do not need to be in contact.

(iii) **Anchor Bolts:** After plumbing the structure, all nuts should first be uniformly Snug-tightened against the base plate. Then, some provision should be made to prevent unauthorized loosening of the nuts.

The two most common methods are:

- A slight amount of additional tightening of each top nut.
- Peening of the threads.

(iv) **All connection bolts with diameters of 1.75 inches or more** should be **Snug-tightened** until the bolt head and the nut are snug against the outer plates and the locking device or nut is fully engaged. All plates do not need to be in contact.

(v) **Cantilever Arms:** Before tightening the arm attachment bolts, the arm should be rotated toward the base of the structure to remove all play in the connection. While tightening the bolts, care should be taken to assure that the arms all remain in the same plane. BOLT TIGHTENING BEYOND THE ABOVE RECOMMENDED PRETENSION IS NOT REQUIRED JUST TO BRING THE CONNECTION PLATES INTO CONTACT. A SMALL GAP BETWEEN THE ARM BRACKET AND CONNECTION VANGS IS ACCEPTABLE.

(vi) **H-frame Structures:** Bolts in connections that are part of the frame assembly (i.e. not attachments of cantilever sections) should be left loose until all such bolts are installed. After all bolts are installed, the nuts should be tightened in the following sequence:

- Connections between main pole sections.
- Connections between cross-arms and poles.
- Connections between cross-braces and poles.
- Connections between cross-braces.

Care should be taken to maintain all alignments during this tightening operation.

4. Corrosion protection and storage:

(a) After assembly, any damage to the protective coating on the structure should be repaired.

(b) **An on-going maintenance program must include periodic inspection for normal deterioration of the protective coating and for any indication of corrosion, which may be localized. Rehabilitation of the protective coating must be done to preserve the structural integrity of each assembly**.

(c) Structures should not be stored longer than 6 months prior to use without a thoughtful storage maintenance and inspection program. The following recommendations should be considered for all stored sections:

(i) All stored structures should be kept well ventilated, which includes not allowing vegetation to grow in and around sections. Sections should be blocked off the ground and separated if sections are stacked on top of each other to provide air flow and ventilation. Storage of structure sections stacked on top of each other should not be higher than used in the original delivery of the sections.???

(ii) Sections should be supported on wooden rafters while placing on the ground. Wooden blocks should be non-treated wood (wood treatments can be caustic to steel) and metal blocking should be coated (rusting of steel will stain the sections).

(iii) Remove all packing and shipping materials to avoid finish deterioration through holding moisture against the surface.

(iv) Provide proper inclination and orientation to allow free drainage of water, including any condensation inside the pole, does not accumulate inside the pole or on outside surfaces.

(v) Rotation of the poles should be performed as necessary to equalize any finish aging?? and to assess the continued effectiveness of blocking and

allowing good air flow ventilation inside and around the sections. All finishes are subject to aging and gradual deterioration.

(vi) Space should be maintained between two sections to avoid white rust.

(d) Deterioration may occur due to many reasons such as:
   (i) Corrosive elements in the atmosphere.
   (ii) Salt spray from road surfaces or a marine environment.
   (iii) Moisture from rainfall or condensation.
   (iv) UV exposure.

5. Erection

(a) Prior to lifting the structure, any slipover joint below the crane attachment point should be securely lashed to prevent any possibility of separation during lifting.

(b) The lifting crane must be attached:
   (i) Above the center-of-gravity of the entire assembly including the weight of all equipment mounted on the structure before erection.
   (ii) To the main pole member(s) or, if to the arms, the attachment(s) must be close to the pole(s).
   (iii) As high as possible since higher attachment will result in more nearly vertical alignment of the assembly while suspended above the foundations.

(c) H-frame structures may require a spreader bar to achieve two points of attachment to the structure and to assure that all lifting forces are applied vertically.

(d) Care should be taken to operate the crane smoothly since *movements inducing jolts* will cause impact loads which could damage some portion of the assembly.

(e) At least a few anchor bolt nuts should be installed as quickly as possible after the base plate is in place. If the pole is eccentrically loaded, such as in the case of arms on only one side *of the structure*, the nuts on the side opposite the direction of eccentricity should be installed first.

(f) The use of grout between the base plate and the concrete foundation is not recommended or structurally required. Galvanized structures require a method of drainage for any moisture that may enter the pole section and weathering steel structures should not have a surface that could hold moisture against the bottom of the base plate. If grouting under the base plate is used, it is critical that sufficient drainage is provided from the inside of the pole.

6. Attachment of equipment:

Transmission structure components may be affected by vibrations induced aerodynamically or from other sources. Although rare, these vibrations can be severe enough to cause damage. This is believed to be more likely to happen when structures (or components such as arms) are installed without insulators and conductors which contribute damping to the system. It is considered good practice for installers to attach at least some equipment to each arm at the time of installation of the structure. The IEEE document, “Guide to the Assembly and Erection of Metal Transmission Structures”, mentions the following methods:

(a) Suspending weights or insulators from the arms;
(b) Tying the arm tips together and to the structure.

Also, damping devices such as the Stockbridge type may be effective. In accordance with IS:1367/IS:12427 (latest revision) bolts and galvanized bolts shall not be reused. Touching up or re-tightening bolts that may have been loosened by the installation of adjacent bolts shall not be considered to be a reuse.

7. Installation:

Prior to installation, the fastener components shall be properly stored. For joints that are designated as snugtightened joints, the bolts shall be installed in accordance with the section **Snug-tightened Joints** below.

Snug-tightened joints:

All bolt holes shall be aligned to permit insertion of the bolts without undue damage to the threads. Bolts shall be placed in all holes with washers positioned as required and nuts threaded to complete the assembly. Compacting the joint to the snug-tight condition shall progress systematically from the most rigid part of the joint. The snug-tightened condition is the tightness that is attained with a few impacts of an impact wrench or the full effort of an ironworker using an ordinary spud wrench to bring the nut and connection plate into firm contact.

Handling of material

a) Suitable capacity of Hydra Cranes or overhead cranes should be used for lifting.
b) Clean Nylon belts of appropriate capacity should be used for material Handling.
c) Sections should be lifted with two nylon belts fixed at the extreme ends from the center of gravity for easy lifting.
d) Only one section should be lifted at time.
e) The sections should be shifted separately.
f) Welded accessories should not come under direct load.

Annexure-H

Safety Guide Lines

The provision in Central Electricity Authority (Measures related to Safety and Power Supply) Regulations and Central Electricity Authority (Safety Requirements for Construction, Operation and Maintenance of Power Plants and Power Lines) Regulations should be followed alongwith the following safety guidelines

(a) Use of Personal Protective Equipment (PPEs):

(a) No work at site should be without proper PPEs in place for all concerned.
(b) All workers are to wear Safety Helmets, Safety Shoes, Hand Gloves & Safety Jackets all the time while executing the work. Contractors' Supervisors will also have to wear Safety Shoes and Safety Helmets while in the field. Goggles & Masks to be used while working in dusty or highly polluted areas.

(b) Working at height:

(a) Full body harness with double lanyard Safety Belts are to be used during working at heights above 1.5 Mtr and secured with safety lifeline OR any other rigid object/structure safely before starting the work.
(b) Also well-built ladders (properly secured at the base) can be used for working at height, where ladders can be used.
(c) Efforts should be made to assemble the poles & accessories on the ground only. so that working on height can be avoided later.
(d) No work at height is to be carried out in case of inclement weather conditions such as rain, lightning, heavy winds, etc.
(e) Ensure use of tool belts / backpack to properly secure hand tools at all times.
(f) Ensure proper barricading of the drop zone to safeguard people at ground from any falling objects.

(c) Proper demarcation & barricading:

(a) Safety barricading to be done around the working area from day one to safe guard against trespassing. "Men at work" board must be put to indicate work under progress in the vicinity. Barricading to be kept in place till the work is over, even if it takes few days to complete. No excavated pits / loose soil areas should be kept open without barricading around the area.
(b) Also all storage area of materials near the working area has to be demarcated & barricaded properly.

(d) Use of cranes & clings:

(a) Cranes with 20% factor of safety (i.e. cranes with a lifting capacity higher than the weight to be lifted) are to be used.
(b) The crane should be operated by a licensed operator only.
(c) Operational fitness of the crane has to be checked before hiring the crane.
(d) The lifting hooks must have a safety lock in place to avoid slipping of the clings.
(e) The lifting capacity of the clings to be checked before starting of the work. The clings with 20% factor of safety in mechanical strength must be used for lifting.

(e) Working near the existing power lines:

(a) No work to be taken up without proper shutdown while working in the existing power line **or** while working in the proximity of any existing power line.
(b) Work to be started only after the line (all the phases) is properly/securely earthed from both the ends and line clearance/work permit is issued by the concerned authority in writing with start & end time specifically mentioned.
(c) All the earthing points to be personally verified by Site Engineer of contractor. Also secure against re-connection.
(d) No shutdown to be arranged over phone communication. Personal check is to be made for every shutdown and line clearance.
(e) The work under shutdown should be executed under direct supervision of a qualified supervisor/engineer of the Vendor only. The work group shouldn't be left alone to execute the work. Company's representative must be intimated in writing prior to the shutdown work.

(f) Material handling & work process:

(a) Poles and accessories to be stored in proper demarcated area and should be away from the routes/places of public use. Ensure adequate ingress & egress around the work area.
(b) While lifting or shifting the HMs/Poles nobody should stay boarded on the HMs/Poles.
(c) Proper/suggested tools & plants must be used for fixing & assembling to avoid accidents in the process. All the work must be supervised by experienced supervisor(s), who can guide the team in every activity.
(d) While lifting heavy poles with multiple sections, proper support clings (along the length of the pole) are to be provided from the point of lifting cling to the bottom of the pole to avoid fall of sections due to malfunction of the slip joints.
(e) No persons under the influence of alcohol neither should be allowed to enter the work location nor should help in the work from outside by any means.

(g) Working at night (After sun set):

(a) No work should be taken up once the day light is over.
(b) However if we need to execute the work at night, proper/sufficient lighting to be arranged to cover the working area and the work should be executed under direct supervision of responsible/qualified supervisor only and prior intimation to the employer representative in writing. The work group shouldn't be left alone to execute the work.

(h) Emergency response plan:

(a) First aid boxes to be kept handy at sites. The contractors' supervisor must have the knowledge of first aid treatment to meet the exigency.
(b) Contact numbers for emergency (like… Doctors, Hospitals, Ambulance services, Fire services, Police, etc) help available in the nearby areas to be kept displayed in the work site at all times.
(c) All incidents including the near misses to be noted down by the contractor's supervisor and reported to the concern authority. However, all major incidents/accidents causing **"**Lost Time Injuries**"** & **"**Medically Treated Injuries**"** should be intimated immediately and in no case more than half an hours of occurrence.

(i) Tool Box Meeting:

(a) Tool Box meetings to be conducted every day before starting of the work. Work Plan for the day along with hazards/risks involved in the activities and safe working practices for the same are to be discussed with the workers, this can be conducted by Contractor's Supervisors as well.
(b) Record of the Tool Box Meeting to be generated and signature of all the workers/supervisor are to be taken on the TBM sheet. This activity will gradually enhance the safety awareness and will also help in operating in a planned manner.

Annexure-I

Standard Field Quality Plan (FQP)

S. No.	Description of Activity	Items to be Checked	Tests/Checks to be done	Ref. documents	Check/Testing		Counter Check/Test by Owner	Accepting authority in Owner
					Agency	Extent		
1.	Detailed Survey	a. Route alignment	Optimisation of route length	a. Preliminary survey. b. Topographical map c. Tower spotting datas given by Engg.	Contractor	100% at Field	100% based on record documents	Project In-charge
		b. Route profiling & tower spotting.	1. Ground clearance. 2. Cold wt. Span 3. Hot wt. Span 4. Sum of Adj. Span (wind span) 5. Angle of Devn.	a. Sag template b. Tower Spotting data c. Route alignment	Contractor -do- -do- -do- -do-	100% at Field -do- -do- -do- -do-	100% based on record documents -do- -do- -do-	Line In-charge

S. No.	Description of Activity	Items to be Checked	Tests/Checks to be done	Ref. documents	Check/Testing		Counter Check/Test by Owner	Accepting authority in Owner
					Agency	Extent		
2.	Check Survey	Tower Location & Final Length	i) Alignment ii) Final Length	a. Route alignment b. Tower Schedule c. Profile	Contractor -do-	100% at Field -do-	i) All angle towers in plains and 50% in hilly terrains. ii) Final length to be checked on 100% basis based on records/documents	Section In-charge
3.	Detailed Soil Investigation	a. Borelog	1. Depth of bore log 2. SPT Test 3. Collection of samples	As per Owner Specification	Contractor	100% at Field	To witness 20% at Field	Section In-charge
		b. Tests on samples	As per tech. Specs.	As per Owner Specification	Lab appd. By Owner	100% by testing lab	Review of lab test results	Line In-charge based on the report review by CC Engg.

S. No.	Description of Activity	Items to be Checked	Tests/Checks to be done	Ref. documents	Check/Testing		Counter Check/Test by Owner	Accepting authority in Owner
					Agency	Extent		
4.	Tower Foundation							
		A. Materials 1. Cement	1. Source approval	Source meeting Owner Specification/Approved vendor	Contractor	As proposed by Contractor	To verify the proposal based on the supply made and factory test results.	Line In-charge
			2. Physical tests	As per document at Annexure-I of this FQP at Pg. 12, 13 & 14.	Samples to be taken jointly with Owner and tested at Owner approved lab	Review of all MTC's and one sample for every 500 MT	100% review of lab test results	Line In-charge
			3. Chemical Tests Chemical composition of Cement	-do-	Contractor to submit MTC	100%% review of MTC by Contractor	100% review of MTC	Line In-charge
		2. Reinforcement Steel	1. Source approval	To be procured from main producers only.	Contractor	As proposed by Contractor	To review the proposal based on the documents.	Line In-charge
			2. Physical and Chemical analysis test	As per annexure-2 of this FQP at pg. 15	Contractor to submit MTC	All MTC's	100% review of MTC	Line In-charge

S. No.	Description of Activity	Items to be Checked	Tests/Checks to be done	Ref. documents	Check/Testing		Counter Check/Test by Owner	Accepting authority in Owner
					Agency	Extent		
		3. Coarse Aggregates	1. Source approval	Source meeting Owner Specification	Contractor	Proposed by the Contractor, indicating the location of the quarry and based on the test results of Joint samples tested in Owner approved lab	To review the proposal based on the documents	Line In-charge
			2. Physical tests	As per document at Annexure-3 of this FQP at page 16	Samples to be taken jointly and tested in Owner approved lab	One sample per lot of 200 cum or part thereof	100% review of lab test results	Line In-charge
		4. Fine aggregate	1. Source approval	Source meeting Owner Specification	Contractor	Proposed by the Contractor, indicating the location of the quarry and based on the results of Joint samples tested in Owner approved lab.	To review the proposal based on the documents.	Line In-charge
			2. Physical test	As per Annexure-4 of this FQP at page 17	Samples to be taken jointly and tested in Owner approved lab	One sample per lot of 200 cum or part thereof	100% review of lab test results	Line In-charge

S. No.	Description of Activity	Items to be Checked	Tests/Checks to be done	Ref. documents	Check/Testing		Counter Check/Test by Owner	Accepting authority in Owner
					Agency	Extent		
		5. Water	1. Cleaniness (Water shall be fresh and clean)	Owner Specification	Contractor	100% visual check at Field	Verification at random	Site Engineer
			2. Suitability of water for concreting	Owner Specification	Contractor	100% Visual Check at Field	Verification at random	Site Engineer
		B. Classification	1. Visual observation of soil strata 2. Ground water level 3. History of water table in adj. Area/surface water 4. Soil Investigation wherever required	Owner Specification	Contractor	100% at Field	100% at Field	a. Section incharge b. In case of WBC/SFR/FS acceptance by Line Incharge c. For Spl. Fdns./pile fdns. Acceptance by Project In-charge

S. No.	Description of Activity	Items to be Checked	Tests/Checks to be done	Ref. documents	Check/Testing		Counter Check/Test by Owner	Accepting authority in Owner
					Agency	Extent		
		C. Concrete Works a. Before concreting						
		1. Bottom of excavated earth	Depth of foundation	Appd. Drgs.	Contractor	100% at Field	100% check by Owner	Jr. Engr./Engr.
		2. Stub setting	1) Centre Line 2) Diagonals 3) Level of stubs	-do-	-do-	-do-	-do-	-do-
		3. Reinforcement steel	Placement	Bar bending schedule	-do-	-do-	-do-	-do-
		b. During concreting						
		1. Workability	Slump test	Range 25 mm to 55 mm refer document at Annexure-5 of this FQP at Pg. 18	Contractor	100% at field	20% check at random	Jr. Engr./Engr.

S. No.	Description of Activity	Items to be Checked	Tests/Checks to be done	Ref. documents	Check/Testing		Counter Check/Test by Owner	Accepting authority in Owner
					Agency	Extent		
		2. Concrete Strength	Cubes Comp Strength	CPWD SPEC as referred in document at annexure-5 of this page at 18	Casting of cubes at site. Cubes to be tested at Owner appd. Lab for 28 days strength	One sample of 3 cubes in each tower locations	100% review of lab test results. Cubes at 20% location are to be taken in presence of Owner officials	Section In-charge
5.	Pile foundations	1. All materials like cement, steel Coarse/fine aggregate, water	To be tested as per procedure enumerated in the respective columns above					
		2. Before concreting	1. Check for center line of each pile	Appd. Drawings	Contractor	100%	100%	Site Engr.
			2. Check for dia/verticality of each pile	-do-	-do-	-do-	-do-	-do-
			3. Check for depth of each pile	-do-	-do-	-do-	-do-	-do-

S. No.	Description of Activity	Items to be Checked	Tests/Checks to be done	Ref. documents	Check/Testing		Counter Check/Test by Owner	Accepting authority in Owner
					Agency	Extent		
		3. During Concreting						
		a. Workability	1. Slump test	100-150 mm as per Owner Specn.	Contractor	Every one hour. For each pile	100% at field	Site Engr.
		b. Concrete strength	2. Cubes compressive strength	As per Owner Specn.	Contractor. One set of cubes (Min. 6 nos.) to be taken and tested for 7&28 days strength at Owner appd. Lab.	One set for each pile. For Pile caps, beams, Chimney, one sample for every 20 Cu.m. or part thereof for each day of concreting.	100% cubes for piles, 20% Pile caps, beams, chimney etc. to be taken in presence of Owner officials. 100% review of test results.	Section In-charge.
6.	Tower Erection	1. Materials a. Tower member/bolts & nuts/washers/accessories	Visual checking for 1. Stacking 2. Cleanliness 3. Galvanizing 4. Damages	Appd. Drgs./BOM	Contractor	100% at stores	100% verification of records	Site Engineer

S. No.	Description of Activity	Items to be Checked	Tests/Checks to be done	Ref. documents	Check/Testing		Counter Check/Test by Owner	Accepting authority in Owner
					Agency	Extent		
		2. Erection of Super-structure	1. Sequence of erection	As per Appd. Drgs./Owner specification	Contractor	100% at field	100% check	Site Engineer
			2. Check for completeness	-do-	-do-	-do-	-do-	-do-
			3. Tightening of nuts and bolts	-do-	-do-	-do-	-do-	-do-
			4. Check for verticality	-do-	-do-	-do-	-do-	-do-
			5. Tack welding for bolts & nuts	Owner Specification	Contractor	100% at Field	100% Check	Site Engineer
		3. Tower footing resistance (TFR)	TFR at locations before and after earthing.	Owner Specification	Contractor	100% at Field	20% locations to be verified	Line In-charge
7.	Stringing	1. Materials						

S. No.	Description of Activity	Items to be Checked	Tests/Checks to be done	Ref. documents	Check/Testing		Counter Check/Test by Owner	Accepting authority in Owner
					Agency	Extent		
		a. Insulators	1. Visual check for cleanliness/glazing/cracks/and white spots.	Owner Specification	Contractor	100% at Field	100% verification of records and to carry random checks 10%	Site Engineer
			2. IR Value	(min. 50M Ohms)	-do-	One test per sample size of 20 for every lot of 10,000	To verify Contractor's records 100% and joint check 20% of total tests	-do-
			3. E&M test	-	Insulator supplier	a. 20 per 10,000 for discs b. 3 per 1500 for long rod	Collection of samples, sealing them and handing over by Owner to Insulator supplier	Tests to be witnessed/ Appd. by QA&I at Manufacturer's works
			4. Traceability (Make/batch No./Locations where installed)	Packing list/CIP	Contractor	100% at field	100% Review of records	Site Engineer

S. No.	Description of Activity	Items to be Checked	Tests/Checks to be done	Ref. documents	Check/Testing		Counter Check/Test by Owner	Accepting authority in Owner
					Agency	Extent		
		b. Conductor	On receipt, 1. Visual check of drum.	Packing list	Contractor	100% at stores	20% check	Site Engineer
			2. Check for seals at both ends, and Owner sticker on outer end	-do-	-do-	-do-	-do-	-do-
			3. Check depth from top of flange to the top of the outer most layer	-do-	-do-	-do-	-do-	-do-
		c. Earthwire	Check for seals at both ends	Packing list	Contractor	100% at stores	20% check	-do-
		2. Field activity						
		a. Before Stringing	Readiness for stringing	Stringing procedures as per Owner specification	Contractor	Readiness certificate to be submitted by the Contractor	Review of Certificate	Line In-charge

S. No.	Description of Activity	Items to be Checked	Tests/Checks to be done	Ref. documents	Check/Testing		Counter Check/Test by Owner	Accepting authority in Owner
					Agency	Extent		
		b. During stringing	(Conductor/Earth-wrie)					
			1. Scratch/cut check (Visual)	Appd. Drawings/ Owner Specn.	Contractor	100% at Field	100% record & Field check 20%	Site Engineer
			2. Repair sleeve	-do-	-do-	-do-	-do-	-do-
			3. Mid span Joints	-do-	-do-	-do-	-do-	-do-
			4. Guying (in case of towers not designed for one side stringing)	Appd. Guying arrangement/Owner specn.	-do-	-do-	100%	Section In-charge
		c. After stringing	Check for,					
			1. Sag/Tension	Sag tension chart/tower Spotting data	-do-	-do-	100% record & Field check 20%	Site Engr.

S. No.	Description of Activity	Items to be Checked	Tests/Checks to be done	Ref. documents	Check/Testing		Counter Check/Test by Owner	Accepting authority in Owner
					Agency	Extent		
			2. Electrical clearances	As per appd. Drgs./Owner specifications	-do-	-do-	-do-	-do-
			i) Ground clearance	-do-	-do-	-do-	-do-	-do-
			ii) Live metal clearance etc.	-do-	-do-	-do-	-do-	-do-
			3. Jumpering	-do-	-do-	-do-	-do-	-do-
			4. Copper bond	As per Appd. Drgns./Owner Specification	Contractor	100% at Field	100% record & Field Check 20%	Site Engineer
			5. Placement of spacer/damper	As per Specn./drgs/ placement chart	-do-	-do-	-do-	-do-
8.	Final Testing							
	a. Pre-commissioning of lines	a. Readiness of lines for pre-commissioning	1. Completeness of line. 2. Meggar test of line	Owner latest pre-commissioning procedures (Doc. No. D-2-01-70-01-00)	Contractor	100%	100% joint checking	Project In-charge

S. No.	Description of Activity	Items to be Checked	Tests/Checks to be done	Ref. documents	Check/Testing		Counter Check/Test by Owner	Accepting authority in Owner
					Agency	Extent		
	b. Commi-ssioning of line	Readiness of lines for commissioning	2. Digital photograph of each tower to ascertain the completeness of tower.	a. Owner latest pre-commissioning procedures (Doc. No. D-2-01-70-01-00) b. Pre-commissioning Report c. CEA clearance	-do-	-do-	-do-	-do-
			3. Electrical Inspectors clearance from CEA.		-do-	-do-	-do-	-do-

Annexure-J

PRE-COMMISSIONING PROCEDURES FOR TRANSMISSION LINES

1.0 Introduction

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

The detailed inspection and handing over documents are required to be checked for the entire length of transmission line before energization. The detailed inspection/test procedures for each activity has also been elaborated.

2.0 Overall procedure

It is to be ascertained that the transmission line to be energized is ready for operation and has been properly handed over (released) in writing. This will include all safety aspects, Electrical inspector clearance, PTCC clearance, Statutory clearance, and final inspection, if any. Instructions for the work and supervision are given by the test leader (Line in charge). However, all switching and all operational activities will be executed by the regular operators.

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

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

When the whole system has been energized, including the AC line, it will be kept in this state for 8 hours or more for "soaking" with continuous inspection and monitoring. However, recommendations of the concerned division / Divisional head may be checked. Otherwise it may be put into continuous operation??.

3.0 Safety procedures

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

In order to avoid serious accidents, thorough information must be imparted to all personnel involved in the construction of transmission line. Incharge of the Transmission line (Group head OR Divisional head) must ensure that due publicity has been made to the public in all the villages/areas along the line route cautioning them against climbing the towers etc. and that the line is proposed to be charged on

It is also to be confirmed that the AGENCIES involved in the construction activities shall not carry out any job on the said line without a valid WORK PERMIT.

It shall be ensured before charging that all material, Tools & Plants and any temporary earthing on any part of the entire length of line are removed and no person is working on the line.

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

All equipment tests and pre-commissioning tests must have been completed and in case cables were isolated for testing purpose, the same shall be connected properly and documented properly.

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

4.0 Final checking / Inspection

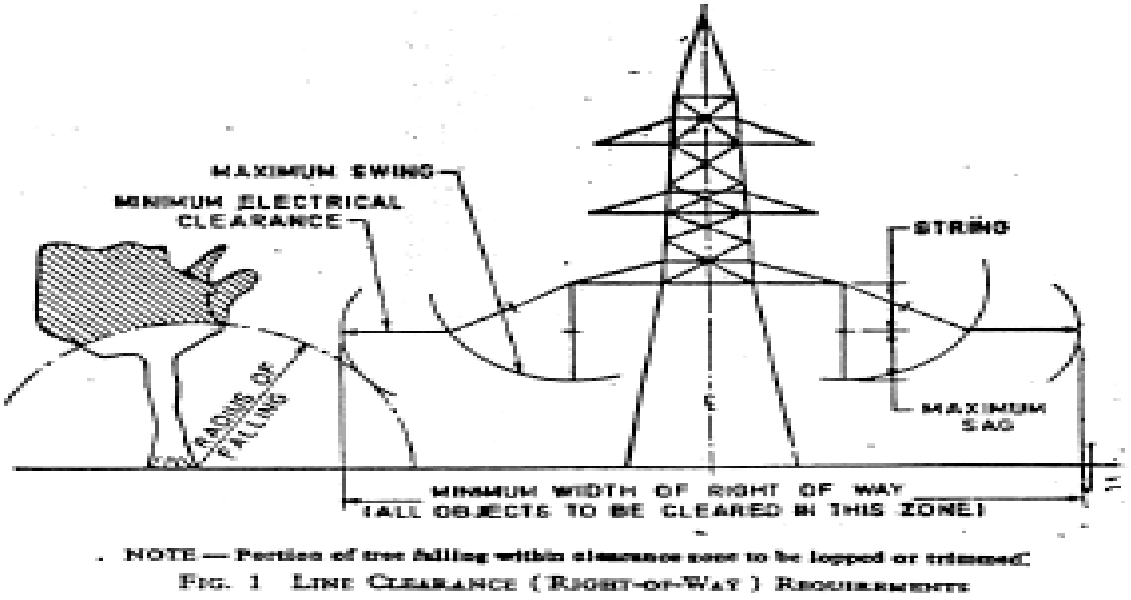
After completion of the works, final checking of the line shall be carried out by the Contractor to ensure that all foundation works, tower erection and stringing have been done strictly according to the specifications and as approved by the Employer. Before the line is scheduled to be handed over for the pre-commissioning/ energization all the works shall be thoroughly inspected by representatives of Owner and Construction Agency in order to ensure that:

(a) Right of way/way leave/electrical clearance
(b) Sufficient backfilled earth covers each foundation pit and is adequately compacted;
(c) Revetments/Protection Work has been completed as per specification.
(d) Concrete chimneys and their copings are in good condition and finely shaped.
(e) All tower members are used strictly according to final approved drawing and are free of any defect or damage whatsoever.
(f) All bolts are properly tightened, punched, tack welded (as applicable) and painted with zinc rich paint;
(g) The stringing of the conductors and earth wire has been done as per the approved sag and tension charts and desired clearances are clearly available;
(h) All conductor and earth wire accessories are properly installed;
(i) All other requirements for completion of works such as fixing of danger plate, phase plate, number plate, anti-climbing device and aviation warning signal (Lights/globules/painting) have been fulfilled.
(j) Wherever required, that proper revetment (erosion protection) is provided;
(k) The original tracings of profile and route alignment as well as tower design, structural drawings, bill of material and shop drawings of all towers are submitted to the Employer for reference and record.
(l) The insulation of the line as a whole is tested by the Supplier through provision of his own equipment, labour etc., to the satisfaction of the Employer.
(m) All towers are properly grounded.
(n) The line is tested satisfactorily for commissioning purpose.

5.0 Right of way/way leave/electrical clearance

5.1. Right of way/Way leave clearance

Ensure that no tree/tree branches are falling within the zone of minimum clearance specified as per Figure given below:



NOTE — Portion of tree falling within clearance zone to be lopped or trimmed.

FIG. 1 LINE CLEARANCE (RIGHT-OF-WAY) REQUIREMENTS

Guidelines of forest/environmental rules shall be followed to avoid excessive tree cutting i.e. all the trees should be cut from ROUTE level in the 3 meter / 5m / 7m ?? to be checked corridor below each line Conductor/Earthwires. In rest area of the corridor, Trees branches are only to be lopped / pruned to achieve the specified clearance as per Table given below.

Clearance for Right of Way (RoW)

Right of way corridor required for different voltage class transmission lines is given below.

Voltage level	RoW / Corridor Requirement (Meters)
66 kV	18
110 kV	22
132 kV	27

220 kV	35
400 kV Single Ckt. (Horizontal Configuration)	52
400 kV Double Ckt./400 kV S/C (Vertical Configuration)	46
765 kV Single Ckt. (Horizontal Configuration)	85
765 kV Single Ckt. (Delta/ Vertical Configuration)	64
765 kV Double Ckt.	67
1200 kV	89
± 500 kV HVDC	52
+/- 800kV HVDC	69

5.2. Electrical Clearance

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

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

Nominal System Voltage (kV)	11-66kV	110-132kV	220kV	400kV	765kV	+/-500kV HVDC	+/-800kV HVDC	1150kV
Low & Medium voltage	2.44	3.05	4.58	5.49	7.94			10.44
11-66	2.44	3.05	4.58	5.49	7.94			10.44
110-132	3.05	3.05	4.58	5.49	7.94	6.86	9.04	10.44
220-230	4.58	4.58	4.58	5.49	7.94	6.86	9.04	10.44
400	5.49	5.49	5.49	5.49	7.94	6.86	9.04	10.44
765	7.94	7.94	7.94	7.94	7.94	7.94	9.04	10.44
+/-500kV HVDC		6.86	6.86	6.86	6.86	7.94	9.04	10.44
+/-800kV HVDC		9.04	9.04	9.04	9.04	9.04	9.04	10.44
1150	10.44	10.44	10.44	10.44	10.44	10.44	10.44	10.44

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

5.2.1. Ground clearance

Normally at the time of construction adequate clearance is provided between lowest conductor and ground, but due to delay in charging/commissioning there is

possibility of reduction in ground clearance due to dumping / extra soil / earth and concrete etc. or staking of bricks etc. In such cases the stored materials shall be removed.

Ensure that there is no temporary or permanent structure / construction of houses or shades below the line and if such things are observed, then the same shall be removed before charging.

The various clearances are given below as guidance however all the clearances indicated in Approved Drawings are to be referred.

The ground profile at the time of commissioning shall be checked with the profile approved at the time of check survey.

Ground clearance of lowest conductors at critical points / locations shall be checked in the field and shall be recorded.

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

The permissible minimum ground clearances for different voltages are as given in the specification.

5.2.2. Clearance for Telephone line crossings

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

Voltage level (kV)	Clearance (mm)
66	**2745**
132	**2745**
220	**3050**
400	**4880**
765	

The vertical clearances between conductors and between conductor and earthwire shall be checked randomly say in any one span of all sections and 10 sections of hilly areas from single line diagram of the towers.

6.0 Foundation and revetments / protection work foundation:

There shall not be any damage/uneven settlement of foundations. For this, tolerances in levels of all four stubs should not exceed the criteria provided in the IS 5613.

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

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

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

6.1. Revetments / protection:

Cracks/damages to revetments shall be repaired.

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

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

7.0 Tower and tower accessories

7.1. Normal Tower

After completion of a transmission line, all the towers shall be thoroughly checked before charging the line. Special attention shall be given to the following points:

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

It is to be ensured that no members are bend, deformed or rusted have been used in towers and if so, the same shall be replaced.
If any members is found missing, a new member shall be Fixed as per erection drawing of Towers.

Nuts shall be sufficiently tightened for the required Torque

Minimum 2/3 complete threads shall be projected outside the nut. All bolts shall have their nuts facing outside of the tower for Horizontal connection and Downwards for Vertical connections.

Nuts & bolts shall be properly tack welded/punched as per the specification and proper zinc rich paint shall be applied. It shall be ensured that the circular length of each welding shall be at least 10mm.

It shall also be ensured that all extra blank holes provided on tower members are filled with correct size of nuts & bolts.

7.2. Special Towers

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

7.3 Earthing of Towers

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

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

Before charging of the line, ensure that tower footing resistance and impedance is less than 10 ohms. If the value (before stringing) has been recorded higher than 10 ohm, proper measures shall be taken to improve earth resistance & impedance.

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

7.4. Tower accessories

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

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

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

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

Fixing of birds guards shall be ensured.

It shall be ensured that Bird Flight Diverter, wherever applicable, are provided as per specification

7.5. Hardware fittings

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

Check the fixing of all security clips (W/R type clips).

Surface condition of corona control rings and distance/alignment between Tower side arcing horn (wherever applicable) and line side arcing horn/corona control ring to be checked as per approved drawings.

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

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

8.0 Insulators

All the damaged/broken insulator discs shall be replaced.

Unusual deflection in suspension strings, if observed, shall be rectified.

The insulators shall be cleaned before charging.

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

9.0. Conductors and earthwires

Surface Condition

Surface of the conductors shall be free from scratches/rubs.

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

9.1. Accessories for conductor and earthwires

9.1.1. Joints

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

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

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

Ensure that all mid span joints on conductors/earthwire and repair sleeves of compression type are free from sharp edges, rust and dust. Wherever grease are specified the same shall be applied in the joints.

9.1.2. Clipping

Ensure that conductor is not over tightened in the suspension clamps.

9.1.3 Spacers, vibration dampers and copper bonds

Placement and no. of spacers/dampers between two sub conductors on each phase shall be verified as per spacer/damper placement chart.

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

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

It is to be ensured that no copper bond is loose/missing.

9.1.4 Jumpers

Verify Electrical clearance of jumpers to tower body as per design. All the jumpers shall be checked properly. In case, jumpers (conductor/earthwire) is found loose, it shall be tightened sufficiently.

9.1.5 Foreign material

Ensure that all foreign materials viz dead bird, fallen tree branches, bird nests etc. on conductors, earthwires, Jumper, insulator string, cross arms are re-moved.

10.0. Others

It shall be ensured that all temporary/local earthing, guys, T & P (Tools and Plants), foreign material and other loose material which were used during stringing/tower erection have been removed.

In case there is any change in the ground profile before commissioning of line from the approved profile, the extra earth / obstruction / temporary sheds /any other structure / construction shall be removed.

11.0 Aviation warning / obstruction signals (lights/ globules /painting).

It shall be ensured that following measures have been taken in the line/ Towers falling within obstruction zone of civil aviation and defense establishments as per their requirement and our specification.

Day markers

Painting of Full/Top portion of Towers with Red/Orange and White Paints. Globules on earthwires have been provided.

Night markers

It shall be ensured that proper aviation lights at the peak level/at specified heights of towers have been provided along with Solar panels/Battery banks/Control cubicles and other accessories as per specification. The functioning of lights with simulation to be checked/verified.

12.0 Statutory requirement

5.1. The concerned authorities shall be informed before commissioning the lines and their approval obtained in accordance with CEA Regulations.

Before charging of the line PTCC approval from P&T Dept. shall be obtained.

13.0 Handing over

The transmission line shall be inspected prior to energization and a formal handing over document to be jointly signed by the representative of SUPPLIER (if applicable), ERECTION AGENCY, OWNER. However all contractual taking over has to be resolved separately as per the terms and conditions of the contract. The Handing over shall be limited to the completion of Erection and ready for Energization.

Any outstanding points or remaining activities are to be listed jointly by OWNER and ERECTION Agency and signed jointly. This document are also to be retained at Divisional level with a copy to Regional Head Quarter. The remaining activities/outstanding points are classified in the following category.

Details of the SECTIONS:

(a) List of outstanding activities remaining in any part of the line
(b) A list of temporary arrangements introduced.
(c) Check list records properly documented, completed and signed??.
(d) Original tracing of Profile, Route Alignment, Tower Design, Structural Drawings, Bill of Materials, Shop Drawings, Stringing charts (initial and final as applicable) etc. of all towers/line submitted to OWNER.

With the outstanding activities mentioned above are solved or with only minor points without influence on the charging remain (minor issues handing over of the transmission line shall be accepted by the pre-commissioning team. This handing over for energization with or without remaining activities shall be made by the group head to the commissioning in charge in writing. Shortcomings noticed during the inspection, "List of outstanding activities" shall be recorded.???

14.0 Protective system

Before energization it must be ascertained that all protective systems for the unit to be energized are operative. This includes confirmation that the protections have been properly tested and that the tests have been documented. It also includes verification by inspection or otherwise, if necessary by repetition of trip test, that the protections are actually functionally enabled. This verification serves to prevent that

energization takes place of a unit where a protection has been disabled for test or other reason.

15.0 Dispatch procedures

All operational activities (switching etc.) must be coordinated and communicated with the system dispatcher i.e. SLDC / RLDC / NLDC.

16.0 Switching procedures

For each activity the instructions to the operators and the communications to the dispatchers will be made in writing or by confirmed telephone messages. The switching procedures first to be properly documented step by step and understood by everybody involved in the switching operation prior to the enerzisation. Any clarification required in the procedures must be resolved. The format established by OWNER for switching orders and operational data logging shall be followed. The implication of this is that each and every activity must be listed and described, so that complete information is available for detail investigation, if required in future.

17.0 Testing and measurement procedures

17.1. Earth Resistance Measurement

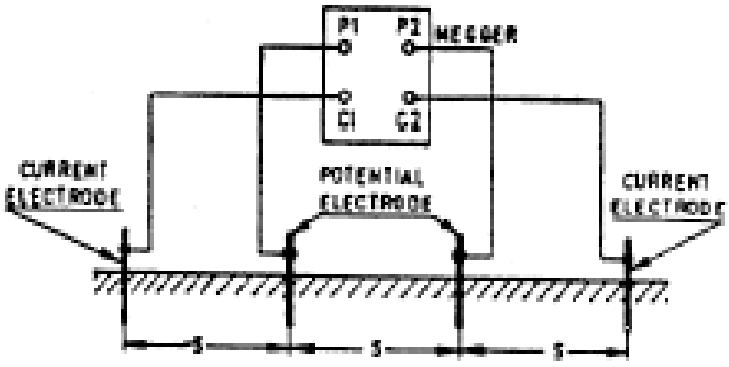
Normally Earth tester is used for measuring

(a) soil resistivity.
(b) earth resistance

Prior to the testing of soil resistivity and earth resistance, the operation manual of the testing instrument available at site may be referred to understand the procedure to be adopted for measurement of soil resistivity and earth resistance.

A typical Earth tester has 4 terminals. C1, P1, C2, P2 and 4 similar electrodes are driven in the ground at equal distances and connected to the instruments in the order of C1, P1 and P2, C2. The reading of the resistance is read on the megger scale. If R is the resistance measured then the
Specific resistivity = $2 \pi a R$
where a is the distance between the electrode and R is the resistance in ohms measured on the megger.

In order to measure earth resistance of electrode of the substation it could be connected to C1 and the value of R could be read. This will give the earth resistance. The value as far as possible shall be below 10 Ohm. To improve the value, water shall be sprinkle at the earthing pit.



Test Connection for a four terminal Megger

17.2 Before commissioning of the lines following tests may be carried out.

17.2.1. Insulation Resistance Test

This test may be carried out with the help of a 10kV or 12kV megger preferably power driven to ascertain the insulation condition of the line. In case 5 kV megger is used for insulation resistance measurement it shall be ensured that the induced voltage (CVT reading) is LESS than the instrument's withstanding capability, otherwise the instrument is likely to be damaged. This Test is to be carried out prior to the continuity test.

Measurement of Insulation Resistance

One of the most common devices used for testing electrical insulation is the Megger Insulation Tester.

If the DC test voltage is generated by a permanent magnet generator, this generator is turned either by hand or by an electric motor. In either case a slip clutch maintains the generator speed at a constant value so long as the slipping speed is exceeded. A constant voltage is important when the insulation under test has a high capacitance. Common generator output voltages are 500, 1000, 2500 and 5000 volts.

Many Meggers have a "guard" terminal as well as "line" and "earth". The guard terminal is useful if one wish to exclude part of the insulation under test from the measurement. This is possible since current flowing to the generator via the guard circuit does not pass through the deflecting coil.

Another use of the guard circuit is to shield the "line" lead between the Megger and the apparatus under test. This prevents leakage to ground from the "line" lead which would invalidate the Megger reading. Insulation resistance is the ratio V_{DC} / I_{DC}. V_{DC} is applied across two conductors separately by the insulation under test.

I_{DC} is the current flowing through/over the insulation. For a healthy and clean insulation the megger reading is in mega-Ohms to infinity. For dirty in, insulation and defective, moist insulation the meggers shows a very low insulation resistance value.

Megger test gives clear indication about the health, cleanliness and dryness of the line/equipment insulation.

5 KV megger or 10 KV megger or 12 KV megger may be used for the Transmission line keeping all safety requirements, Permit to work, clearance from statutory bodies and other conditions prevailing at the Sub-station where charging of the line is being co-ordinated.

17.2.2. Conductor Continuity Test

(a) The objective of this test is to verify that each conductor of the overhead line properly connected electrically (the value of electrical resistance of line does not vary abnormally from that of a continuous conductor of the same size and length). The electrical resistance of the conductor shall be measured with a Whetstone bridge or other suitable instrument, if available taking the safety aspects of Equipment as well as testing Engineer. A simple method of continuity test is illustrated below:

Once the insulation test is completed and the results confirms that there is no short circuit, carry out the following:

Sending End	Receiving End	Results (ohms)
Close R-Ph GS	Megger R- Ph	Zero / Low
Open Y-Ph GS	Megger Y- Ph	High
Open B-Ph GS	Megger B- Ph	High
Open R-Ph GS	Megger R- Ph	High
Close Y-Ph GS	Megger Y- Ph	Zero / Low
Open B-Ph GS	Megger B- Ph	High
Open R-Ph GS	Megger R- Ph	High
Open Y-Ph GS	Megger Y- Ph	High
Close B-Ph GS	Megger B- Ph	ZERO/LOW

(ALL GS OPEN CONDITION)

GS means GROUND SWITCH

If the above test results are OK it confirms the continuity of the line.

(b) The continuity Test of the line with proper phase indication or phase marking can be checked by continuity test as described below:

Sending End	Receiving End Megger Between	Results (Ohm)
Connect R & Y Phase B-Phase & All GS open	R-Phase & Y-Phase	Zero / Low
	Y-Phase & B-Phase	High
	B-Phase & R-Phase	High
Connect R & B Phase	R-Phase & Y-Phase	High

Y- Phase & All GS open	Y-Phase & B-Phase	High
	B-Phase & R-Phase	Zero / Low
Connect Y & B Phase R-phase & All GS open	R-Phase & Y-Phase	High
	Y-Phase & B-Phase	Zero / Low
	B-Phase & R-Phase	High

If the test results are OK it confirm that marking of the phases are in order.

(c) Phase Sequence

Once the line is charged from one end, without closing the Breaker at the other end the Phase sequence is to be checked from the CVT output by the help of Phase Sequence Meter. In case there are other feeders available Phase sequence is to be RECHECKED by the measurement of secondary voltage of both the Feeders (New line & available charged line).

Let the secondary Voltage of CVT is 110 volts (ph to ph) for both the Circuit. In case of correct Phase Sequence the voltage reading shall be as follows:

New Circuit	Old Circuit	Voltage (V)
R-Phase	R-Phase	0
R-Phase	Y-Phase	110
R-Phase	B-Phase	110
Y-Phase	R-Phase	110
Y-Phase	Y-Phase	0
Y-Phase	B-Phase	110
B-Phase	R-Phase	110
B-Phase	Y-Phase	110
B-Phase	B-Phase	0

In case the results are not matching the phase sequence is to be rechecked and reconfirmed before closing the breaker.

18.0 Energization

Execution of the energization is simply the last event in the switching sequence, switching of the close control button for the relevant circuit breaker.

19.0 De-energization

Instructions about de-energization will be given only if this is part of the test. Otherwise de-energization will be considered part of regular operation.

20.0 Observation and duration

Visual and audible inspection (look and listen) of the relevant equipment and reading of permanent instrumentation will be made.

The system shall be charged at least for 8 hours. During this time continuous monitoring and inspection will be maintained in control room, auxiliary systems areas and switch yards.

This will include frequent, scheduled inspection of all equipment and reading of all permanent instruments and recorders, and surge arrester counters, especially system parameters as per standard procedures adopted by OWNER.

21.0 Passing criteria

Neither insulation breakdown nor protective system actions must occur. No irregular equipment behaviour noise, vibration, high temperature is permitted. Corona discharges may not be “unreasonable”. Local discharges that may be attributable to sharp points shall be carefully located and recorded. After termination of the energization the equipment shall be closely inspected and the points rounded or covered.

No unscheduled changes of system nor of equipment is permitted during the 8 hour energized condition.

22.0 Documentation

Switching and operational activities will be recorded in regular manner in the operators log. Likewise all readings of permanent instruments. Copies of this log, notes on special observations from inspections and other measurements will constitute the test records.

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Bill of Quantity format for Transmission Line

Name of line: **Voltage Level(kV):**

Sl.No.	Description	Unit	Quantity
1	Line Length	km	
(a)	Plain Terrain	km	
(b)	Hilly Terrain		
	(i) Hilly Terrain	km	
	(ii) Mountaineous terrain	km	
2	GPS Co-ordinates		
(a)	Start Point		
(b)	End Point		
3	Route marked on google earth / Bhuvan Map	Yes / No	
4	Detail Wind zone (Lenthwise)		
	WZ----	km	
	WZ----	km	
5	States		
(a)	----------	km	
(b)	----------	km	
(c)	----------	km	
(d)	----------	km	
6	Length of RC Section	km	
7	No. of Circuits	No.	
8	No. of Bundle conductor	No.	
9	Earthing		
(a)	Pipe Type		
(i)	Normal Earthing	No.	
(ii)	Chemical Earthing	No.	
(b)	Counterpoise Type		
(i)	Normal Earthing	No.	
(ii)	Chemical Earthing	No.	
(c)	Shieldwire Earthing	No.	
(i)	Pipe type Earthing	Sets	
(ii)	Counterpoise Earthing	Sets	
(d)	Rod type (Qty. same as pipe type earthing)	No.	
(e)	Earthing for RC location	No.	
10	Survey		
(a)	Detail survey	km	

(b)	Check survey	km	
11	Soil Investigation		
(a)	All kind of soil except FR & HR	Loc.	
(b)	Fissured rock	Loc.	
(c)	Rocky soil	Loc.	
(d)	River crossing location	Loc.	
12	Benching		
(a)	All kind of soil except FR * HR	m3	
(b)	Fissured Rock	m3	
(c)	Hard rock	m3	
13	Tower Protection		
(a)	Random Rubble	m3	
(b)	Stone Bound	m3	
(c)	Back Filling	m3	
(d)	M-15 cover seal	m3	
14	Aviation Requirement		
(a)	Painting of Towers	No.	
(b)	Unit weight of Towers to be painted	MT	
(c)	Span Markes	No.	
(d)	Aviation lights		
	(i) 1 medium + 2 Low Intensity	No.	
	(ii) 1 medium + 4+C23 Low Intensity	No.	
15	No. of Transposition Towers	No.	
16	River Crossings		
	Name of River		
	Crossing Span (Bank-Bank)	m	
	Type of foundation for river crossing tower pile or open		
17	Road / Railway Crossings		
	Road Crossings (NH/SH)	No.	
	Powerline Crossings (66kV & above)	No.	
	Railway Crossing- electrified	No.	
	Railway Crossing- non-electrified	No.	
18	Forest details		
	Reserved forest	kms	
	Protected Forest	kms	
	Social / Revenue forest	kms	
	Other area	kms	
19	Power line Crossing		

	765kV	No.	
	400kV	No.	
	220kV/230kV	No.	
	110kV/132kV	No.	
	66kV	No.	
20	Stringing of Power line crossing under live line condition	No.	
21	Pollution details		
	Line stretch in polluted areas / fog prone area /	kms	
	near coast / creeks / backwaters		
22	Other important Details		

Name of line:		Voltage Level(kV):													
Tower Type	**Unit**	**Quantity**	**Foundation Classification**												
			Dry	**Wet**	**Wet Cultiv**	**PS**	**FS**	**WBC**	**DFR**	**WFR**	**SFR**	**HR**	**Sandy**	**Pile**	**Well**
PA/DPA/MCPA/MVPA															
Normal Tower	Nos.														
+ 3m Extn	Nos.														
+ 6m Extn	Nos.														
+ 9m Extn	Nos.														
+ 18m Extn	Nos.														
+ 25m Extn	Nos.														
PB/DPB/MCPB/MVPB															
Normal Tower	Nos.														
+ 3m Extn	Nos.														
+ 6m Extn	Nos.														
+ 9m Extn	Nos.														
+ 18m Extn	Nos.														
+ 25m Extn	Nos.														
PC/DPC/MCPC/MVPC															
Normal Tower	Nos.														
+ 3m Extn	Nos.														
+ 6m Extn	Nos.														
+ 9m Extn	Nos.														
+ 18m Extn	Nos.														
+ 25m Extn	Nos.														
PD/DPD/MCPD/MVPD															
Normal Tower	Nos.														
+ 3m Extn	Nos.														
+ 6m Extn	Nos.														
+ 9m Extn	Nos.														
+ 18m Extn	Nos.														
+ 25m Extn	Nos.														

	S/C	D/C	MC	MV	Total
Total Suspension Towers					
Total D-Type Towers					
Total Tension Towers					
Total Normal Towers					
Total Anchor Towers					
Total River Crossing (RC) Towers					
Total Towers					