Nepal Electricity Authority

(A Government of Nepal Undertaking)

Transmission Directorate

Nepal-India Electricity Transmission and Trade Project

HETAUDA-BHARATPUR-BARDAGHAT 220 KV TRANSMISSION LINE PROJECT

Bidding Document
For

"PROCUREMENT OF PLANT DESIGN, SUPPLY, INSTALLATION, TESTING AND COMMISSIONING OF

HETAUDA-BHARATPUR 220 KV TRANSMISSION LINE PROJECT"

Single Stage-International Competitive Bidding Procedure

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TECHNICAL SPECIFICATIONS

I. GENERAL INFORMATION AND SCOPE

1. General Information and Scope

1.1 Scope

1.1.1 Hetauda-Bharatpur-Bardghat 220 kV Transmission Line Project has two sections (a) Hetauda-Bharatpur section and, (b) Bharatpur-Bardghat section. The scope includes the installation of about 74 km of double circuit 220 kV including 2 km of four circuits (4DD) 220 transmission line of Hetauda-Bharatpur section originating from a new substation at Hetauda and terminating at a new substation at Bharatpur. This Specification for Procurement of Plant Design, Supply, Installation, Testing And Commissioning of Hetauda-Bharatpur 220 kV Transmission Line covers (i) geotechnical investigation for multi circuit (4DD) towers; (ii) Prototype testing of multi circuit tower, fabrication and supply of 220 kV double circuit transmission line towers and 220 kV multi circuit transmission line towers including bolts, nuts and washers, hangers, D-shackles and all types of tower accessories like phase plate, circuit plate, number plate, danger plate, anti-climbing device as specified in Bill of Quantities (BOQ), (iii) supply of Conductor, Insulator, Earth wire and OPGW, Hardware Fittings, and Conductor & Earth wire Accessories, (iv) classification of foundation for different multi circuit towers and installation of foundation as per approved drawings; (v) erection of towers, tack welding of bolts and nuts including supply and application of zinc rich primer & enamel paint, tower earthing, fixing of insulator strings, stringing of conductors and earth wires along with all necessary line accessories, (vi) testing and commissioning of the transmission lines and (vii) other items not specified above but required as per Bid Forms & Price Schedules.

For the construction of the 220 kV Hetauda- Bharatpur transmission line, contract agreement was previously signed with ICOMM Tele India Ltd., India and subsequently contract was terminated. The transmission line materials, tower parts and accessories that are not included in the prices schedule are already supplied and NEA will hand over the same to the new contractor. After handover, the safeguard, protection for sites and materials and all necessary insurance of materials come under the obligation of successful bidder. Along with this, NEA will also provide already approved design drawings related with the transmission line construction works to the Bidders. However, for those design and drawings which are not completed as necessary, revision and modification of the approved design and drawings, if necessary, is in the scope of the contractor.

1.1.1.1 Contractor shall develop all shop drawings of 220 kV remaining Double circuit towers & shop drawings and Bill of Materials, and tower schedule of four circuit towers after completion of proto type testing of four circuit towers.

1.1.1.2 (a) Scope of Part I of Price Schedule quantifies those which are clearly quantifiable as per the scope of the work and are given under this heading.

i. Schedule No. 1: Plant and Equipment (including Mandatory Spares Parts) Supplied from Abroad: supply of complete sets of Towers and hardware fittings for 220KV T/L, including bolt and nuts, hangers, U-bolts complete.

ii. Schedule No. 2. Plant and Equipment (including Mandatory Spares Parts) Supplied from Within Employer's Country: supply of complete sets of Towers and hardware fittings for 220KV T/L, including bolt and nuts, hangers, U-bolts complete.

iii. Schedule No. 4. Installation and Other Services, Part A: Local Transportation, Insurance and Other Incidental Services quantifies the local transportation, insurance and other Incidental Services for supply complete sets of Towers and hardware fittings for 220KV T/L, including bolt and nuts, hangers, U-bolts complete.

iv. Schedule No. 4. Installation and Other Services, Part B: Installation Charges quantifies work associated with installation of tower foundations for complete sets of Towers For 220KV T/L, including bolt and nuts, hangers, U-bolts complete, erection of towers & its body extensions (Complete) including bolts & nuts, tack welding and supply and application of enamel & zinc rich paint, and installation of insulator strings complete with arcing horns & necessary hardware, installing of bundle conductor including fixing of conductor accessories, installing & stringing of earthwire including fixing of earthwire accessories (Twin bundle Conductor) in Double circuit Line including 2 km four circuit line.

(b) Scope of Part II quantities are those which are provided for information only and need to be verified by prospective bidders prior to preparing the bids and entering into contract.

i. Schedule No. 1: Plant and Equipment (including Mandatory Spares Parts) Supplied from Abroad: supply of Missing Tower Parts and Hardware Fittings For 220KV T/L, including bolt and nuts, hangers, U-bolts complete.

Missing tower parts shall be the members of tower not fitted as per approved drawings, cut and bent members fitted in already erected towers.

ii. Schedule No. 2: Plant and Equipment (including Mandatory Spares Parts) Supplied from Within Employer's Country: supply of Missing Tower Parts and Hardware Fittings For 220KV T/L, including bolt and nuts, hangers, U-bolts complete.

Missing tower parts shall be the members of tower not fitted as per approved drawings, cut and bent members fitted in already erected towers.

iii. Schedule No. 4. Installation and Other Services, Part A: Local Transportation, Insurance and Other Incidental Services quantifies the local transportation, insurance and other Incidental Services for Supply of Missing Tower Parts and Hardware Fittings For 220KV T/L, including bolt and nuts, hangers, U-bolts complete.

Missing tower parts shall be the members of tower not fitted as per approved drawings, cut and bent members fitted in already erected towers.

iv. Schedule No. 4. Installation and Other Services, Part B: Installation Charges: Work associated with dismantling and installation of existing damaged tower foundations as per instruction of Engineer, dismantling and Re-erection of

towers & its body extensions (Complete) including bolts & nuts, tack welding, coping & backfilling of foundations and supply and application of enamel & zinc rich paint as per instruction of Engineer, re-drumming of conductors at store and Re-installation of insulator strings complete with arcing horns & necessary hardware, reinstalling & restringing of bundle conductor including fixing of conductor accessories, reinstalling & restringing of earthwire including fixing of earthwire accessories (Twin bundle Conductor) in Double Circuit Line as per instruction of Engineer.

Damaged tower foundation shall mean degraded foundations including damaged/distorted stubs.

Re-erection of towers shall mean erection of towers & its body extensions (Complete) including bolts & nuts, tack welding and supply and application of enamel & zinc rich paint after complete dismantling of towers.

Re-drumming of conductors shall mean the drumming of conductors on a new drum for convenience in transportation and stringing works.

Re-installation shall mean the dismantling and installing of the respective items.

(c) Scope of Part III quantities are those which are clearly quantifiable as per the scope of the work. However, the approved design (both structural and foundation) should be reviewed on their own cost from the successful bidder before testing and supply.

i. Schedule No. 1: Plant and Equipment (including Mandatory Spares Parts) Supplied from Abroad: Supply of Towers For 220 KV, 4CCT, T/L ,including bolt and nuts, hangers, U-bolts complete.

ii. Schedule No. 2: Plant and Equipment (including Mandatory Spares Parts) Supplied from Within Employer's Country Supply of Towers For 220 KV, 4CCT, T/L, including bolt and nuts, hangers, U-bolts complete

iii. Schedule No. 4. Installation and Other Services, Part A: Local Transportation, Insurance and Other Incidental Services: local transportation, insurance and other Incidental Services for Supply of Towers For 220 KV, 4CCT, T/L, including bolt and nuts, hangers, U-bolts complete.

(d) Scope of Part IV quantities are those which are provided for information only and need to be verified by prospective bidders prior to preparing the bids and entering into contract.

i. Schedule No. 4. Installation and Other Services, Part B: Installation Charges: Rectification of Erected towers & its body extensions (Complete) including bolts & nuts, tack welding, coping & backfilling of foundations and supply and application of enamel & zinc rich paint as per instruction of Engineer.

Rectification shall mean the installation of missing members of tower not fitted as per approved drawings, reinstallation of cut and bent members fitted in already erected.

1.1.1.3 (a) The provisional quantities of fabricated & galvanised steel towers as per specifications requirement, foundation type and their numbers, quantity of various line materials and other items are given in appropriate Price Schedule in

Volume-III of the bid documents. However, the work shall be executed as per approved construction drawings and project requirement.

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

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

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

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

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

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

In the hilly terrain or in thick forest areas, the Contractor may carry out stringing work by manual method with approval of the Employer. The Contractor shall deploy appropriate tools /equipment /machinery to ensure that the stringing operation is carried out without causing damage to conductor/earthwire/OPGW and the conductor/earthwire/OPGW is installed at the prescribed sag-tension as per the approved stringing charts.

1.1.4 Location Details and Terminal Points

The 220 kV (twin bundle) transmission line shall emanate from the switchyard of the new Bharatpur 220 kV substation to be created in ward no 2 of Bharatpur Municipality and shall terminate in the switchyard of new Hetauda 220 kV substation created at ward no 11 of Hetauda Municipality. Further, 220 kV double circuit line (initially charged at 132 kV) will originate from new Hetauda 220 kV

substation and terminate at existing 132 kV Hetauda substation. The entire line under this project scope shall be initially charged at 132 kV level. The transmission line shall be passing through rolling hills, sparse settlements and forests.

1.1.5 The Contractor shall have to construct the above 220 kV transmission line completely up to dead end towers in the proposed switch yards at new Hetauda and new Bharatpur and existing Hetauda 132 kV substation. Stringing shall also be carried out from dead end tower to terminal arrangements/terminal points.

1.2 Details of Transmission Line Routes and Terrain

Detailed survey including route alignment, profiling, have been carried out by the Owner and these are not expected to vary.

The details collected through detailed survey viz, route alignment maps etc. will be given to the Contractor during execution stage.

Bidders may visit the line route to acquaint themselves with terrain conditions, may visit tower to tower visit to check conditions of already erected towers, strung conductors and associated details of the proposed transmission lines.

1.3 Access to the Line and Right of Way

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

2.0 Line Data for 220 kV:

2.1 Electrical System Data:

a	Nominal Voltage	kV	220
b	Maximum system voltage	kV	245
c	BIL(Impulse)	kV (Peak)	1250
d	Power frequency withstand voltage (Wet)	kV (rms)	460
e	Minimum Corona extinction voltage at 50Hz AC system under dry condition	kV (rms) phase to earth.	154 Min
f	Radio interference voltage at one MHz for phase to earth voltage of 154 KV under dry condition.	Micro Volts	1000 Max

2.2 Details of Line Materials

A. Conductor and earth wire for 220 kV line

Sl. No.	Description	Unit	Earth wire	Conductor

1.	Name/Type		Galvanised steel and OPGW	ACSR /AACSR Bison
2.	Size	mm	7/3.35 (for steel),	54/3.0 Aluminium/AA 24 pairs for OPGW+7/3.0 steel
3.	Conductor per phase	No.	N.A.	2
4.	Spacing between conductor of same phase (sub conductor spacing)	mm	N.A.	450
5.	Configuration		*Two continuously to run horizontally on top of the towers and conductors.	Vertical
6.	Overall diameter	mm	10.05	27
7.	Ruling Design Span	Meters	350	350

** Initially one circuit shall be strung with both E/W and OPGW.*

2.3 Details of Insulator Strings with disc insulator for 220 kV line

Sl. No.	Particulars	Single/Twin tension string	Single/double suspension pilot string
1.	Type of Disc	Standard	Standard
2.	E&M Strength of each insulator in the string in KN	120	70
3.	Nos. of insulator disc per string	1x17/2x17	1x16/2x16
4.	Size of disc in mm	280x145	280x145 or 255x145
5.	Size and designation of pin ball shank in mm.	20	16
6.	Minimum creepage distance of	292	292

each disc in mm.

Note: For crossing of Long valleys twin strings of 160 kN EMS disc insulators of 280x 170 size shall be used with matching Hardware.

2.4 Insulator String Hardware (As may be applicable)

a) Anchor Shackle

b) Chain Link

c) Ball Clevis

d) Arcing horn holding plate

e) Yoke plate

f) Socket clevis

g) Arcing horns

h) Corona control ring/grading ring.

i) Clevis Eye

j) Free center type/Armour grip suspension clamp for suspension strings.

k) Compression type dead end clamp.

l) Sag adjuster.

m) Balancing weight

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

a) Preformed Armour rods

b) Mid Span compression joint

c) Repair Sleeves

d) Flexible copper bonds

e) Vibration dampers

f) Rigid Spacers

g) Suspension clamp for earth wire.

h) Tension clamp for earth wire.

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

TECHNICAL SPECIFICATIONS

II. GENERAL TECHNICAL CONDITIONS

1.1 General

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

1.2 Engineering Data

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

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

1.3 Drawings

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

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

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

1.3.3 The drawings submitted by the Contractor shall be reviewed by the Employer as far as practicable within 28 days and shall be modified by the Contractor if any modifications and/or corrections are required by the Employer. The Contractor shall incorporate such modifications and/or corrections and submit the final drawings for approval. Any delays arising out of failure by the Contractor to rectify the drawings in good time shall not alter the contract completion date.

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

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

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

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

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

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

In no case the approval by the Employer of any document does imply compliance with technical requirements nor the absence of errors in such documents.

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

1.3.8 All drawings shall be prepared using AutoCAD software version 2007 or later only. Drawings, which are not compatible to AutoCAD software version 2007 or later, shall not be acceptable. After final approval all the drawings shall be submitted to the Employer in PenDrives.

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

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

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

a) Work Schedule (Master Network) Plan.

b) Detailed survey report and profile drawings showing ground clearance and tower locations (as applicable).

c) Tower schedule and foundation classification for individual tower locations (as applicable).

d) Tower structural drawing and bill of materials.

e) Soil Investigation report.

f) Foundation working drawings/excavation Plan.

g) Tower footing earthing drawing.

h) Stub and stub-setting template drawings.

i) Stringing procedure and stringing chart.

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

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

l) Sub-vendors approval, etc.

m) Line material drawings.

n) Type test report for line materials.

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

1.4 Design Improvements

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

1.5 Design Co-ordination

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

1.6 Design Review Meeting

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

1.7 Quality Assurance, Inspection & Testing

1.7.1 Quality Assurance Manual

To ensure that the supply and services under the scope of this Contract whether manufactured or performed within the Contractor's works or at his Sub-Contractor's premises or at site or at any other place of work are in accordance with the specifications. The Contractor shall adopt suitable quality assurance programme to control such activities at all points necessary. Such programme shall be broadly outlined by the Contractor and shall be finalised after discussions before the award of Contract. The detailed programme shall be submitted by the contractor after the award of contract and finally accepted by the Employer after discussion. A quality

assurance programme of the Contractor shall generally cover but not limited to the following:

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

(b) Documentation control System.

(c) Qualification data for Contractor's Project Manager.

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

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

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

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

(h) Inspection and test procedure for manufacture.

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

(j) System for quality audits.

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

(l) System for maintenance of records.

(m) System for handling storage and delivery and

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

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

1.7.1.1 Quality Assurance Documents

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

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

1.7.2 Employer's Supervision

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

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

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

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

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

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

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

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

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

1.7.3 Inspection & Inspection Certificate

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

1.7.3.2 The Contractor shall give the Employer's Inspector fifteen (15) days (in case of domestic testing and thirty (30) days (in case of foreign testing), as the case may be, written notice of any material being ready for testing. All such inspections shall be to the Contractor's account except for the expenses of the Employer’s inspector. The Employer’s inspector, unless witnessing of the tests is virtually waived, will attend such tests within fifteen (15) days (in case of domestic testing) and thirty (30) days in (in case of foreign testing) of the date of which the equipment is notified as being ready for test/inspection or on a mutually agreed date, failing which the Contractor may proceed with the test which shall be deemed to have been made in the inspector's presence and he shall forthwith forward to the inspector duly certified copies of test reports / certificates in triplicate.

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

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

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

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

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

b) The acceptance of any part of items shall in no way relieve the Contractor of any part of his responsibility for meeting all the requirements of the Specifications.

1.7.3.8 The Employer or his representative shall have free access at all reasonable times to those parts of the Contractor's works which are concerned with the fabrication of the Employer's material for satisfying himself that the fabrication is being done in accordance with the provisions of the Specifications.

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

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

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

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

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

1.7.4 Tests and Standards

1.7.4.1 Tests

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

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

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

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

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

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

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

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

1.7.4.2 Standards

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

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

1.7.4.2.2 The standards are available from**:**

Reference/Abbreviation	**Name and address from which the Standards/guides are available**
IS	Bureau of Indian Standards Manak Bhawan, 9, Bahadur Shah Zafar Marg, New Delhi India.
ISO	International Organisation for Standardisation, Danish Board for Standardisation, Dansk Standardising Sraat, Aurehoegvei-12 DK-2900 Hellepruip, DENMARK

CSA	Canadian Standard Association 178,Rexadale Boulevard, Rexdale(Ontario) Canada M9W 1R3
DIN	Deutsches Institute Fiir Normung Burggrafenstrassee 4-10 Post Fach 1107 D-1000, Berlin-30 GERMANY
ASTM	American Society for Testing and Material 1916 Race Street Philadelphia.PA 19103-1187 USA
ASCE	American Society of Civil Engineers 345 East 47th Street New York, NY 10017-2398 USA
IEEE	Institute of Electrical and Electronics Engineers 445 Hoes Lane Piscataway, NJ 0085-1331 USA
IEC	International Electrotechnical Commission Bureau Central de la Commission 1 rue, de varembe, Geneva Switzerland.

1.8 Guaranteed Technical Particulars

1.8.1 The Guaranteed Technical Particulars of the various items shall be furnished by the Bidders in one original and two (2) copies in the prescribed schedules of the Specifications. The Bidder shall also furnish any other information as in their opinion is needed to give full description and details to judge the item(s) offered by them

1.8.2 The data furnished in Guaranteed Technical Particulars should be the minimum or maximum value (which ever is ruling condition as per the requirement of the specification) required. A Bidder may guarantee a value more stringent than the specification requirement. However, for testing purpose or from performance point of view, the material shall be considered performed successfully if it achieves the minimum / maximum value required, which ever is ruling condition, as per the Technical Specification. No preference what so ever shall be given to the bidder offering better/more stringent values than those required as per specification except where stated otherwise.

1.9 Packing

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

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

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

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

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

2.0 Environmental Mitigation Measures

2.1 Physical Environment

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

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

2.2 Biological Environment

None

2.3 Socio-economic and cultural Environment

In the construction phase following mitigation measures shall be adopted to minimize the impacts:

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

- Insurance against health and safety.

2.4 Employment

The job preferences during construction shall be given to local project affected family people.

TECHNICAL SPECIFICATIONS

III. TRANSMISSION LINE TOWER

1.0 Transmission Tower

1.1 General Description of the Tower

1.1.1 The towers shall be of the following types:

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

B) Four Circuit towers (4DD).

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

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

1.2 Type of Towers

1.2.1 The towers for 220 kV Lines are classified as given below:

Type of Tower	Deviation Limit	Typical Use
DA	0 – 2 deg.	To be used as tangent / suspension Tower with suspension insulator string
DB	2 - 15 deg	a) Angle towers with tension insulator string. b) Also to be used for uplift force resulting from an uplift span up to 360m under broken wire conditions. c) Also to be used for Anti Cascading Condition.
DB	0 deg.	To be used as Section Tower.
DC	15 - 30 deg.	a) Angle tower with tension insulator string. b) Also to be used for uplift forces resulting from an uplift span up to 360m under broken wire condition. c) Also to be used for anti cascading condition.
DC	0 deg.	To be used as Section tower.
DD	30 - 60 deg.	a) Angle tower with tension insulator string. b) Also to be used for uplift forces resulting from an uplift span up to 600m under broken wire

		condition. c) Dead end with 0 deg to 15 deg deviation both on line side and sub-station side (slack span)
DDE	0 deg.	a) Complete dead end. b) For river crossing anchoring with longer wind span & 0 deg. deviation on crossing span side and 0 deg to 30 deg. deviation on other side.
4DD	30 - 60 deg.	a) Angle tower with tension insulator string. b) Also to be used for uplift forces resulting from an uplift span up to 600m under broken wire condition. c) Dead end with 0 deg to 15 deg deviation both on line side and sub-station side (slack span)

1.2.2 Towers for Major Crossings

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

1.2.3 Extensions

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

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

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

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

1.3 Spans

1.3.1 Design Span or Normal Span

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

1.3.2 Wind Span

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

1.3.3 Weight span

The weight span is the horizontal distance between the lowest point of the conductors on the two spans adjacent to the tower. For spotting of structures, the span limits are given in Table 1.1 & Table 1.2

TABLE 1.1
(FOR 220 kV LINE)

TOWER TYPE	NORMAL CONDITION		BROKEN WIRE CONDITION	
	MAX. (m)	MIN. (m)	MAX. (m)	MIN. (m)
DA	600	200	360	100
DB, DC	600	-600	360	-360
DD	1000	-1000	600	-600

TABLE 1.2
(FOR 220 AND 132 kV FOUR CIRCUITS LINE)

TOWER TYPE	NORMAL CONDITION		BROKEN WIRE CONDITION	
	MAX. (m)	MIN. (m)	MAX. (m)	MIN. (m)
4ST	600	200	360	100
4DB, 4DC	600	-600	360	-360
4DD	1000	-1000	600	-600

1.3.4 In case at certain locations where actual spotting spans exceed the design spans and cross-arms and certain members of towers are required to be modified / reinforced, in that case design, structural & shop drawings for the modified / reinforced towers will be prepared by the Contractor as per requirement on basis of approved line diagram without any additional financial implications to the Employer for the design and drawings.

1.4 Electrical Clearances

1.4.1 Ground Clearance

The minimum ground clearance from the bottom conductor shall not be less than 7500 mm for 220 kV lines at the maximum sag conditions i.e at 80°C and still air.

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

b) Conductor creep shall be compensated by over tensioning the conductor at a temperature of 26°C, lower than the stringing temperature for ACSR "BISON" for 220kV transmission lines.

1.4.3 Power Line Crossing

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

1.4.4 Live Metal Clearance

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

TABLE 1.2

DESCRIPTION	SWING ANGLE	LIVE METAL CLEARENCE
		2000 M EL
	NIL	2400 mm
Suspension String	15 Degree	2230 mm
(Single / Double)	30 Degree	2060 mm
	45 Degree	1885 mm
Tension String	--	2400 mm
(Single / Double)		
Jumper	NIL	2400 mm
	10 Degree	2400 mm
	20 Degree	2060 mm

NOTE: IN CASE OF PILOT INSULATOR STRINGS, THE ANGLE OF SWING OF THE JUMPER ALONGWITH THE PILOT STRING SHALL BE CONSIDERED AS 15 DEG.

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

1.4.6 For computing the live metal clearances the dimensions of Single Suspension, Double Suspension, Single Suspension Pilot, Single Tension and Double Tension strings shall be taken as given in enclosed drawings. The design of the tower shall be such that it should satisfy all the above conditions when clearances are measured from any live point of the strings.

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

1.4.8 Angle of Shielding

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

1.4.9 Mid Span Clearance

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

1.5 Normal Loading Conditions

1.5.1 Loads at Conductor and OPGW/Earthwire Points

Employer has calculated the ultimate external loadings at conductor and OPGW/ earthwire points and enclosed along with the specification. The Bidder shall develop the tower designs based on the loadings given by the Employer. Load trees have been provided for double circuit towers only. For the four-circuit towers, the loading of each circuit and OPGW are identical to that of the respective type of the double circuit towers. Accordingly, the four-circuit towers design shall be proposed by the bidder. Tower configuration to be adopted shall be the square type.

1.5.2 Wind Loads on Tower Body

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

a) Dynamic reference wind pressure shall be considered as 71.5 Kg/m^2.

b) Terrain shall be cross country lines, sparse settlements and forest areas.

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

1.5.3 Maximum Tension

1.5.3.1 Max. tension shall be based on either

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

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

1.5.3.2 Employer has calculated sag tension calculation for a normal span of 350 meter. Sag tensions calculations are furnished along with the specification (Refer Drawing No. HB-D/220 kV/Sag-ten 1 of 2 and 2 of 2).

1.5.3.3 The initial conductor and OPGW/earthwire tension (maximum) at 32ºC and without wind shall be 22% of the ultimate tensile strength of the conductor and 20% of the ultimate tensile strength of the OPGW/earthwire.

1.5.4 Limiting Tensions of Conductor & OPGW/Earthwire

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

1.5.5 Broken Wire Condition

1.5.5.1 Suspension Tower Type DA

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

1.5.5.2 Tension Tower Type DB and DC

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

1.5.5.3 Tower Type DD

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

1.6 Design of Towers

1.6.1 Design Criteria

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

1.6.2 Design Temperatures

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

i)	Minimum Temperature	:	0 deg.C
ii)	Every day temperature of conductor	:	32 deg.C
iii)	Max. temperature of		
	a) Conductor	:	80 deg.C
	b) OPGW/Earthwire exposed to sun	:	53 deg.C

1.6.3 Conductor and OPGW/Earthwire Configuration

For double circuit towers the three phases shall be in vertical formation. The phase to phase spacing for conductors shall be not less than 4.9 metres vertically for DA, DB and DC tower and 8.3 meters for DD tower. However, the minimum horizontal separation between phase conductors of two circuits shall be 8.4 meters. In double

circuit suspension towers single suspension vertical (I-type) insulator strings shall be used.

1.6.4 Redundant Design

1.6.4.1 All redundant in the tower are to be triangulated.

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

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

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

1.6.5 Thickness of Members

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

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

b) For all other members : 4 mm

1.6.6 Bolts and Nuts

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

TABLE 1.3

Bolt Diameter (mm)	Hole Diameter (mm)	Min. Bolt Spacing (mm)	Min. Rolled Distance (mm)	Min. Sheared Edge Distance (mm)
16	17.5	40	20	23
24	25.5	60	33	38

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

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

1.6.7 Slenderness Ratio

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

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

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

	VALUE OF KL/R
a) For main corner leg members including the corner members of OPGW/earthwire peak and the lower corner members of the cross-arms	120
b) For other members having calculated stresses	200
c) For redundant members	250
d) For members having tensile stress only	375

1.6.8 Erection Stress

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

1.6.9 Structural Arrangement of Members in a Tower

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

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

Design Calculation and Drawings

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

A) ALONGWITH THE BID:

Detailed design calculations and drawings for DA and DB type towers only.

B) AFTER AWARD OF CONTRACT:

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

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

a) Detailed design calculation and drawing for towers and foundations.

b) Detailed structural drawings indicating section size, length of members, sizes of plates along with hole to hole distance & joint details etc.

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

d) Shop drawings showing all details relevant to fabrication.

e) All the drawings for the tower accessories.

1.6.10.3 The Contractor is required to submit four copies of the drawings as mentioned in clause 1.6.10.2 for Employer's approval. While submitting the designs, structural drawings bill of materials and any other drawing pertaining to the subject transmission line, the Contractor shall clearly indicate on each drawing NEA Specification No., Name of the transmission line and project , letter reference No. and date on which the submission are made. The same practice is also to be followed while submitting distribution copies.

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

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

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

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

1.6.10.7 All the drawings shall have a proper name plate clearly displaying the name of Employer on right hand bottom corner. The approval for exact format of the nameplate shall be obtained by the successful bidder from the Employer for adopting the same on all the drawings. Also all the drawings shall carry the following statement and shall be displayed conspicuously on the drawing:

WARNING **:** THIS IS PROPRIETORY ITEM AND DESIGN RIGHT IS STRICTLY RESERVED WITH NEA (Nepal Electricity Authority). UNDER NO

CIRCUMSTANCES THIS DRAWING SHALL BE USED BY ANYBODY WITHOUT PRIOR PERMISSION FROM NEA IN WRITING.

1.7 Materials

1.7.1 Tower Steel Sections

IS Steel Sections of tested quality of conformity with IS: 2062 (Designated Y.S. 250 MPa) or / and IS: 8500 grade 490 (Designated Yield Strength 350 MPa) are to be used in towers, extensions, stub and stub setting templates. The Contractor can use other equivalent grade of structural steel angle sections and plates conforming to latest International Standards. However, use of steel grade having designated yield strength more than that of EN 10025 grade 355 JR /JO is not permissible. The Bidders are permitted to opt for not more than two (2) grades of steel in the package.

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

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

1.7.2 Fasteners: Bolts, Nuts and Washers

1.7.2.1 All tower members shall be joined together with Bolts and nuts. All hexagonal bolts and nuts shall conform to IS-12427. They shall have hexagonal head and nuts, the heads being forged out of the solid, truly concentric, and square with the shank, which must be perfectly straight.

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

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

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

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

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

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

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

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

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

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

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

1.8 Tower Accessories

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

1.8.1 Step Bolts & Ladders

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

1.8.2 Insulator String Attachments

a) For the attachment of suspension Insulator string, a suitable dimensioned swinging hanger on the tower shall be provided so as to obtain specified clearances under respective swinging condition of the strings. The hanger, extensions links, D-shackles etc. as required and considered in the design of the tower shall have minimum ultimate tensile strength of 240KN for double suspension string for 220 kV suspension towers. The design and supply of hanger, D-shackles, strain plate etc. are also in the scope of Contractor.

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

1.8.3 Earth wire Clamp Attachments

a) Suspension Clamps

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

b) Tension Clamps

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

1.8.4 Anti Climbing Device

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

1.8.5 Danger, Number, Circuit and Phase plate

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

a) Each tower shall be fitted with a danger plate, number plate and one (1) set of phase plates for double circuit tower. Circuit plates shall be provided on all the Double Circuit towers.
b) The letters, figures and the conventional skull and bones of danger plates shall conform to IS-2551 and shall be in a signal red on the front of the plate.
c) The corners of the danger, number and circuit plates shall be rounded off to remove sharp edges.
d) The letters of number and circuit plates shall be red enameled with white enameled background.

1.9 Tower Fabrication

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

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

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

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

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

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

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

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

1.9.5 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.

1.9.6 All identical 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. No rough edges shall be permitted in the entire structure.

1.9.7 Drilling and Punching

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

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

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

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

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

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

1.9.8 Erection mark

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

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

A = Employer's code assigned to the Contractors- Alphabet

BB = Contractor's Mark-Numerical

CC = Tower Type Alphabet.

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

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

1.10 Quantities and weights

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

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

1.10.2 The estimated unit weight of each type of galvanized towers, stubs and leg extensions shall be furnished by the bidder. The weight of tower shall mean the weight of tower calculated by using the black sectional (i.e. ungalvanised) weight of steel members of the size indicated in the approved fabrication drawings and bill of materials, without taking into consideration the reduction in weights due to holes, notches and bevel cuts etc. but taking into consideration the weight of the anticlimbing devices, D shackles, hangers, strain plates, pack plates, gusset plates and pack washers etc. The weight of gusset plates shall mean the weight of its circumscribing rectangle, without taking into consideration the reduction in weights due to holes, notches etc. For bolts and nuts along with spring washers and step bolts, the weight per tower shall be calculated from the bolt schedule applicable to each type of towers, stubs and leg extensions as approved by the Employer. The rate

quoted by the bidder for supply of tower / tower parts is deemed to be inclusive of galvanizing charges including the cost of zinc.

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

1.11 Galvanising

1.11.1 Fabricated Tower Parts & Stubs

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

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

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

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

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

(ii) Pickling: Pickling shall be done using either hydrochloric or sulfuric acid as recommended at clause 4.3 of IS 2629 -1985. The actual concentration of the acids and the time duration of immersion shall be determined by the Contractor depending on the nature of material to be pickled. Suitable inhibitors also shall be used with the acids to avoid over pickling. The acid concentration, inhibitors used, and maximum allowable iron content shall form part of plant standard to be formulated and submitted to Purchaser along with Quality Assurance Program.

(iii) Rinsing: After pickling, the material shall be rinsed, preferably in running water to remove acid traces, iron particles or any other impurities from the surface. Two rinse tanks are preferable, with water cascading from the second tank to the first to ensure thorough cleaning. Wherever single tank is employed, the water shall be periodically changed to avoid acid contamination, and removal of other residue from the tank.

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

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

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

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

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

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

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

1.11.2. Fasteners

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

1.12 Earthing

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

IS: 3043 or equivalent national or international Code of practice for Earthing.

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

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

1.12.2 For counterpoise type earthing the earthing will vary depending on soil resistivity. For soil resistivity less than 1500 ohms-meter, earthing shall be established by providing 4 lengths of 30m counterpoise wire. Otherwise, for soil resistivity greater than 1500 ohms meter earthing shall be established by providing 4 length of 70m counterpoise wire. In case resistivity does not come down less than 10 ohms even after providing 70 m counterpoise wire, Contractor shall submit a statement in this regard to Employer to know further course of action.

1.12.3 The provisional quantities for pipe type earthings and counterpoise earthing are furnished in the Price Schedule. The bidders are required to quote unit rates for the same in appropriate Price Schedule. The quoted price shall include fabrication, supply and installation of earthing material including supply of coke, salt etc. In case of counterpoise type earthing, the quotation shall be based on 120 meters of wire per tower.

1.13 Inspection and Tests

1.13.1 General

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

1.13.2 Inspection

In addition to the provision of GCC and Clause 1.7.3 of Section 2 of this Specification, the following shall also apply:

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

b) The acceptance of any part of items shall in no way relieve the Contractor of any part of his responsibility for meeting all the requirements of the Specification.

1.13.2.2 The Employer or his representative shall have free access at all reasonable times to those parts of the Contractor's works which are concerned with the fabrication of the Employer's material for satisfying himself that the fabrication is being done in accordance with the provisions of the Specification.

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

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

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

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

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

1.14 Tower Load Tests

1.14.1 Testing of Tower

A Galvanized tower of each type complete with 9 M extension shall be subjected to design and destruction tests by first applying test loads applied in a manner approved by the Employer. The tower shall withstand these tests without showing any sign of failure or permanent distortion in any part. Thereafter the tower shall be subjected to destruction by increasing the loads further in an approved manner till it fails. The tower shall be tested for all the conditions considered for the design of tower. The

Contractor shall submit to the Employer, for approval, the detailed programme and proposal for testing the towers showing the methods of carrying out the tests and manner of applying the loads. After the Employer has approved the test procedures and programmes the Contractors will intimate the Employer about carrying out the tests at least 30 days in advance of the scheduled date of tests during which the Employer will arrange to depute his representative to be present at the time of carrying out the tests. Six copies of the test reports shall be submitted. The Contractor shall submit one set of shop drawings along with the bill of materials at the time of prototype tower testing for checking the tower material. Further at the time of submitting test report, the contractor has to submit the final drawings of shop drawings and Bill of materials for Employer's reference and record. The type testing charges shall be released only after approval of test report, structural drawings, bill of material and shop drawings of tower.

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

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

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

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

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

1.14.1.6 All the measuring instruments shall be calibrated in systematic / approved manner with the help of standard weight / device. Calibration shall be done before commencing the test of each tower upto the maximum anticipated loads to be applied during testing.

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

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

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

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

1.14.2 Method of Load Application

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

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

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

1.14.3 Tower Testing Procedure

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

1.14.3.1 Bolt Slip Test

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

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

1.14.3.2 Normal Broken Wire Load Tests

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

25 percent,

50 percent,

75 per cent,

90 percent,

95 percent and

100 percent

1.14.3.3 Observation Periods

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

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

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

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

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

1.14.3.4 Recording

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

1.14.3.5 Destruction Test

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

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

1.15 Packing

1.15.1 Angle section shall be wire bundled.

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

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

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

1.16 Standards

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

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

Sl. No.	**Indian Standards (IS)**	**Title**	**Internationally recognized**
	Standards/Guides		
1.	IS: 209-1992	Specification for Zinc	ISO/R/752 ASTM B6
2.	IS: 278-1991	Galvanized Steel Barbed wire	ASTM A131
3.	IS: 800-1991	Code of Practice for General Building Construction in Steel	CSA 6.1
4. (a)	IS: 802(Part1) Sec 1-1995	Code of Practice for General Building Construction in Steel Sec 2-1992 in Overhead Transmission Line Towers : Materials, loads and Permissible Stresses Section 1 Materials and loads Section 2 Permissible stresses.	ASCE 52 IEC 826 BS 8100
4. (b)	IS: 802-1990 (Part 2)	Code of practice for use of structural steel in over-head Transmission Line : Fabrication, Galvanizing, Inspection and Packing	ASCE 52
4. (c)	IS: 802-1990 (Part 3)	Code of practice for use of Structural Steel in over-load Transmission Line Towers Testing	ASCE 52 IEC 652
5.	IS: 808-1991	Dimensions for Hot Rolled Steel Beam, Column, Channel and Angle Sections.	
6.	IS: 875-1992	Code of Practice for Design	

		Loads (other than Earthquakes) for Buildings and Structures.	
7.	IS: 1363-1990	IS: 1363-1990 Hexagon Nuts (size range M5 to M36)	
8.	IS: 1367-1992	Technical Supply Conditions for Threaded Steel/ Fasteners	
9.	IS: 1477-1990	Code of practice for Painting of Ferrous Metals in Buildings: Part-I Pre-treatment Part-II Painting	
10.	IS: 1573-1991	Electro-Plated Coatings of zinc on iron and Steel	
11.	IS: 1852-1993	Rolling and Cutting Tolerances of Hot Rolled Steel Products	
12.	IS-1893-1991	Criteria for Earthquake Resistant Design of Structures	IEEE 693
13.	IS: 2016-1992	Plain Washers ISO/R887	ANSIB18-22.1
14.	IS: 2062-1992	Steel for general structural purposes	
15.	IS: 2074-1992	Ready Mixed Paint. Air Drying, Red Oxide, Zinc Chrome, Priming Specification.	
16.	IS: 2551-1990	Danger Notice Plates	
17.	IS: 2629-1990	Recommended Practice for Hot Dip Galvanizing of iron and steel.	
18.	IS: 2633-1992	Method of Testing Uniformity of Coating of Zinc Coated Articles	ASTM A123 CSA G164
19.	IS: 3043-1991	Code of Practice for Earthing	
20.	IS: 3063-1994	Single coil Rectangular section Spring Washers for Bolts, Nuts Screws	DIN-127
21.	IS: 3757-1992	High Strength Structural Bolts	
22.	IS: 4759-1990	Specification for Hot zinc coatings on structural steel and other Allied products	
23.	IS: 5369-1991	General Requirements for Plain Washers	

24.	IS: 5613-1993	Code of Practice for Design installation and Maintenance of Overhead Power Lines Section 1 Design Part 2, Section 2 Installation and Maintenance	
25.	IS: 6610-1991	Specification for Heavy Washers for Steel structures.	
26.	IS: 6623-1992	High Strength Structural Nuts	
27.	IS: 6639-1990	Hexagon Bolts for Steel Structure.	ASTM A394 CSA B334
28.	IS: 6745-1990	Method for Determination of weight of Zinc coated iron and Steel Articles.	ASTM A90
29.	IS: 8500-1992	Specification for Weldable Structural Steel (Medium & High Strength Qualities)	
30.	IS: 10238-1989	Step Bolts for Steel Structures	
31.	IS: 12427-1988	Bolts for Transmission Line Towers	

TECHNICAL SPECIFICATIONS

IV. DETAILED SURVEY, SOIL INVESTIGATION, FOUNDATION, ERECTION, STRINGING & COMMISSIONING

1.0 Detailed Survey, Optimization of Tower Location

1.1 Detailed survey along the route alignment has been carried out and profile has been plotted on the drawings by the Employer. Details of angle of deviation and section lengths along with route alignment drawings have been given in Section VI/9 of Vol. II. The Contractor shall have to do tower spotting on already prepared profile drawings, optimize tower locations and carry out the check survey for the total length of transmission line. Tower spotting, optimization of tower locations and check survey shall have to be carried out by the Contractor in line with the provision stated in Clause 1.2 of Section 1 of this Specification. The Provisional quantity for detailed survey & check survey has been indicated in Price Schedule. The final quantity for the detailed survey shall be the route length along the revised route alignment, if any, and final quantity of check survey shall be the route length along the final route alignment. The tower spotting and optimization of tower locations shall be carried out by the Contractor on the basis of approved Tower Spotting Data.

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

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

1.4 The check survey shall be made along the approved route alignment after finalizing the detailed survey.

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

1.6 Detailed Survey

Following activities shall be part of Detailed Survey work:

1.6.1 Route Marking

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

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

1.6.2 Profile Plotting & Tower Spotting

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

1.7 Spotting of Tower Location

1.7.1 Sag Template & Tower Spotting Data

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

1.7.2 Tower Spotting

With the help of approved sag template and tower spotting data, tower locations shall be marked on the profiles. While locating the towers on the profile sheet, the following shall be borne in mind:

(a) Span

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

(b) Extension

An individual span shall be as near to the normal design span as possible. In case an individual span becomes too short with normal supports on account of undulations in ground profile, one or both the supports of the span may be extended by inserting standard body and/or leg extension designed by the Contractor.

(c) Loading

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

(d) Road Crossing

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

(e) River Crossings

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

(f) Power Line Crossings

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

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

(g) Telecommunication Line Crossings

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

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

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

(h) Details En-route

All topographical details, permanent features, such as trees, building etc. 30m for 220 kV on either side of the alignment shall be detailed on the profile drawing.

1.8 Clearance from Ground, Building, Trees etc.

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

1.8.1 The tree cutting shall be the responsibility of the Employer except for that required during survey. However, the Contractor shall count, mark and put proper numbers with suitable quality of paint at his own cost on all the trees that are to be cut by the Employer at the time of actual execution of the work as detailed below. Contractor may please note that Employer shall not pay any compensation for any loss or damage to the properties or for tree cutting due to Contractor's work.

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

1.8.3 To evaluate and tabulate the trees and bushes coming within 20m on either side of the central line alignment the trees will be numbered and marked with quality paint serially from angle point AP (I) onwards (where I is tree no.) and the corresponding number will be painted on the stem of trees at a height of 1 meter from ground level. The trees list should contain the following:

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

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

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

d) The bushy and under growth encountered in the 40M belt should also be evaluated with its type, height, girth and area in square meters, clearly indicating the growth in the tree/bush statement.

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

1.9 Preliminary Tower Schedule

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

1.10 Check Survey for Tower Location

1.10.1(a) The check survey shall be conducted to locate and peg mark the tower positions on ground conforming to the approved profile and tower schedule. In the process, it is

necessary to have the pit centers marked according to the excavation marking charts. The levels, up or down of each pit center with respect to the center of the tower location shall be noted and recorded for determining the amount of earthwork required to meet the approved design parameters &/or for determining the suitable leg extensions.

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

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

1.10.4 Identification of ROW and land parcel

1.10.4.1 The Scope of work of "Check Survey" also includes the identification of the land parcel and permanent structures owned by public as well as private individuals on the Right of Way of Transmission Line (ROW is 15m on either side of Route Alignment) The Contractor shall mark the tower locations showing its boundary covering all four foundation pads and submit the details of affected Land Parcel numbers along with their areas for all tower locations to the Employer after the approval of check survey. The detail of which should include land plot number, and owners name and address as obtained from the records of Land revenue Office (Maalpot) and Survey Division (Naapi Sakha) of the concerned districts. It will be the responsibility of the Contractor to hire the Land Surveyors (Amin) and other required manpower, survey instruments & accessories, cadastal maps and collect the required information as mentioned herein above.

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

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

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

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

1.10.5 Right of Way (ROW) Clearance (Forest)

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

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

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

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

2.0 Environmental Conditions

2.1 Forest

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

2.2 General Climatic Conditions

Climatic conditions shall be as indicated at Clause 3.0 of Section 1 of this Specification.

2.3 Statutory Regulations and Standards

2.3.1 Statutory Regulations

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

2.3.2 Reference Standard

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

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

3.0 Geotechnical Investigations

3.1 General

3.1.1 Employer desires that a detailed Geotechnical investigation be carried out at various tower locations to provide the designer with sufficiently accurate information, both general and specific, about the substrata profile and relevant soil and rock parameters at site on the basis of which the foundation of transmission line towers can be classified and selected/designed rationally. The entire soil investigation work at river crossing locations (if required) shall be carried out by the Purchaser. The range of load intensities from the various structures is expected to be between 100 KN/sq. m and 500 KN/sq.m.

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

3.2 Scope

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

3.2.2 These specifications cover the technical requirements for a detailed Geotechnical investigation and preparation & submission of a detailed Geotechnical Report. The work shall include mobilization of all necessary tools and equipment, provision of necessary engineering supervision and technical personnel, skilled and unskilled

labor, etc. as required to carryout the entire field investigation as well as laboratory tests, analysis and interpretation of data collected and preparation of the Geotechnical Report. The Contractor shall also collect data regarding variation of subsoil water table along the proposed line route. The aforementioned work shall be supervised by a graduate in Civil Engineering having at least 5 years of site experience in geotechnical investigation work.

3.2.3 Contractor shall make its own arrangements to establish the co-ordinate system required to position boreholes, trial pits and other field test locations as per the drawings/sketches supplied by Employer. Contractor shall determine the reduced levels (R. L's) at these locations with respect to benchmarks used in the detailed survey. Two reference lines shall be established based on survey data/details. Contractor shall provide at site all required survey instruments to the satisfactions of the Employer so that the work can be carried out accurately according to specifications and drawings. Contractor shall arrange to collect the data regarding change of course of rivers, major natural streams and nalas (canals), 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.

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

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

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

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

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

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

3.3. General Requirements

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

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

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

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

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

3.4 Codes and Standards for Geotechnical Investigations

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

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

Indian Standards (IS)	**Title**	**International and Internationally**

		Recognize Standard/Code
IS: 1080-1990	Codes of Practice for Design and Construction of Simple Spread Foundations	
IS: 1498-1992	Classification and identification of Soils for General Engineering purposes.	ASTM D 2487/ ASTM D 2488
IS: 1888- 1982	Method of load tests on soil	
IS: 1892-1992	Code of Practice for Subsurface Investigation for Foundation	
IS: 1904-1986	Code of Practice for Design and Construction of foundation in Soils: General Requirements.	
IS: 2131-1992	Method of Standard Penetration Soils	ASTM D 1586
IS: 2132-1992	Code of Practice for Thin Walled Sampling of Soils	ASTM D 1587
IS: 2720-1992	Method of Test for Soils (Relevant Parts)	ASTM D 420
IS: 2809-1991	Glossary of Terms and symbols Relating to Soil Engineering	ASTM D 653
IS: 2810- 1979	Glossary of terms and symbols related to soil dynamics	
IS: 2911-1980	Code of Practice for Design and construction of pile Foundations (Relevant Parts).	
IS: 3025	Methods of Sampling and Testing (Physical and Chemical) for water used in industry.	
IS: 3043-1991	Code of Practice for Earthing.	
IS: 4078-1990	Code of Practice for Indexing and Storage of Drill Cores.	
IS: 4091-1987	Code of Practice for Design and Construction of Foundations for Transmission Line Towers and Poles.	
IS: 4434-1992	Code of Practice for in-situ Vane Shear Test for Soils.	ASTM D 2573/ ASTM D 4648
IS: 4453-1992	Code of Practice for Exploration by Pits, Trenches, Drifts and Shafts.	

IS: 4464-1990	Code of Practice for Presentation of Drilling Information and core description in Foundation Investigation	
IS: 4968-(Part-II)-1992	Method for Subsurface sounding for soils, dynamic method using cone and Bentonite slurry	
IS: 5313-1989	Guide for Core Drilling observations.	
IS: 6403-1990	Code Practice for Determination of Allowable Bearing Pressure on Shallow Foundation.	ASTM D 194
IS: 6926-1990	Code of Practice for Diamond Core Drilling for Site Investigation for River Valley Projects.	
IS: 6935-1989	Method of Determination of Water level in a Bore Hole.	
IS: 7422-1990	Symbols and Abbreviations for use in Geological Maps Sections and subsurface Exploratory Logs (Relevant parts).	
IS: 8009 (Part-I)-1993	Code of Practice for Calculation of Settlements of Foundations (Shallow Foundations subjected to symmetrical Vertical Loads).	
IS: 8764-1991	Method of Determination of Point Load Strength Index of Rocks.	
IS: 9143-1991	Method of Determination of Unconfined Compressive Strength of Rock Materials.	ASTM D 2938
IS: 9179-1991	Method of Preparation of Rock Specimen for Laboratory Testing.	ASTM D 4543
IS: 9259-1992	Specification for Liquid Limit Apparatus.	ASTM D 4318
IS: 9640-1992	Specification for Split Spoon Sampler.	ASTM D 1586
IS: 10050-1992	Method of Determination of Slake Durability Index of Rocks.	ASTM D 4644
IS: 11315-	Description of Discontinuities in	

(Part-II)-1991 Rock Mass-Core Recovery and Rock Quality.

CBIP Manual on transmission line towers, Chapter – 10 Foundations

3.5 Field Investigation for Soils

Tentative numbers of detailed soil investigation to be done are given in Bid Price Schedule.

3.5.1 Boring

Boreholes are required for detailed soil investigations.

3.5.1.1 General Requirements

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

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

c) Casing pipe shall be used when collapse of a borehole wall is probable. The bottom of the casing pipe shall at all times be above the test of sampling level but not more than 15 cm above the borehole bottom. In case of cohesion less soils, the advancement of the casing pipe shall be such that it does not disturb the soil to be tested or sampled. The casing shall preferably be advanced by slowly rotating the casing pipe and not by driving.

d) In-situ tests shall be conducted and undisturbed samples shall be obtained in the boreholes at intervals specified hereafter. Representative disturbed samples shall be preserved for conducting various identification tests in the laboratory. Water table in the borehole shall be carefully recorded and reported following IS: 6935. No water or drilling mud shall be used while boring above ground water table. For cohesion less soil below water table, the water level in the borehole shall at all times be maintained slightly above the water table.

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

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

3.5.1.2 Auger Boring

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

3.5.1.3 Shell and Auger Boring

3.5.1.3.1 Shell and auger boring may be used in all types of soil that are free from boulders. For cohesion less soil below ground water table, the water level in the borehole shall always be maintained at or above ground water level.

3.5.1.3.2 The use of chisel bits shall be permitted in hard strata having SPT-N value greater than 100. Chisel bits may also be used to extend the borehole through local obstructions such as old construction, boulders, rocky formations, etc. The requirements in Clause 3.5.1.2 shall apply for this type of boring also.

3.5.1.4 Rotary Boring

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

3.5.2 Standard Penetration Test (SPT)

3.5.2.1 This test shall be conducted in all types of soil deposits encountered within a borehole, to find the variation in the soil stratification by correlating with the number of blows required for unit penetration of a standard penetrometer. Structure sensitive engineering properties of cohesive soils and sifts such as strength and compressibility shall not be inferred based on SPT values. No extra payment shall be made for carrying out Standard Penetration Tests.

The test shall be conducted at depths as follows:

Location	Depths (m)
Normal Soils	2.0, 3.0, 5.0, 7.0

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

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

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

3.5.3 Sampling

3.5.3.1 General

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

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

c) All samples shall be identified with date, borehole or test pit number, date of sampling, etc. It is also essential to mark an arrow pointing towards the top surface of the undisturbed sample tube as the soil in-situ. Care shall be taken to keep the core and box samples vertically, with the arrow mark directing upwards. All undisturbed samples shall be properly trimmed at one end and suitably capped and sealed with molten paraffin wax on both sides. The Contractor shall be responsible for packing, storing in a cool place and transporting all the samples from site to the laboratory within seven days after sampling with proper protection against loss and damage.

3.5.3.2 Disturbed Samples

a) Disturbed soil samples shall be collected in boreholes at regular intervals. Jar samples weighing approximately (10 N)1 Kg shall be collected at 0.5m intervals starting from a depth of 0.5m below ground level and at every identifiable change of strata to supplement the boring records and at the levels of Standard Penetration Tests (SPT), obtained in a SPT sampler shall also be collected. Samples shall be stored immediately in airtight jars, which shall be filled to capacity as much as possible.

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

3.5.3.3 Undisturbed Samples

The undisturbed soil samples shall be collected immediately after drilling and cleaning the borehole upto the desired depth. Effort shall be made that the preparations are made before hand to collect the sample after reaching to the desired

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

Location	Depths (m)
Normal foundations	1.0, 4.0, 6.0

3.5.3.3.1 The depth interval between the top levels of undisturbed sampling and standard penetration testing shall not be less than 1.0m. Undisturbed samples shall be of 100 mm diameter and 450 mm in length. Samples shall be collected in a manner to preserve the structure, density and moisture content of the soil. Accessories required for sampling and sampling procedures shall conform to IS: 1892 and IS: 2132 and other related IS Codes. Undisturbed sampling in sand shall be done using compressed air technique mentioned in IS: 8763.

a) Undisturbed sampling in cohesive soil:

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

b) Undisturbed samples in very loose saturated sandy and silty soils and very soft clays shall be obtained by using a piston sampler consisting of a sampling cylinder and piston system. In soft clays and silty clays, with water standing in the casing pipe, piston sampler shall be used to collect undisturbed samplers in the presence of expert supervision.

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

c) Undisturbed sampling in cohesion less soil

Undisturbed samples in cohesion less soils shall be obtained as per the procedure given in IS: 8763. Compressed air Sampler shall be used to take sample of cohesion less soils below water table.

d) The sampler should be cleaned (not rusted), oiled and connected with straight drill rods coupled tightly. The air-released valve should be checked every time before lowering the sampler. At the time of lowering the sampler it should be ensured that bore hole is cleaned, casing is not below the depth of sampling and water level in the bore hole is above the water table preferably up to ground surface if sampling is done below water table.

e) The collected sample should be sealed on both ends of the sampler with wax. They should be given identification numbers and kept in the airtight wooden boxes. They should be transported in truck with a care that the structure of soil samples would not

change due to vibration during transportation. They should be kept in a testing laboratory and should be tested within seven days or before**.**

3.5.4 Ground Water Table

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

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

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

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

3.5.4.3 Subsoil water samples

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

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

3.5.5 Dynamic Cone Penetration Test (For marshy locations, with bentonite slurry)

Dynamic cone penetration test shall be conducted with bentonite slurry to predict stratification, density, bearing capacity of granular soils, etc. The test shall be conducted by driving a standard size cone attached to the bottom of a string of straight and tightly coupled drill rods to the specified depth or refusal, whichever comes first. Refusal shall be considered when the blow count exceeds 100 ~~150~~ for 300mm penetration. The Equipment, accessories required for performing the test, test procedures, field observations and reporting of results shall conform to IS: 4968, Part-II. The driving system shall comprise of a 650 N weight having a free fall of 750mm. The cone shall be 60^0 and of 65mm diameter provided with vents for continuous flow of bentonite slurry through the cone and rods in order to avoid friction between the rods and soil. On completion of the test the results shall be presented as a continuous record of the number of blows required for every 300mm

penetration of the cone into the soil in a suitable chart supplemented by a graphical plot of blow count for 300mm penetration vs. depth. On completion of the test, the results shall be presented on the format approved by the Purchaser.

3.5.6 Dynamic cone penetration test without slurry

The test shall be conducted for prediction of different soil strata, their relative strength or density or both. The 50mm diameter 60^0 cone shall be fitted loosely to the driving rod through a cone adopter. The cone shall be driven in to the soil by allowing the 650 N weight hammer to fall freely through a height of 750mm each time. The number of blows for every 75mm penetration shall be recorded. The process shall be repeated till the cone is driven to the required depth. The penetration depth shall be limited to 5m in cohesion less soil and 10m in mixed soil with some binding material. The cone driving rods, driving head, hoisting equipment shall conform to IS: 10589. The test and report should be prepared as per guidelines of IS: 4968 (Part I).

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

Field vane shear test shall be performed inside the borehole to determine the shear strength of cohesive soils, especially of soft and sensitive clays, which are highly susceptible to sampling disturbance. This test shall be conducted by advancing a four-winged vane of suitable size (75mm or 100mm diameter as per the soil condition) into the soil at the desired depth and measuring the torque required to rotate the vane. The equipments and accessories required for conducting test, test procedures and field observations shall correspond to IS: 4432. Tests may also be conducted by direct penetration from ground surface. If the cuttings at the test depth in the borehole show any presence of gravel, sand, shells, decomposed wood, etc., which are likely to influence the test results substantially, the test at that particular depth may be omitted with the permission of the Purchaser. However, the test shall be conducted at a depth where these obstructions cease to occur. On completion of the test, the results shall be reported in an approved Performa as specified in IS: 4434, Appendix-A.

3.6 Field Investigation for Rock

3.6.1 Rock Drilling

3.6.1.1 If, during the investigations, large hard fragments or natural rock beds like but not limited to igneous, sedimentary and metamorphic formations are encountered, work shall proceed with core drilling methods. The equipment and procedures for this operation shall conform to IS: 1892. The starting depth of drilling in rock shall be certified by the Purchaser. At the end of the investigation, the hole drilled in rock shall be backfilled with grout consisting of 1 part cement and 3 parts sand by weight.

3.6.1.2 Drilling shall be carried out with NX size tungsten carbide (TC) or diamond tipped drill bits, depending on the type of rock and according to IS: 6929. Suitable type of drill bit (TC/Diamond) and core catchers shall be used to ensure continuous and good core recovery. Core barrels and core catchers shall be used for breaking off the core and retaining it when the rods are withdrawn. Double and triple tube core barrels shall be used to ensure better core recovery and to retrieve cores from layers of bedrock. Water shall be circulated continuously in the hollow rods and the sludge conveying the rock cuttings to the surface shall be collected. A very high core recovery ratio shall be aimed in order to obtain a satisfactory undisturbed sample. Attempt shall be made to recover cores of 1.5m in length. Normally TC bit shall be used. Change over to a diamond bit shall require the specific written approval of the Purchaser, and his decision as to whether a TC or a diamond bit is to be used shall be final and binding on Contractor.

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

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

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

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

c) Special conditions like the depth at which grouting was done during drilling, presence of artesian conditions, loss of drilling fluid,

d) Observations of gas discharge with return water, etc., shall also be observed and recorded.

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

3.6.2 Core Sampling

3.6.2.1 Core samples shall be extracted by the application of a continuous pressure at one end of the core with the barrel held horizontally without vibration. Friable cores shall be extracted from the barrel directly into a suitably sized half round plastic channel section. Care shall be taken to maintain the direction of extrusion of sample same as while coring, to avoid stress reversal.

3.6.2.2 Immediately after withdrawal from the core barrel; the cores shall be placed in a tray and transferred to core boxes specially prepared for this purpose. The boxes shall be made from seasoned timber or any other durable material and shall be indexed on top of the lid according to IS: 4078. The cores shall be numbered serially and arranged in the boxes in a sequential order. The description of the core samples shall be recorded as instructed in IS: 4464. Where no core is recovered, it shall be recorded as

specified in the standard. Continuous records of core recovery and rock quality designation (RQD) are to be mentioned in the bore log in accordance with IS: 11315 (Part-II). Colour photograph of cores shall be taken. The core shall be put in sealed polythene bags. The core boxes should be transported carefully so that core should not be broken. They should be stored in dry place and should be sent for testing immediately.

3.7 Laboratory Testing

3.7.1 Essential Requirements

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

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

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

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

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

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

3.7.2 Tests

Tests as indicated in this specification and as may be requested by the Purchaser, shall be conducted. These tests shall include but may not be limited to the following:

a) Tests of undisturbed and disturbed samples

- Visual and engineering classification;
- Sieve analysis and hydrometric analysis;
- Liquid, plastic and shrinkage limits;
- Specific gravity;
- Chemical analysis
- Swell pressure and free swell index determination
- Proctor compaction test.

b) Tests of undisturbed samples:

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

c) Tests on rock samples

- Visual classification;
- Moisture content, porosity and density;
- Specific gravity;
- Hardness
- Stake durability;
- Unconfined compression test (both saturated and at in-situ water content;
- Point load strength index;
- Deformability test (both saturated and dry samples).

d) Chemical analysis of sub soil water.

3.7.3 Salient Test Requirement

a) Triaxial shear tests shall be conducted on undisturbed or remoulded soil samples, saturated by the application of back pressure. Only if the water table is at sufficient depth so that chances of its rising to the base of the footing are small or nil, the triaxial tests shall be performed on specimens at natural moisture content. Each test shall be carried out on a set of three test specimens from one sample at cell pressures equal to 100, 200 and 300 KN/sq.m respectively or as required depending on the soil conditions. Great care shall be taken to select the rate of shearing depending upon the soil type and drainage condition. The filter paper and the porous stone shall be cleaned and de-aired properly by boiling in water (for a minimum of 10 minutes after reaching the boiling temperature) before commencement of each test.

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

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

d) Chemical analysis of subsoil shall include determination of PH value, carbonate, sulphate (both SO3 and SO4), chloride and nitrate contents, organic matter, salinity and any other chemicals, which may be harmful to the foundation material. The contents in the soil shall be indicated as percentage (%);

e) Chemical analysis of subsoil water samples shall include the determination of properties such as colour, odour, turbidity, PH value and specific conductivity both at 25^0C, and chemical contents such as chlorides, nitrates, carbonates, sulphates (both SO_3 and SO_4), organic matter and any other chemical harmful

to the foundation material. The contents shall be indicated as parts per million (PPM) by weight.

3.8 Geotechnical Investigation Report

3.8.1 General

a) On completion of all the field and laboratory work, the Contractor shall submit a formal report containing geological information of the region, procedures adopted for geotechnical investigation, field observations and test results, laboratory observations and test results, summarized test data, conclusions and recommendations. The report shall also include detailed bore logs, subsoil sections, field test results, laboratory observations and test results both in tabular as well graphical form, practical and theoretical considerations for the interpretation of test results, supporting calculations for the conclusions drawn, etc.

b) Initially, Contractor shall submit three copies of the draft report for Purchaser's review. After receiving Purchaser's comments, if any, Contractor shall incorporate the same in the report and resubmit the revised report for approval. Ten copies of the detailed final approval report shall be submitted to Purchaser together with one set of reproducible of the graphs, tables etc.

c) The detailed final report based on field observations, in-situ and laboratory tests shall encompass theoretical as well as practical considerations for foundations for different types of structures as discussed in Clause 2.3 of Section-IV of this specification.

3.8.2 Data to be furnished

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

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

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

c) Geological information of the area including geomorphic, geological structure, litho logy, stratigraphy and tectonics, core recovery and rock quality designation (RQD), quantitative description of discontinuities in rock mass along the line route etc.;

d) Observations and data regarding change of course of rivers, velocity, flood details (including past history) etc. in the vicinity of the locations

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

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

g) Results of all laboratory test summarized according to Table 4.1 (i) for each sample as well as (ii) for each layer, along with all the relevant charts, tables, graphs, figures, supporting calculations, conclusions and photographs of representative rock cores.

h) For all triaxial shear tests, stress vs. strain diagrams as well as Mohr's circle envelopes shall be furnished. If backpressure is applied for saturation, the magnitude of the same shall be indicated. The value of modulus of elasticity (E) shall be furnished for all tests along with relevant calculations. If it is not possible to get proper c- values of Mohr circles, the same may be obtained from p-q plots.

i) For all consolidation tests, the following curves shall be furnished

   i) e vs. log p;

   ii) e vs. p;

   iii) Compression vs log t or Compression vs t (depending upon the shape of the plot, for proper determination of coefficient of consolidation). The point showing the initial condition (e0, p0) of the soil shall be marked on the curves;

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

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

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

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

n) For Rock, drilling procedure adopted, drilling parameters, core recovery, RQD, core logs, joint parameters, core boxes with proper numbering, core box photographs and water levels etc. should be furnished in the report.

TABLE 4.1

SUMMARY OF RESFULTS OF LABORATORY TESTS ON SOIL AND WATER SAMPLES

1. Bore hole/ test pit. no
2. Depth (m)
3. Type of sample
4. Density (kg/m3)

a) Bulk

b) Dry.

c) Submerged

5. Water content (%)

6. Particle Size (%)

a) Gravel

b) Sand

c) Silt

d) Clay

7. Consistency properties

a) LL

b) PL

c) Pl

d) L1

8. Soil

a) Classification-IS

b) Description

c) Specific gravity

9. Strength Test

a) Type

b) c (Cohesion)

c) (angle of internal fraction)

10. Consolidation Test

a) e0

b) Pc

c) Cc

d) DP

e) Mv

f) Cv

11. Shrinkage limit (%)

12. Swell Test

a) S.Pr

b) FS

13. Relative Density (%)

14. Remarks

Notations:

I. For type of Sample:

DB - Disturbed bulk soil sample.

DP - Disturbed samples from cutting edge of undisturbed soil sample.

Rm - Remoulded soil sample

UB - Undisturbed block soil sample

US - Undisturbed soil sample by sampler

W - Water sample

II. For Strength Test:

SCPT - Static Cone Penetration Test

UCC - Unconfined Compression Test

VST - Vane Shear Test

Tuu - Unconsolidated Undrained Traixial Test

Note: Replace T by D for Direct Shear Test

Tod - Consolidation Drained Triaxial Test

III. For Others:

LL - Liquid Limit (%)

PL - Plastic Limit

Pl - Plasticity Index

LI - Liquidity Index

C - Cohesion (kPa)

O - Angle of Internal Fraction (degrees)

S - Pr. - Swelling Pressure (kPa)

e0 - Initial Void Ratio

Pc - Reconsolidation Pressure (kPa)

Cc - Compression Index

DP - Change in pressure (kPa)

mv - Coefficient of Volume Compressibility (m2/KN)

Cv - Coefficient of Consolidation (m2/hr)

IV. For Chemical Test

As per Specifications - Clause 3.8.4

Rock samples

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

3.8.3 Recommendations

3.8.3.1 Recommendations shall be provided for each tower location duly considering soil type and tower spotting data. The recommendations shall provide all design parameters and considerations required for proper selection, dimensioning and future performance of tower foundations, as discussed in this part but not limited to Clause 2.3 of Section IV of this specification and the following

a) The subsurface material must provide safe bearing capacity and uplift resistance by incorporating appropriate safety factors specified in Clause 2.3 of Section IV of this specification all the while experiencing small deformations throughout, thereby avoiding rupture under ultimate loads;

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

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

Cone resistance, fractional total resistance, relation between core resistance, Standard Penetration Test No value, and settlement analysis for different sizes of foundation based on static cone penetration test.

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

i) Net Safe allowable bearing pressure for isolated square footing of sizes 2.0, 3.0, and 4.0 m at three different founding depths of 1,2 and 3m below ground level considering both shear failure and settlement criteria giving reasons for type of shear failure adopted in the calculation.

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

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

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

e) The stable slopes for shallow and deep excavations, active and passive earth pressure at rest and angle of repose for sandy soils shall be furnished. the loading of the foundations shall not compromise the stability of the surrounding subsurface materials and the stability of the foundation shall be ensured against sliding or overturning:-

f) Depending on the subsurface material, water table level and tower type, either reinforced concrete isolated pad and chimney or any other type of foundations shall be installed at a given location

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

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

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

ii) Suitable founding strata for the pile.

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

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

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

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

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

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

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

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

3.8.4 Hydro-geological Conditions

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

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

b) pH value

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

d) content of magnesia salts. mg/l, recalculated in terms of ions Mg2+

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

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

g) contents of chlorides,mg/l, recalculated in terms of ions Cl-

h) contents of sulphates, mg/l, recalculated in terms of ions SO4

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

3.9 Rates and Measurements

3.9.1 Rate

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

4.0 Foundations

4.1 Reinforced cement concrete footing shall be used for all types of towers in conformity with the present day practices followed in the country and the specification laid herein. Footings for all the four legs (without unequal chimney extension) of the tower and their extension shall be similar, irrespective of down thrust and uplift.

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

4.2 Classifications of Foundations

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

4.2.1 Dry Foundation

To be used for locations where normal dry cohesive or non cohesive soils are met and sub- soil water is met at 3.5 meters or more below the ground level

4.2.2 Wet Foundation

To be used for locations

a) Where sub- soil water is met at 1.5 meters or more below the ground level
b) Which are in surface water for long periods with water penetration not exceeding one meter below the ground level e.g. the paddy fields

4.2.3 Fully Submerged Foundation

To be used at locations where sub-soil water is met at less than 1.5 meters below the ground level.

4.2.4 Dry Fissured Rock Foundation

To be used at locations where decomposed or fissured rock, hard gravel, kankar, limestone, laterite or any other soil of similar nature is met and sub- soil water is met at 3.5 meters or more below the ground level. Under cut type foundations is to be used for this Foundation.

4.2.5 Wet Fissured Rock Foundation

To be used at locations where decomposed or fissured rock, hard gravel, kankar, limestone, laterite or any other soil of similar nature is met and sub- soil water is met at 1.5 meters or more below the ground level. Under cut type foundations is to be used for this Foundation.

4.2.6 Hard Rock Foundation

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

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

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

(a) Shallow Depth or Raised Chimney foundations are necessarily required to suit the site condition or

(b) Soil properties as per the soil report at particular location are found inferior than that considered in design. However, in case, soil properties as per soil report are found superior than that considered in design, no change in foundation design / price shall be applicable.

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

4.3 Type of Foundations

The Bidder shall offer open type of foundation (i.e. slab and chimney) with maximum depth of foundation as 3.5 meter for above classification of foundations depending on economy and feasibility of construction at site.

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

4.4 Soil Investigation

The contractor shall undertake soil investigatiion as per Clause 3.5 of this section at tower locations as approved by the Employer. The provisional number of soil testing locations is furnished in Schedule of Prices. Unit rates for the same are to be furnished by the bidder in appropriate Schedules of Price, for adjustment purpose with actual quantities required for soil testing.

4.5 Loads on Foundations

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

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.

4.5.1 Overload Factor for Foundation Loads

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

4.6 Stability Analysis

4.6.1 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.

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

A) RESISTANCE AGAINST UPLIFT

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

the earth frustum will be assumed truncated by a vertical plane passing through the centre line of the tower base.

B) RESISTANCE AGAINST DOWN THRUST

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

C) RESISTANCE AGAINST SIDE-THRUST

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

The chimney shaft shall be reinforced for the combined action of axial force, tension and compression and the associated maximum bending moment. In these calculations, the tensile strength of concrete shall be ignored. Similarly, since stub angle is embeded in the centre of the chimney, its effectiveness in the reinforcement calculation is to be ignored.

The increase in vertical toe pressure due to maximum bending moment at the bottom of the slab shall be taken into account and the base itself shall be designed for structural adequacy. In this case, the allowable vertical toe pressure may be increased by 25%. The unit weight of reinforced concrete is stipulated in Table 4.2.

4.7 Properties of Concrete

The cement concrete used for the foundations shall be of grade M-20 corresponding to 1:1.5:3 nominal mix ratio with 20 mm coarse aggregate for chimney portion and 40 mm coarse aggregate for pyramid or slab portion. All the properties of concrete regarding its strength under compression tension, shear, punching and bend etc. as well as workmanship will conform to IS: 456:2002.

4.7.1 The weight of concrete to be considered for design of foundations is given in TABLE 4.2.

TABLE 4.2

WEIGHT OF CONCRETE

TYPE OF CONCRETE	WEIGHT OF DRY REGION KN / M3(Kg/m3)	WEIGHT IN PRESENCE OF SUB-SOIL WATER KN / M3(Kg/m3)
Plain Concrete	21.96 (2240)	12.16 (1240)
Reinforced Concrete	23.54 (2400)	13.73 (1400)

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

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

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

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

4.7.4 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.

4.7.5 Reinforcement shall conform to IS: 432-1966 for M.S bars and hard drawn steel wires and to IS: 1138-1966 and IS: 1786-1966 for deformed and cold twisted bars respectively. All reinforcement shall be clean and free from loose mill scales, dust, loose rust, and coats of paint, oil or other coatings, which may destroy or reduce bond. Contractor shall supply, fabricate and place reinforcement to shapes and dimensions as indicated or as required to carry out intent of drawings and specifications.

5.0 Design of Foundations

5.1 Structural design of the foundations shall be done by Limit State Method.

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

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

5.4 The physical properties of soil under various conditions are furnished in TABLE 4.3 to be considered for the design of foundations. These types of foundations correspond to list of foundations furnished in Price Schedule.

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

However, it may be noted that the soil properties furnished in TABLE 4.3 are tentative in nature. After soil investigations, if it is found that the foundations listed in Price Schedule cannot be used at that location, new foundation design shall be developed by the Contractor based on properties furnished in soil report. The payment for these foundations shall be made based on unit rate quoted for excavation, concreting and reinforcement.

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

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

5.7 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 and the main corner legs of the tower.

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

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

5.10 In case of reinforced concrete slab, the slab thickness should not be less than 300 mm.

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

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

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

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

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

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

TABLE 4.3

PROPERTIES OF EARTH

PROPERTIES OF SOIL	ULTIMATE BEARING CAPACITY KN/M2 (Kg/M2)	ANGLE OF REPOSE DEGREE
1. For Normal Soil		
(a) Normal Dry Soil	268 (27350)	25
(b) Wet Soil Due to Presence of Subsoil/Surface Water	134 (13675)	15
2. Weight of Earth for Normal soil	UNIT	VALUE

	(a) Dry	KN/M3 (Kg/M3)	14.12 (1440)
	(b) In presence of Surface Water	KN/M3 (Kg/M3)	14.12 (1440)
	(c) In presence of Subsoil Water	KN/M3 (Kg/M3)	9.22 (940)
3.	Fissured Rock		
	(a) Ultimate Bearing Capacity (both for Dry & Wet Fissured Rock)	KN/M2 (Kg/M2)	498 (50800)
	(b) WEIGHT OF FISSURED ROCK		
	i) Dry	KN/M3 (Kg/M3)	14.12 (1440)
	ii) In presence of Subsoil Water	KN/M3 (Kg/M3)	9.22 (940)
	(c) ANGLE OF REPOSE		
	i) Fissured Rock in Dry Portion	Degrees	20
	ii) Fissured Rock in Presence of Water	Degrees	10
4.	Hard Rock		
	a) Ultimate Bearing Capacity	KN/M2 (Kg/M2)	1225.83 (125000)
	b) Ultmate Bond between steel	KN/M2 (Kg/M2)	0.147 (15)

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

6.0 Measurement ,Unit Rates and Payment for Foundation

6.1 Measurement

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

6.1.2 The Bidder has to provide in the Bid the guaranteed foundation quantities (i.e. Excavation volume, Concrete volumes and Weight of Reinforcements) and unit rates for excavation, concreting and reinforcement for each type of foundation (as classified in Clause 4.2 of this section) for each type of tower**. C**omposite price quoted (as described in clause 5.4 of this section) in respective Schedule for each type of foundation must comply with unit rate quoted and guaranteed foundation quantities mentioned.

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

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

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

6.2 Unit Rate

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

6.2.2 Form boxes shall be used for casting of foundations. The unit rate of concreting shall include the cost of supply, fabrication and placement of form boxes, cement, water, coarse and fine aggregates mixing and placing of concrete, curing of concrete and any other activities related to completion of concreting works of foundation.

6.2.2.1 The unit rate of 'Reinforcement Steel' shall include supply and placement of reinforcement steel, stirrups, wire for binding the reinforcement, chairs, bolsters and spacers etc. as required to complete the foundation work.

6.3 Payment For Foundation

6.3.1 Normal Foundations

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

6.3.2 Special Foundations

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

6.3.2.1 Excavation

The measurement for this item shall be made on the basis of design excavation volume arrived at considering dimension of pit leaving 150 mm gap around (except for under cut foundations) the base pad or actually excavated whichever is less and the unit rate of this item as indicated in Contract. The payment for excavation shall be made as per actual type of soil encountered at the time of excavation, but the total payment for excavation portion shall not exceed the amount as payable for excavation considering the soil type same as that of foundation classification. The decision of the Employer shall be final and binding with respect to classification of soil and foundations. In case unit rates for the same soil type under different tower types are different then the lowest rate among them shall be used for the payment purpose.

6.3.2.2 Concrete

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

6.3.2.3 Reinforcement

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

6.4 Construction of Tower Foundation

6.4.1 Testing of Soil

6.4.1.1 The Contractor shall be required to undertake testing of soil for the tower locations in the manner specified under Clause 3.0 of this section 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.

6.4.2 Excavation

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

6.4.2.2 Except as specifically otherwise provided, all excavation for footings shall be made to the lines and grades of the foundations. The excavation wall shall be vertical and the pit dimensions shall be based on an assumed clearance of 150mm on all sides of the foundation pad. For footings with undercut, care shall be taken to carry out

excavation as per drawings without any side clearance. All excavation shall be protected so as to maintain a clean sub grade and provide worker safety until the footing is placed, using timbering, shoring, shuttering, dewatering etc. as approved by the Employer. Contractor shall especially avoid disturbing the bearing surface of the pad. Any sand, mud, silt or other undesirable materials which may accumulate in the excavated pit or borehole shall be removed by Contractor before placing concrete.

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

a) Dry Soil

Soil removable either manually, means of a spade and shovel or mechanically by proclains, excavator etc. Excavation done in dry soil for wet and fully submerged type of foundations shall also be covered under this.

b) Wet Soil

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

c) Dry Fissured Rock

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

d) Wet Fissured Rock

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

e) Hard Rock

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

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

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

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

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

6.4.3 Setting of Stubs

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

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

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

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

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

6.4.4 Stub Setting Templates / Props

6.4.4.1 Stub setting templates shall be designed and arranged by the Contractor at his own cost for all types of towers with or without body extension. Stub templates for standard towers and towers with body extension upto 9 M shall be of adjustable type. The Contractor shall also arrange for props for setting of stubs at specific locations where use of prop is approved by the Employer. Stub templates / props should be painted.

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

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

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

Templates for tower type		Nos. to be deployed
i)	DA	3
ii)	For each type of DB, DC and DD type	6 for DB and 3 Each for others

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

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

6.4.5 Mixing, Placing and Compacting of Concrete

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

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

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

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

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

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

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

6.4.6 Curing

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

6.4.7 Backfilling and Removal of Stub Templates

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

6.4.7.2 The backfilling materials shall be clean and free from organic or other foreign materials. A clay type soil with a grain size distribution of 50% or more passing the number 200 sieve as well as a black cotton soil is unacceptable for backfilling. The earth shall be deposited in maximum 200mm layers, leveled, wetted if necessary and compacted properly before another layer is deposited. The moisture content for compaction shall be based on the Proctor compaction test results given in the Geo-technical Report, Clause 3.0 of Section 3. The density of the compacted backfill material may further be verified to the satisfaction of the Employer based on the sand-cone method described in the ASTM D1556-82 standard.

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

6.4.8 Benching

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

6.4.9 Protection of Tower and Tower Footing

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

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

6.4.9.3 In protection of tower footings works the backfilling shall generally be done using soil excavated at site unless deemed unsuitable for backfilling. In the latter case, backfilling shall be done with borrowed earth of suitable quality irrespective of leads and lift. The unit rate for backfilling quoted in Price Schedules shall include the required lead and consolidation and leveling of earth after backfilling.

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

6.4.9.5 The unit rates for random rubble masonry revetment quoted in price schedule shall also include excavation & (1:5) random masonry and unit rate for top sealing with M-15 concrete. For payment purposes the volume of random rubble masonry revetment shall be measured from bottom to top sealing coat and paid at the quoted rates indicated in price schedule.

No extra rates shall be paid for allied work such as excavation, for revetment, packed stone at head of weep holes etc. However, no deduction shall be made for the volume enclosed by weep holes. The locations where both benching and protection of tower footing are envisaged, an economy got to be established against providing unequal leg extension.

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

7.0 Tower Erection, Stringing and Installation of Line Materials

7.1 General

7.1.1 The scope of erection work shall include the cost of all labor, tools and plant such as tension stringing equipment and all other incidental expenses in connection with erection and stringing work. The bidders shall indicate in the offer the sets of stringing equipment he would deploy exclusively for this transmission line package.

The stringing equipment shall be of sufficient capacity to string simultaneously a bundle of TWIN BISON Conductors.

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

7.1.3 Contractor shall set up required number of stores along the line and the exact location of such stores shall be discussed and agreed upon with the Employer. Purchaser supplied items shall be dispatched to nearest store set up by the Contractor. At the store receipt, unloading and further transportation to the site shall be the entire responsibility of the Contractor.

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

7.2 Treatment of Minor Damage in Galvanization

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

7.3 Assembly of Tower

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

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

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

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

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

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

e) Tower shall be fitted with number plates, danger plates, phase plates, Circuit Plates and anti-climbing device as described.

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

7.4 Tightening of Bolts and Nuts

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

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

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

7.5 Insulator Hoisting

Suspension insulator strings shall be used on Suspension towers (DA) and double tension insulator strings on angle and dead end towers. These shall be fixed on all the towers just prior to the stringing. Damaged insulators and strings, if any, shall not be employed in the assemblies. Prior to hoisting, all insulators shall be cleaned in a manner that will not spoil, injure or scratch the surface of the insulator, but in no case shall any oil be used for that purpose. For checking the soundness of insulators, IR measurement using 5 kV (DC) Megger shall be carried out on 100% insulators. Corona control rings/arcing horn shall be fitted in an approved manner. The yoke arrangements be horizontal for tension string and vertical (parallel to transverse face of tower) for suspension strings. Torque wrench shall be used for fixing various line materials and components, such as suspension clamp for conductor and earth wire, etc., whenever recommended by the manufacturer of the same.

7.6 Handling of Conductor and Earth wire/ OPGW

7.6.1 Running Out of the Conductors

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

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

7.6.1.3 The sequence of running out shall be from the top to downwards i.e. the earth wire shall be run out first followed in succession by the conductors. Unbalanced loads on towers shall be avoided as far as possible.

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

7.6.1.5 Though towers shall be designed for one side stringing condition, towers shall be well guyed and all necessary steps shall be taken by the Contractor to avoid damage tower / conductor during stringing operations. Guying proposal along with necessary calculations shall be submitted by the Contractor to Employer for approval. All expenditure related to this work is deemed to be included in the Price quoted for stringing and no extra payment shall be made for the same.

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

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

7.6.2 Running Blocks

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

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

7.6.3 Repairs to Conductors

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

7.6.3.2 Repairs to conductor if necessary, shall be carried out with repair sleeve.

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

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

7.6.4 Crossings

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

7.7 Stringing of Conductor and Earth wire/ OPGW

7.7.1 The stringing of the conductor for 220 kV line shall be done by the control tension method. The equipment shall be capable of maintaining a continuous tension per bundle such that the sag for each conductor is about twenty percent greater than the sags specified in the stringing sag table.

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

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

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

7.8 Jointing

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

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

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

7.8.4 All the joints of splices shall be made at least 30 meters away from the tower structures. No joints or splices shall be made in spans crossing over main roads and small rivers with tension spans. Not more than one joint per sub conductor per span shall be allowed. The compression type fittings shall be of the self centering type or care shall be taken to mark the conductors to indicate when the fitting is centered properly. During compression or splicing operation, the conductor shall be handled in such a manner as to prevent lateral or vertical bearing against the dies. After compressing the joint the aluminium sleeve shall have all corners rounded, burrs and sharp edges removed and smoothened.

7.8.5 During stringing of conductor to avoid any damage to the joint, the Contractor shall use a suitable protector for mid span compression joints in case they are to be passed over pulley blocks / aerial rollers. The pulley groove size shall be such that the joint along with protection can be passed over it smoothly.

7.9 Tensioning and Sagging Operations

7.9.1 Tensioning and Sagging operations shall be done in accordance with the approved stringing charts or sag tables before conductors and earth wire are finally attached to the towers through insulator strings and earth wire clamps respectively. The "initial" stringing chart shall be used for the conductor and final stringing chart for the earth wire. The conductors shall be pulled up to the desired sag and left in running blocks for at least one hour after which the sag shall be rechecked and adjusted, if necessary, before transferring the conductors from the running blocks to the suspension clamps. The conductor shall be clamped within 96 hours of sagging in.

7.9.2 Dynamometers shall be employed for measuring tension in the conductor and earthwire. Dynamometers employed shall be periodically checked and calibrated with the standard Dynamometer.

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

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

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

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

7.10 Clipping In

7.10.1 Clipping of the conductors into position shall be done in accordance with the manufacturer's recommendations. Conductor shall be fitted with armor rods where it is made to pass through suspension clamps.

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

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

7.11 Fixing of Conductors and Earth wire/ OPGW Accessories

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

7.12 Replacement

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

7.13 Permitted Extra Consumption of Line materials

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

Quantify of Conductor = Final Line Length as per Detailed/Check survey x 3 phases x Nos. of conductor per bundle (for Single Circuit Strung Double Circuit Line)

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

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

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

7.13.4 The Contractor shall not be required to return to the Employer empty conductor and earth wire drums and shall dispose off the same at its cost.

7.13.5 Any conductor and earth wire drum shall be opened by the Contractor, if required.

7.13.6 For calculation of conductor & earth wire/OPGW consumption in hilly stretches inclined distance between towers may be considered, instead of horizontal distance between them.

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

7.14 Final checking, Testing and Commissioning

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

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

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

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

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

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

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

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

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

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

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

k) All towers are properly grounded.

l) The line is tested satisfactorily for commissioning purpose.

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

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

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

5.14.2 The contractor should also fulfill the requirements of pre-commissioning procedure as given in Appendix – I to this Specification.

8.0 Field Quality Plan

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

APPENDIX-I

PRE-COMMISSIONING PROCEDURES FOR TRANSMISSION LINES

Introduction

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

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

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

1. Definition
2. Overall Procedures
3. Safety procedures
4. Inspection
5. Statutory Requirements
6. Handing over
7. Protective system
8. Dispatch procedures
9. Switching procedures

10. Testing
11. Energization
12. De-energization
13. Observations and duration
14. Passing criteria
15. Documentation

1.0 Definition

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

"Power System" means a system under the control of the Government or any other statutory body of Generating Company or other agency and having one or more-

i) generating station; or

ii) main transmission lines and sub-stations; or

iii) generating stations and main transmission lines and substations;

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

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

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

2.0 Overall Procedure

First it is to be ascertained that the transmission line to be energized is ready for operation and has been properly handed over (released) in writing. This will include all safety aspects, Electrical inspector clearance, 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 Head Office/Corporate Engineering are clearly understood by the Line in charge and doubts, if any, are to be got clarified prior to the energisation of the line.

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

When the whole system has been energized, including the AC line, it will be kept in this state for 8 hours or more for "soaking" with continuous inspection and monitoring.

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. It should be ensured that due publicity has been made to the public in all the villages/areas along the line route cautioning them against climbing the towers etc. and that the line is proposed to be charged on so and so date. It is also to be confirmed that the AGENCIES involved in the construction activities shall not carry out any job on the said line without a valid WORK PERMIT.

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

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

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

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

4.0 Inspection

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

Such an inspection shall include:

i) Right of way/way leave/electrical clearance

ii) Foundation and Revetments/Protection Work

iii) Tower and Tower accessories

iv)Hardware Fittings

v) Insulators

vi)Conductors and Earthwire

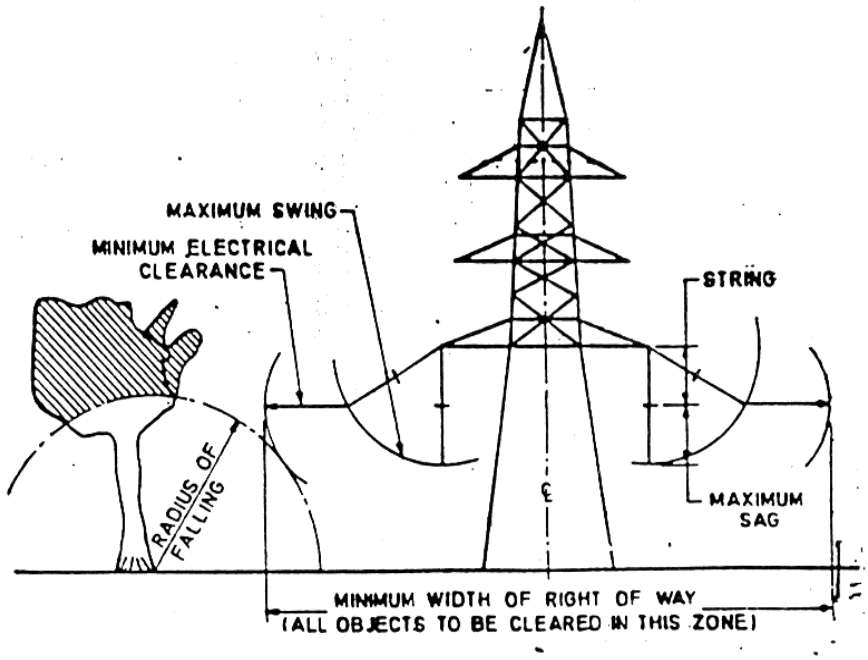
vii) Accessories for conductor and Earthwire

viii) Aviation Warning Signals (Lights/globules/painting)

4.1 Right of Way/Way Leave/Electrical Clearance

4.1.1 Right of way/Way leave clearance

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



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 corridor below each line Conductor/Earthwires. In the balance corridor, Trees branches are only to be lopped to attain the specified clearance as per Table no 1.

TABLE NO. 1

CLEARANCE FOR RIGHT OF WAY

TRANSMISSION VOLTAGE IN KV	MINIMUM RIGHT OF WAY (IN MTRS)
220	**30**

4.1.2. Electrical Clearance

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

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

Sl. No.	Nominal System Voltage	132 kV	220 kV
1.	132 kV	3050	4580
2.	220 kV	4580	4580

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

4.1.2.1. Ground clearance

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

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

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

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

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

4.1.2.2. Clearance for Telephone line crossings

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

VOLTAGE	CLEARANCE
(kV)	(MM)
132	2745
220	3050

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

4.2. Foundation and Revetments / Protection Work

FOUNDATION:

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

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

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

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

REVETMENTS / PROTECTION:

Cracks/damages to revetments shall be repaired.

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

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

4.3 Tower and Tower Accessories

4.3.1. Normal Tower

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

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

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

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

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

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

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

4.3.2 Special Towers

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

Earthing of Towers

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

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

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

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

4.3.3. Tower accessories

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

All plates shall be properly tightened.

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

It shall be ensured that the anti-climbing device (ACD) is provided, at the suit-able height of tower. In case of barbed wire ACD, barbed wire shall be tightly fixed.

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 (wherever applicable) shall be ensured.

4.4. Hardware Fittings

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

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

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

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

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

4.5 Insulators

All the damaged/broken insulator discs shall be replaced.

Unusual deflection in suspension strings if observed shall be rectified.

The insulators shall be cleaned before charging.

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

4.6. Conductors and Earthwires

Surface Condition

Surface of the conductors shall be free from scratches/rubs

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

4.7. Accessories for Conductor and Earthwires

4.7.1. Joints

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

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

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

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

4.7.2. Clipping

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

4.7.3 Spacers, vibration dampers and copper bonds

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

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

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

To be ensured that no copper bond is loose/missing.

4.7.4 Jumpers

Verify Electrical clearance of jumpers to tower body as per design.

All the jumpers shall be checked properly. In case, jumpers (conductor/earthwire) are found loose, it shall be tightened adequately.

4.7.5 Foreign material

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

4.7.6. Others

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

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

4.8 Aviation Warning / Obstruction Signals (Lights / Globules / Painting)

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

Day markers

Painting of Full/Top portion of Towers with Red/Orange and White Paints.

Globules on earthwires have been provided.

Night markers

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

5.0 Statutory Requirement

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

6.0 Handing Over

The transmission line shall be inspected prior to energization and a formal handing over document to be jointly signed by the representative of Contractor and NEA. 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. 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-coinmissioning 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.

7.0 Protective System

Before energization it must be ascertained that all protective systems for the unit to be energized are operative.

This includes confirmation that the protections have been properly tested and that the tests have been documented.

It also includes verification by inspection or otherwise, if necessary by repetition of trip test, that the protections are actually functionally enabled. This verification serves to prevent that energization takes place of a unit where a protection has been disabled for test or other reason.

8.0 Dispatch Procedures

All operational activities (switching etc.) must be coordinated and communicated with the system dispatcher.

In this respect the general procedures already established by NEA will be followed.

9.0 Switching Procedures

For each activity the instructions to the operators and the communications to the dispatchers will be made in writing or by confirmed telephone messages. The switching procedures first to be properly documented step by step and understood by everybody involved in the switching operation prior to the 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.

10.0 Testing and Measurement Procedures

10.1. Earth Resistance Measurement

Normally Earth tester is used for measuring

a) soil resistivity.

b) earth resistance

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

A typical Earth tester has 4 terminals. C1, P1, C2, P2 and 4 similar electrodes are driven in the ground at equal distances and connected to the instruments in the order of C1' P1 and P2, C2. Then the handle is rotated or button is pressed and the reading of the resistance is read on the megger scale. If R is the resistance measured then the

Specific resistivity = 2 aR

where a is the distance between the electrode and R is the resistance in ohms measured on the megger.

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

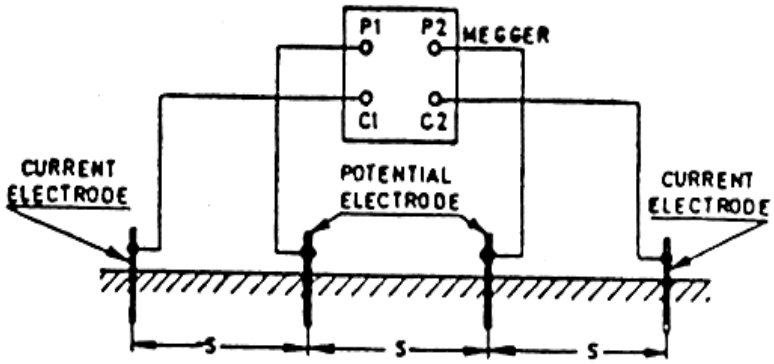


fig : 2 Test connection for a four terminal Megger

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

10.2.1 Insulation Resistance Test

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

This Test is to be carried out First prior to the continuity test.

Measurement of Insulation Resistance

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

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

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

Another use of the guard circuit is to shield the “line” lead between the Megger and the apparatus under test. This prevents leakage to ground from the “line” lead which would invalidate the Megger reading.

Insulation resistance is the ratio $V_{DC}/I_{DC}.V_{DC}$ 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.

10.2.2 Conductor Continuity Test

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

A simple method of continuity test is illustrated below :

Once the insulation test is completed and the results confirms no short circuit carry the following:

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.

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

SENDING END	RECEIVING END MEGGER BETWEEN	RESULTS (OHMS)
CONNECT R&Y PHASE B-PHASE & ALL GS OPEN	R PHASE & Y PH	ZERO OR LOW
	Y PHASE & B PH	HIGH
	B PHASE & R PH	HIGH
CONNECT R & B PHASE Y PHASE & ALL GS OPEN	R PHASE & Y PH	HIGH

	Y PHASE & B PH	HIGH
	B PHASE & R PH	ZERO OR LOW
CONNECT Y & B PHASE R-PHASE & ALL GS OPEN	R PHASE & Y PH	HIGH
	Y PHASE & B PH	ZERO OR LOW
	B PHASE & R PH	HIGH

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

10.2.2.2 Phase Sequence

Once the line is charged from one end, without closing the Breaker at the other end the Phase sequence is to be checked from the CVT/PT 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/PT 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
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 in to be rechecked and reconfirmed before closing the breaker.

11.0 Energization

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

12.0 De-Energization

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

13.0 Observation and Duration

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

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

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

14.0 Passing Criteria

Neither insulation breakdown nor protective system actions must occur. No irregular equipment behaviour noise, vibration, high temperature is permitted.

Corona discharges may not be “unreasonable”. Local discharges that may be attributable to sharp points shall be carefully located and recorded. 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.

15.0 Documentation

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

APPENDIX-II

FIELD QUALITY PLAN FOR TRANSMISSION LINES

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 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	To be notified by the Owner(NEA)

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. Tests on samples	As per tech. Specs.	As per Owner Specification	Lab appd. By Owner	100% by testing lab	Review of lab test results	To be notified by the Owner(NEA)
2.	Construction of 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.	-do-
			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	-do-
			3. Chemical Tests Chemical composition of Cement	-do-	Contractor to submit MTC	100%% review of MTC by Contractor	100% review of MTC	-do-
		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.	-do-
			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	-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. 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	To be notified by the Owner(NEA)
			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	- do-
		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.	- do-
			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	- do-
		5. Water	1. Cleaniness (Water shall be fresh and clean)	Owner Specification	Contractor	100% visual check at Field	Verification at random	- 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		
			2. Suitability of water for concreting	Owner Specification	Contractor	100% Visual Check at Field	Verification at random	- do-
		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	- do-
		C. Concrete Works a. Before concreting						
		1. Bottom of excavated earth	Depth of foundation	Appd. Drgs.	Contractor	100% at Field	100% check by Owner	- do-
		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						

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. Workability	Slump test	Range 25 mm to 55 mm	Contractor	100% at field	20% check at random	- do-

				refer document at Annexure-5 of this FQP at Pg. 18				
		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	- do-
		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.	. - do-
3.	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	- do-
		2. Erection of Super-structure	1. Sequence of erection	As per Appd. Drgs./Owner specification	Contractor	100% at field	100% check	- 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		
			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	- do-
		3. Tower footing resistance (TFR)	TFR at locations before and after earthing.	Owner Specification	Contractor	100% at Field	20% locations to be verified	- do-
4.	Stringing	1. Materials						- do-
		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%	- do-
			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-

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. 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. at Manufactu-rer's works
			4. Traceability (Make/batch	Packing list/CIP	Contractor	100% at field	100% Review of records	To be notified by the Owner(NEA)

			No./Locations where installed)					
		b. Conductor	On receipt, 1. Visual check of drum.	Packing list	Contractor	100% at stores	20% check	To be notified by the Owner(NEA)
			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						
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. Before Stringing	Readiness for stringing	Stringing procedures as per Owner specification	Contractor	Readiness certificate to be submitted by the Contractor	Review of Certificate	-do-
		b. During stringing	(Conductor/Earth-wrie)					-do-
			1. Scratch/cut check (Visual)	Appd. Drawings/ Owner Specn.	Contractor	100% at Field	100% record & Field check 20%	-do-
			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%	-do-
		c. After stringing	Check for,					
			1. Sag/Tension	Sag tension chart/tower Spotting data	-do-	-do-	100% record & Field check 20%	-do-
			2. Electrical clearances	As per appd. Drgs./Owner specifications	-do-	-do-	-do-	-do-
			i) Ground clearance	-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**		
			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%	-do-
			5. Placement of spacer/damper	As per Specn./drgs/ placement chart	-do-	-do-	-do-	-do-
5.	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	-do-
	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 b. Pre-commissioning Report	-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. Electrical Inspectors clearance		-do-	-do-	-do-	-do-

Annex-1

ACCEPTANCE CRITERIA AND PERMISSIBLE LIMITS FOR CEMENT

ORDINARY PORTLAND CEMENT					
S. No.	**Name of the test**	**Ordinary Portland Cement 33 grade as per IS 269**	**Ordinary Portland Cement 43 grade as per IS 8112**	**Ordinary Portland Cement 53 grade as per IS 12269**	**Remarks**
a)	**Physical tests**				To be conducted in apprd. Lab
(i)	Fineness	Specific surface area shall not be less than 225 sq.m. per Kg. or 2250 Cm2/gm.	Specific surface area shall not be less than 225 sq.m. per Kg or 2250 Cm2/gm.	Specific surface area shall not be less than 225 sq.m. per Kg or 2250 Cm2/gm.	Blaine's air permeability method as per IS 4031 (Part-2)
(ii)	Compressive strength	72+/- 1 hour : Not less than 16 Mpa (16 N/mm2) 168+/-2 hour : Not less than 22 Mpa (22 N/mm2) 672+/-4 hour : Not less than 33 Mpa (33 N/mm2)	72+/- 1 hour : Not less than 23 Mpa (23 N/mm2) 168+/-2 hour : Not less than 33 Mpa (33 N/mm2) 672+/-4 hour : Not less than 43 Mpa (43 N/mm2)	72+/- 1 hour : Not less than 27 Mpa (27 n/mm2) 168+/-1 hour : Not less than 37 Mpa (37 N/mm2) 672+/-1 hour : Not less than 53 Mpa (53 N/mm2)	As per IS 4031 (Part-6)
(iii)	Initial & Final setting time	Initial setting time : Not less than 30 minutes Final setting time : Not more than 600 minutes	Initial setting time : Not less than 30 minutes Final setting time : Not more than 600 minutes	Initial setting time : Not less than 30 minutes Final setting time : Not more than 600 minutes	As per IS 4031 (Part-5) -do-
(iv)	Soundness	Unaerated cement shall not have an expansion of more than 10mm when tested by Le chatlier and 0.8% Autoclave test.	Unaerated cement shall not have an expansion of more than 10mm when tested by Le chatlier and 0.8% Autoclave test	Unaerated cement shall not have an expansion of more than 10mm when tested by Le chatlier and 0.8% Autoclave test.	Le chatlier and Autoclave test as per IS 4031 (Part-3)

S. No.	Name of the test	Ordinary Portland Cement 33 grade as per IS 269	Ordinary Portland Cement 43 grade as per IS 8112	Ordinary Portland Cement 53 grade as per IS 12269	Remarks
b)	**Chemical composition tests**				Review of MTCC only
		a) Ratio of percentage of lime to percentage of silica, alumina & iron oxide 0.66 to 1.02	a) Ratio of percentage of lime to percentage of silica, alumina % iron oxide **0.66 to 1.02**	a) Ratio of percentage of lime to percentage of silica, alumina % iron oxide **0.66 to 1.02%**	
		b) Ratio of percentage of alumina to that of iron oxide **Minimum 0.66%**	a) Ratio of percentage of alumina to that of iron oxide **Minimum 0.66**	a) Ratio of percentage of alumina to that of iron oxide **Minimum 0.66%**	
		c) Insoluble residue, percentage by mass **Max. 4.00%**	c) Insoluble residue, percentage by mass **Max. 4.00%**	c) Insoluble residue, percentage by mass **Max. 4.00%**	
		d) Magnesia percentage by mass Max. 6%	d) Magnesia percentage by mass Max. 6%	d) Magnesia percentage by mass Max. 6%	
		e) Total sulphur content calculated as sulphuric anhydride (SO3), percentage by mass **Not more than 2.5 and 3.0 when tri-calcium aluminate percent by mass is 5 or less and greater than 5 respectively.**	e) Total sulphur content calculated as sulpuric anhydride (SO3), percentage by mass **Not more than 2.5 and 3.0 when tri-calcium aluminate percent by mass is 5 or less and greater than 5 respectively.**	e) Total sulphur content calculated as sulpuric anhydride (SO3), percentage by mass **Not more than 2.5 and 3.0 when tri-calcium aluminate percent by mass is 5 or less and greater than 5 respectively.**	
c)	**Total loss on Ignition**	Not more than 5 percent	Not more than 5 percent	Not more than 5 percent	

S. No.	Name of the test			Remarks
2.	**POZZOLANA PORTLAND CEMENT AS PER IS 1489**			
a)	**Physical tests**	i) Fineness	Specific surface area shall not be less than 300 sq.m. per Kg. or 3000 Cm2/gm	
		ii) Compressive strength	168+/- 2 hour : Not less than 22 Mpa (22 N/mm2) 672+/- 2 hour : Not less than 33 Mpa (33 N/mm2)	
		iii) Initial & Final setting time	Initial setting time : Not less than 30 minutes Final setting time : Not more than 600 minutes	
		iv) Soundness	Unaerated cement shall not have an expansion of more than 10mm	Le chatlier and Autoclave test as per IS 4031 (Part-3)
b)	**Chemical composition tests**			
		a) Magnesia percentage by mass Max. 6%		Review of MTCC only
		b) Insoluble material, percentage by mass x + 2 (100-x)/100 where x is the declared % of pozzolana in the PPC		-do-
		c) Total sulphur content calculated as sulpuric anhydride (SO3), percentage by mass **Not more than 2.75 and 3.0 when tri-calcium aluminate percent by mass is 7 or less and greater than 7 respectively.**		-do-
c)	**Total loss on Ignition**	Not more than 5 percent		

Annex-2

ACCEPTANCE CRITERIA AND PERMISSIBLE LIMITS FOR REINFORCEMENT STEEL

S. No.	Name of the test	Mild and medium tensile steel as per IS 432	Cold twisted Deformed bars Fe 415 as per IS 1786	Remarks
i)	Chemical analysis test	Carbon (For 20 mm dia and below) 0.23% Max. Carbon (For over 20 mm dia) 0.25%	Carbon 0.30% Max	
		Sulpher 0.055%	Sulpher 0.060%	
		Phosphorus 0.055%	Phosphorus 0.060%	
			Sulpher & Phosphorus 0.11%	
ii)	Physical tests	a) Ultimate Tensile stress For all dia bars 410 N/Sq.mm. (min.)	a) Ultimate Tensile stress 10% more than actual 0.2% proof stress but not less than 485 N/Sq.mm.)	Testing in approved lab
		b) Yield stress (N/Sq.mm) min. For bars upto 20 mm dia 250 For bars above 20 mm dia 240 c) Percentage of elongation 23%	b) 0.2% of proof stress/Yield stress (N/Sq.mm) min. For bars upto 20 mm dia 415 c) Percentage of elongation 14.5% (min.)	Testing in approved lab
iii)	Bend & Rebend tests	Pass	Pass	Testing in approved lab

Annex-3

ACCEPTANCE CRITERIA AND PERMISSIBLE LIMITS FOR COARSE AGGREGATES AS PER IS 383

3.	**Coarse Aggregates**										
i)	Physical Tests										
	a) Determination of particles size	a. IS Sieve Designation	**%age passing for Single-Sized Aggregate of nominal size**					**Percentage Passing for grades Aggregate of nominal size**			
			40 mm	**20 mm**	**16 mm**	**12.5 mm**	**10 mm**	**40 mm**	**20 mm**	**16 mm**	**12.5 mm**
		63 mm	100	-	-	-	-	-	-	-	-
		40 mm	85 to 100	100	-	-	-	95 to 100	100	-	-
		20 mm	0 to 20	85 to 100	100	-	-	30 to 70	95 to 100	100	100
		16 mm	-	-	85 to 100	100	-	-	-	90-100	-
		12.5 mm	-	-	-	85 to 100	100	-	-	-	90 to 100
		10 mm	0 to 5	0 to 20	0 to 30	0 to 45	85 to 100	10 to 35	25 to 35	30 to 70	40 to 85
		4.75 mm	-	0 to 5	0 to 5	0 to 10	0 to 20	0 to 5	0 to 10	0 to 10	0 to 10
		2.36 mm	-	-	-	-	0 to 5	-	-	-	-
	b. Flakiness index		Not to exceed 25%								
	c. Crushing Value		Not to exceed 45%								
	d. Presence of deletrious material		Total presence of deleterious materials not to exceed 5%								
	e. Soundness test (for concrete work subject to frost action)		12% when tested with sodium sulphate and 18% when tested with magnesium sulphate								

Annex-4

ACCEPTANCE CRITERIA AND PERMISSIBLE LIMITS FOR FINE AGGREGATES AS PER IS 383

4.	**Fine aggregates**				
i)	Physical Tests	**IS Sieve Designation**	**Percentage passing for graded aggregate of nominal size**		
	a) Determination of particle size		**F.A. Zone I**	**F.A. Zone II**	**F.A. Zone III**
		10 mm	100	100	100
		4.75 mm	90-100	90-100	90-100
		2.36 mm	60-95	75-100	85-100
		1.18 mm	30-70	55-90	75-100
		600 microns 12.5 mm	15-34	35-59	60-79
		300 microns	5 to 20	8 to 30	12 to 40
		150 microns	0-10	0-10	01-0
	b) Silt content		Not to exceed 8%	Not to exceed 8%	Not to exceed 8%
	c) Presence of deleterious material	Total presence of deleterious materials shall not exceed 5%			
	d) Soundness Applicable to concrete work subject to frost action	12% when tested with sodium sulphate and 15% when tested with magnesium sulphate			

Annex-5

ACCEPTANCE CRITERIA AND PERMISSIBLE LIMITS FOR CONCRETE WORK

1)	**Concrete**	a) Workability	Slump shall be recorded by slump cone method and it shall between 25-55 mm.
		b) Compressive strength	Three samples of 15 cm cube for 28 days compressive strength for all concrete works except pile foundation work shall be taken. For pile foundation works, six cubes, three for 7 days testing and balance three for 28 days testing shall be taken.

Notes :

1) For nominal (volumetric) concrete mixes, compressive strength for 1:1.5:3 (Sand: Fine aggreagate: Coarse aggregates) concrete shall be 265 kg/Sq.cm. for 28 days and for 1:2:4 nominal mix, it shall be 210 kg/Sq.cm.

2) ACCEPTANCE CRITERIA BASED ON 28 DAYS COMPRESSIVE STRENGTHS FOR NOMINAL MIX CONCRETE :

a) the average of the strength of three specimen be accepted as the compressive strength of the concrete, provided the strength of any individual cube shall neither be less than 70% nor higher than 130% of the specified strength.

b) If the actual average strength of accepted sample exceeds specified strength by more than 30%, Project Manager, if he so desires, may further investigate the matter. However, if the strength of any individual cube exceeds more than 30% of the specified strength, it will be restructed to 30% only for computation of strength.

c) If the actual average strength of accepted sample is equal to or higher than specified upto 30%, the strength of the concrete shall be considered in order and the concrete shall be accepted at full rates.

d) If the actual average strength of accepted sample is less than specified strength but not less than 70% of the specified strength, the concrete may be accepted at reduced rate at the discretion of Project Manager.

e) If the actual average strength of accepted sample is less than 70% of specified strength, the Engineer-in-charge shall reject the defective portion of work represent by sample and nothing shall be paid for the rejected work. Remedial measures necessary to retain the structure shall be taken

at the risk and cost of contractor. If, however, the Engineer-in-charge so desires, he may order additional tests to be carried out to ascertain if the structure can be retained. All the charges in connection with these additional tests shall be borne by the Contractor.

General Notes :

1) This Field Quality Plan is not to limit the supervisory checks which are otherwise required to be carried out during execution of work as per drawings/Technical specifications etc.

2) Contractor shall be responsible for implementing/documenting the FQP. Documents shall be handed over by the contractor to Owner after the completion of the work.

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

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

TECHNICAL SPECIFICATIONS

V. CONDTUCTOR

1G Technical Description of ACSR 'BISON' /AACSR 'BISON' Conductor

1.1(A) Details of ACSR Conductor

1.1.1(A) The ACSR Conductor shall generally conform to BS:215(Part-2) /IS : 398 (Part-II) except where otherwise specified herein.

1.1.2(A) The details of the ACSR BISON Conductor are tabulated below :

a)	Designation as per BS-215(Part-2)	
b)	Stranding and wire diameter	54/3.00 mm Aluminium +7/3.00 mm steel
c)	Number of Strands	
	Steel core	1
	1st steel layer	6
	1st Aluminium layer	12
	2nd Aluminium layer	18
	3rd Aluminium layer	24
d)	Sectional area of Aluminium	381.80 sq. mm
e)	Total sectional area	431.30 sq. mm
f)	Overall diameter	27.00 mm
g)	Approximate mass	1444 (Kg/ KM)
h)	Calculated D.C. resistance at 20 deg. Centigrade	0.07573 Ohm/KM
i)	Minimum UTS	120.90 kN
j)	Direction of lay of outer layer	Right hand

1.1.3(A) The details of Aluminium strand are as follows :

1.1.3

a)	Minimum breaking load of strand before stranding	1.17 kN
b)	Minimum breaking load of strand after stranding	1.11 kN
c)	Maximum D.C. resistance of strand at 20 deg. Centigrade	0.004079 Ohm/meter

1.1.4(A) The details of steel strand are as follows :

a)	Minimum breaking load of strand before stranding	9.29 kN
b)	Minimum breaking load of strand after stranding (KN)	8.83 kN
c)	Minimum number of twists to be withstood in torsion test when tested on a gauge length of 100 times diameter of wire	18 (Before stranding) 16 (After stranding)

1.1(B) **Details of AACSR Conductor**

For crossings involving longer spans, Aluminium Alloy Conductor Steel Reinforced shall be used in this project. The Aluminium Alloy of Silicon-Magnesium **(**6201**)** shall be used.

1.1.1(B) The AACSR Conductor shall generally conform to IS: 398 –Part 4 except where otherwise specified herein.

1.1.2(B) The details of the AACSR BISON Conductor are tabulated below :

a)	Designation as per -	
b)	Stranding and wire diameter	54/3.00 mm Aluminium Alloy +7/3.00 mm steel
c)	Number of Strands	
	Steel core	1
	1st steel layer	6
	1st Aluminium Alloy layer	12
	2nd Aluminium Alloy layer	18
	3rd Aluminium Alloy layer	24
d)	Sectional area of Aluminium Alloy	381.80 sq. mm
e)	Total sectional area	431.30 sq. mm
f)	Overall diameter	27.00 mm
g)	Approximate mass	1444 (Kg/ KM)
h)	Calculated D.C. resistance at 20 deg. Centigrade (Min)	0.07603 Ohm/KM
i)	Minimum UTS	160.20 kN
j)	Direction of lay of outer layer	Right hand

1.1.3(B) The details of Aluminium strand are as follows :

1.1.3

a)	Minimum breaking load of strand before stranding	1.60 kN
b)	Minimum breaking load of strand after stranding	1.55 kN
c)	Maximum D.C. resistance of strand at 20 deg. Centigrade	0.004179 Ohm/meter

1.1.4(B) The details of steel strand are as follows :

a)	Minimum breaking load of strand before stranding	9.29 kN
b)	Minimum breaking load of strand after stranding (KN)	8.83 kN
c)	Minimum number of twists to be withstood in torsion test when tested on a gauge length of 100 times diameter of wire	18 (Before stranding) 16 (After stranding)

The details of ACSR Bear are tabulate below.

Item	Description	Unit	Data
1.	ACSR "BEAR"		
1.1	Conductor size	mm^2	326.10
1.2	Conductor type	ACSR	Bear
1.3	Number and size of wires		
1.3.1	Aluminum	No dia. mm	30 3.35
1.3.2	Steel	No. dia. mm	7 3.35
1.4	Cross section		
1.4.1	Aluminum	mm^2	264.4
1.4.2	Steel	mm^2	61.7
1.4.3	Total	mm^2	326.10
1.5	Conductor diameter	mm	23.45
1.6	Ultimate strength	g	11,340

1.7	Modulus of elasticity final	kg/ mm^2	8,200
1.8	Coefficient of linear expansion	per^{O} C	17.8x10-6
1.9	Standard mass of conductor	kg/km	1,214
1.10	Electrical D.C. resistance at 25^0 C	ohm/km	0.1093
1.11	Standard of jointed length on reel	m	2,000
1.12	Standards		BS 215 PART 2 or equivalent national or international standard

1.2 Workmanship

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

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

1.2.3 The steel strands shall be hot dip galvanized and shall have a minimum zinc coating of 260 gms/sq.m after stranding. The zinc coating shall be smooth, continuous, of uniform thickness, free from imperfections and shall withstand minimum three dips in standard Preece test. The steel wire rods shall be of such quality and purity that, when drawn to the size of the strands specified and coated with zinc, the finished strands and the individual wires shall be of uniform quality and have the same properties and characteristics as prescribed in IEC: 888.

1.2.4 The steel strands shall be preformed and post formed in order to prevent spreading of strands in the event of cutting of composite core wire. Care shall be taken to avoid, damages to galvanization during pre-forming and post-forming operation.

1.3 Joints in Wires

1.3.1 Aluminium /Aluminium Alloy Wires

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

1.3.1.2 No joints shall be permitted in the individual wires in the outer most layer of the finished conductor. However joints are permitted in the 12 wire and 18 wire inner layer of the conductor unavoidably broken during stranding, provided such breaks are not associated with either inherently defective wire or with the use of short

lengths of aluminium/aluminium alloy wires. Such joints shall not be more than four (4) per conductor length and shall not be closer than 15 meters from joint in the same wire or in any other aluminium/aluminium alloy wire of the completed conductor.

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

1.3.2 Steel Wires

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

1.4 **Tolerances**

The manufacturing tolerances to the extent of the following limits only shall be permitted in the diameter of individual aluminium and steel strands and lay-ratio of the conductor :

a) Diameter of Aluminium and Steel Strands

	Standard	Maximum	Minimum
Aluminium/Aluminium Alloy	3.00 mm	3.03 mm	2.97 mm
Steel	3.00 mm	3.06 mm	2.94 mm

b) Lay ratio of Conductor

		Maximum	Minimum
Steel	6 wire layer	28	13
Aluminium/Aluminium Alloy	12 wire layer	17	10
	18 wire layer	16	10
	24 wire layer	14	10

1.5 Materials

1.5.1 Aluminium and Aluminium Alloy

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

Aluminium Alloy Strands shall be drawn from Silicon-Magnesium Alloy rods(6201) with appropriate tampering followed by solution treatment.

1.5.2 Steel

The steel wire strands shall be drawn from high carbon steel wire rods produced by either the acid or the basic open-hearth process, the electric furnace process, or the basic oxygen process and shall conform to the following requirements as to the chemical composition:

Element	% Composition
Carbon	0.50 to 0.85
Manganese	0.50 to 1.10
Phosphorous	Not more than 0.035
Sulphur	Not more than 0.045
Silicon	0.10 to 0.35

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

1.5.3 Zinc

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

1.6 Standard Length

1.6.1 The standard length of the conductor shall be 1800 meters. A tolerance of +/-5% on the standard length offered by the Bidder shall be permitted. All lengths outside this limit of tolerance shall be treated as random lengths. Not less than 90% total quantity of the conductor shall be supplied in standard lengths. For valley crossings specific single length conductor will be required for which length shall be intimated after tower spotting.

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

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

2.0 Tests and Standards

2.1 Type Tests

The following tests shall be conducted once on a sample/samples of conductor for every 1000 kms. of production from each manufacturing facility:

a)	DC resistance test on stranded conductor	As per Annexure-A
b)	UTS test on stranded conductor	
c)	Radio interference voltage test (dry)	
d)	Corona extinction voltage test (dry)	
e)	Test on Wooden Drum i) Barrel batten strength test	IS: 1778-1980

2.2 Acceptance Tests

a)	Visual and dimensional check on drum	As per Annexure-A
b)	Visual check for joints scratches etc. and length measurement of conductor by rewinding	
c)	Dimensional check on steel and aluminium/aluminium alloy strands	
d)	Check for lay-ratios of various layers	
e)	Galvanizing test on steel strands	
f)	Check for lay-ratios of various layers	
g)	Torsion and Elongation tests on steel strands	
h)	Breaking load test on steel and Aluminium/Aluminium alloy strands	
i)	Wrap test on steel & Aluminium/Aluminium Alloy strands	IEC: 888 & 889
j)	DC resistance test on Aluminium/Aluminium Alloy strands	IEC: 889
k)	Procedure qualification test on welded joint of Aluminium/Aluminium Alloy strands	Annexure-A
l)	Drum marking check	

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

2.3 Routine Test

a) Check to ensure that the joints are as per Specification

b) Check that there are no cuts, fins etc., on the strands.

c) Check that drums are as per Specification

d) All acceptance test as mentioned above to be carried out on each coil

2.4 Tests during Manufacture

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

2.5 Testing Expenses

2.5.1 The break-up of the testing charges for the type tests specified shall be indicated separately.

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

2.5.3 In case of failure in any type test the Supplier is either required to manufacture fresh sample lot and repeat all the tests successfully once or repeat that particular type test three times successfully on the sample selected from the already manufactured lot at his own expenses. In case a fresh lot is manufactured for testing then the lot already manufactured shall be rejected.

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

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

2.6 Additional Tests

2.6.1 The Purchaser reserves the right of having at his own expenses any other test(s) of reasonable nature carried out at Supplier’s premises, at site or in any other place in addition to the aforesaid type, acceptance and routine tests to satisfy himself that the materials comply with the Specifications.

2.6.2 The Purchaser also reserves the right to conduct all the tests mentioned in this specification at his own expense on the samples drawn from the site at Supplier’s premises or at any other test centre. In case of evidence of non compliance, it shall be binding on the part of Supplier to prove the compliance of the items to the technical specifications by repeat tests, or correction of deficiencies, or replacement of defective items all without any extra cost to the Purchaser.

2.7 Sample Batch for Type Testing

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

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

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

2.8 Test Reports

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

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

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

2.9 Inspection

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

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

2.9.3 No material shall be dispatched from its point of manufacture before it has been satisfactorily inspected and tested, unless the inspection is waived off by the Purchaser in writing. In the latter case also the conductor shall be dispatched only after satisfactory testing for all tests specified herein have been completed.

2.9.4 The acceptance of any quantity of material shall in no way relieve the Supplier of any of his responsibilities for meeting all requirements of the Specification, and shall not prevent subsequent rejection if such material is later found to be defective.

2.10 Test Facilities

2.10.1 The following additional test facilities shall be available at the Supplier's works:

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

b) Standard resistance for calibration of resistance bridges.

c) Finished conductor shall be checked for length verification and surface finish on separate rewinding machine at reduced speed (variable from 8 to 16 meters per minute). The rewinding facilities shall have appropriate clutch system and free of vibrations, jerks etc. with traverse laying facilities.

2.11 Packing

2.11.1 The conductor shall be supplied in non-returnable, strong, wooden drums provided with lagging of adequate strength, constructed to protect the conductor against all damage and displacement during transit, storage and subsequent handling and stringing operations in the field. The Supplier shall be responsible for any loss or damage during transportation handling and storage due to improper packing. The drums shall generally conform to IS: 1778, except as otherwise specified hereinafter.

2.11.2 The drums shall be suitable for wheel mounting and for letting off the conductor under a minimum controlled tension of the order of 5 KN.

2.11.3 The general outline of the drum for conductor shall be as in the annexed drawings. The Bidder should submit their proposed drum drawings along with the bid.

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

2.11.5 All wooden components shall be manufactured out of seasoned soft wood free from defects that may materially weaken the component parts of the drums. Preservative treatment shall be applied to the entire drum with preservatives of a quality which is not harmful to the conductor.

2.11.6 The flanges shall be of two ply construction with each ply at right angles to the adjacent ply and nailed together. The nails shall be driven from the inside face flange, punched and then clenched on the outer face. The thickness of each ply shall not vary by more than 3mm from that indicated in the figure. There shall be at least 3 nails per plank of ply with maximum nail spacing of 75mm. Where a slot is cut in the flange to receive the inner end of the conductor the entrance shall be in line with the periphery of the barrel.

2.11.7 The wooden battens used for making the barrel of the conductor shall be of segmental type. These shall be nailed to the barrel supports with at least two nails. The battens shall be closely butted and shall provide a round barrel with smooth external surface. The edges of the battens shall be rounded or chamfered to avoid damage to the conductor.

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

2.11.9 Normally, the nuts on the studs shall stand protruded of the flanges. All the nails used on the inner surface of the flanges and the drum barrel shall be counter sunk. The ends of barrel shall generally be flushed with the top of the nuts.

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

2.11.11 Before reeling, card board or double corrugated or thick bituminized water-proof bamboo paper shall be secured to the drum barrel and inside of flanges of the drum by means of a suitable commercial adhesive material. After reeling the conductor, the exposed surface of the outer layer of conductor shall be wrapped with water proof thick bituminized bamboo paper to preserve the conductor from dirt, grit and damage during transport and handling.

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

2.11.13 Each batten shall be securely nailed across grains as far as possible to the flange, edges with at least 2 nails per end. The length of the nails shall not be less than twice the thickness of the battens. The nails shall not protrude above the general surface and shall not have exposed sharp, edges or allow the battens to be released due to corrosion.

2.11.14 The nuts on the barrel studs shall be tack welded on the one side in order to fully secure them. On the second end, a spring washer shall be used.

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

2.11.16 Outside the protective lagging, there shall be minimum of two binder consisting of hoop iron/galvanized steel wire. Each protective lagging shall have two recesses to accommodate the binders.

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

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

2.12 Marking

Each drum shall have the following information stenciled on it in indelible ink along with other essential data:

(a) Contract/Award letter number.

(b) Name and address of consignee.

(c) Manufacturer's name and address.

(d) Drum number

(e) Size of conductor

(f) Length of conductor in meters

(g) Arrow marking for unwinding

(h) Position of the conductor ends

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

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

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

(m) Gross weight of drum after putting lagging.

(n) Tear weight of the drum without lagging.

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

(p) Material Inspection & Clearance certificate No.

The above should be indicated in the packing list also.

2.13 Verification of Conductor Length

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

2.14 Standards

2.14.1 The conductor shall conform to the following Indian/International Standards, which shall mean latest revisions, with amendments/changes adopted and published, unless specifically stated otherwise in the Specification.

2.14.2 In the event of the supply of conductor conforming to standards other than specified, the Bidder shall confirm in his bid that these standards are equivalent to those specified. In case of award, salient features of comparison between the standards proposed by the Supplier and those specified in this document will be provided by the Supplier to establish their equivalence.

Sl. No.	Indian Standard	Title	International Standard
1.	IS: 209-1992	Specification for zinc	BS: 3436-1986
2.	IS: 398-1982	Specification for Aluminium Conductors for Overhead Transmission Purposes	IEC: 1089-1991 BS: 215-1970

3.	IS: 398-1990 Part-II and IS:398-1994 Part-4	Aluminum Conductor Galvanized Steel Reinforced and All Aluminium Alloy Conductors	BS: 215-1970 IEC: 1089-1991
4.	IS: 1778-1980	Reels and Drums for Bare Conductors	BS: 1559-1949
5.	IS: 1521-1991	Method of Tensile Testing of Steel Wire	ISO 6892-1984
6.	IS: 2629-1990	Recommended Practice for Hot Dip Galvanizing of Iron and Steel	
7.	IS: 2633-1992	Method of Testing Uniformity of Coating on Zinc Coated Articles	
8.	IS: 4826-1992	Galvanized Coating on Round Steel Wires	IEC: 888-1987 BS: 443-1969
9.	IS: 6745-1990	Methods of Determination of Weight of Zinc Coating of Zinc Coated Iron and Steel Articles	BS: 433-1969 ISO 1460 - 1973
10.	IS: 8263-1990	Method of Radio Interference Tests on High Voltage Insulators	IEC: 437-1973 NEMA: 107-1964 CISPR
11.		Zinc Coated steel wires for stranded Conductors	IEC: 888-1987
12.		Hard drawn Aluminium wire for overhead line conductors	IEC: 889-1987

TECHNICAL SPECIFICATIONS

VII. OPGW AND ACCESSORIES

1. Technical Description of Optical Ground Wire, OPGW and Optical Approach Cable

1 General

2 Technical Requirements

The optical fiber ground wire (OPGW) shall have supporting cross section of 68 mm^2 and ACS cross section of 68 mm^2. Aluminum clad steel or/and aluminum alloy wires shall form the stranding part of earth wire. The ground wire of the 220 kV line shall be a steel wire with an OPGW Composite Fiber Optic communication cable in the center. The Optical Fiber Cable, containing 24 *single-mode* optical fibers shall be embedded loosely inside the protective tube. The protective tube shall be of aluminum alloy or stainless steel. Both fiber optic and stranding part of OPGW shall comply with this Specification, and with the following standards:

Single mode fibers	ITU-T (former CCITT) G. 652
Optical fiber cables	IEC 60793-1 & 2
	IEC 1089/91, IEC 60889/87
Stranding part	IEC 60104/87; BS 3242

The earth wire shall be suitable for the climatic conditions with no attenuation changes or negative effects on the cable, and compatible with the stringing condition of the phase conductor. Under no condition shall the OPGW sag exceed the conductor sag.

The optical fiber shall be made of germanium doped silica glass or pure silica glass. It shall have a primary coating made of silicone or similar material with physical and mechanical properties at least those of silicone (acrylic or similar).

The tube shall be made of suitable material sufficiently strong to hold its shape and provide protection for the optical fibers against deformation and friction. The strength member of the fiber optic cable shall provide protection against buckling, kinking and strain. The material to be used shall be fiber reinforced plastic.

The direction of lay of the outer layer of strands shall be right hand. Lay ratio of any layer shall be not greater than the lay ratio of the layer immediately beneath it.

The make up of shield wire shall be such that the strand shall remain and shall not twist when the conductor is cut. The earth wire shall be manufactured so that no twisting occurs when subjected to axial loads, i.e. when unrolling and stringing.

All wires used in the manufacture of the earth wire shall be free from protrusion, sharp edges, abrasion and any other imperfections.

No jointing of the aluminum clad steel wires shall be permitted.

There shall be no joints or splices in any optical fiber in any reel length of the complete optical cable.

The creep characteristic of the finished earth wire shall be of virtually unvarying uniformity.

3. Optical fibers

All fiber installed as a part of this Contract shall have a minimum life of 30 years from the date of final acceptance.

The OPGW shall include minimum 24 fibers. The main optical characteristics of the OPGW are shown in the Appendix (Schedule A).

The other characteristics of the OPGW shall be as follows:

Outer diameter:	11.4 mm
Cable weight:	approximately 487 Kg/km
Calculated breaking load:	86.6 kN
Modulus of elasticity:	162 kN/mm^2
Coefficient of thermal expansion:	$3.0x10^{-6}$ per degree K
Nominal short time current capacity at initial/final temperature 20/200 ^0C:	5.5 kA
DC resistance at 20 ^0C:	Not more than 1.247 ohm /km

3.1 Attenuation

The attenuation coefficient for wavelengths between 1285 nm and 1330 nm shall not exceed the attenuation coefficient at 1310 nm by more than $\pm$ 0.05 dB/km.

The attenuation coefficient for wavelengths between 1535 and 1565 shall not exceed the attenuation coefficient at 1550 mm by more than $\pm$ 0.05 dB/km. The attenuation of the fiber shall be distributed uniformly throughout its length such that there are no point discontinuities in excess of 0.1 dB.

The cable shall consist of single mode dual-window color coded optical fibers. There shall be no factory splices within the cable structure.

3.2 Optical fiber identification

Color-coding is essential for identifying individual optical fibers and groups of optical fibers. Individual optical fibers within a fiber unit, and fiber units will be identifiable using a color-coding scheme. The color-coding system shall be discernible throughout the design life of the cable.

Each cable shall be traceable of each fiber back to the original fiber manufacture's fiber number and parameters of the fiber.

If more than the specified numbers of fibers are included in any cable, the cable manufacturer shall test the spare fibers and any defective fibers shall be suitably

bundled, tagged and identified at the factory by the fiber manufacturer.

3.3 Buffer tube

Loose tube buffer construction shall be applied. A buffer for protection from physical damage shall surround the individually coated optical fiber(s) during fabrication, installation and performance of the cable. The fiber coating and buffer shall be strippable for splicing and termination. The inside diameter of the buffer tube shall be of appropriate size to allow free movement of the fibers during cable Contraction or elongation resulting from thermal, tensile or vibration loads.

Buffer tubes shall be sleeved over multiple fibers forming a fiber unit. A fiber unit may consist of up to 6 fibers, individually identifiable utilizing the color code in conformance with EIA 359 A.

3.4 Optical fiber termination and splicing

Suitable splice boxes (enclosures) shall be provided to encase the optical cable ends and fusion splices in protective, moisture and dust free environment. The splice boxes shall be designed for the storage and protections of a minimum of 12 fibers cables and provide access through locked doors.

Fiber-optic cable of adequate length shall be provided so that all splicing can be performed at ground level at the towers. All splicing and necessary material shall be included in the price schedule presented by the Contractor.

3.5 Outdoor splice boxes

Splice boxes provided by the Contractor for outdoor use shall be suitable for use with the cable type provided as part of this Contract. The splice boxes shall be appropriate for mounting on steel structures and accommodate pass-through splicing and fiber terminations.

The splice box, including organizer/ splice trays, shall be designed to seal and protect the fiber cable splices from the environment defined in this specification and it shall provide easy access for any maintenance function.

All splice boxes shall be of metal construction that are clean and smooth finished, treated to resist rust, accommodate the storage of a minimum of 3 meters of coiled fiber and allow easy access to the splice trays. In addition there shall be a steel frame to coil up about 10 meters of OPGW outside the protection box.

3.6 The testing must be done by recognized equipment and it shall be possible to produce a computerized print out from the computer and the software, all of which (lap top computer, printer and software) must be included in the testing, commissioning or installation unit prices.

3.7 Maintenance

To maintain the cable the Contractor shall propose suitable equipment and necessary training for the Employer personnel to execute the work.

3.8 Joints

Number of Joints shall be kept to a minimum. Approved equipment and methods must be used to test the cable from both ends.

3.9 Particular requirement for OPGW earth wire fittings and accessories

The associated fittings and other accessories have to satisfy the specific function of OPGW and fiber optics requirements for a total integrity of their components. The best way to achieve these goals shall be in application of suitable performed products. A brief description of the accessories is as follows:

a) Suspension Assembly: Suspension assembly shall consist of:

armor grip suspension clamp (aluminum alloy hyper formed armor rods and suspension clamp);
associated hardware for earth wire suspension:
flexible grounding loop connection.

b) Tension Assembly: The tension assembly shall consists of:

Hyper formed alum weld dead end grip;
associated hardware for earth wire attachment (shackle, link, clevis, clamps);
flexible grounding loop connection.

c) Vibration Dampers

Dampers where necessary, shall be of Stockbridge type installed complete with the armor rods of the size suitable to the earth wire size.

d) Fiber Optic Splice Closure-Joint Box

The fiber optic splice closure allows clamping of the cables to be spliced. It shall have the following characteristics:

The splice capacity for minimum 12 single-mode fibers from metal free optical cable with loose tube construction;
waterproof housing of the closure aluminum or stainless steel construction with protection class IP 65 of IEC 60529;
box and cable glands tightened by sealing compound.

Installation height shall be 1.5 m above the anti-climbing devices of the towers.

e) Fiber Optic Hood Closure-Terminal Box

The fiber optic splice closure allows termination of OPGW on the substation gantry and interface with the underground fiber optic cable leading into the control building. It shall have the following characteristics:

the cable glands for accepting of one metal free optical cables with minimum 12 single-mode fibers and loose tube construction;
waterproof housing of the closure aluminum or stainless steel

construction with protection class IP 65 of IEC 60529;
box and cable glands tightened by sealing compound.

It shall be installed on the terminal gantry 1.5 m above ground level.

3.10 Payment for OPGW and Accessories

Payment for the supply and delivery for the contract item "Steel ground Wire with Optical Fiber" will be made at the unit bid price. Therefore, in the Price Schedule, the unit bid price shall include full compensation for all the costs incurred in furnishing all materials, equipment, labors and all other operations related to OPGW conductor and accessories fabrication, delivery etc.

4.0 Tests

The following tests shall be conducted once on a sample/samples of OPGW for every 50 km of production from the manufacturing facility:

a. Structure and dimension test
b. Transmission characteristics test
c. Characteristics test of ACS
d. UTS test

5. Optical Approach Cable

5.1 Construction and Design

Optical approach cable shall be employed in connecting the optic fibers of OPGW from outdoor splice box to the Optical Distribution Frame inside the communication room of the Control Building. They shall be laid in the conduit pipe or in the cable trench.

Optical fibers shall have necessary mechanical and thermal characteristics. Optic fiber unit shall meet the ITU recommendations G652 and the material of them shall also meet the requirements of IEC 60739-1 and 2. The general features are as follows:

a. Type Single mode type
b. Wave length 1310 or 1550
c. Number of cores 24
d. Optical attenuation Max. 0.45 dB/km
e. Concentricity error Less than 1 μm

6. Indoor Splice Box/ Optical Distribution Frame

6.1 Construction and Design

The indoor splicing box/ optical distribution frame shall be of the wall mounted type and accommodates pass-through the splicing and interconnection for the equipment.

TECHNICAL SPECIFICATIONS

VI. GALVANIZED STEEL EARTH WIRE

1.0 Technical Description of Galvanized Steel Earth wire

1.1 Details of Earth wire

1.11 The galvanized steel earth wire shall generally conform to the specification of ACSR core wire as mentioned in IS: 398 (Part-II)-1976 except where otherwise specified herein.

1.1.2 The details of the earth wire for 220 kV are tabulated below:

a)	Stranding and wire diameter	:	7/3.35 mm steel
b)	Number of strands		
	Steel core	:	1
	Outer steel layer	:	6
c)	Total sectional area	:	73.65 sq mm
d)	Overall diameter	:	10.05 mm
e)	Approximate weight	:	550 kg/km
f)	Calculated D.C. resistance at 20 deg. Centigrade	:	2.5 Ohms/km
g)	Minimum ultimate tensile strength	:	68.4 kN
h)	Direction of lay of outer layer	:	Right hand

1.2 Workmanship

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

1.2.2 The finished material shall have minimum brittleness as it will be subjected to appreciable vibration while in use.

1.2.3 The steel strands shall be hot dip galvanized and shall have minimum, Zinc coating of 275 gms/sq m after stranding. The zinc coating shall be smooth, continuous, of uniform thickness, free form imperfections and shall withstand three and half dips after stranding in standard Preece test. The steel wire rod shall be of such quality and purity that, when drawn to the size of the strands specified and coated with zinc, the finished strands shall be of uniform quality and have the same properties and characteristics as prescribed in ASTM designation B498-M.

1.2.4 The steel strands shall be preformed and post formed in order to prevent spreading of strands while cutting of composite earth wire. Care shall be taken to avoid damage to galvanization during preforming and postforming operation.

1.2.5 To avoid susceptibility towards wet storage stains (white rust), the finished material shall be provided with a protective coating of boiled linseed oil.

1.3 Joints in Wires

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

1.4 Tolerances

The manufacturing tolerance to the extent of the following limits only shall be permitted in the diameter of the individual steel strands and lay length of the earth wire:

For 7/3.35 mm size Earth wire

		Standard	**Maximum**	**Minimum**
Diameter	3.35 mm	3.43 mm	3.31 mm	
Lay length		181 mm	198 mm	165 mm

1.5 Materials

1.5.1 Steel

The steel wire strands shall be drawn from high carbon steel rods and shall conform to the following requirements as to the chemical composition:

Element	% Composition
Carbon	Not more than 0.55
Manganese	0.4 to 0.9
Phosphorous	Not more than 0.04
Sulphur	Not more than 0.04
Silicon	0. 15 to 0.35

1.5.2 Zinc

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

1.6 Standard Length

1.6.1 The standard length of the earth wire shall be 2000 meters. The tolerance on length shall be ± 5% on the standard length.

1.6.2 Random length will be accepted provided no length is less than 70% of standard length and the total quantity of random lengths is not more than ten (10) percent of the total quantity in each shipment.

2.0 Tests and Standards

2.1 Type Tests

Type Tests on Earth wire

The following tests shall be conducted once on a sample of earth wire.

(a)	UTS test	Annexure - A
(b)	DC resistance test	

2.2 Acceptance Tests on Earth wire

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

2.3 Routine Tests

2.3.1 Routine Tests on Earth wire

(a) Check for correctness of stranding

(b) Check that there are no cuts, fins etc. on the strands.

(c) Check that drums are as per Specification.

2.4 Tests during Manufacture

(a)	Chemical analysis of zinc used for galvanizing	Annexure - A

(b) Chemical analysis of steel)

2.5 Testing Expenses

2.5.1 The break-up of the testing charges for the type tests specified shall be indicated separately.

2.5.2 Bidders shall indicate the laboratories in which they propose to conduct the type tests. They shall ensure that the tests can be completed in these laboratories within the time schedule guaranteed by them.

2.5.3 In case of failure in any type test the Contractor is either required to manufacture fresh sample lot and repeat all the tests successfully once or repeat that particular type test three times successfully on the sample selected from the already manufactured lot at his own expenses. In case fresh lot is manufactured for testing then the lot already manufactured shall be rejected. The decision of the Employer in this regard shall be final and binding on Contractor.

2.5.4 The entire cost of testing for the acceptance and routine tests and tests during manufacture specified herein shall be treated as included in the quoted unit price of earthwire except for the expenses of the inspector/ Employer 's representative.

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

2.6 Additional Tests

2.6.1 The Employer reserves the right of having at his own expenses any other test(s) of reasonable nature carried out at Contractor’s premises, at site, or in any other place in addition to the aforesaid type, acceptance and routine tests to satisfy himself that the materials comply with the Specifications.

2.6.2 The Employer also reserves the right to conduct all the tests mentioned in this specification at his own expense on the samples drawn from the site at Contractor’s premises or at any other test center. In case of evidence of non compliance, it shall be binding on the part of Contractor to prove the compliance of the items to the technical specifications by repeat tests, or correction of deficiencies, or replacement of defective item all without any extra cost to the Employer.

2.7 Sample Batch for Type Testing

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

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

2.7.3 The Contractor is required to carry out all the Acceptance tests successfully in presence of Employer's representative before sample selection.

2.8 Test Reports

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

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

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

2.9 Inspection

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

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

2.9.3 No material shall be despatched from its point of manufacture before it has been satisfactorily inspected and tested, unless the inspection is waived off by the Employer in writing. In the latter case also the earth wire shall be despatched only after satisfactory testing for all tests specified herein have been completed.

2.9.4 The acceptance of any quantity of material shall in no way relieve the Contractor of any of his responsibilities for meeting all requirements of the Specification, and shall not prevent subsequent rejection if such material is later found to be defective.

2.10 Test Facilities

2.10.1 The following additional test facilities shall be available at the Contractor's works:

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

b) Standard resistance for calibration of resistance bridges.

c) Finished Earth wire shall be checked for length verification and surface finish on separate rewinding machine at reduced speed (variable from 8 to 16 meters per minute). The rewinding facilities shall have appropriate clutch system and free of vibrations, jerks etc., with traverse laying facilities.

2.11 Packing for Earth wire

2.11.1 The Earth wire shall be supplied in non-returnable, strong, wooden drums and provided with lagging of adequate strength, constructed to protect the Earth wire against all damage and displacement during transit, storage and subsequent handling and stringing operations in the field. The Contractor shall be responsible for any loss or damage during transportation handling and storage due to improper packing. The drums shall generally conform to IS: 1778-1980, except as otherwise specified hereinafter.

2.11.2 The drums shall be suitable for wheel mounting and for letting off the earth wire under a minimum controlled tension of the order of 5 kN

2.11.3 The general outline of the drum for Earth wire shall be as per annexed drawing. The Contractor should submit their proposed drum drawings along with the bid.

2.11.4 For Earth wire, two standard length shall be wound on each drum.

2.11.5 For Earth wire, each strand shall be individually welded to prevent parting of two lengths at a tension less than 15 kN. The two ends where the first length finishes and the second length starts, shall be clearly marked with adhesive tape and no weld should be present outside these marks. The length between the two marks shall be treated as scrap and will not be taken into account for measurement purposes.

2.11.6 All wooden components shall be manufactured out of seasoned softwood free from defects that may materially weaken the component parts of the drums. Preservative treatment shall be applied to the entire drum with preservatives of a quality which is not harmful to the earth wire.

2.11.7 The flanges shall be of two ply construction with each ply at right angles to the adjacent ply and nailed together. The nails shall be driven from the inside face flange, punched and then clenched on the outer face. The thickness of each ply shall not vary by more than 3 mm from that indicated in the figure. There shall be at least 3 nails per plank of ply with maximum nail spacing of 75 mm. Where a slot is cut in the flange to receive the inner end of the earth wire the entrance shall be in line with the periphery of the barrel.

2.11.8 The wooden battens used for making the barrel of the earth wire shall be of segmental type. These shall be nailed to the barrel supports with at least two nails. The battens shall be closely butted and shall provide a round barrel with smooth external surface. The edges of the battens shall be rounded or chamfered to avoid damage to the earth wire.

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

2.11.10 Normally, the nuts on the studs shall stand protruded of the flanges. All the nails used on the inner surface of the flanges and the drum barrel shall be counter sunk. The ends of barrel shall generally be flushed with the top of the nuts.

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

2.11.12 Before reeling, cardboard or double corrugated or thick bituminous waterproof bamboo paper shall be secured to the drum barrel and inside of flanges of the drum by means of a suitable commercial adhesive material. After reeling the earth wire, the exposed surface of the outer layer of earth wire shall be wrapped with water proof thick bituminous bamboo paper to preserve the earth wire from dirt, grit and damage during transport and handling.

2.11.13 A minimum space of 50 mm for earth wire shall be provided between the inner surface of the external protective lagging and outer layer of the earth wire.

2.11.14 Each batten shall be securely nailed across grains as far as possible to the flange, edges with at least 2 nails per end. The length of the nails shall not be less than twice the thickness of the battens. The nails shall not protrude above the general surface and shall not have exposed sharp edges or allow the battens to be released due to corrosion.

2.11.15 The nuts on the barrel studs shall be tack welded on the one side in order to fully secure them. On the second end, a spring washer shall be used.

2.11.16 Outside the protective lagging there shall be minimum of two binder consisting of hoop iron/galvanized steel wire. Each protective lagging shall have two recesses to accommodate the binders.

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

2.12 Marking

Each drum shall have the following information stenciled on it in indelible ink along with other essential data

(a) Contract/Award letter number.

(b) Name and address of consignee.

(c) Manufacturer’s name and address.

(d) Drum number

(e) Size of earth wire

(f) Length of earth wire in meters

(g) Gross weight of drum with earth wire & lagging

(h) Weight of empty drum with lagging

(i) Arrow marking for unwinding

(j) Position of the earth wire ends

(k) Distance between outer most layer of Earth wire and the inner surface of lagging

(l) Barrel diameter at three locations and an arrow marking at the location of measurement

2.13 Verification of Earth wire Length

The Employer reserves the right to verify the length of earth wire after unreeling atlest ten (10) percent of the drums in a lot offered for inspection.

2.14 Standards

The earth wire shall conform to the following Indian/ International Standards, which shall mean latest revisions, amendments/changes adopted and published, unless otherwise in the Specification.

In the event of the supply of earth wire conforming to standards other than specified, the Contractor shall confirm in his bid that these standards are equivalent to those specified. In case of award salient features of comparison between the standards proposed by the Contractor and those specified in this documents will be provided by the Contractor to establish their equivalence.

Sl. No.	Indian Standards	Title	International Standards
1.	IS: 209-1992	Specification for Zinc	BS: 3436-1986
2.	IS: 398-1990	Specification for Aluminium Conductors for Overhead Transmission Purposes	IEC: 1089-1991 BS: 215-1970
3.	IS: 398-1998 Part-II	Aluminum Conductor Galvanised Steel Reinforced	BS-215-1970 IEC: 1089-1991
4.	IS: 398-1996 Part-IV	Aluminum Alloy stranded conductor	BS-3242-1970 IEC: 1089-1991 ASTM-8399 M86
5.	IS: 398-1992	Aluminium conductor	IEC:1089-1991
	Part-V	Galvanised Steel-Reinforced for-Extra High Voltage (400 KV) and above	BS: 215-1970
6.	IS: 1778-1997	Reels and Drums for Bare Conductors	BS: 1559-1949
7.	IS: 1521-1991	Method of Tensile Testing of Steel Wire	ISO: 6892-1984
8.	IS: 2629-1997	Recommended Practice for Hot Dip Galvanising of Iron and Steel	
9.	IS: 2633-1990	Method of Testing Uniformity of Coat-	

		ing on Zinc Coated Articles	
10.	IS: 4826-1991	Galvanized coating on Round Steel Wires	IEC 888-1987 BS: 443-1969
11.	IS: 6745-1991	Methods of Determination of Weight of Zinc Coating of Zinc Coated Iron and Steel Articles	BS: 433-1969 ISO: 1460-1973
12.	IS: 8263-1983	Method of Radio Interference Tests on High Voltage Insulators	1EC: 437-1973 NEMA: 107-1964 CISPR
13.	IS: 9997-1991	Aluminium Alloy Redraw Rods	IEC: 104-1987
14.		Zinc Coated steel wires for stranded Conductors	IEC: 888-1987
15.		Hard drawn aluminium wire for overhead line conductors	IEC: 889-1987
16.	IS: 5714	Method of measurement of resistivity of metallic materials	
17.	IS: 12776	Specification for galvanized strand for earthing	

ANNEXURE-A

1.0 Tests on Earth wire

1.1 UTS Test

Circles perpendicular to the axis of the earth wire shall be marked at two places on a sample of earth wire of minimum 5 m length suitably compressed with dead end clamps at either end. The load shall be increased at a steady rate up to 50% of UTS and held for one minute. The circles drawn shall not be distorted due to relative movement of strands. Thereafter the load shall be increased at steady rate to 100% of UTS and held for one minute. The earth wire sample shall not fail during this period. The applied load shall then be increased until the failing load is reached and the value recorded.

1.2 D.C. Resistance Test

On a earth wire sample of minimum 5m length two contact clamps shall be fixed with a predetermined bolt torque. The resistance shall be measured by a Kelvin double bridge/digital micro meter by placing the clamps initially at zero meter and subsequently one meter apart. The test shall be repeated at least five times and the average value recorded. The value obtained shall be corrected to the value at 20^{O}C. The resistance corrected at 20^{O}C shall conform to the requirements of this Specification.

1.3 Chemical Analysis of Zinc

Samples taken from the zinc ingots shall be chemically/ spectrographically analyzed. The same shall be in conformity to the requirements stated in the Specification.

1.4 Chemical Analysis of Steel

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

1.5 Visual and Dimensional Check on Drums and its barrel strength test.

The drums shall be visually and dimensionally checked to ensure that they conform to the requirements of this Specification. The details regarding barrel strength test will be discussed and mutually agreed to by Contractor and Employer in the quality assurance programme.

1.6 Visual Check for Joints, Scratches etc. and Length of Earth wire

Ten percent drums from each lot shall be rewound in the presence of the Employer. The Employer shall visually check for scratches, joints etc. and see that the earth wire generally conforms to the requirements of this Specification. The length of earth wire wound on the drum shall be measured with the help of counter meter during rewinding.

1.7 Dimensional Check

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

1.8 Lay Length Check

The lay length shall be checked to ensure that they conform to the requirements of this Specification.

1.9 Galvanizing Test

The test procedure shall be as specified in IS: 4826-1979. The material shall conform to the requirements of this Specification. The adherence of zinc shall be checked by wrapping around a mandrel four times the diameter of steel wire.

1.10 Torsion Test

The minimum number of twists which a single steel strand shall withstand during torsion test shall be eighteen for a length equal to 100 times the standard diameter of the strand. In case test sample length is less or more than 100 times the stranded diameter of the strand the minimum number of twists will be proportioned to the length and if number comes in the fraction then it will be rounded off to next higher whole number.

TECHNICAL SPECIFICATIONS

VIII. DISC INSULATORS

1.0 Technical Description of Disc Insulators

1.1 Details of Disc Insulators

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

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

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

Sl. No.	Type of string	Size of disc insulators (mm)	Minimum creepage distance of each disc (mm)	No. of disc	Electro-mechnical strength of insulator disc(kN)	Mechanical strength of insulator string along with hardware fittings (kN)
1.	Single "I" suspension	255x145 or 280x145	292	1×16	70	70
2.	Single 'I' suspension Pilot	255x145 or 280x145	292	1x16	70	70
3.	Double "I" suspension	255x145 or 280x145	292	2x16	70	140
4.	Double Tension String	280 x 145	292	2 x 17	120	2 x 120
5.	Double Tension String(with AACSR conductor)	280 x 170	292	2 x 17	160	2 x 160

1.2 Pin and Cap

1.2.1 Pin and Cap shall be designed to transmit the mechanical stresses to the shell by compression and develop uniform mechanical strength in the insulator. The cap shall be

circular with the inner and outer surfaces concentric, of such design that it will not yield or distort under load conditions.

1.2.2 The pin ball shall move freely in the cap socket but without danger of accidental uncoupling during erection or in position. The design of the disc should be such that stresses due to expansion or contraction in any part of the insulator shall not lead to deterioration.

1.3 Security clip

1.3.1 Security clip for use with ball and socket coupling shall be of R-shaped hump type which shall provide positive locking of the coupling as per IS: 2486-(Part-Ill)/IEC: 372. The legs of the security clips shall be spread after installation to prevent complete withdrawal from the socket. The locking device should be resilient, corrosion resistant and of suitable mechanical strength. There shall be no risk of the locking device being displaced accidentally or being rotated when in position. Under no circumstances shall locking device allow separation of insulator units or fittings.

1.3.2 The hole for the security clip shall be countersunk and the clip shall be of such design that the eye of clip may be engaged by a hot line clip puller to provide for disengagement under energized conditions. The force required to pull the security clip into its unlocked position shall not be less than 50N (5 kg) or more than 500N (50 kg).

1.4 Ball and Socket Designation

The dimensions of the balls and sockets shall be of 16 mm designation for 70 kN & 20 mm designation for 120 & 160 kN disc insulator in accordance with the standard dimensions stated in IS: 2486 - (Part - II)/IEC:120.

1.5 Dimensional Tolerance of Insulator Disc (Standard)

It shall be ensured that the dimensions of the disc insulators are within the limits specified below:

a) Diameter of Disc (mm)

	Standard	Maximum	Minimum
120 kN Disc	255/280	266/293	244/267
160 kN Disc	280	293	267

b) Ball to ball spacing between discs

	Standard	Maximum	Minimum
120 kN Disc	145	149	141
160 kN Disc	170	175	165

1.6 Interchangeability

The disc insulators inclusive of the ball and socket fittings shall be of standard design suitable for use with the hardware fittings of any make conforming to relevant Indian/International Standards.

1.7 Corona and RI Performance

All surfaces must be clean, smooth, without cuts, abrasions or projections. No part shall be subjected to excessive localized pressure. The metal parts shall be so designed and manufactured that it shall not generate any Radio Interference beyond specified limit and not produce any noise generating corona under the operating conditions.

1.8 Maintenance

1.8.1 The disc insulators offered shall be suitable for employment of hot line maintenance techniques so that the usual hot line operations can be carried out with ease, speed and safety.

1.8.2 Bidders shall indicate the methods generally used in the routine hot and dead line maintenance of EHV Lines for which similar disc insulators have been supplied by them. Bidders shall also indicate the recommended periodicity of such maintenance.

1.9 Materials

1.9.1 Porcelain

The porcelain used in the manufacture of shells shall be sound, free from defects thoroughly vitrified and smoothly glazed. The porcelain used shall be non-porous of high dielectric, mechanical and thermal strength, free from internal stress blisters, laminations, voids, foreign matter, imperfections or other defects which might make it any way unsuitable for insulator shells. Porcelain shall remain unaffected by climatic conditions, ozone, acid, alkalies, zinc or dust.

1.9.2 Glaze

The finished porcelain shall be glazed in brown colour. The glaze shall cover all exposed parts of the insulator and shall have a good lusture, smooth surface and good performance under the extreme weather conditions of a tropical climate. It shall not crack or chip by ageing under the normal service conditions. The glaze shall have the same coefficient of expansion as of the porcelain body throughout the working temperature range.

1.9.3 Toughened Glass

The glass used for the shells shall be sound, free from defects such as flaws, bubbles, inclusions etc. and be of uniform toughness over its entire surface. All exposed glass surfaces shall be smooth.

1.9.4 Cement

Cement used in the manufacture of the insulator shall not cause fracture by expansion or loosening by contraction. The cement shall not give rise to chemical reaction with metal fittings and its thickness shall be as small and uniform as possible. Proper care shall be taken to correctly centre and locate individual parts during cementing.

1.9.5 Pins and Caps

Pins and Caps shall be made of drop forged steel and malleable cast iron/spheriodal graphite iron/drop forges steel respectively, duly hot dip galvanized and shall not be made by jointing, welding, shrink fitting or any other process from more than one piece of material.

1.9.6 Security Clips

Security clips shall be made of good quality stainless steel or phosphor bronze as per IS: 1385. 2.5% extra security clip shall be provided.

1.10 Workmanship

1.10.1 All the material shall be of the latest design and conform to the best modern practices adopted in the extra high voltage field. Suppliers shall offer only such insulators as are guaranteed by him to be satisfactory and suitable for 220 kV Transmission lines and will give continued good service.

1.10.2 The design, manufacturing process and material control at various stages shall be such as to give maximum working load, highest mobility, best resistance to corrosion, good finish and elimination of sharp edges and corners to limit corona and radio interference.

1.10.3 The design of the insulators shall be such that stresses due to expansion and contraction in any part of the insulator shall not lead to deterioration.

1.10.4 Metal caps shall be free from cracks, seams, shrinks, air holes, burrs and rough edges. All surfaces of the metal parts shall be perfectly smooth with no projecting points or irregularities which may cause corona. All load bearing surfaces shall be smooth and uniform so as to distribute the loading stresses uniformly.

1.10.5 All ferrous parts shall be hot dip galvanized to give a minimum average coating of Zinc equivalent to 600 gm/sq.m and shall be in accordance with the requirement of IS:2629 and shall satisfy the tests mentioned in IS:2633. The zinc used for galvanizing shall be of Grade Zn 99.95 as per IS: 209. The zinc coating shall be uniform, adherent, smooth, reasonably bright, continuous and free from imperfections such as flux, ash, rust stains, bulky white deposits and blisters. The galvanized metal parts shall be guaranteed to withstand atleast six successive dips each lasting for one (1) minute duration under the standard preece test.

1.10.6 Before ball fittings are galvanized, all die flashing on the shank surface of the ball shall be carefully removed without reducing the dimensions below the design requirements.

1.10.7 The design of the insulators shall be such that the shell shall not engage directly with hard metal. The design shall also be such that when units are coupled together there is no contact between the shell of one unit and metal of the next adjacent unit. The design of the shell ribs shall be such that the security clip of the insulator can be engaged and disengaged easily with hot stick without damaging the shell ribs.

1.10.8 Insulator units after assembly shall be concentric and co-axial within limits as permitted by the relevant Indian Standards.

1.10.9 The manufacturer of the insulators shall guarantee an insulator failure rate not exceeding 1 (one) per 10000 (ten thousand) per year for disc insulator per year. In case the annual failure rate during the first ten years of service exceeds the above figure, under normal operating condition, as will be determined by check to be conducted as per mutually agreed procedure and conditions upto ten years, (as permitted by the operating situation), the Supplier shall supply to the Employer free of cost spare insulators equal to 10 time the excess failure.

1.10.10 The Supplier shall guarantee that there shall not be any decapping/breaking of insulators on line under normal operating conditions.

2.0 Equipment Marking

2.1 Each insulator disc shall be legibly and indelibly marked with the trade mark of the manufacturer, name of NEA and month & year of manufacture. The guaranteed combined mechanical and electrical strength shall be indicated in kilo Newton followed by the word ‘kN’ to facilitate easy identification and to ensure proper use.

2.2 For porcelain insulator, the marking shall be on porcelain. The marking shall be printed, not impressed and shall be applied before firing. For toughened glass insulators the marking shall be on the metal parts.

2.3 One 10 mm thick ring or 20 mm thick spot of suitable quality of paint shall be marked on the cap of each porcelain insulator disc of particular strength for easy identification of the type of insulator. The paint shall not have any deteriorating effect on the insulator performance. Following codes shall be used as identification mark:

For	70 kN disc	:	Red
For	120 kN disc	:	Yellow
For	160 kN disc	:	Green

3.0 Bid Drawings

3.1 The Bidder shall furnish full description and illustration of the material offered.

3.2 The Bidder shall furnish along with the bid the outline drawing (6 copies) of each insulator unit including a cross sectional view of the insulator shell. The drawing shall include but not limited to the following information:

(a) Shell diameter and ball to ball spacing with manufacturing tolerances

(b) Minimum creepage distance with positive tolerance

(c) Protected creepage distance

(d) Eccentricity of the disc

(i) Axial run out

(ii) Radial run out

(e) Unit mechanical and electrical characteristics

(f) Size and weight of ball and socket parts

(g) Weight of unit insulator disc/long rod units

(h) Materials

(i) Identification mark

(j) Manufacturer's catalogue number

3.3 After placement of award, the Supplier shall submit full dimensioned insulator drawings containing all the details as given in Clause No. 3.2 above, in four (4) copies to Employer for approval. After getting approval from Employer and successful completion of all the type tests, the Supplier shall submit 10 more copies of the same drawing to the Employer for further distribution and field use at Employer's end.

3.4 After placement of award the Supplier shall also submit fully dimensioned insulator crate drawing for different type of insulators.

3.5 After placement of award, the Supplier shall submit full dimensioned manufacturing drawing of insulator cap, pin and insulator shell in six (6) copies to the Employer for reference and record.

4.0 Tests and Standards

4.1 Type Tests

The following type tests shall be conducted on a suitable number of individual standard disc insulators, components, materials or complete strings:

4.1.1 On unit disc Insulators (70 and 120 kN only)

a)	Verification of dimensions	As per IEC: 60383
b)	Thermal mechanical performance test	As per Annexure-A
c)	Power frequency voltage withstand and flashover test under (i) dry (ii) wet condition	As per IEC: 60383
d)	Impulse voltage withstand and flashover test (dry)	As per IEC: 60383
e)	Visible Discharge test (dry)	As per IS:731, Cl. 10.2
f)	RIV test (dry)	As per IEC: 60437
g)	Residual strength Test	As per Annexure-A
h)	Steep wave front Test	As per Annexure-A
i)	Impact Test	As per Annexure-A

4.1.2 On the complete Disc Insulator String with Hardware Fittings

a)	Power frequency voltage withstand test with corona control rings/grading ring and arcing horns under wet condition	As per IEC: 60383
b)	Switching surge voltage withstand test under wet condition	As per IEC: 60383
c)	Impulse voltage withstand test under dry condition	As per IEC: 60383
d)	Impulse voltage flash over test under dry condition	As per IEC: 60383
e)	Voltage distribution test	As per Annexure-A
f)	Corona and RIV test under dry condition	As per Annexure-A
g)	Mechanical Strength test	As per Annexure-A
h)	Vibration test	As per Annexure-A
i)	Power-Arc Test	As per Annexure-A

4.1.3 All the type test given in Clause No. 4.1.2 for disc insulator string shall be conducted on Single 'I' suspension and Double tension insulator string (with 120 kN EMS) only along with hardware fittings.

4.2 Acceptance Tests

4.2.1 For Disc Insulators (Both porcelain and glass)

a)	Visual examination	As per IEC: 60383
b)	Verification of dimensions	As per IEC: 60383
c)	Temperature cycle test	As per IEC: 60383

	d)	Galvanizing test	As per IEC: 60383
	e)	Mechanical performance test	As per IEC: 60575Cl 4.0
	f)	Test on locking device for ball and socket coupling	As per IEC: 60372
	g)	Eccentricity test	As per IEC: 60383
	h)	Residual Strength Test	As per IEC: 797 Clause 4.4 & 4.5
	i)	Metallurgical Test (For metal fittings only in black condition) i) Grain size ii) Inclusion rating iii) Chemical analysis iv) Microstructure	As per Annexure-A
	j)	Chemical analysis of Zinc Sleeve	As per Annexure-A
	k)	IR Measurement	As per Annexure-A
	l)	Impact Test	As per Annexure-A
	m)	Steep Wave front test	As per Annexure-A
	n)	Thermal Mechanical performance test	As per Annexure-A

4.2.2 For Porcelain disc Insulators Only

	a)	Electro-mechanical strength test	As per Annexure-A
	b)	Porosity test	As per IEC: 60383
	c)	Puncture test	As per IEC: 60383

4.2.3 For Glass Insulators Only

	a)	Thermal shock test	As per IEC: 60383
	b)	Steep wave front test/Puncture test	As per Annexure-A
	c)	Mechanical failing load Test	As per Annexure-A

4.3 Routine Tests

4.3.1 For Disc Insulators

	a)	Visual Inspection	As per IS: 731, Cl. 10.13
	b)	Mechanical routine test	As per IS: 731 Cl. 10.14
	c)	Electrical routine test (for porcelain disc insulator only)	As per IS: 731 Cl. 10.15
	d)	Thermal shock routine test (for glass insulator only)	As per IEC: 60383

e)	Polarized Light Inspection (for glass insulator only)	As per Annexure-A

4.4 Tests during Manufacture

On all components as applicable

a)	Chemical analysis of zinc used for galvanizing	As per Annexure-A
b)	Chemical analysis, mechanical, metallographic test and magnetic particle inspection for malleable castings.	As per Annexure-A
c)	Chemical analysis hardness tests and magnetic particle inspection for forgings	As per Annexure-A
d)	Hydraulic Internal Pressure tests on disc insulator shells	As per Annexure-A
e)	Autoclave Test on Cement	As per Annexure-A

4.5 Testing Expenses

4.5.1 Testing charges for the type test specified shall be indicated separately in the prescribed schedule.

4.5.2 Bidder shall indicate unit type test charges for all type tests covered under Clause 4.1 separately, in the relevant schedule of Prices as applicable. Charges for each type tests shall be separately indicated.

4.5.3 For Type Tests which involves the tests on the complete insulator string with hardware fitting the vendor of hardware fittings shall supply the necessary number of sets of hardware fittings at the place of testing free of cost.

4.5.4 In case of failure in any type test the bidder whose material has failed is either required to modify the design of the material & successfully carryout all the type tests as has been detailed out in Clause 4.1 of this specifications or to repeat that particular type test at least three times successfully at his own expenses. Incase of failure of the complete string in any type test, the manufacturer whose product has failed in the use shall get the test repeated at his cost. The Supplier whose material has not failed in the test shall be required to supply the requisite quantity of material (that is insulator or hardware fittings as the case may be) required for repeat testing at the place of testing and the cost of supply shall be borne by the Supplier whose material has failed in testing.

4.5.5 Supplier shall indicate the laboratories in which they propose to conduct the type tests. They shall ensure that adequate facilities are available in the laboratory and the tests can be completed in these laboratories within the time schedule guaranteed by them in the appropriate schedule.

4.5.6 The entire cost of testing for acceptance and routine tests and tests during manufacture specified herein shall be treated as included in the quoted Ex-works/CIF Price.

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

4.5.8 The Supplier shall intimate the Employer about carrying out of the type tests along with detailed testing programme at least 3 weeks in advance (in case of Domestic Supplier) and at least 6 weeks advance (in case of foreign Supplier) of the scheduled date of testing during which the Employer will arrange to depute his representative to be present at the time of carrying out the tests.

4.6 Sample Batch for Type Testing

4.6.1 The Supplier shall offer material for sample selection for type testing only after getting Quality Assurance Programme approved by the Employer. The Supplier shall offer at least three times the quantity of materials required for conducting all the type tests for sample selection. The sample for type testing will be manufactured strictly in accordance with the Quality Assurance Programme approved by the Employer.

4.6.2 Before sample selection for type testing, the Supplier shall be required to conduct all the acceptance tests successfully in presence of Employer's representative.

4.7 Schedule of Testing

4.7.1 The Bidder has to indicate the schedule of following activities in their bids:

a) Submission of drawing for approval.

b) Submission of Quality Assurance Programme for approval.

c) Offering of material for sample selection for type tests.

d) Type testing.

4.8 Repeat E&M Strength Test

4.8.1 The Employer reserves the right of having at his own expenses any other test(s) of reasonable nature carried out at Supplier's premises, at site, or in any other place in addition to the aforesaid type, acceptance and routine tests to satisfy himself that the material comply with the Specifications.

4.8.2 The Employer also reserves the right to conduct all the tests mentioned in this specification at his own expense on the samples drawn from the site at Supplier's premises or at any other test centre. In case of evidence of non compliance, it shall be binding on the part of the Supplier to prove the compliance of the items to the technical specifications by repeat tests or correction of deficiencies or replacement of defective items, all without any extra cost to the Employer.

4.9 Co-ordination for Testing

The Supplier shall have to co-ordinate testing of insulators with hardware fittings to be supplied by other Supplier and shall have to guarantee overall satisfactory performance of the insulators with the hardware fittings.

4.10 Guarantee

The Supplier of insulators shall guarantee overall satisfactory performance of the insulators with the hardware fittings.

4.11 Test Reports

4.11.1 Copies of type test reports shall be furnished in at least six (6) copies along with one original. One copy shall be returned duly certified by the Employer only after which the commercial production of the concerned material shall start.

4.11.2 Copies of acceptance test reports shall be furnished in at least six (6) copies. One copy shall be returned duly certified by the Employer, only after which the material shall be dispatched.

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

4.11.4 Test certificates of test during manufacture shall be maintained by the Supplier. These shall be produced for verification as and when desired by the Employer.

4.12 Inspection

4.12.1 The Employer's representative shall at all times be entitled to have access to the works and all places of manufacture, where insulator, and its component parts shall be manufactured and the representatives shall have full facilities for unrestricted inspection of the Supplier's and sub-Supplier's works, raw materials, manufacture of the material and for conducting necessary test as detailed herein.

4.12.2 The material for final inspection shall be offered by the Supplier only under packed condition.

The Employer shall select samples at random from the packed lot for carrying out acceptance tests. Insulators shall normally be offered for inspection in lots not exceeding 10,000 nos. for disc insulator. The lot should be homogeneous and should contain insulators manufactured in 3-4 consecutive weeks.

4.12.3 The Supplier shall keep the Employer informed in advance of the time of starting and the progress of manufacture of material in their various stages so that arrangements could be made for inspection.

4.12.4 No material shall be dispatched from its point of manufacture before it has been satisfactorily inspected and tested unless the inspection is waived off by the Employer in writing. In the latter case also the material shall be dispatched only after satisfactory testing for all tests specified herein have been completed.

4.12.5 The acceptance of any quantity of material shall be no way relieve the Supplier of his responsibility for meeting all the requirements of the specification and shall not prevent subsequent rejection, if such material are later found to be defective.

4.13 Packing and Marking

4.13.1 All insulators shall be packed in strong seasoned wooden crates. The gross weight of the crates along with the material shall not normally exceed 200 Kg to avoid handling problem. For marine transportation crates shall be palleted.

4.13.2 The packing shall be of sufficient strength to withstand rough handling during transit, storage at site and subsequent handling in the field.

4.13.3 Suitable cushioning, protective padding, or dunnage or spacers shall be provided to prevent damage or deformation during transit and handling.

4.13.4 All packing cases shall be marked legibly and correctly so as to ensure safe arrival at their destination and to avoid the possibility of goods being lost or wrongly dispatched on account of faulty packing and faulty or illegible markings. Each wooden case/crate shall have all the markings stencilled on it in indeliable ink.

4.14 Standards

The insulator strings and its components shall conform to the following lndian/ International Standards which shall mean latest revision, with amendments/ changes adopted and published, unless specifically stated otherwise in the Specification.

4.10.1 In the event of supply of insulators conforming to standards other than specified, the Bidder shall confirm in his bid that these standards are equivalent to those specified. In case of award, salient features of comparison between the standards proposed by the Bidder and those specified in this document will be provided by the Supplier to establish equivalence.

Sl. No.	Indian Standard	Title	International Standard
1.	IS: 209-1992	Specification for zinc	BS: 3436
2.	IS: 406-1991	Method of Chemical Analysis of Slab Zinc	BS: 3436
3.	IS: 731-1991	Porcelain insulators for overhead Power lines with a nominal voltage greater than 1000 V	BS: 137- (I&II) IEC: 60383
4.	IS:2071 Part (I) – 1993 (Part(II)-1991 Part(III)-1991	Methods of High Voltage Testing	IEC:60060-1
5.	IS: 2486 Part- I-1993 Part- II-1989 Part-III-1991	Specification for Insulator fittings for Overhead Power Lines with a nominal voltage greater than 1000V General Requirements and Tests Dimensional Requirements Locking Devices	 BS: 3288 IEC: 60120 IEC: 60372
6.	IS:2629-1990	Recommended Practice for Hot, Dip Galvanization for iron and steel	ISO-1461 (E)
7.	IS:2633-1992	Testing of Uniformity of Coating of zinc coated articles	
8.	IS:3188-1988	Dimensions for Disc Insulators	IEC: 60305
9.	IS:6745-1990	Determination of Weight of Zinc Coating on Zinc coated iron and steel articles	BS: 433-1969 ISO:1460-1973
10.	IS:8263-1990	Methods of RI Test of HV insulators	IEC: 60437 NEMA Publi-cation No.07/ 1964/ CISPR
11.	IS:8269-1990	Methods for Switching Impulse test on HV insulators	IEC: 60506
12.		Thermal Mechanical Performance test and mechanical performance test on string insulator units	IEC: 60575
13.		Salt Fog Pollution Voltage Withstand Test	IEC: 60507
14.		Residual Strength of String Insulator Units of Glass or Ceramic Material for Overhead Lines after Mechanical Damage of the Dielectric	IEC: 60797
15.		Guide for the selection of insulators in respect of polluted conditions	IEC:60815
16.		Tests on insulators of Ceramic material or glass or glass for overhead lines with a nominal voltage greater than 1000V	IEC:60383
17.		Characteristics of string insulator units of	IEC : 60433

		the long rod type	
18.		Standard Test Method for Autoclave Expansion of Portland Cement	ASTM C151-93-a
19.		American National Standard for Insulators wet process porcelain and toughened glass suspension type	ANSI C29-2-1992

ANNEXURE-A

1. Tests on Complete Strings with Hardware Fittings

1.1 Voltage Distribution Test (For Disc Insulators only)

The voltage across each insulator unit shall be measured by sphere gap method. The result obtained shall be converted into percentage. The voltage across any disc shall not exceed 9% for suspension insulator strings and 10% for tension insulator strings.

1.2 Corona Extinction Voltage Test (Dry)

The sample assembly when subjected to power frequency voltage shall have a corona extinction voltage of not less than 154 kV (rms) line to ground under dry condition. There shall be no evidence of corona on any part of the sample. The atmospheric condition during testing shall be recorded and the test results shall be accordingly corrected with suitable correction factor as stipulated in IEC: 383.

1.3 RIV Test (Dry)

Under the conditions as specified under (1.2) above, the insulator string along with complete hardware fittings shall have a radio interference voltage level below 1000 micro volts at one MHz when subjected to 50 Hz AC voltage of 154 kV line to ground under dry condition. The test procedure shall be in accordance with IS: 8263/IEC: 437.

1.4 Mechanical Strength Test

The complete insulator string along with its hardware fitting excluding arcing horn, corona control ring, grading ring and suspension assembly/dead end assembly shall be subjected to a load equal to 50% of the specified minimum ultimate tensile strength (UTS) which shall be increased at a steady rate to 67% of the minimum UTS specified. The load shall be held for five minutes and then removed. After removal of the load, the string components shall not show any visual deformation and it shall be possible to disassemble them by hand. Hand tools may be used to, remove cotter pins and loosen the nuts initially. The string shall then be reassembled and loaded to 50% of UTS and the load shall be further increased at a steady rate till the specified minimum UTS and held for one minute. No fracture should occur during this period. The applied load shall then be increased until the failing load is reached and the value recorded.

1.5 Vibration Test

The suspension string shall be tested in suspension mode, and tension string in tension mode itself in laboratory span of minimum 30 metres. In the case of suspension string a load equal to 600 kg shall be applied along the axis of the suspension string by means of turn buckle. The insulator string along with hardware fittings and two sub-conductors (each tensioned at 43 kN shall be secured with clamps. The system shall be suitable to maintain constant tension on each sub-conductors throughout the duration of the test. Vibration dampers shall not be used on the test span. Both the sub-conductors shall be vertically vibrated simultaneously at one of the resonance frequencies of the insulators string (more than 10 Hz) by means of vibration inducing equipment. The peak to peak displacement in mm of vibration at the antinode point, nearest to the string, shall be measured and the same shall not be less than $1000/f^{1.8}$ where f is the frequency of vibration in cycles/sec. The insulator string shall be vibrated for not less than 10 million cycles without any failure. After the test the insulators shall be examined for looseness of pins and cap or any crack in the cement. The hardware shall be examined for looseness, fatigue failure and mechanical strength test. There shall be no deterioration of properties of hardware components and insulators after the vibration test. The insulators shall be subjected to the following tests as per relevant standards:

	Tests Percentage of	Percentage of units to be tested
		Disc insulators
a)	Temperature cycle test followed by mechanical performance test	60
b)	Puncture test/steep wave front test	40

1.6 Power - Arc Test

This test shall be performed on the complete string in accordance with IEC Technical Report IEC: 61467-1997 with the following test series:

Test circuit	Short circuit current	Number and duration of test
B	$I_n = I_{sys} = 35$ KA	Two of $t_n = 0.2$s and one of $t_n = 0.5$s

The acceptance criteria after the completion of test series shall be following.

a) Insulator separation not permitted.

b) Burning/melting of metal components, breakage of insulator sheds, glaze removals are permitted.

c) The complete insulator string along with its hardware fitting excluding arching horn, corona control ring/grading ring shall withstand 80% of UTS.

2.0 On Disc Insulator Units

2.1 Steep Wave Front Test (For Disc Insulator only)

Test following test shall be performed on 10 insulator units in case of disc insulators selected at random from the lot offered for selection of sample for type test.

a) Each insulator unit shall be subjected to five successive positive and negative impulse flashovers with a wave having minimum effective rate of rise of 2500 kV per microseconds.

b) Each unit shall then be subjected to three dry power frequency voltage flashovers.

Acceptance Criteria

An insulator shall be deemed to have met the requirement of this test if, having been successfully subjected to the ten impulse flashovers, the arithmetic mean of the three subsequent dry/power frequency voltage flashover values equals or exceeds 95% of the rated dry power frequency flashover voltage.

An insulator shall be deemed to have failed to meet the requirement of above testing if,

(a) It has not flash over when the oscillogram or peak voltage indicator shows a marked reduction in voltage.

or

(b) Any one of the subsequent three dry power frequency voltage flashover value is less than 80% of the value specified.

Failure of any one unit either in the steep wave front or subsequent low frequency voltage test shall cause for testing on double number of units.

2.2 Polarized Light Inspection (only for Glass Disc Insulator)

The disc insulator shall be held over a polarized light source and the stress lines viewed thereon. There shall be no uneven stress distribution in the toughened glass insulators. This shall be carried out on 100% glass shells.

2.3 Hydraulic Internal Pressure Test on Shells

The test shall be carried out on 100% shells before assembly. The details regarding test will be as discussed and mutually agreed to by the Supplier and Employer in Quality Assurance Programme. However in no case the value of pressure shall be 120kg/cm square

2.4 Thermal Mechanical Performance Test

Thermal Mechanical Performance Test shall be performed in accordance with IEC-60383-1 Clause 20 with the following modifications :

(1) The applied mechanical load during this test shall be 70% of the rated electromechanical or mechanical value.

(2) The acceptance criteria shall be

(a) X greater than or equal to R + 3S.

Where

X = Mean value of the individual mechanical failing load.

R = Rated electro-mechanical / mechanical failing load.

S = Standard deviation.

(b) The minimum sample size shall be taken as 20 for disc insulator units and 5 units for long rod units.

(c) The individual electromechanical failing load shall be at least equal to the rated value. Also puncture shall not occur before the ultimate fracture.

2.5 Electromechanical/Mechanical Failing Load Test

This test shall be performed in accordance with clause 18 and 19 of IEC 383 with the following acceptance

(i) X greater than or equal to R + 3S

Where

X = Mean value of the electro-mechanical/mechanical/ failing load.

R = Rated electro-mechanical / mechanical failing load.

S = Standard deviation.

(ii) The minimum sample size shall be taken as 20 for disc insulators units and 5 for long rod units. However, for larger lot size, IEC 591 shall be applicable.

(iii) The individual electro-mechanical/mechanical failing load shall be at least equal to the rated value. Also electrical puncture shall not occur before the ultimate fracture.

2.6 Residual Strength Test

The above test shall be performed as per clause 4.4 and 4.5 of IEC 797 preceded by the temperature cycle test, on both glass and porcelain disc insulators. The Sample size shall be 25 and the evaluation of the results and acceptance criteria shall be as per clause No. 4.6 of IEC: 797.

2.7 IR Measurements

IR measurement shall be carried out by the instrument operating at 1 kV DC. IR value when measured under fair weather condition, shall not be less than 50 M-ohm.

2.8 Impact Test

The Impact Test shall be carried out in accordance with ANSI-C-29.2 Clause 8.2.8 with the following modification.

The breaking point of the pendulum shall be so adjusted that, when released the copper nose will strike the outer rim of the shell or the most protuded rim of the shell squarely in a direction parallel to the axis of the unit and towards the cap.

The test specimen shall receive an impact of 7 N-m for 70 kN & 120 kN Disc & 10N-m for 160 kN Disc by releasing the pendulum.

3.0 Tests on All components (As applicable)

3.1 Chemical Analysis of Zinc used for Galvanizing

Samples taken from the zinc ingot shall be chemically analyzed as per IS: 209-1979. The purity of zinc shall not be less than 99.95%.

3.2 Tests for Forgings

The chemical analysis hardness tests and magnetic particle inspection for forgings, will be as per the internationally recognized procedures for these tests. The sampling will be based on heat number and heat treatment batch. The details regarding test will be as discussed and mutually agreed to by the Supplier and Employer in Quality Assurance Programme.

3.3 Tests on Castings

The chemical analysis, mechanical and metallographic tests and magnetic, particle inspection for castings will be as per the internationally recognized procedures for these tests. The samplings will be based on heat number and heat treatment batch. The details regarding test will be as discussed and mutually agreed to by the Supplier and Employer in Quality Assurance Programme.

3.4 Autoclave Test

For cement used in the assembly of the insulators six samples from different batches shall be tested in accordance with ASTM C-151. The cement shall have an expansion less than 0.12%.

TECHNICAL SPECIFICATIONS

IX. HARDWARE AND FITTINGS

1.0 Technical Description of Hardware Fittings

1.1 Details of Hardware Fittings

1.1.1 The hardware fittings shall be as per the specification drawings enclosed with Section 9 of the specification. Single "I" suspension, Single suspension pilot and Double tension hardware fittings shall be supplied suitable for attaching to hanger/strain plate fixed to tower. Each hardware fitting shall be supplied complete in all respects and shall include the following hardware parts:

1.1.2 Suitable arcing horn as specified in Clause 1.8 hereinafter.

1.1.3 Suitable yoke plates complying with the specifications given hereinafter.

1.1.4 Corona control rings/grading ring with fittings for attachment to line side yoke plate

1.1.5 Sag -Adjustment plate for double tension hardware fittings.

1.1.6 Suspension and dead end assembly to suit conductor size as detailed in clause 1.13, 1.14 and 1.15 hereinafter.

1.1.7 Provisions for attaching balancing weights on the line side yoke plate of single suspension pilot hardware fittings.

1.1.8 Other necessary fittings viz D-shackles, eye links, extension links, ball clevis, socket clevis, clevis eye, U clevis and chain link etc. to make the hardware fittings complete.

1.1.9 2.5% extra fasteners and aluminium filler plugs.

1.2 Dimensions of Insulator String Along with Hardware Fitting

The various limiting dimensions of the Single "I" Suspension, Single suspension pilot and Double tension insulator strings along with hardware fittings shall be as per the specification drawings enclosed with Section-9 of the specification.

1.3 Interchangeability

1.3.1 The hardware for insulator strings with disc insulators / porcelain long rod insulators together with ball and socket fittings shall be of standard design, so that these hard wares are inter-changeable with each other and suitable for use with insulators of any make conforming to relevant Indian/International Standard.

1.4 Corona and RI Performance

Sharp edges and scratches on all the hardware fittings shall be avoided. All surfaces must be clean, smooth, without cuts and abrasions or projections. The

Contractor must give suitable assurance about the satisfactory corona and radio interference performance of the materials offered by him.

1.5 Maintenance

1.5.1 The hardware fittings offered shall be suitable for employment of hot line maintenance technique so that usual hot line operations can be carried out with ease, speed and safety. The technique adopted for hot line maintenance shall be generally bare hand method & hot stick method. The Bidder should clearly establish in the bid, the suitability of his fittings for hot line maintenance.

1.5.2 The line side yoke plate shall have a notch & a working hole of suitable size. The design of corona control rings/grading ring shall be such that it can be easily replaced by employing hot line maintenance technique.

1.6 Designation

1.6.1 Ball and Socket Designation

The dimensions of the ball and socket shall be of 20mm designation for 120 kN & 160 kN insulators and 16 mm for 70 kN insulators. The designation should be in accordance with the standard dimensions stated in IS:2486-(Part-II)/IEC:120. The dimensions shall be checked by the appropriate gauge after galvanising only.

1.7 Security Clips and Split Pins

1.7.1 Security clips for use with ball and socket coupling shall be R-shaped, hump type which provides positive locking of the coupling as per IS:2486-(Part-III)/ IEC : 372. The legs of the security clips shall be spread after assembly in the works to prevent complete withdrawal from the socket. The locking device should be resilient, corrosion resistant and of suitable mechanical strength. There shall be no risk of the locking device being displaced accidentally or being rotated when in position. Under no circumstances, the locking devices shall allow separation of fittings.

1.7.2 The hole for the security clip shall be countersunk and the clip should be of such design that the eye of clip may be engaged by a hot line clip puller to provide for disengagement under energised conditions. The force required to pull the security clip into its unlocked position shall not be less than 50 N (5 kg) or more than 500 N (50 kg).

1.7.3 Split pins shall be used with bolts & nuts.

1.8 Arcing Horn/Intermediate Arcing Horn

1.8.1 The arcing horn / Intermediate Arcing Horn shall be either ball ended rod type or tubular type.

1.8.2 For insulator strings with disc insulators, the arcing horn shall be provided as shown on the drawing of the hardware fittings, in this specification.

1.8.3 The air gap shall be so adjusted to ensure effective operation under actual field conditions.

1.9 Yoke Plates

The strength of yoke plates shall be adequate to withstand the minimum ultimate tensile strength as specified in the bid drawings.

The plates shall be either triangular or rectangular in shape as may be necessary. The design of yoke plate shall take into account the most unfavorable loading conditions likely to be experienced as a result of dimensional tolerances for disc insulators as well as components of hardware fittings within the specified range. The plates shall have suitable holes for fixing corona control rings/grading ring/arcing horn. All the corners and edges should be rounded off with a radius of atleast 3 mm. Design calculations i.e. for bearing & tensile strength, for deciding the dimensions of yoke plate shall be furnished by the bidder. The holes provided for bolts in the yoke plate should satisfy shear edge condition as per Clause No. 8.10 of IS:800-1984.

1.10 Corona Control Rings/Grading Ring

1.10.1 The Corona control rings/grading ring shall be provided with hardware fittings and shall be of such design that it should cover at least one disc insulator in disc insulator strings so that they will reduce the voltage across the insulator units. It shall also improve corona and radio interference performance of the complete insulator string along with hardware fittings.

1.10.2 The corona control rings/grading ring shall be made of high strength heat treated aluminium alloy tube of minimum 2.5 mm wall thickness. If mild steel brackets are used then the brackets shall not be welded to the pipe but shall be fixed by means of bolts and nuts on a small aluminium plate attachment welded to the pipe. The welded center of the corona control ring/grading ring shall be grinded before buffing. Alternately, Aluminium tube/flats of suitable dimensions welded to the corona control rings/grading rings may be used for connection to yoke plate.

1.10.3 The Corona control rings/grading ring should have a brushed satin finish and not a bright glossy surface. No blemish should be seen or felt when rubbing a hand over the metal.

1.10.4 The limiting dimensions of corona control ring shall be as per the specification drawings.

1.10.5 Bidder may quote for grading ring with armour grip suspension assembly. The grading ring shall be of open type design with a gap of 125 mm. The open ends shall be suitably terminated. The outside diameter of the tube shall be 60 mm. The ends of grading ring tube shall be sealed with welded aluminium cap duly buffed.

1.11 Sag Adjustment Plate

1.11.1 The sag-adjustment plate to be provided with the double tension hardware fitting shall be of three plate type. The sag adjustment plate shall be provided with a

safety locking arrangement. The device shall be of such design that the adjustment is done with ease, speed and safety.

1.11.2 The maximum length of the sag adjustment plate from the connecting part of the rest of the hardware fittings shall be 520 mm. The details of the minimum and maximum adjustment possible and the steps of adjustment shall be clearly indicated in the drawing. An adjustment of 150 mm minimum at the interval of 6 mm shall be possible with the sag adjustment plate.

1.11.3 Design calculations for deciding the dimensions of sag adjustment plate shall be furnished by bidder. The hole provided for bolts should satisfy shear edge condition as per Clause No.8.10 of IS: 800-1984.

1.12 Suspension Assembly

1.12.1 The suspension assembly shall be suitable for ACSR 'BISON' Conductor.

1.12.2 The suspension assembly shall include free center type suspension clamp along with standard preformed armour rods or armour grip suspension clamp; except for Pilot insulator string for which only suitable Envelope type suspension clamp shall be used.

1.12.3 The suspension clamp along with standard preformed armour rods set shall be designed to have maximum mobility in any direction and minimum moment of inertia so as to have minimum stress on the conductor in the case of oscillation of the same.

1.12.4 The suspension clamp along with standard preformed armour rods/armour grip suspension clamp set shall have a slip strength between 18 to 26 KN for ACSR 'BISON' Conductor.

1.12.5 The suspension assembly shall be designed, manufactured and finished to give it a suitable shape, so as to avoid any possibility of hammering between suspension assembly and conductor due to vibration. The suspension assembly shall be smooth without any cuts, grooves, abrasions, projections, ridges or excrescence, which might damage the conductor.

1.12.6 The suspension assembly/clamp shall be designed so that it shall minimise the static & dynamic stress developed in the conductor under various loading conditions as well as during wind induced conductor vibrations. It shall also withstand power arcs & have required level of Corona/RIV performance.

1.12.7 Bids offering suspension assemblies with magnetic power loss more than 4 watts except for envelope type clamps for which magnetic power loss more than 8 watts at sub-conductor current of 600 amps shall be liable to be rejected. The Bidder's are requested to enclose test certificates for magnetic power loss test along with the bid.

1.12.8 In case, the magnetic power loss of the suspension assembly obtained during type testing of the same exceeds the value guaranteed by the Bidder in his bid, the material shall be rejected outright or the same shall be accepted after suitable liquidated damages for non-performance calculated at the rate of US$ 4.68 per

suspension assembly for each watt of additional power loss, which shall be recovered from the contract price.

1.12.9 Free Center Type Suspension Clamp

For the Free Center Suspension Clamp seat shall be smoothly rounded and curved into a bell mouth at the ends. The lip edges shall have rounded bead. There shall be at least two U-bolts for tightening of clamp body and keeper pieces together.

1.12.10 Standard Preformed Armour Rod Set

1.12.10.1 The Preformed Armour Rods Set suitable for ACSR 'BISON' Conductor shall be used to minimise the stress developed in the sub-conductor due to different static and dynamic loads because of vibration due to wind, slipping of conductor from the suspension clamp as a result of unbalanced conductor tension in adjacent spans and broken wire condition. It shall also withstand power arcs. chafing and abrasion from suspension clamp and localised heating effect due to magnetic power losses from suspension clamps as well as resistance losses of the conductor.

1.12.10.2 The preformed armour rods set shall have right hand lay and the inside diameter of the helics shall be less than the outside diameter of the conductor to have gentle but permanent grip on the conductor. The surface of the armour rod when fitted on the conductor shall be smooth and free from projections, cuts and abrasions etc.

1.12.10.3 The pitch length of the rods shall be determined by the Bidder but shall be less than that of the outer layer of conductor and the same shall be accurately controlled to maintain uniformity and consistently reproducible characteristic wholly independent of the skill of linemen.

1.12.10.4 The length of each rod shall be as follows:

	Length	Diameter
ACSR 'BISON'	2540±25 mm	9.27±0.10 mm

The tolerance in length of the rods in complete set should be within 13 mm between the longest and shortest rod. The end of armour rod shall be parrot billed.

1.12.10.5 The number of armour rods in each set shall be twelve for ACSR 'BISON'. Each rod shall be marked in the middle with paint for easy application on the line.

1.12.10.6 The armour rod shall not loose their resilience even after five applications.

1.12.10.7 The conductivity of each rod of the set shall not be less than 40% of the conductivity of the International Annealed Copper Standard (IACS).

1.12.11 Armour Grip Suspension Clamp

1.12.11.1 The armour grip suspension clamp shall comprise of retaining strap, support housing, elastomer inserts with aluminium reinforcements and AGS preformed rod set.

1.12.11.2 Elastomer insert shall be resistant to the effects of temperature up to 75^{O}C, Ozone, ultraviolet radiations and other atmospheric contaminants likely to be encountered in service. The physical properties of the elastomer shall be of approved standard. It shall be electrically shielded by a cage of AGS performed rod set. The elastomer insert shall be so designed that the curvature of the AGS rod shall follow the contour of the neoprene insert.

1.12.11.3 The AGS preformed rod set shall be as detailed in clause 1.12.10.4 to 1.12.10.7 in general except for the following.

1.12.11.4 The length of the AGS preformed rods shall be such that it shall ensure sufficient slipping strength as detailed under Clause 1.12.4 and shall not introduce unfavorable stress on the conductor under all operating conditions. However the length of AGS preformed rods shall not be less than 2235 $\pm$ 25 mm for ACSR 'BISON'.

1.13 Envelope Type Suspension Clamp

1.13.1 The seat of the envelope type suspension clamp shall be smoothly rounded & suitably curved at the ends. The lip edges shall have rounded bead. There shall be at least two U-bolts for tightening of clamp body and keeper pieces together. Hexagonal bolts and nuts with split-pins shall be used for attachment of the clamp.

1.14 Dead end Assembly

1.14.1 The dead end assembly shall be suitable for ACSR 'BISON' Conductor and for AACSR 'BISON' conductor (only with 160 kN insulator string).

1.14.2 The dead end assembly shall be compression type with provision for comprising jumper terminal at one end. The angle of jumper terminal to be mounted should be 30° with respect to the vertical line. The area of bearing surface on all the connections shall be sufficient to ensure positive electrical and mechanical contact and avoid local heating due to I^2R losses. The resistance of the clamp when compressed on Conductor shall not be more than 75% of the resistance of equivalent length of Conductor.

1.14.3 Die compression areas shall be clearly marked on each dead-end assembly designed for continuous die compressions and shall bear the words 'COMPRESS FIRST' suitably inscribed near the point on each assembly where the compression begins. If the dead end assembly is designed for intermittent die compressions it shall bear identification marks 'COMPRESSION ZONE' AND 'NON-COMPRESSION ZONE' distinctly with arrow marks showing the direction of compressions and knurling marks showing the end of the zones. Tapered aluminium filler plugs shall also be provided at the line of demarcation between compression & non-compression zone. The letters, number and other markings on the finished clamp shall be distinct and legible.

1.14.4 The assembly shall not permit slipping of, damage to, or failure of the complete conductor or any part there of at a load less than 95% of the ultimate tensile strength of the conductor.

1.15 Fasteners: Bolts, Nuts and Washers

1.15.1 All bolts and nuts shall conform to IS: 6639. All bolts and nuts shall be galvanised as per IS-1367 - (Part 13)/IS-2629. All bolts and nuts shall have hexagonal heads, the heads being forged out of solid truly concentric, and square with the shank, which must be perfectly straight.

1.15.2 Bolts up to M16 and having length up to 10 times the diameter of the bolt should be manufactured by cold forging and thread rolling process to obtain good and reliable mechanical properties and effective dimensional control. The shear strength of bolt for 5.6 grade should be 310 MPa minimum as per IS: 12427. Bolts should be provided with washer face in accordance with IS: 1363 Part-1 to ensure proper bearing.

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

1.15.4 Fully threaded bolts shall not be used. The length of the bolt shall be such that the threaded portion shall not extend into the place of contact of the component parts.

1.15.5 All bolts shall be threaded to take the full depth of the nuts and threaded enough to permit the firm gripping of the component parts but no further. It shall be ensured that the threaded portion of the bolt protrudes not less than 3 mm and not more than 8 mm when fully tightened. All nuts shall fit and tight to the point where shank of the bolt connects to the head.

1.15.6 Flat washers and spring washers shall be provided wherever necessary and shall be of positive lock type. Spring washers shall be electro-galvanised. The thickness of washers shall conform to IS: 2016-1967.

1.15.7 The Bidder shall furnish bolt schedules giving thickness of components connected. the nut and the washer and the length of shank and the threaded portion of bolts and size of holes and any other special details of this nature.

1.15.8 To obviate bending stress in bolt, it shall not connect aggregate thickness more than three time its diameter.

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

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

1.15.11 Fasteners of grade higher than 8.8, are not to be used.

1.16 Materials

The materials of the various components shall be as specified hereunder. The Bidder shall indicate the material proposed to be used for each and every component of hardware fittings stating clearly the class, grade or alloy

designation of the material, manufacturing process & heat treatment details and the reference standards.

1.16.1 The details of materials for different component are listed as in Table No-1.

1.17 Workmanship

1.17.1 All the equipment shall be of the latest design and conform to the best modern practices adopted in the Extra High Voltage field. The Bidder shall offer only such equipment as guaranteed by him to be satisfactory and suitable for 220 kV transmission lines and will give continued good performance.

1.17.2 The design, manufacturing process and quality control of all the materials shall be such as to give the specified mechanical rating, highest mobility, elimination of sharp edges and corners to limit corona and radio-interference, best resistance to corrosion and a good finish.

1.17.3 All ferrous parts including fasteners shall be hot dip galvanized, after all machining has been completed. Nuts may, however, be tapped (threaded) after galvanizing and the threads oiled. Spring washers shall be electro galvanized. The bolt threads shall be undercut to take care of the increase in diameter due to galvanizing. Galvanizing shall he done in accordance with IS: 2629-1985 / IS-1367 (Part 13) and shall satisfy the tests mentioned in IS: 2633-1986. Fasteners shall withstand four dips while spring washers shall withstand three dips of one minute duration in the standard preece test. Other galvanized materials shall have a minimum average coating of zinc equivalent to 600/gm/sq.m., shall be guaranteed to withstand at least six successive dips each lasting one (1) minute under the standard preece test for galvanizing.

1.17.4 Before ball fittings are galvanized, all die flashing on the shank and on the bearing surface of the ball shall be carefully removed without reducing the dimensions below the design requirements.

1.17.5 The zinc coating shall be perfectly adherent, of uniform thickness, smooth, reasonably bright, continuous and free from imperfections such as flux, ash, rust stains, bulky white deposits and blisters. The zinc used for galvanizing shall be Zinc of any grade in IS: 209:1992 ingot (fourth revision) or IS: 13229- 1991.

1.17.6 Pin balls shall be checked with the applicable “GO” gauges in at least two directions, one of which shall be across the line of die flashing, and the other 90^{o} to this line. "NO GO" gauges shall not pass in any direction.

1.17.7 Socket ends, before galvanizing, shall be of uniform contour. The bearing surface of socket ends shall be uniform about the entire circumference without depressions of high spots. The internal contours of socket ends shall be concentric with the axis of the fittings as per IS: 2486/IEC: 120.

The axis of the bearing surfaces of socket ends shall be coaxial with the axis of the fittings. There shall be no noticeable tilting of the bearing surfaces with the axis of the fittings.

1.17.8 In case of casting, the same shall be free from all internal defects like shrinkage, inclusion, blow holes, cracks etc. Pressure die casting shall not be used for casting of components with thickness more than 5 mm.

1.17.9 All current carrying parts shall be so designed and manufactured that contact resistance is reduced to minimum.

1.17.10 No equipment shall have sharp ends or edges, abrasions or projections and cause any damage to the conductor in any way during erection or during continuous operation which would produce high electrical and mechanical stresses in normal working. The design of adjacent metal parts and mating surfaces shall be such as to prevent corrosion of the contact surface and to maintain good electrical contact under service conditions.

1.17.11 All the holes shall be cylindrical, clean cut and perpendicular to the plane of the material. The periphery of the holes shall be free from burrs.

1.17.12 All fasteners shall have suitable corona free locking arrangement to guard against vibration loosening.

1.17.13 Welding of aluminium shall be by inert gas shielded tungsten arc or inert gas shielded metal arc process. Welds shall be clean, sound, smooth, uniform without overlaps, properly fused and completely sealed. There shall be no cracks, voids incomplete penetration, incomplete fusion, under-cutting or inclusions. Porosity shall be minimized so that mechanical properties of the aluminium alloys are not affected. All welds shall be properly finished as per good engineering practices.

1.18 Bid Drawings

1.18.1 The Bidder shall furnish full description and illustrations of materials offered.

1.18.2 Fully dimensioned drawings of the complete insulator string hard wares and their component parts showing clearly the following arrangements shall be furnished in five (5) copies along with the bid. Weight, material and fabrication details of all the components should be included in the drawings.

(i) Attachment of the hanger or strain plate.

(ii) Suspension or dead end assembly.

(iii) Arcing horn attachment to the string as specified in clause 1.8 of this technical Specification.

(iv) Yoke plates

(v) Hardware fittings of ball and socket type for inter connecting units to the top and bottom Yoke plates.

(vi) Corona control rings/grading ring attachment to conductor and other small accessories.

(vii) Links with suitable fittings.

(viii) Details of balancing weights and arrangements for their attachment in the single suspension pilot insulator string.

1.18.3 All drawings shall be identified by a drawing number and contract number. All drawings shall be neatly arranged. All drafting & lettering shall be legible. The minimum size of lettering shall be 3 mm. All dimensions & dimensional tolerances shall be mentioned in mm.

The drawings shall include:

(i) Dimensions and dimensional tolerance.

(ii) Material, fabrication details including any weld details & any specified finishes & coatings. Regarding material designation & reference of standards are to be indicated.

(iii) Catalogue No.

(iv) Marking

(v) Weight of assembly

(vi) Installation instructions

(vii) Design installation torque for the bolt or cap screw.

(viii) Withstand torque that may be applied to the bolt or cap screw without failure of component parts.

(ix) The compression dies number with recommended compression pressure.

(x) All other relevant terminal details.

1.18.4 After placement of award, the Contractor shall submit fully dimensioned drawing including all the components in four (4) copies to the Employer for approval. After getting approval from the Employer and successful completion of all the type tests, the Contractor shall submit ten (10) more copies of the same drawings to the Employer for further distribution and field use at Employer's end.

TABLE-1

Details of Material

Sl. No.	Name of Item	Material Treatment	Process of Standard	Reference	Remarks
1.	Security Clips	Stainless Steel/Phos pher Bronze	-	AISI 302 or 304-L/ IS-1385	
2.	Arcing Horn	Mild Steel Rod/Tube Type	Hot dip galvanised	As per IS-226- or IS-2062	
3.	Ball Fittings, Socket, All shackles, links, clevis,	Class-IV Steel	Drop forged& normalised Hot dip	As per IS: 2004	

			galvanised		
4.	Yoke Plate	Mild Steel	Hot dip galvanised	As per IS: 226/IS-2062	
5.	Sag Adjustment plate	Mild Steel	Hot dip galvanised	As per IS: 226/IS-2062	
6.	(a) Corona Control ring/Grading ring (220 kV)	High Strength Al. Alloy tube (6061/6063/1100 type or 65032/63400 Type)	Heat treated	ASTM-B429 or as per IS	Mech. strength of welded joint shall not be less than 20 KN
	(b) Supporting Brackets & Mounting Bolts	High Strength Al. alloy 6061/6063 65032/ 63400 Type) or Mild Steel	Heat treated or IS-2062 Hot dip galvanised	ASTM-B429 or as per IS:226	
7.	Free Center clamp/Envelope type Clamp				
	(a) Clamp Body/ Keeper Piece	High Strength Al. Alloy 4600/ LM-6 or 6061/65032	Casted or forged & Heat treated	IS:617 or ASTM-B429	
	(b) Cotter bolts, Hangers, Shackles, Brackets	Mild Steel	Hot dip galvanised	IS-226/IS-2062	
	(c) U Bolts	Stainless Steel or High Strength Al. alloy 6061/6063 or 65032/63400	Forged & heat treated	AISI 302 or 304-L ASTM-B429	
8.	P.A. Rod	High Strength Al. alloy type 6061/ 65032	Heat treatment during manufacturing	ASTM-B429	Min tensile strength of 35 kg/ mm^2
9.	AGS Clamp (a) Supporting	High Strength Corros	Cast/ forged	IS:617 or ASTM-B429	

House	-ion resistant AL. Alloy LM6, 4600 or 6061/65032	Heat treated	
(b) Al. Insert & Retaining strap	High Stren--gth Al. Alloy of type 6061/ 65032	forged & Heat treated	ASTM-B429 or as per IS
(c) Elastomer Cushion	Moulded on Al. reinforcement		
10. Dead End Assembly			
(a) Outer Sleeve	EC grade Al/Al purity not less than 99.50%	Alloy (for AACSR Al Alloy) of	
(c) Steel Sleeve	Mild Steel	Hot Dip Galvanised	As per IS:226/IS-2062
11. Balancing Weights	Cast Iron /MCI/Mach-ined Mild Steel	Hot dip galvanised	

Note: Alternate materials conforming to other national standards of other countries also may be offered provided the properties and compositions of these are close to the properties and compositions of material specified. Bidder should furnish the details of comparison of material offered visa a vis specified in the bid or else the bids are liable to be rejected.

2.0 Accessories for ACSR 'BISON' and AACSR 'BISON' Conductor

2.1 General

2.1.1 This portion (under Clause 2.0) details the technical particulars of the accessories for ACSR and AACSR 'BISON' Conductors.

2.1.2 2.5% extra fasteners, filler plugs and retaining rods shall be provided.

2.2 Mid Span Compression Joint

2.2.1 Mid Span Compression Joint shall be used for joining two lengths of conductor. The joint shall have a resistively less than 75% of the resistivity of equivalent length of conductor. The joint shall not permit slipping off, damage to or failure of the complete conductor or any part thereof at a load less than 95% of the ultimate tensile strength of the conductor.

2.2.2 The joint shall be made of steel and aluminium/aluminium alloy sleeves for jointing the steel core and aluminium/aluminium alloy wires respectively. The

steel sleeve should not crack or fail during compression. The Brinnel Hardness of steel sleeve shall not exceed 200. The steel sleeve shall be hot dip galvanized. The aluminium sleeve shall have aluminium of purity not less than 99.5%. Tapered aluminium filler plugs shall also be provided on the line of demarcation between compression and non compression zone.

2.3 Repair Sleeve

Repair Sleeve of compression type shall be used to repair conductor with not more than two strands broken in the outer layer. The sleeve shall be manufactured from 99.5% pure aluminium and shall have a smooth surface. The repair sleeve shall comprise of two pieces with a provision of seat for sliding of the keeper piece. The edges of the seat as well as the keeper piece shall be so rounded that the conductor strands are not damaged during installation.

2.4 Vibration Damper

2.4.1 Vibration dampers of 4R-stockbridge type with four (4) different resonances spread within the specified aeolian frequency band width corresponding to wind speed of 1 m/s to 7 m/s shall be used at suspension and tension points on each conductor in each span along with bundle spacers to damp out aeolian vibration as mentioned hereinafter.

2.4.2 Alternate damping systems or “Dogbone” dampers offering equivalent or better performance also shall be accepted provided the manufacturer meets the qualifying requirements stipulated in the Specifications. Relevant technical documents to establish the technical suitability of alternate systems shall be furnished by the Bidder along with the bid.

2.4.3 One damper minimum on each side per Conductor/Sub-conductor for suspension points and two dampers minimum on each side per conductor/sub-conductor for tension points shall be used for ruling design span of 350 meters for 220 kV.

2.4.4 The Bidder may offer damping system involving more number of dampers per ruling design span than the specified.

2.4.5 The clamp of the vibration damper shall be made of high strength aluminium alloy of type LM-6. It shall be capable of supporting the damper and prevent damage or chafing of the conductor during erection or continued operation. The clamp shall have smooth and permanent grip to keep the damper in position on the conductor without damaging the strands or causing premature fatigue failure of the conductor under the clamp. The clamp groove shall be in uniform contact with the conductor over the entire clamping surface except for the rounded edges. The groove of the clamp body and clamp cap shall be smooth, free from projections, grit or other materials which could cause damage to the conductor when the clamp is installed. Clamping bolts shall be provided with self locking nuts and designed to prevent corrosion of threads or loosening in service.

2.4.6 The messenger cable shall be made of high strength galvanized steel/stain less steel with a minimum strength of 135 kg/sq.mm. It shall be of preformed and post formed quality in order to prevent subsequent droop of weight and to maintain consistent flexural stiffness of the cable in service. The number of strands in the messenger cable shall be 19. The messenger cable, other than stainless steel shall

be hot dip galvanized in accordance with the recommendations of IS: 4826 for heavily coated wires.

2.4.7 The damper mass shall be made of hot dip galvanized mild steel/cast iron or a permanent mould cast zinc alloy. All castings shall be tree from defects such as cracks, shrinkage, inclusions and blowholes etc. The surface of the damper masses shall be smooth.

2.4.8 The damper clamp shall be cast over the messenger cable and offer sufficient and permanent grip on it. The messenger cable shall not slip out of the grip at a load less than the mass pull-off value of the damper. The damper masses made of material other-than zinc alloy shall be fixed to the messenger cable in a suitable manner in order to avoid excessive stress concentration on the messenger cables which shall cause premature fatigue failure of the same. The messenger cable ends shall be suitably and effectively sealed to prevent corrosion. The damper mass made of zinc alloy shall be cast over the messenger cable and have sufficient and permanent grip on the messenger cable under all service conditions.

2.4.9 The damper assembly shall be so designed that it shall not introduce radio interference beyond acceptable limits.

2.4.10 The vibration damper shall be capable of being installed and removed from energized line by means of hot line technique. In addition, the clamp shall be capable of being removed and reinstalled on the conductor at the designated torque without shearing or damaging of fasteners.

2.4.11 The contractor must indicate the clamp bolt tightening torque to ensure that the slip strength of the clamp is maintained between 2.5 kN and 5 kN. The clamp when installed on the conductor shall not cause excessive stress concentration on the conductor leading to permanent deformation of the conductor strands and premature fatigue failure in operation.

2.4.12 The vibration damper shall not have magnetic power loss more than 1 watt at 600 Amps. 50 Hz alternating current per sub-conductor when installed on a twin bundle system for 220 kV line.

2.4.13 The vibration analysis of the system, with and without damper and dynamic characteristics of the damper as detailed under Annexure-A, shall have to be submitted. The technical particulars for vibration analysis and damping design of the system are as follows:

Sl. No.	Description		Technical Particulars
			ACSR 'BISON'
1.	Span length in meters		
	(i) Ruling design span	:	350 meters
	(ii) Maximum span	:	1200 meters
	(iii)Minimum span	:	100 meters
2.	Configuration	:	Twin bundle conductor

			per phase in vertical configuration (D/C)
3.	Tensile load in each sub-conductor At temperature of 0 deg.C and still air	:	4144 Kgf
4.	Armour rods used	:	Standard preformed armour rods/AGS
5.	Maximum permissible dynamic strain	:	+/- 150 micro strains

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2.4.14 The damper placement chart for spans ranging from 100m to 1200m shall be submitted by the Bidder. Placement charts should be duly supported with relevant technical documents and sample calculations.

2.4.15 The damper placement charts shall include the following

(1) Location of the dampers for various combinations of spans and line tensions clearly indicating the number of dampers to be installed per conductor per span.

(2) Placement distances clearly identifying the extremities between which the distances are to be measured.

(3) Placement recommendation depending upon type of suspension clamps (viz Free center type/Armour grip type etc.)

(4) The influence of mid span compression joints, repair sleeves and armour rods (standard and AGS) in the placement of dampers.

2.5 **Bundle Spacer**

2.5.1 Armour grip bundle spacers shall be used to maintain the spacing of 450 mm between the two sub-conductors of each bundle under all normal working conditions.

2.5.2 Spacers offering equivalent or better performance shall also be accepted provided offer meets the qualifying requirements stipulated in the Specification.

2.5.3 The offer shall include placement charts recommending the number of spacers per phase per span and the sub span lengths to be maintained between the spacers while installing on the twin bundle conductors.

2.5.3.1 The placement of spacers shall be in such a way that adjacent sub spans are sufficiently detuned and the critical wind velocity of each sub span shall be kept more than 30 km/hr and to avoid clashing of sub conductors. The placement shall ensure bundle stability under all operating conditions.

2.5.3.2 The placement chart shall be provided for spans ranging from 100 m to 1200m. The number of spacers recommended for a ruling design span of 350m shall however be seven with no sub-span greater than 70m and no end sub-span longer than 40m.

2.5.3.3 The Bidder may offer more number of spacers per ruling design span than the specified.-

2.5.3.4 The Bidder shall also furnish all the relevant technical documents in support of their placement charts along with the bid.

2.5.4 Jumpers at tension points shall also be fitted with spacers so as to limit the length of free conductor to 3.65 m and to maintain the sub conductor spacing of 450 mm. Bidder shall quote for rigid spacer for jumper. It shall meet all the requirements of spacer used in line except for its vibration performance. Spacers requiring retaining rods shall not be quoted for jumpers.

2.5.5 The spacer offered by the Bidder shall satisfy the following requirements.

2.5.5.1 Spacer shall restore normal spacing of the sub conductors after displacement by wind, electromagnetic and the electrostatic forces under all operating conditions including the specified short circuit level without permanent deformation damage either to conductor or to the assembly itself. They shall have uniform grip on the conductor

2.5.5.2 For spacer requiring retaining rods, the retaining rods shall be designed for the specified conductor size. The preformed rods shall be made of high strength, special aluminium alloy of type 6061/65032 and shall have minimum tensile strength of 35 kg/sq.mm. The ends of retaining rods should be ball ended. The rods shall be heat-treated to achieve specified mechanical properties and give proper resilience and retain the same during service.

2.5.5.3 4 (Four) number of rods shall be applied on each clamp to hold the clamp in position. The minimum diameter of the rods shall be 7.87 $\pm$ 0.1 mm and the length of the rods shall not be less than 1100 mm.

2.5.5.4 Where elastomer surfaced clamp grooves are used, the elastomer shall be firmly fixed to the clamp. The insert should be forged from aluminium alloy of type 6061/65032. The insert shall be duly heat treated and aged to retain its consistent characteristics during service.

2.5.5.5 Any nut used shall be locked in an approved manner to prevent vibration loosening. The ends of bolts and nuts shall be properly rounded for specified corona performance or suitably shielded.

2.5.5.6 Clamp with cap shall be designed to prevent its cap from slipping out of position when being tightened.

2.5.5.7 The clam grooves shall be in uniform contact with the conductor over the entire surface, except for rounded edges. The groove of the clamp body and clamp cap shall be smooth and free of projections, grit or other material, which cause damage to the conductor when the clamp is installed.

2.5.5.8 For the spacer involving bolted clamps, the manufacturer must indicate the clamp bolt tightening torque to ensure that the slip strength of the clamp is maintained between 2.5 kN and 5 kN. The clamp when installed on the conductor shall not cause excessive stress concentration on the conductor leading to permanent deformation of the conductor strands and premature fatigue failure in operation.

2.5.5.9 Universal type bolted clamps, covering a range of conductor sizes, will not be permitted.

2.5.5.10 No rubbing, other than that of the conductor clamp hinges or clamp swing bolts, shall take place between any parts of the spacer. Joint incorporating a flexible medium shall be such that there is no relative slip between them.

2.5.5.11 The spacer shall be suitably designed to avoid distortion or damage to the conductor or to themselves during service.

2.5.5.12 Rigid spacers shall be acceptable only for jumpers.

2.5.5.13 The spacer shall not damage or chafe the conductor in any way which might affect its mechanical and fatigue strength or corona performance.

2.5.5.14 The clamping system shall be designed to compensate for any reduction in diameter of conductor due to creep.

2.5.5.15 The spacer assembly shall not have any projections, cuts, abrasions etc. or chattering parts which might cause corona or RIV.

2.5.5.16 The spacer tube shall be made of aluminium alloy of type 6061/65032. If fasteners of ferrous material are used, they shall conform to and be galvanized conforming to relevant Indian Standards. The spacer involving ferrous fasteners shall not have magnetic power loss more than one watt at 600 Amps 50 Hz alternating current per sub- conductor.

2.5.5.17 Elastomer, if used, shall be resistant to the effects of temperature up to 75deg.C, ultraviolet radiation and other atmospheric contaminants likely to be encountered in service. It shall have good fatigue characteristics. The physical properties of the elastomer shall be of approved standard.

2.5.5.18 The spacer assembly shall have electrical continuity. The electrical resistance between the sub-conductor across the assembly in case of spacer having elastomer clamp grooves shall be suitably selected by the manufacturers to ensure satisfactory electrical performance and to avoid deterioration of elastomer under all service conditions.

2.5.5.19 The spacer assembly shall have complete ease of installation and shall be capable of removal/reinstallation without any damage.

2.5.5.20 The spacer assembly shall be capable of being installed and removed from the energized line by means of hot line technique.

2.6 Material and Workmanship

2.6.1 All the equipment shall be of the latest proven design and conform to the best modern practice adopted in the extra high voltage field. The Bidder shall offer only such equipment as guaranteed by him to be satisfactory and suitable for 220 kV transmission line application with bundle conductors and will give continued good performance.

2.6.2 The design, manufacturing process and quality control of all the materials shall be such as to achieve requisite factor of safety for maximum working load, highest mobility, elimination of sharp edges and corners, best resistance to corrosion and a good finish.

2.6.3 All ferrous parts shall be hot dip galvanized, after all machining has been completed. Nuts may, however, be tapped (threaded) after galvanizing and the threads oiled. Spring washers shall be electro galvanized as per grade 4 of IS-1573-1970. The bolt threads shall be undercut to take care of increase in diameter due to galvanizing. Galvanizing shall be done in accordance with IS: 2629/IS-1367 (Part-13) and satisfy the tests mentioned in IS-2633. Fasteners shall withstand four dips while spring washers shall withstand three dips. Other galvanized materials shall have a minimum overall coating of Zinc equivalent to 600 gm/sq.m and shall be guaranteed to withstand at least six dips each lasting one minute under the standard Preece test for galvanizing unless otherwise specified.

2.6.4 The zinc coating shall be perfectly adherent, of uniform thickness, smooth, reasonably bright, continuous and free from imperfections such as flux, ash, rust stains, bulky white deposits and blisters. The zinc used for galvanizing shall be of grade Zn.99.95 as per IS: 209.

2.6.5 In case of castings, the same shall be free from all internal defects like shrinkage, inclusion, blow holes, cracks etc.

2.6.6 All current carrying parts shall be so designed and manufactured that contact resistance is reduced to minimum and localized heating phenomenon is averted.

2.6.7 No equipment shall have sharp ends or edges, abrasions or projections and shall not cause any damage to the conductor in any way during erection or during continuous operation which would produce high electrical and mechanical stresses in normal working. The design of adjacent metal parts and mating surfaces shall be such as to prevent corrosion of the contact surface and to maintain good electrical contact under all service conditions.

2.6.8 Particular care shall be taken during manufacture and subsequent handling to ensure smooth surface free from abrasion or cuts.

2.6.9 The fasteners shall conform to the requirements of IS: 6639. All fasteners and clamps shall have corona free locking arrangement to guard against vibration loosening.

2.7 Compression Markings

Die compression areas shall be clearly marked, on each equipment designed for continuous die compressions and shall bear the words 'COMPRESS FIRST' suitably inscribed on each equipment where the compression begins. If the equipment is designed for intermittent die compressions, it shall bear the identification marks 'COMPRESSION ZONE' and 'NON-COMPRESSION ZONE' distinctly with arrow mark showing the direction of compression and knurling marks showing the end of the zones. The letters, number and other markings on finished equipment shall be distinct and legible.

2.8 Bid Drawings

2.8.1 The Bidder shall furnish detailed dimensioned drawings of the equipments and all component parts. Each drawing shall be identified by a drawing number and Contract number. All drawings shall be neatly arranged. All drafting and lettering shall be legible. The minimum size of lettering shall be 3 mm. All dimensions and dimensional tolerances shall be mentioned in mm.

2.8.2 The drawings shall include

(i) Dimensions and dimensional tolerances

(ii) Material, fabrication details including any weld details and any specified finishes and coatings. Regarding material, designations and reference of standards are to be indicated.

(iii) Catalogue No.

(iv) Marking

(v) Weight of assembly

(vi) Installation instructions

(vii) Design installation torque for the bolt or cap screw

(viii) Withstand torque that may be applied to the bolt or cap screw without failure of component parts

(ix) The compression die number with recommended compression pressure.

(x) All other relevant technical details

2.8.3 Placement charts for spacer and damper

2.8.4 The above drawings shall be submitted in five copies with all the details as stated above along with the bid document. After the placement of award, the Contractor shall again submit the drawings in four copies to the Employer for approval. After Employer's approval and successful completion of all type tests, 10 (ten) more sets of drawings shall be submitted to Employer for further distribution and field use at Employer's end.

3.0 G.S. Earth wire Accessories

3.1 General

3.1.1 This portion Specify the details of the technical particulars of the accessories for Galvanized Steel Earth wire.

3.1.2 2.5% extra fasteners shall be supplied.

3.2 Mid Span Compression Joint

Mid Span Compression Joint shall be used for joining two lengths of earth wire. The joint shall be made of mild steel with aluminium encasing. The steel sleeve should not crack or fail during compression. The Brinnel Hardness of steel should not exceed 200. The steel sleeve shall be hot dip galvanized. The aluminium sleeve shall have aluminium of purity not less than 99.5%. Filler aluminium sleeve shall also be provided at the both ends. The joints shall not permit slipping off, damage to or failure of the complete earth wire or any part thereof at a load not less than 95% of the ultimate tensile strength of the earth wire. The joint shall have resistivity less than 75% of resistivity of equivalent length of earth wire. The dimensions and the dimensional tolerances of the joint shall be as per the table given below.

S. No.	Item	Dimensions before compression		Dimensions after compression		
		Inner dia. (mm)	Outer dia. (mm)	Length (mm)	Corner To Corner (mm)	Face to Face
	7/3.35 G.S. Earthwire					
1.	Aluminium Sleeve	22±0.5	32±0.5	400±5	29.4±0.5	25.0±0.5
2.	Steel Sleeve	11.5±0.2	21±0.5	230±5	20.2±0.5	17.5±0.5
3.	Filler Aluminium Sleeve	11.5±0.2	21±0.5	60±5		

3.3 Vibration Damper

3.3.1 Vibration dampers of 4R-Stockbridge type with four (4) different frequencies spread within the specified aeolian frequency band-width corresponding to wind speed of M/s to 7 m/s shall be used for suspension and tension points on each earth wire in each span to damp out aeolian vibrations as mentioned herein after.

3.3.2 Alternate damping systems or “Dogbone” dampers offering equivalent or better performance also shall be acceptable provided the manufacturer meets the qualifying requirements stipulated in the Specifications. Relevant technical documents to establish the technical suitability of alternate systems shall be furnished by the Bidder along with the bid.

3.3.3 One damper minimum on each side per earth wire at suspension points and two dampers on each side per earth wire at tension points shall be used for ruling design span of 350 meters for 220 kV line.

3.3.4 The Bidder may offer damping system involving more number of dampers per ruling design span than the specified.-

3.3.5 The clamp of the vibration damper shall be made of aluminium alloy. It shall be capable of supporting the damper during installation and prevent damage or chafing of the earth wire during erection or continued operation. The clamp shall have smooth and permanent grip to keep the damper in position on the earth wire without damaging the strands or causing premature fatigue failure of the earth wire under the clamp. The clamp groove shall be in uniform contact with the earth wire over the entire clamping surface except for the rounded edges. The groove of the clamp body and clamp cap shall be smooth, free from projections, grit or materials which could cause damage to the earth wire when the clamp is installed. Clamping bolts shall be provided with self locking nuts designed to prevent corrosion of the threads or loosening during service.

3.3.6 The messenger cable shall be made of high strength galvanized steel/stainless steel with a minimum strength of 135 Kg/sq.mm. It shall be of preformed and post formed quality in order to prevent subsequent droop of weights and to maintain consistent flexural stiffness of the cable in service. The number of standards in the messenger cable shall be 19. The messenger cable ends shall be suitably and effectively sealed to prevent corrosion.

3.3.7 The damper mass shall be made of hot dip galvanized mild steel/cast iron or a permanent mould cast zinc alloy. All castings shall be free from defects such as cracks, shrinkages, inclusions and blow holes etc. The inside and outside surfaces of the damper masses shall be smooth.

3.3.8 The vibration analysis of the system, with and without damper, dynamic characteristic of the damper as detailed under Annexure-A, shall have to be submitted by the Bidder along with his bid. The technical particulars for vibration analysis and damping design of the system are as follows:

Sl. No.	Description		Technical Particulars
			220 kV
1.	Span length in meters		
	(i) Ruling design span	:	350 meters
	(ii) Maximum span	:	1200 meters
	(iii) Minimum span	:	100 meters
2.	Tensile load in each earth wire at temperature of 0° C and still air	:	1340 Kgf

3.	Tensile load in each earth wire at temperature of 32° C and full wind	:	2620 Kgf
4.	Maximum permissible dynamic strain	:	±150 micro strains

3.3.9 The damper placement chart for spans ranging from 100 m to 1200 m shall be submitted by the Bidder. All the placement charts should be duly supported by relevant technical documents.

3.3.10 The damper placement charts shall include the following:

(1) Location of the dampers for various combinations of spans and line tensions clearly indicating number of dampers to be installed per earth wire per span.

(2) Placement distances clearly identifying the extremities between which the distances are to be measured.

(3) Placement recommendation depending upon type of suspension clamps (viz, free center type/trunion type etc.)

(4) The influence of mid span compression joints in the placement of dampers.

3.4 Flexible Copper Bond

The flexible copper bond shall be circular in cross-section of minimum 34 sq.mm equivalent copper area and not less than 500 mm in length. It shall consist of 259 wires of 0.417 mm dia. tinned copper conductor. It shall be laid up as 7 stranded ropes, each of 37 bunched wires. The tinning shall be as per relevant Indian Standard. Two tinned copper connecting lugs shall be press jointed to either ends of the flexible copper cable. One lug shall be suitable for 12 mm, dia. bolt and the other for 16 mm dia bolt. The complete assembly shall also include one 16 mm dia., 40 mm long HRH MS Bolt hot dip galvanized with nut and lock washer.

3.5 Suspension Clamp

3.5.1 Standard anchor shackle/twisted shackle for earth wire suspension clamp shall be supplied for attaching to the hanger plate of tower.

3.5.2 At all suspension towers, suitable suspension clamps shall be used to support the earth wire of 7/3.35 mm size for 220KV. The clamps shall be of either free center type or trunion type and shall provide adequate area of support to the earth wire. The groove of the clamp shall be smooth, finished in an uniform circular or oval shape and shall slope downwards in a smooth curve to avoid edge support and hence to reduce the intensity of bending moment on earth wire.

3.5.3 There shall be no sharp point in the clamps coming in contact with earth wire. There shall not be any displacement in the configuration of the earth wire strands

nor shall the strands be unduly stressed in final assembly during working conditions.

3.5.4 The clamping piece and the clamp body shall be clamped by at least two U-bolts of size not less than 10 mm diameter having one nut and one 3 mm thick lock nut with washer on each of its limbs. Suspension clamps shall be provided with inverted type U-bolts. One limb of the U-bolt shall be long enough to accommodate the lug of the flexible copper bond.

3.5.5 The Contractor shall supply all the components of the suspension assembly including shackles, bolts, nuts, washers, split pin etc. The total drop of the suspension assembly from the center point of the attachment to the center point of the earth wire shall not exceed 150 mm. The design of the assembly shall be such that the direction of run of the earth wire shall be same as that of the conductor.

3.5.6 The complete assembly shall be guaranteed for slip strength of not less than 12 kN and not more than 17 kN. The breaking strength of the assembly shall not be less than 25 kN.

3.6 Tension Clamp

3.6.1 At all tension towers suitable compression type tension clamps shall be used to hold 7/3.35 mm galvanized steel earth wire for 220KV. Anchor shackle shall be supplied which shall be suitable for attaching the tension clamp to strain plates.

3.6.2 The clamps shall have adequate area of bearing surface to ensure positive electrical and mechanical contact and shall not permit any slip to the earth wire under working tension and vibration conditions. The angle of jumper terminal to be mounted should be 30 deg. with respect to the vertical line.

3.6.3 The clamps shall be made of mild steel with aluminium encasing. The steel should not crack or fail during compression. The Brinnel hardness of steel sleeve shall not exceed 200. The steel sleeve shall be hot dip galvanized. The aluminium encasing shall have aluminium of purity not less than 99.5%. Filler aluminium sleeve shall also be provided at the end.

3.6.4 The complete assembly shall be so designed as to avoid undue bending in any part of the clamp and shall not produce any hindrance to the movements of the clamps in horizontal or vertical directions.

3.6.5 The slip strength of the assembly shall not be less than 95% of the ultimate strength of the earth wire.

3.6.6 The clamps shall be complete with all the components including anchor shackle, bolts, nuts, washers, split pin, jumper arrangement etc.

3.7 Material and Workmanship

Same as Clause 2.6 of this section

3.8 Compression Marking

Same as Clause 2.7 of this section

3.9 Bid Drawings

Same as Clause 2.8 of this section

4.0 Tests and Standards

4.1 Type Tests

4.1.1 On the complete Insulator String with Hardware Fittings (ref Insulator section)

4.1.2 On Suspension Hardware Fitting only

(a)	Magnetic power loss test for suspension assembly	
(b)	Clamp slip strength Vs torque test for suspension clamp	Annexure-A
(c)	Mechanical strength Test	
(d)	OZONE Test on elastomer	
e)	Shore hardness test of elastomer cushion for AG suspension clamp	
(f)	Bend test for armour rod set	IS:2121-(Part-I), Clause 7.5, 7.10, 7.11
(g)	Resilience test for armour rod set	
(h)	Conductivity test for armour rods set	IS:2121-(Part-I) - Clause7.5,7.10, 7.11
(i)	Visual Examination	IS: 2486-(Part-I),
(j)	Verification of dimensions	
(k)	Galvanizing/Electroplating test	
(l)	Mechanical strength test of each component (excluding corona control rings/ grading ring and arcing horn)	Annexure-A
(m)	Mechanical Strength test of welded joint	
(n)	Test on locking device for ball and	

	socket coupling	)	IEC: 60372 (2)
4.1.3	On Tension Hardware fittings only		
	(a) Electrical resistance test for dead end Assembly	)))	
	(b) Heating cycle test for dead- end Assembly	)))	IS: 2486-(Part-I), Clause 5.4&5.6
	(c) Slip strength test for dead-end Assembly	))	
	(d) Mechanical strength test	)	Annexure-A
	(e) Visual Examination	)	IS: 2486-(Part-I),
	(f) Verification of dimensions	))	
	(g) Galvanizing/Electroplating test	)	
4.1.4	Mid Span Compression Joint for Earth wire		
	(a) Chemical analysis of materials	))	Annexure - A
	(b) Electrical resistance test	))	IS:2121-(Part-II), Clause 6.5&6.6
	(d) Slip strength test	))	Annexure - A
4.1.5	Flexible Copper Bond		
	(a) Slip Strength Test	)	Annexure-A
4.1.6	Vibration Damper for Conductor & Earth wire		
	(a) Chemical analysis of materials	)	
	(b) Dynamic characteristics test	))	
	(c) Vibration analysis	))	Annexure-A
	(d) Clamp slip test	))	
	(e) Fatigue tests	)	
	(f) Damper Efficiency test	)	IS: 9708

	(g) Magnetic Power loss test	)	Annexure – A
	(h) Corona extinction voltage test (Dry)	)	
	(i) Radio interference voltage test (Dry)	)	
4.1.7	Bundle Spacer		
	(a) Chemical analysis of materials	)	
	(b) Clamp slip test	)	
	(c) Vibration test	)	
	(i) Vertical vibration	)	
	(ii) Longitudinal vibration	)	Annexure - A
	(iii) Sub span Oscillation	)	
	(d) Ozone Test	)	
	(e) Magnetic Power loss Test	)	
	(f) Corona Extinction Voltage Test (Dry)	)	
	(g) Radio Interference Voltage Test (Dry)	)	Annexure - A
	(h) Compression - Tension Test	)	
4.1.8	Rigid Spacer for Jumper (For ACSR 'BISON')		
	(a) Chemical analysis of materials	)	
	(b) Clamp slip test	)	Annexure - A
	(c) Magnetic power loss test (if applicable)	)	
	(d) Tension compression test	)	
	(e) Corona extinction voltage test (dry)	)	Annexure - A
	(f) Radio interference voltage test (dry)	)	
4.1.9	Earth wire Suspension Clamp Assembly		
	(a) Chemical analysis of materials	)	
	(b) Mechanical strength test	)	Annexure-A

	(c)	Clamp slip strength Vs Torque test for Suspension assembly	
	(d)	Visual examination and Dimensional verification	IS: 2121-(Part-II)
4.1.10		Earth wire Tension Clamp Assembly	
	(a)	Chemical analysis of materials	
	(b)	Mechanical strength	Annexure - A
		test (excluding clamp)	Annexure - A
	(c)	Slip strength test on tension assembly	
	(d)	Electrical resistance test on tension clamp	
	(e)	Visual examination and dimensional verification	IS: 2121-(Part-II)

4.1.11 The magnetic power loss test specified under clause no. 4.1.2 (a) shall be conducted on Single I suspensions and Single suspension pilot assembly.

4.1.12 Heating cycle test on dead end assembly, mid span compression joint for Conductor and performance test on dampers shall not be required to be carried out if a valid test certificate is available for a similar design, i.e., test conducted earlier should have been conducted in accredited laboratory (accredited based on ISO/IEC guide 25/17025 or EN 45001 by the National Accreditation body of the country where laboratory is located) or witnessed by the representative of NEA. The test reports submitted shall be for tests conducted within the last 5 (five) years prior to the date of Bid opening.

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

4.2 Acceptance Tests

4.2.1 On Both Suspension and Tension Hardware Fittings

	(a)	Visual Examination	IS: 2486-(Part-I), Clause 5.8 & 5.9
	(b)	Verification of dimensions	
	(c)	Galvanizing/Electroplating test	

	(d)	Mechanical strength test of each component (excluding corona control rings/ grading ring and arcing horn)	Annexure-A
	(e)	Mechanical Strength test of welded joint	
	(f)	Mechanical strength test for corona control rings/ grading ring and arcing horn	BS: 3288- (Part-I), Clause 7.3.2
	(g)	Test on locking device for ball and socket coupling	IEC:372 (2)
	(h)	Chemical analysis, hardness tests, grain size, inclusion rating & magnetic particle inspection for forgings/castings	Annexure - A
	(i)	Assembly test	
4.2.2	On Suspension Hardware Fitting only		
	(a)	Clamp Slip strength Vs Torque test for suspension clamp	Annexure-A
	(b)	Shore hardness test of elastomer cushion for AG suspension clamp	
	(c)	Bend test for armour rod set	IS: 2121-(Part-I), Clause 7.5, 7.10, 7.11
	(d)	Resilience test for armour rod set	IS: 2121-(Part-I) - Clause7.5, 7.10, 7.11
	(e)	Conductivity test for armour rods set	
4.2.3	On Tension Hardware Fittings Only		
	(a)	Slip strength test for dead- end assembly	IS: 2486 (Part-I) Clause 5.4
4.2.4	Mid Span Compression Joint for Earth wire		
	(a)	Visual examination and Dimensional verification	IS: 2121-(Part-II)- Clause 6.2, 6.3 and 6.7
	(b)	Galvanising test	

		)	Annexure - B
	(c) Hardness test	)	
	(d) Slip strength test	)	IS: 2121-(Part-II)
4.2.5	Flexible Copper Bond		
	(a) Visual examination and Dimensional verification	))	IS: 2121-(Part-II)- Clause 6.2, 6.3
	(b) Slip strength test	)	Annexure - B
4.2.6	Vibration Damper for Conductor & Earthwire		
	(a) Visual examination and dimensional verification	))))	IS: 2121-(Part- II)- Clause 6.2, 6.3
	(b) Galvanizing test	)	and 6.7
	(i) On damper masses	))	
	(ii) On messenger cable	))	
	(c) Verification of resonance frequencies	))	
	(d) Clamp slip	))	
	(e) Clamp bolt torque test	))	
	(f) Strength of the messenger cable	)))	Annexure - B
	(g) Mass pull off test	))	
	(h) Dynamic characteristics test	)	
4.2.7	Spacer for Conductor/Spacer for jumper		
	(a) Visual examination and Dimensional verification	)))	IS: 2121-(Part-II)- Clause 6-2, 6.3 and 6.7
	(b) Galvanizing test	))	
	(c) Movement test (except for spacers for jumpers)	))	Annexure-B
	(d) Clamp slip test	))	
	(e) Clamp bolt torque test	))	Annexure -B

	(f)	Compressive and tensile test	)	
			)	
	(g)	Assembly torque test	)	
			)	
	(h)	Hardness test for Elastomer (if applicable)	)	Annexure-B
4.2.8	Earth wire Suspension Clamp Assembly			
	(a)	Visual examination and Dimensional verification	)	IS: 2121-(Part-II)
	(b)	Galvanizing test	)	
	(c)	Clamp slip strength test	)	Annexure - A
	(d)	Mechanical strength test on each component	)	
	(e)	Chemical analysis of materials	)	
4.2.9	Earth wire Tension Clamp Assembly			
	(a)	Visual examination and Dimensional verification	)	IS: 2121(Part-II)
	(b)	Galvanizing test	)	
	(c)	Slip strength test for tension clamp	)	
	(d)	Mechanical strength test on each component (excluding clamp)	)	Annexure - A
	(e)	Hardness test	)	
	(f)	Chemical analysis of materials	)	
4.3	**Routine Tests**			
4.3.1	for Hardware Fittings			
	(a)	Visual examination	)	IS: 2486-(Part-I)
	(b)	Proof Load Test	)	Annexure - A
4.3.2	For Conductor and Earth wire Accessories			
	(a)	Visual examination and Dimensional verification	)	IS: 2121-(Part-II) Clause 6.2 & 6.3
4.4	**Tests during Manufacture**			
	On all components as applicable			
	(a)	Chemical analysis of Zinc used for	)	

	galvanizing	)	
		)	
(b)	Chemical analysis, mechanical metallographic test and magnetic particle inspection for malleable castings.	)))))	Annexure-A
(c)	Chemical analysis, hardness tests and magnetic particle inspection for forgings	))	

4.5 Testing Expenses

4.5.1 Testing charges for the type test specified shall be indicated separately in the prescribed schedule.

4.5.2 Bidder shall indicate charges for all type tests covered under Clause No. 4.1.2 to 4.1.10 separately. The charges for each type test shall be separately indicated.

4.5.3 For type tests which involve the tests on the complete insulator string with hardware fittings, the sub-vendor of hardware fittings shall supply the necessary number of sets of hardware fittings at the place of testing free of cost.

4.5.4 In case of failure in any type test, the Bidder whose material has failed is either required to modify the design of the material & successfully carryout all the type tests as has been detailed out in Clause 4.1 of this specification or to repeat that particular type test at least three times successfully at his own expenses. In case of failure of the complete string in any type test, the manufacturer whose product has failed in the test shall get the test repeated at his cost. The Supplier whose material has not failed in the test shall be required to supply the requisite quantity of material (that is, insulator discs or hardware fittings as the case may be) required for repeat testing at the place of testing and the cost of supply shall be borne by the sub-vendor whose material has failed in testing.

4.5.5 Bidder shall indicate the laboratories in which they propose to conduct the type tests. They shall ensure that adequate facilities for conducting the tests are available in the laboratory and the tests can be completed in these laboratories within the time schedule guaranteed by them in the appropriate schedule.

4.5.6 The entire cost of testing for acceptance and routine tests and tests during manufacture specified herein shall be treated as included in the quoted Ex-works/CIF Price.

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

4.5.8 The Contractor shall intimate the Employer about carrying out of the type tests along with detailed testing programme at least 3 weeks in advance (in case of Domestic Contractor and at least 6 weeks advance in case of Foreign Contractor)

of the scheduled date of testing during which the Employer will arrange to depute his representative to be present at the time of carrying out the tests.

4.6 Sample Batch For Type Testing

4.6.1 The Contractor shall offer material for sample selection for type testing only after getting Quality Assurance Programme approved by the Employer. The Contractor shall offer at least three times the quantity of materials required for conducting all the type tests for sample selection. The sample for type testing will be manufactured strictly in accordance with the Quality Assurance Programme approved by the Employer.

4.6.2 Before sample selection for type testing the Contractor shall be required to conduct all the acceptance tests successfully in presence of Employer's representative.

4.7 Schedule of Testing and Additional Tests

4.7.1 The Bidder has to indicate the schedule of following activities in their bids

(a) Submission of drawing for approval.

(b) Submission of Quality Assurance programme for approval.

(c) Offering of material for sample selection for type tests.

(d) Type testing.

4.7.2 The Employer reserves the right of having at his own expense any other test(s) of reasonable nature carried out at Contractor’s premises, at site, or in any other place in addition to the aforesaid type, acceptance and routine tests to satisfy himself that the material comply with the specifications.

4.7.3 The Employer also reserves the right to conduct all the tests mentioned in this specification at his own expense on the samples drawn from the site at Contractor’s premises or at any other test center. In case of evidence of non compliance, it shall be binding on the part of Contractor to prove the compliance of the items to the technical specifications by repeat tests, or correction of deficiencies, or replacement of defective items, all without any extra cost to the Employer.

4.8 Co-ordination for testing

This being a turn-key contract, the Contractor shall have to co-ordinate testing of its hardware fittings with insulators, which may be supplied by other manufacturer.

4.9 Test Reports

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

4.9.2 Copies of acceptance test report shall be furnished in at least six copies. One copy shall be returned, duly certified by the Employer, only after which the materials will be dispatched.

4.9.3 Record of routine test report shall be maintained by the Contractor at his works for periodic inspection by the Employer's representative.

4.9.4 Test certificates of tests during manufacture shall be maintained by the Contractor. These shall be produced for verification as and when desired by the Employer.

4.10 Inspection

4.10.1 The Employer's representative shall at all times be entitled to have access to the works and all places of manufacture, where the material and/or its component parts shall be manufactured and the representatives shall have full facilities for unrestricted inspection of the Contractor's, sub-Contractor's works raw materials, manufacturer's of all the material and for conducting necessary tests as detailed herein.

4.10.2 The material for final inspection shall be offered by the Contractor only under packed condition as detailed in clause 4.11 of this part of the Specification. The engineer shall select samples at random from the packed lot for carrying out acceptance tests.

4.10.3 The Contractor shall keep the Employer informed in advance of the time of starting and of the progress of manufacture of material in its various stages so that arrangements could be made for inspection.

4.10.4 Material shall not be dispatched from its point of manufacture before it has been satisfactorily inspected and tested unless the inspection is waived off by the Employer in writing. In the latter case also the material shall be dispatched only after all tests specified herein have been satisfactorily completed.

4.10.5 The acceptance of any quantity of material shall in no way relieve the Contractor of his responsibility for meeting all the requirements of the Specification, and shall not prevent subsequent rejection, if such materials are later found to be defective.

4.11 Packing and Marking

4.11.1 All material shall be packed in strong and weather resistant wooden cases/crates. The gross weight of the packing shall not normally exceed 200 Kg to avoid handling problems.

4.11.2 The packing shall be of sufficient strength to withstand rough handling during transit, storage at site and subsequent handling in the field.

4.11.3 Suitable cushioning, protective padding, dunnage or spacers shall be provided to prevent damage or deformation during transit and handling.

4.11.4 Bolts, nuts, washers, cotter pins, security clips and split pins etc. shall be packed duly installed and assembled with the respective parts and suitable measures shall be used to prevent their loss.

4.11.5 Each component part shall be legibly and indelibly marked with trade mark of the manufacturer and year of manufacture.

4.11.6 All the packing cases shall be marked legibly and correctly so as to ensure safe arrival at their destination and to avoid the possibility of goods being lost or wrongly dispatched on account of faulty packing and faulty or illegible markings. Each wooden case/crate shall have all the markings stenciled on it in indelible ink.

4.12 Standards

4.12.1 The Hardware fittings; conductor and earth wire accessories shall conform to the following Indian/International Standards which shall mean latest revisions, with amendments / changes adopted and published, unless specifically stated otherwise in the Specification.

4.12.2 In the event of the supply of hardware fittings; conductor and earth wire accessories conforming to standards other than specified, the Bidder shall confirm in his bid that these standards are equivalent to those specified. In case of award, salient features of comparison between the Standards proposed by the Contractor and those specified in this document will be provided by the Contractor to establish their equivalence.

Sl. No.	Indian Standard	Title	International Standards
1.	IS : 209	Specification for Zinc	BS:3436-1986
2.	IS : 398 - Part-V	Aluminium Conductor Galvanized Steel-Reinforced for Extra High Voltage (400 KV) and above	IEC:1089-1991
3.	IS 1573	Electroplated Coating of Zinc on iron and Steel	
4.	IS : 2121	Specification for Conductor and Earth-wire Accessories for Overhead Power lines	
	Part-I	Mid-span Joints and Repair Sleeves for Conductors	
5.	IS: 2486	Specification for Insulator Fittings for Overhead power Lines with Nominal Voltage greater than 1000 V	
	Part-I	General Requirements and Tests	
6.	IS: 2629	Recommended Practice for Hot Dip Galvanizing of Iron and Steel	

7.	IS: 2633	Method of Testing Uniformity of Coating on Zinc Coated Articles	
8.		Ozone test on Elastomer	ASTM-D1171
9.		Tests on insulators of Ceramic material or glass for overhead lines with a nominal voltage greater than 1000V	IEC: 383-1993
10.	IS: 4826	Galvanized Coating on Round Steel Wires	ASTMA472-729 BS:443-1969
11.	IS: 6745	Methods of Determination of Weight of Zinc Coating of Zinc Coated Iron and Steel Articles	BS: 433-1969 ISO : 1460 (E)
12.	IS: 8263 Interference Tests on High Voltage Insulators	Method of Radio NEMA: 107-1964 CISPR	IEC:437-1973
13.	IS: 6639	Hexagonal Bolts for Steel Structures	ISO/R 272-1968
14.	IS: 9708	Specification for Stock Bridge Vibration Dampers for Overhead Power Lines	
15.	IS: 10162	Specification for Spacers Dampers for Twin Horizontal Bundle Conductors	

ANNEXURE - A

1.0 Tests on Complete Strings with Hardware Fittings (Refer Insulator Section)

2.0 Tests on Hardware Fittings

2.1 Magnetic Power Loss Test for Suspension Assembly

For Twin bundle "BISON" two hollow aluminium tubes of 32 mm diameter shall be placed 450 mm apart. An alternating current over the range of 400 to 800 Amps, shall be passed through each tube. The reading of the wattmeter with and without two suspension assemblies along with line side yoke plate, clevis eye shall be recorded. Not less than three suspension assemblies shall be tested. The average power loss for suspension assembly shall be plotted for each value of current. The value of the loss corresponding to 600 amperes for 220 kV line, shall be read off from the graph.

2.2 Galvanizing/Electroplating Test

The test shall be carried out as per Clause no. 5.9 of IS: 2486-(Part-1) except that both uniformity of zinc coating and standard Preecee test shall be carried out and the results obtained shall satisfy the requirements of this specification.

2.3 Mechanical Strength Test of Each Component

Each component shall be subjected to a load equal to the specified minimum ultimate tensile strength (UTS) which shall be increased at a steady rate to 67% of the minimum UTS specified. The load shall be held for five minutes and then removed. The component shall then again be loaded to 50% of UTS and the load shall be further increased at a steady rate till the specified UTS and held for one minute. No fracture should occur. The applied load shall then be increased until the failing load is reached and the value recorded.

2.4 Mechanical Strength Test of Welded Joint

The welded portion of the component shall be subjected to a Load of 2000 kgs for one minute. Thereafter, it shall be subjected to die-penetration/ultrasonic test. There shall not be any crack at the welded portion.

2.5 Clamp Slip Strength Vs Torque Test for Suspension Clamp

The suspension assembly shall be vertically suspended by means of a flexible attachment. A suitable length of ACSR 'BISON" Conductor shall be fixed in the clamp. The clamp slip strength at various tightening torques shall be obtained by gradually applying the load at one end of the conductor. The Clamp slip strength vs. torque curve shall be drawn. The above procedure is applicable only for free center type suspension clamp. For AG suspension clamp only clamp slip strength after assembly shall be found out.

2.6 Shore Hardness Test for Elastomer Cushion for AG Suspension Assembly

The shore hardness at various points on the surface of the elastomer cushion shall be measured by a shore hardness meter and the shore hardness number shall be between 65 to 80.

2.7 Proof Load Test

Each component shall be subjected to a load equal to 50% of the specified minimum ultimate tensile strength which shall be increased at a steady rate to 67% of the UTS specified. The load shall be held for one minute and then removed. After removal of the load the component shall not show any visual deformation.

2.8 Tests for Forging Casting and Fabricated Hardware

The chemical analysis, hardness test, grain size, inclusion rating and magnetic particle inspection for forging, castings and chemical analysis and proof load test for fabricated hardware shall be as per the internationally recognized procedures for these tests. The sampling will be based on heat number and heat treatment batch. The details regarding test will be as in the Quality Assurance programme.

2.9 Mechanical Strength Test for Suspension/Tension Hardware Fittings

The complete string without insulators excluding arcing horn, corona control rings/grading ring and suspension assembly/dead end assembly shall be subjected to a load equal to 50% of the specified minimum ultimate tensile strength (UTS) which shall be increased at a steady rate to 67% of the minimum UTS specified. This load shall be held for five minutes and then removed. After removal of the load, the string component shall not show any visual deformation and it shall be possible to disassemble them by hand. Hand tools may be used to remove cotter pins and loosen the nuts initially. The string shall then be reassembled and loaded to 50% of UTS and the load shall be further increased at a steady rate till the specified minimum UTS is reached and held for the one minute. No fracture should occur during this period. The applied load shall then be increased until the failing load is reached and the value recorded.

2.10 Ozone Test for Elastomer

This test shall be performed in accordance with ASTM D-1171 by the Ozone chamber exposure method (method B). The test duration shall be 500 hours and the ozone concentration 50 PPHM. At the test completion, there shall be no visible crack under a 2 x magnification.

3.0 Tests on Conductor and Earth wire Accessories

3.1 Mid Span Compression Joint for Conductor and Earth wire

(a) Slip Strength Test

The fitting compressed on conductor/earth wire shall not be less than one meter in length. The test shall be carried out as per IS:2121 (Part-II) clause 6.4 except that the load shall be steadily increased to 95% of minimum ultimate tensile strength of conductor/earth wire and retained for one minute at this load. There shall be no movement of the conductor/ earth

wire relative to the fittings and no failure of the fit tings during this one minute period.

3.2 Flexible Copper Bond

Slip Strength Test

On applying a load of 3 kN between the two ends, stranded flexible copper cable shall not come out of the connecting lugs and none of its strands shall be damaged. After the test, the lugs shall be cut open to ascertain that the gripping of cable has not been affected.

3.3 Vibration Damper for Conductor and Earth wire

(a) Dynamic Characteristics, Test

The damper shall be mounted with its clamp tightened with torque recommended by the manufacturer on shaker table capable of simulating sinusoidal vibrations for aeolian vibration frequency band ranging from 5 to 40 Hz for damper for 'BISON' conductor, and 10 to 60 Hz for damper for earth wire. The damper assembly shall be vibrated vertically with a ± 1 mm amplitude from 5 to 15 Hz frequency and beyond 15 Hz at ± 0.5mm to determine following characteristics with the help of suitable recording instruments:

(i) Force Vs frequency

(ii) Phase angle Vs frequency

(iii) Power dissipation Vs frequency

The Force Vs frequency curve shall not show steep peaks at resonance frequencies and deep troughs between the resonance frequencies. The resonance frequencies shall be suitably spread within the aeolian vibration frequency-band between the lower and upper dangerous frequency, limits determined by the vibration analysis of conductor/earth wire without dampers.

Acceptance criteria for vibration damper:

(i) The above dynamic characteristics test on five damper shall be conducted.

(ii) The mean reactance and phase angle Vs frequency curves shall be drawn with the criteria of best fit method.

(iii) The above mean reactance response curve should lie within following limits:

V.D. for "BISON" - 0.191 f to 0.762 f kgf/mm

V.D. for "7/3.35" Earth wire - 0.060 f to 0.357 f kgf/mm

Where, f is frequency in Hz.

(iv) The above mean phase angle response curve shall be between 25^{o} to 130^{o} within the frequency range of interest.

(v) If the above curve lies within the envelope, the damper design shall be considered to have successfully met the requirement.

(vi) Visual resonance frequencies of each mass of damper is to be recorded and to be compared with the guaranteed values.

(b) Vibration Analysis

The vibration analysis of the conductor/earthwire shall be done with and without damper installed on the span. The vibration analysis shall be done on a digital computer using energy balance approach. The following parameters shall be taken into account for the purpose of analysis :

(i) The analysis shall be borne for single conductor/earthwire without armour rods as per the parameters given under clause 2.5.13 and 3.3.8 of this part of the Specification. The tension shall be taken as 43 kN and 14 kN for ACSR 'BISON' conductor and 7/3.35 mm earthwire respectively for a span ranging from 100 m to 1200 m.

(ii) The self damping factor and flexural stiffness (El) for conductor and earthwire shall be calculated on the basis of experimental results. The details of experimental analysis with these data should be furnished.

(iii) The power dissipation curve obtained from Dynamic Characteristics Test shall be used for analysis with damper.

(iv) Examine the aeolian vibration level of the conductor/earthwire with and without vibration damper installed at the recommended location or wind velocity ranging from 0 to 30 Km per hour, predicting amplitude, frequency and vibration energy input.

(v) From vibration analysis of conductor/earthwire without damper, antinode vibration amplitude and dynamic strain levels at clamped span extremities as well as antinodes shall be examined and thus lower and upper dangerous frequency limits between which the aeolian vibration levels exceed the specified limits shall be determined.

(vi) From vibration analysis of conductor/earthwire with damper/dampers installed at the recommended location, the dynamic strain level, at the clamped span extremities, damper attachment point and the antinodes on the conductor/earthwire shall be determined. In addition to above damper clamp vibration amplitude and antinode vibration amplitudes shall also be examined.

The dynamic strain levels at damper attachment points, clamped span extremities and antinodes shall not exceed the specified limits. The damper vibration amplitude shall not be more than that of the specified fatigue limits.

(c) Clamp Slip and Fatigue Tests

(i) Test Set Up

The clamp slip and fatigue tests shall be conducted on a laboratory set up with a minimum effective span length of 30 m. The ACSR 'BISON' conductor shall be tensioned at 43 kN, 7/3.35 mm earthwire at 14 kN and shall not be equipped with protective armour rods at any point. Constant tension shall be maintained within the span by means of lever arm arrangement. After the conductor/earthwire has been tensioned, clamps shall be installed to support the conductor/earthwire at both ends and thus influence of connecting hardware fittings are eliminated from the free span. The clamps shall not be used for holding the tension on the conductor/earthwire. There shall be no loose parts, such as suspension clamps, U bolts on the test span supported between clamps mentioned above. The span shall be equipped with vibration inducing equipment suitable for producing steady standing vibration. The inducing equipment shall have facilities for step less speed control as well as step less amplitude arrangement. Equipment shall be available for measuring the frequency, cumulative number of cycles and amplitude of vibration at any point along the span.

(ii) Clamp Slip test

The vibration damper shall be installed on the test span. The damper clamp, after lightning with the manufacturer's specified tightening torque, when subjected to a longitudinal pull of 2.5 kN parallel to the axis of conductor/earthwire for a minimum duration of one minute shall not slip i.e. the permanent displacement between conductor/earthwire and clamp measured after removal of the load shall not exceed 1.0 mm. The load shall be further increased till the clamp starts slipping. The load at which the clamp slips shall not be more than 5 kN.

(iii) Fatigue Test

The vibration damper shall be installed on the test span with the manufacturer's specified tightening torque. It shall be ensured that the damper shall be kept minimum three loops away from the shaker to eliminate stray signals influencing damper movement.

The damper shall then be vibrated at the highest resonant frequency of each damper mass. For dampers involving torsional resonant frequencies, tests shall be done at torsional modes also in addition to the highest resonant frequencies at vertical modes. The resonance frequency shall be identified as the frequency at which each damper mass vibrates with the maximum amplitude on itself. The amplitude of vibration of the damper clamp shall be maintained not less than ± 25/f mm, where f is the frequency in Hz.

The test shall be conducted for minimum ten million cycles at each resonant frequency mentioned above. During the, test if resonance shift is observed the test frequency shall be tuned to the new resonant frequency.

The clamp slip test as mentioned hereinabove shall be repeated after fatigue test without retorquing or adjusting the damper clamp and the clamp shall withstand a minimum load equal to 80% of the slip strength for a minimum duration of one minute.

After the above tests, the damper shall be removed from conductor/earthwire and subjected to dynamic characteristics test. There shall not be any major deterioration in the characteristic of the damper. The damper then shall be cut open and inspected. There shall not be any broken, loose, or damaged part. There shall not be significant deterioration or wear of the damper. The conductor/earthwire under clamp shall also be free from any damage.

For the purpose of acceptance, the following criteria shall be applied.

(1) There shall not be any frequency shift by more than ±2 Hz for frequencies lower than 15 Hz and ± 3 Hz for frequencies higher than 15 Hz.

(2) The force response curve shall generally lie within guar anteed % variation in reactance after fatigue test in comparison with that before fatigue test by the Contractor.

(3) The power dissipation of the damper shall not be less than guaranteed % variation in power dissipation before fatigue test by the Contractor. However, it shall not be less than minimum power dissipation which shall be governed by lower limits of reactance and phase angle indicated in the envelope.

3.4 Spacer (for twin bundle)

(a) Vibration Tests

The spacer assembly shall be clamped to conductor. During the vibration tests the axis of the clamp of sample shall be maintained parallel to its initial static position by applying a tension of 43 kN on the ACSR 'BISON' conductor. The spacer assembly shall be free to vibrate and shall not be re-torqued or adjusted between the tests.

All the vibration tests mentioned hereunder shall be conducted on the same sample on the same test span. The samples shall withstand the vibration tests without slipping on the conductor. loosening, damage or failure of component parts. After each vibration test, clamp slip test shall be carried out as per the procedure given in Clause No 3.5 (b) below

(i) Longitudinal Vibration Test

The stationary conductor and the vibrating conductor/equivalent diameter of aluminium alloy tube shall be restrained by fixed clamps. The displacement of the vibrating conductor shall be 25mm minimum on either side. The longitudinal movement shall be parallel to the conductor at frequency not less than 2 Hz for minimum one million cycles.

(ii) Vertical Vibration Test

The spacer/spacer damper shall be installed in the middle of the test span and the frequency chosen so as to get an odd number of loops. The shaker shall be positioned at least two loops away from the test specimen to allow free movement of the conductor close to the test specimen. One conductor shall be connected to the shaker and vibrated to an amplitude such that.

$f^{1.8}$ Ymax > 1000 mm/sec.

Where Ymax being the antinode displacement (mm) and f is the test frequency (Hz). The test frequency shall be greater than 24 Hz and the total number of cycles shall be more than 10 millions.

(iii) Sub-span Oscillation Test

The test shall be conducted for oscillation in horizontal plane at frequency higher than 3 Hz for minimum one million cycles. The amplitude for oscillation shall be kept equivalent to an amplitude of 150 mm for a full sub-span of 80m. Both the conductor shall be vibrated 180 deg. out of phase with the above minimum amplitude.

(b) Clamp Slip Test

The spacer assembly shall be installed on test span of twin ACSR 'BISON' conductor bundle string at a tension of 43 kN. In case of spacer for jumper, the clamp of sample shall be tightened with a specified tightening torque. One of the clamp of the sample when subjected to a longitudinal pull of 2.5 kN parallel to the axis of conductor for a minimum duration of one minute shall not slip on the conductor i.e. the permanent displacement between the conductor and the clamp of sample measured after removal of the load, shall not exceed 1.0 mm. Similar test shall be performed on the other clamp of the same sample. Such clamp slip tests shall also be conducted after each of the vibration test mentioned in clause 3. 5(a). Each clamp shall withstand a minimum longitudinal load of 2 kN for a minimum duration of one minute after the vibration test without any adjustment of sample.

3.5 Magnetic Power Loss Test for Damper/Spacer

The sample involving ferrous parts shall be tested in a manner to simulate service conditions for 50 Hz pure sine-wave. The test should be carried out at various currents ranging from 400 amperes to 800 amperes and the magnetic power loss at various currents should be specified in tabulated graphical form. The

difference between the power losses without and with sample at room temperature shall be limited to 1 watt for 600 amperes current (rms) for 'BISON' conductor. The losses shall be determined by averaging the observations obtained from at least four samples.

3.6 Mechanical Strength Test for Earthwire Suspension/Tension Clamp

(a) The suspension assembly/tension assembly (excluding tension clamp) shall be subjected to a load equal to 50% of the specified minimum ultimate tensile strength (UTS) which shall be increased at a steady rate to 67% of the minimum UTS specified. This load shall be held for five minutes and then removed. After removal of the load, the components shall not show any visual deformation and it shall be possible to disassemble them by hand. Hand tools may be used to loosen the nuts initially. The assembly shall then be reassembled and loaded to 50% of UTS and the load shall be further increased at a steady rate till the specified minimum UTS is reached and held for one minute. No fracture should occur during this period. The applied load shall then be increased until the failing load is reached and the value recorded.

(b) Clamp Slip Strength Vs Torque Test for Suspension Assembly

The suspension assembly shall be vertically suspended by means of a flexible attachment. A suitable length of Earthwire shall be fixed in the clamps. The clamp slip strength at various tightening torques shall be obtained by gradually applying the load at one end of the earthwire. The clamp slip strength Vs torque curve shall be drawn. The clamp slip strength at the recommended tightening torque shall be more than 12 kN but less than 17 kN for 7/3.35 mm earthwire.

(c) Slip Strength Test of Tension Clamp

Tension clamps shall be compressed on a 5 m length of earthwire on both ends. The assembly shall be mounted on a tensile testing machine and anchored in a manner similar to the arrangement to be used in service. A tensile load of 50% of the specified breaking load of the earthwire shall be applied & the sample shall be marked in such a way that movement relative to the fitting can easily be detected. Without any subsequent adjustment of the fitting, the load shall be steadily increased to 95% of the specified breaking load and maintained for one minute. There shall be no movement of the earthwire relative to the fitting during this one minute period and no failure of the fitting also.

(d) Electrical Resistance Test of Tension Clamp

The tension clamp and the jumper shall be compressed on two suitable lengths of earthwire. The electrical resistance shall be measured between points on earthwire near the clamp and near the jumper mouth keeping 25 mm clearance of the fitting and should not exceed 75% of the measured resistance of equivalent length of earthwire. The test shall be conducted with direct current. The current connections shall be at a distance not less than 50 times the diameter of earthwire from the fitting and shall be made

so that effective contact is ensured with all those strands of the earth wire which would be taken into account in calculating its equivalent resistance. The test shall be repeated with the polarity reversed and the average of the two results considered as the measured value.

3.7 Corona Extinction Voltage Test (Dry)

The sample when subjected to power frequency voltage shall have a corona extinction voltage of not less than 154 kV rms line to ground under dry condition for 220 kV line. There shall be no evidence of corona on any part of the sample. The atmospheric condition during testing shall be recorded and the test results shall be accordingly corrected with suitable correction factor as stipulated in IS: 731

3.8 Radio Interference Voltage Test (Dry)

Under the conditions as specified under (3.7) above, the sample shall have a radio interference voltage level below 1000 micro volts at one MHz when subjected to 50 Hz AC voltage of 154 kV rms line to ground for 220 kV under dry condition. The test procedure shall be in accordance with IS: 8263.

3.9 Chemical Analysis Test

Chemical analysis of the material used for manufacture of items shall be conducted to check the conformity of the same with Technical Specification and approved drawing.

4.0 Tests on All components (As applicable)

4.1 Chemical Analysis of Zinc used for Galvanizing

Samples taken from the zinc ingot shall be chemically analyzed as per IS-209-1979. The purity of zinc shall not be less than 99.95%.

4.2 Tests for Forgings

The chemical analysis hardness tests and magnetic particle inspection for forgings, will be as per the internationally recognized procedures for these tests. The, sampling will be based on heat number and heat treatment batch. The details regarding test will be as discussed and mutually agreed to by the Contractor and Employer in Quality Assurance Programme.

4.3 Tests on Castings

The chemical analysis, mechanical and metallographic tests and magnetic particle inspection for castings will be as per the internationally recognized procedures for these tests. The samplings will be based on heat number and heat treatment batch. The details regarding test will be as discussed and mutually agreed to by the Contractor and Employer in Quality Assurance Programme.

ANNEXURE-B

Acceptance Tests

1 Mid Span Compression Joint for Conductor and Earthwire

(a) Hardness Test

The Brinnel hardness at various points on the steel sleeve of conductor core and of the earthwire compression joint and tension clamp shall be measured.

2. Flexible Copper Bond

(a) Slip Strength Test

Same as clause 3.3 of Annexure - A.

3. Vibration Damper for Conductor and Earthwire

(a) Verification of Resonance Frequencies

The damper shall be mounted on a shaker table and vibrate at damper clamp displacement of +/-0.5 mm to determine the resonance frequencies. The resonance shall be visually identified as the frequency at which damper mass vibrates with maximum displacement on itself. The resonance frequency thus identified shall be compared with the guaranteed value. A tolerance of ± 1 Hz at a frequency lower than 15 Hz and ± 2 Hz at a frequency higher than 15 Hz only shall be allowed.

(b) Clamp Slip Test

Same as Clause 3.4 (c) (ii) of Annexure - A.

(c) Clamp Bolt Torque Test

The clamp shall be attached to a section of the conductor/earthwire. A torque of 150 percent of the manufacturer's specified torque shall be applied to the bolt. There shall be no failure of component parts. The test set up is as described in Clause 3.4 (c) (i), Annexure-A.

(d) Strength of the Messenger Cable

The messenger cable shall be fixed in a suitable tensile testing machine and the tensile load shall be gradually applied until yield point is reached. Alternatively, each strand of message caste may be fixed in a suitable tensile testing machine and the tensile load shall be gradually applied until yield point is reached. In such a case, the 95% of yield strength of each wire shall be added to get the total strength of the caste. The load shall be not less than the value guaranteed by the Contractor

(e) Mass Pull off Test

Each mass shall be pulled off in turn by fixing the mass in one jaw and the clamp in the other of a suitable tensile testing machine. The longitudinal pull shall be applied gradually until the mass begins to pull out of the

messenger cable. The pull off loads shall not be less than the value guaranteed by the Contractor.

(f) Dynamic Characteristics Test

The test will be performed as acceptance test with the procedure mentioned for type test with sampling mentioned below

Vibration Damper of Conductor	-	1 Sample for 1000 Nos. & below
	-	3 Samples for lot above 1 000 & up to 5000 nos.
	-	Additional 1 sample for every additional 1500 pieces above 5000.

The acceptance criteria will be as follows

(i) The above dynamic characteristics curve for reactance & phase angle will be done for frequency range of 10 Hz to 60 Hz for vibration damper for 7/3.35 mm earthwire.

(ii) If all the individual curve for dampers are within the envelope as already mentioned for type test for reactance & phase angle, the lot passes the test.

(iii) If individual results do not fall within the envelope, averaging of characteristics shall be done.

(a) Force of each damper corresponding to particular frequency shall be taken & average force of three dampers at the frequency calculated.

(b) Similar averaging shall be done for phase angle.

(c) Average force Vs frequency and average phase Vs frequency curves shall be plotted on graph paper. Curves of best fit shall be drawn for the entire frequency range.

(d) The above curves shall be within the envelope specified.

4. Spacer

(a) Test Set up

The test set up for the test described hereunder shall be as per clause 3.4 (c) (i) Annexure-A.

(b) Movement Test

The spacer assembly shall be capable of the following movements without damaging the conductor, assuming one conductor is fixed and the other moving:

(i)	Longitudinal movement parallel to the conductor	± 50 mm

(ii)	Vertical movement in a vertical direction at right angle to the conductor	± 25 mm
(iii)	Torsional movement/angular movement in a vertical plane parallel to the conductor	± 5 deg.

(c) Compressive and Tensile Test

The spacer assembly shall withstand ultimate compressive load of 14 kN and tensile load of 7.0 kN applied between sub conductor bundle and held for one minute without failure. Line distance between clamps shall be recorded during each of the compression and tension test. Measurement shall be recorded at (i) no load (ii) with load (iii) after release of load. The center line distance under load shall be within ± 100 mm of the nominal design spacing. After release of load it shall be possible to retain the clamps at their original position using only slight hand pressure. There shall be no deformation or damage to the spacer assembly which would impair its function of maintaining the normal spacing.

(d) Clamp Slip Test

Same as clause 3.5(b) of Annexure-A.

(e) Clamp Bolt Torque Test

The spacer assembly shall be attached to conductor. A torque of 150 per cent of the manufacturer's specified tightening torque shall be applied to the clamp bolts or cap screws. There shall be no failure of the component parts.

(f) Assembly Torque Test

The spacer assembly shall be installed on conductor. The same shall not rotate on either clamp on applying a torque of 0.04 kN in clockwise or anti-clockwise direction.

(g) Hardness test for Elastomer

The shore hardness at different points on the elastomer surface of cushion grip clamp shall be measured by shore hardness meter. They shall lie between 65 and 80.

(h) UTS of Retaining Rods

The ultimate tensile strength of the retaining rods shall be measured. The value shall not be less than 35 kg/sq.mm.

SAG TENSION CHART FOR CONDUCTOR

Data		
Basic span	m	350
Wind pressure	kg/sq cm	71.46
Conductor details:		
Type	BISON	
Overall diameter	cm	2.7000
Cross sectional area	sq cm	4.3120
Unit weight	kg/m	1.4440
Ultimate tensile strength	kgs	12328.0000
Coef. Of thermal expansion	/deg C	0.1930 E-04
Modulus of elasticity	kg/sq cm	703400.0000
Creep	%	0.0000
Shape factor		1.0000
Gust factor		2.3090
Drag factor		1.0000
Basic conditions:		
Temperature	deg C	32.0000
Wind factor		0.0000
Ice thickness	cm	0.0000
Factor of safety		4.5450

SAG_TENSION_FOS COMPUTATIONS

S. No.	Environmental temperature (deg C)	Wind factor	Ice thickness (cm)	Vertical sag (m)	Tension (kg)	FOS	Remarks
1	32.00	0.00	0.00	8.152	2712.43	4.545	
2	32.00	1.00	0.00	3.423	6460.34	1.908	
3	80.00	0.00	0.00	10.061	2197.82	5.609	
4	0.00	0.36	0.00	5.228	4229.21	2.915	
5	0.00	0.00	0.00	6.800	3251.47	3.792	
6	32.00	0.75	0.00	4.103	5388.65	2.288	

Max vertical sag (m):	10.061
Max tension (kg) :	6460.34

Hetauda-Bharatpur-Bardaghat 220 kV Transmission Line Project
PROCUREMENT OF PLANT DESIGN, SUPPLY, INSTALLATION, TESTING AND COMMISSIONING OF
HETAUDA-BHARATPUR 220 KV TRANSMISSION LINE PROJECT

SAG TENSION CHART FOR OPGW

Data

Basic span	m	350
Wind pressure	kg/sq cm	71.46

Conductor details:

Type		OPGW-24 fibers
Overall diameter	cm	1.1400
Cross sectional area	sq cm	0.6800
Unit weight	kg/m	0.4870
Ultimate tensile strength	kgs	8828.0000
Coef. Of thermal expansion	/deg C	0.13 E-04
Modulus of elasticity	kg/sq cm	1650000.0000
Creep	%	0.0000
Shape factor		1.0000
Gust factor		2.3090
Drag factor		1.0000

Basic conditions:

Temperature	deg C	32.0000
Wind factor		0.0000
Ice thickness	cm	0.0000
Factor of safety		7.2000

SAG_TENSION_FOS COMPUTATIONS

S. No.	Environmental temperature (deg C)	Wind factor	Ice thickness (cm)	Vertical sag (m)	Tension (kg)	FOS	Remarks	
1	32.00	0.00	0.00	7.026	1061.40	8.317	% GW/COND Sag=	86.18
2	32.00	1.00	0.00	2.406	3098.92	2.849	% GW/COND Sag=	70.29
3	53.00	0.00	0.00	7.642	975.80	9.047	% GW/COND Sag=	75.96
4	0.00	0.36	0.00	4.033	1848.99	4.774	% GW/COND Sag=	77.14
5	0.00	0.00	0.00	6.082	1226.11	7.200	% GW/COND Sag=	89.44
6	32.00	0.75	0.00	2.892	2578.98	3.423	% GW/COND Sag=	70.05

Max vertical sag (m): 7.642
Max tension (kg) : 3098.92